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Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery

Second Edition

Springer

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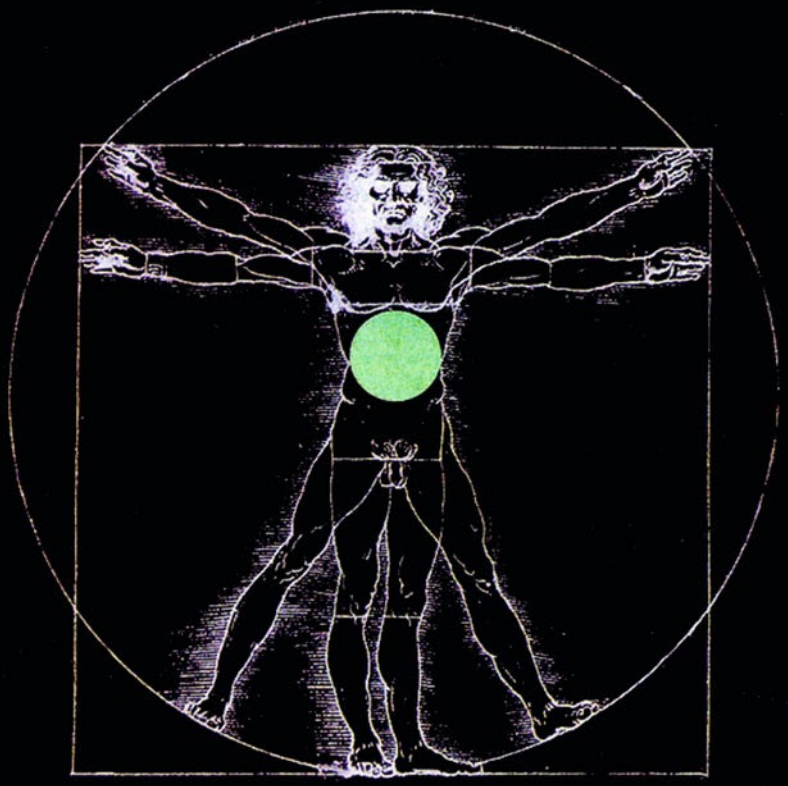
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Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery

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The medicine
and
the arts
as a symbiosis
give us humans
a healthy community

Gottfried Honegger



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Preface

The success of the first version of the *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery*, published in 2007, encouraged us to prepare an updated version keeping the spirit of the original Atlas, and adding modifications, novelties, and new innovations in the technical aspects of these operative procedures. For the new edition, we added a leader in the field of Liver and Biliary Surgery from Asia, Dr. Masaru Miyazaki. Modifications of the text were needed in about 60% of the chapters, and modifications and additions in the artwork in about 30% of the chapters. To follow emerging developments in surgery, we added new approaches in laparoscopic and robotic surgery in many chapters. Also to enhance clarity, the liver section is now divided into transplant and non-transplant procedures. New procedures are described, such as the new two-staged liver resection ALPPS or the use the new electroporation technology for targeted tumor ablation. Two new chapters were added to Section 1 on general principles including: general surgical devices for cutting and sealing and an introduction to robotic surgery, because this section showed highest rank in online downloads for the first edition of the Atlas.

Knowledge of anatomy and precise surgical technique remain the foundation of high-quality surgery. A knowledgeable surgeon, equipped with excellent theoretic and clinical skills, will only be accomplished when he or she masters the operative techniques of the practice of surgery. The legacy of an academic surgeon or a surgical educator relies in great part on the transmission of his or her surgical abilities to hands-on clinical practice. During the last few years, we as surgical educators felt more and more that teaching surgical skills and techniques are compromised due to the plethora of new information dealing with other aspects of surgery. The number of new procedures and techniques developed since the early 1990s, as for example, laparoscopic liver resection or Roux-en-Y gastric bypass, although offering obvious advantages for the patients, constitute a real technical challenge for us surgeons. Therefore, possibly more than ever before, surgeons need to update their knowledge about the various surgical procedures and techniques available.

In bringing forth the first and second editions of the atlas, our goal was to create a comprehensive and educational tool focusing on the upper abdomen and emphasizing all details of operative techniques including "tricks" from experienced surgeons. In view of the availability of many textbooks describing non-technical aspects of surgery, we purposely avoided writing a text addressing the disease processes, but instead concentrated on the operative techniques, which are evolving rapidly. The technical aspects described are the real message of the atlas. We standardized the text associated with each procedure, covering a list of the most common indications and contraindications, a step-by-step description of the procedure, a list of the most common complications, and finally the insightful tricks of the experienced surgeon. We also included an introductory section covering basic principles of operative surgery including operative accesses, positioning of the patient, and the use of retractors, drains, staplers, and the newer devices to facilitate dissection, transection, and hemostasis both for laparoscopy and open surgery.

While a surgeon 50 years ago could treat diseases from head to toe, this concept has evolved, and today some degree of specialization is the rule worldwide. Most countries or accrediting authorities have designed various boards for sub-specializations; indeed, after a broad training in general surgery, many young surgeons will move on further into a specific field. Upper gastrointestinal and hepato-pancreato-biliary surgery have emerged as specialized fields of general surgery, including common procedures belonging to the scope of general surgery as well as complex procedures, that probably should be performed only by specialized surgeons. We opted for a comprehensive approach of upper gastrointestinal and hepato-pancreato-biliary surgery, covering most open and laparoscopic procedures ranging from straightforward procedures such as laparoscopic cholecystectomy to the more complex procedures, such as spleno-renal shunt and liver or pancreas transplantation.

This second edition of the *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery* presents consistent illustrations created by a single artist. This approach is key to following a procedure, step-by-step, in a consistent and attractive manner. In selecting contributors from literally all around the world, we sought surgeons who had extensive and recognized experience with the procedure. The contributors are established educators and have successfully mentored many young surgeons.

The *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery* is subdivided into seven sections, each coordinated by a section editor in a close collaboration with the artist. A balance was achieved in each procedure to highlight the educational message in combination with the art of medical drawing.

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Based on the personal experience of the expert authors, a few tricks are presented at the end of each procedure. Some procedures, such as those related to portal hypertension, are becoming less popular. This atlas may contribute significantly to preserving the accumulating knowledge of these demanding surgical procedures as these procedures become less frequent.

The second edition of the *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery* is intended for students and residents in surgery and for fellows specializing in upper gastrointestinal and hepato-pancreato-biliary surgery preparing themselves for the operation. At the same time, this atlas will be useful for specialists and general surgeons who may compare their techniques with the one described herein or find some additional help or tricks when performing rare procedures.

In summary, we believe that the second edition of the *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery* is truly a new atlas, new in concept, and new in scope.

We hope that specialists as well as surgeons at various levels of training will benefit from this huge effort, combining the work of many experts, a gifted artist, and the publisher.

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Acknowledgments

The creation of an atlas covering the entire scope of upper gastrointestinal and hepato-pancreato-biliary surgery is dependent on a team effort, which is possible only with the support and enthusiasm of many individuals. First of all, an atlas is a series of drawings, which should transmit the appropriate knowledge in an artistic way.

We are deeply indebted to Mr. Jörg Kühn, who undertook so successfully the daunting task of creating an entirely new and exhaustive visual depiction of many upper gastrointestinal and hepato-pancreato-biliary procedures. His imagination, ingenuity, understanding of surgical anatomy, and artistic skill have produced what we believe is the definitive rendering of today's upper gastrointestinal and hepato-pancreato-biliary operations. The original work from Mr. Jörg Kühn and the new drawings were arranged and harmonized by the huge effort from Mr. Lee Klein, senior editor at Springer in Philadelphia, USA.

A very special acknowledgment should go to the Associate Editor Dr. Christoph Tschuor, who took over the challenging task of coordinating this book from Panco Georgiev, who coordinated the first edition of the Atlas. Dr. Christoph Tschuor is a bright senior resident, who, following an academic track in surgery at the University Hospital in Zürich, devoted an incredible amount of time and effort to organizing and supervising the second edition of the atlas on behalf of the Editors. We are also indebted to Madeleine Meyer and Susanne Gaal, Staff Assistants in the Zurich office, who also put tireless efforts into assisting the Editors in many of their tasks. Furthermore, we are grateful for the support from the Liver and Gastrointestinal Disease Foundation (LGID).

Finally, we would like to thank the entire staff at Springer, particularly Gabriele Schröder, who was very supportive from the first idea of this atlas, and maintained their enthusiasm until the end.

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Introduction: General Principles

Pierre-Alain Clavien, Michael G. Sarr

A competent surgeon must be aware of all the general aspects of a surgical procedure to be able to perform specific interventions successfully and expeditiously. The old adage that "exposure, exposure, and exposure" are the three most important factors for the good outcome of a surgical procedure remains true for both open and laparoscopic approaches.

Each procedure must start with careful positioning of the patient prior to wide disinfection of the operative field, draping, and incision. Compared to the first edition of the Atlas, we added two new chapters: one on new devices for cutting and sealing tissues, and a second one to introduce robotic surgery. Significant changes were performed in about one third of the other chapters. The second chapter covers the various options for positioning of the patient on the operating table and describes the incisions that are available to enter the abdominal cavity. The third chapter focuses on different principles of exposure through the use of various types of retractors, providing examples of the most commonly used retractors. The fourth chapter addresses the use of mechanical staplers. Currently, staplers are increasingly being used for many open and laparoscopic procedures, and the industry has partnered actively with the surgical field in developing new devices enabling sophisticated maneuvers, often to reach otherwise small and relatively inaccessible areas. Proper knowledge of the general principles of the use, limitations, and function of mechanical staplers is mandatory for modern surgery, because their misuse or naiveté about their limitations may result in devastating complications such as anastomotic leakage or bleeding. While Billroth claimed more than a century ago that "drainage saves many lives", the use of the "time-honored" surgical drain has changed dramatically, because accumulating studies have shown convincingly that drains are often useless or even harmful in many procedures. Open drains are rarely needed today. This chapter presents the principles of the various types of drains including a table of "evidence-based" utility of drains for upper abdominal surgery. A new chapter introduces devices for cutting and sealing tissues which are nowadays used in most centers and allow accurate dissection and hemostasis of tissue. The last chapter introduces robotic surgery for procedures such as robotic cholecystectomy, distal pancreatectomy, gastrectomy, and hepatectomy outlined in following sections.

These chapters covering the general aspects of surgery were prepared in a simple, yet comprehensive manner. We believe that the didactic and basic information provided in these introductory chapters of the Atlas will be of value for both trainees and specialized surgeons.

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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Positioning and Accesses

Yvonne Knoblauch, Dieter Hahnloser

Positioning

Correct and stable positioning of the patient is the first step for a successful operation. Safe positioning of the arm and leg are crucial in preventing pressure lesions, such as ulnar or peroneal neuropathy and neurologic "stretch" injuries to the upper extremities.

Supine Position

The supine position is used for most abdominal procedures. The arms can be left out (Fig. 2.1a) or kept close to the body (Fig. 2.1b), depending on the type of operation to be performed.

- Anchor the patient's legs and/or ankles with a strap in case tilt is required
- Protect arms with a pillowcase, gauze sponge, or silicone pad
- Avoid traction on the brachial plexus (abduction of the shoulder should be < 90°)

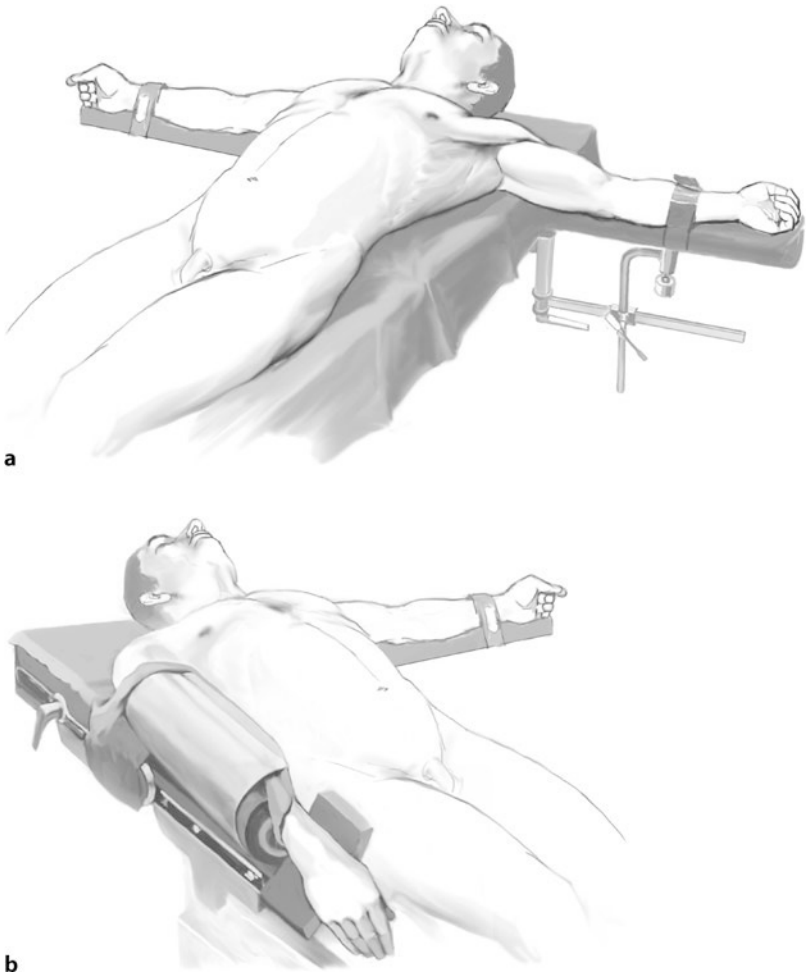


Fig. 2.1

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2

French Position

The French position (Fig. 2.2) is one possible patient position for a laparoscopic cholecystectomy (the "American" supine position with both arms tucked alongside the body being the other). This position can also be used for upper abdominal operations such as laparoscopic fundoplication or gastric surgery.

- The patient's legs are placed in stirrups or supported under the knee
- Legs need to be placed horizontally or slightly bent to allow free movements with laparoscopic tools
- Avoid any pressure on the peroneal (lateral popliteal) nerve

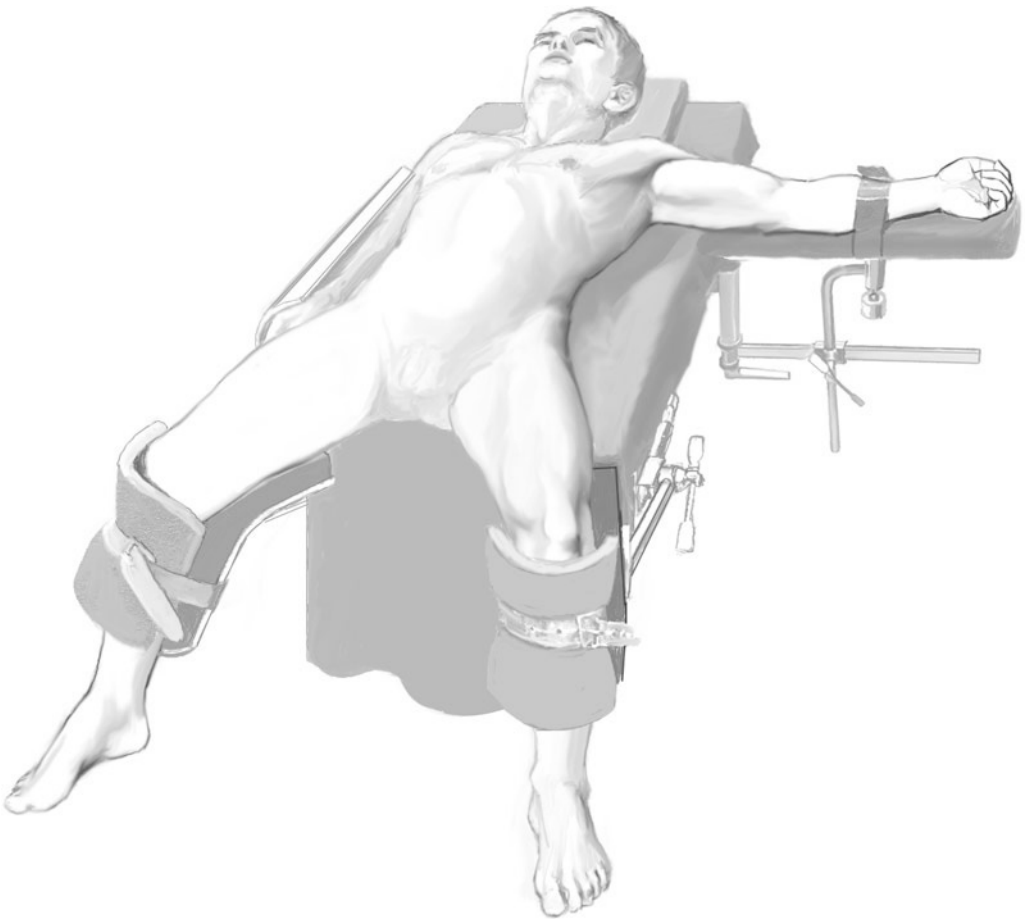


Fig. 2.2

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Beach Chair Position

The beach chair position (Fig. 2.3) is used for most laparoscopic obesity surgery procedures
- Requires a special weight-bearing table
- The patient is almost "sitting" on the table
- Avoid any pressure on arms, the brachial plexus, and the peroneal (lateral popliteal) nerve



Fig. 2.3

Positioning for Esophageal Surgery

For esophageal resection and reconstruction, several approaches can be used. Depending on the location of the disease and the surgical approach, the positioning is adapted accordingly.

The positions used are:

a) *Supine* position with overextended thoracic spine, the head rotated to the right and extended. The right arm is left out and the left arm is tucked alongside the body (Fig. 2.4). This position is commonly used for transhiatal esophagectomies enabling
- Good exposure of the upper abdomen
- Good exposure for the cervical anastomosis

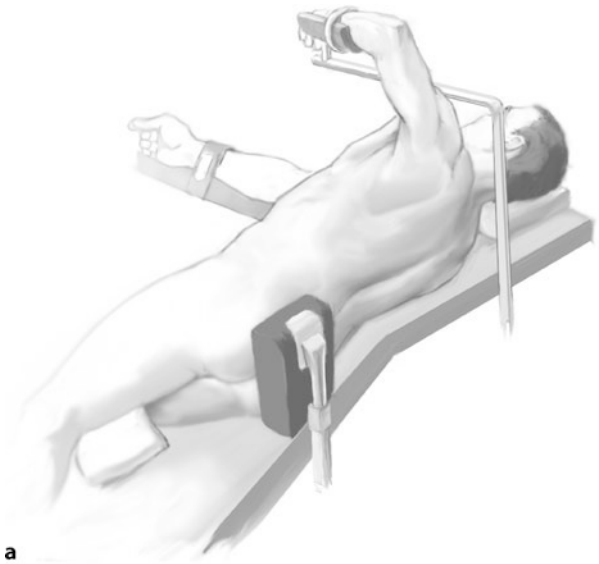
b) *Right or left lateral decubitus* (Fig. 2.5a)
- Good for the intrathoracic anastomosis distal to azygous vein; left decubitus is good for higher intrathoracic anastomoses
- Procedures on the upper thoracic esophagus are approached via a right posterolateral thoracotomy, and similar procedures on the lower esophagus are best approached through the same incision on the left side
- The table is bent slightly at the thoracic level, allowing further opening of the thoracic cavity after thoracotomy

c) *45° lateral decubitus or screw position* (Fig. 2.5b)
- An advantage is that the abdominal, thoracic, and/or cervical phase of the procedure can be performed without changing the position
- For optimal access, the operating table can be tilted side-to-side
- The main disadvantage is a more limited exposure

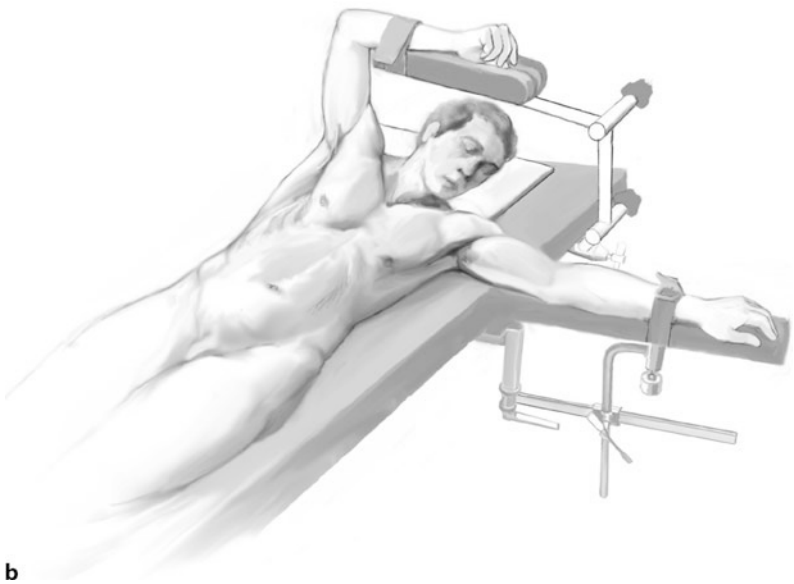
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Fig. 2.4



a



b

Fig. 2.5

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Incisions

Abdomen

Choice of approach for entering the abdominal cavity depends upon:

- The accuracy of the preoperative diagnosis
- The location and extent of the disease
- Previous scars
- The requirement of a possible extension of the incision
- Anatomic structures, such as skin, fascia, muscles, nerves, and blood vessels. The abdominal wall should stay functional. Whenever possible, incisions are placed along the lines of Langer, and muscles and fascia are divided along their fibers; all attempts to avoid transection of muscles of the abdominal wall should be entertained

Mark the incision prior to cutting to prevent malpositioning.

Midline Incision

The midline incision is the most expedient choice for opening the abdomen and provides unrestricted access, regardless of the patient's size or shape (including exposure of the pelvis). The advantages of a midline incision are:

- Can be extended into a median sternotomy
- Minimal blood loss
- No muscle fibers are divided
- No nerves are injured
- Is suitable for repeated celiotomies
- Offers best exposure to all areas of the peritoneal cavity in an emergency situation with unclear diagnosis

The Steps

- Place skin incision exactly in the midline, above and below the umbilicus from the tip of the xiphoid to the pubis (extension as needed) (Fig. 2.6a); avoid transecting midline fascia all the way up to the xiphoid
- Deflect the incision around the umbilicus to the left or the right. The evasion of the umbilicus on the left side is preferred, because of possible rudimentary umbilical vessels. In general, use the opposite side of the umbilicus if an ostomy is planned
- The scalpel or the cautery can be used all the way
- By pulling the wound edges laterally, the fat spreads and the plane separates down to the midline fascia (Fig. 2.6b and 2.6c)
- Apply digital pressure to minimize bleeding
- Incise the fascia with the scalpel or cautery just above or below the umbilicus, as the linea alba is widest around the umbilicus
- Gently lift up the peritoneum with pickups before opening to avoid small bowel lesions (Fig. 2.6d)
- Care to incise the linea alba without any lateral exposure of the rectus muscles markedly facilitates the closure

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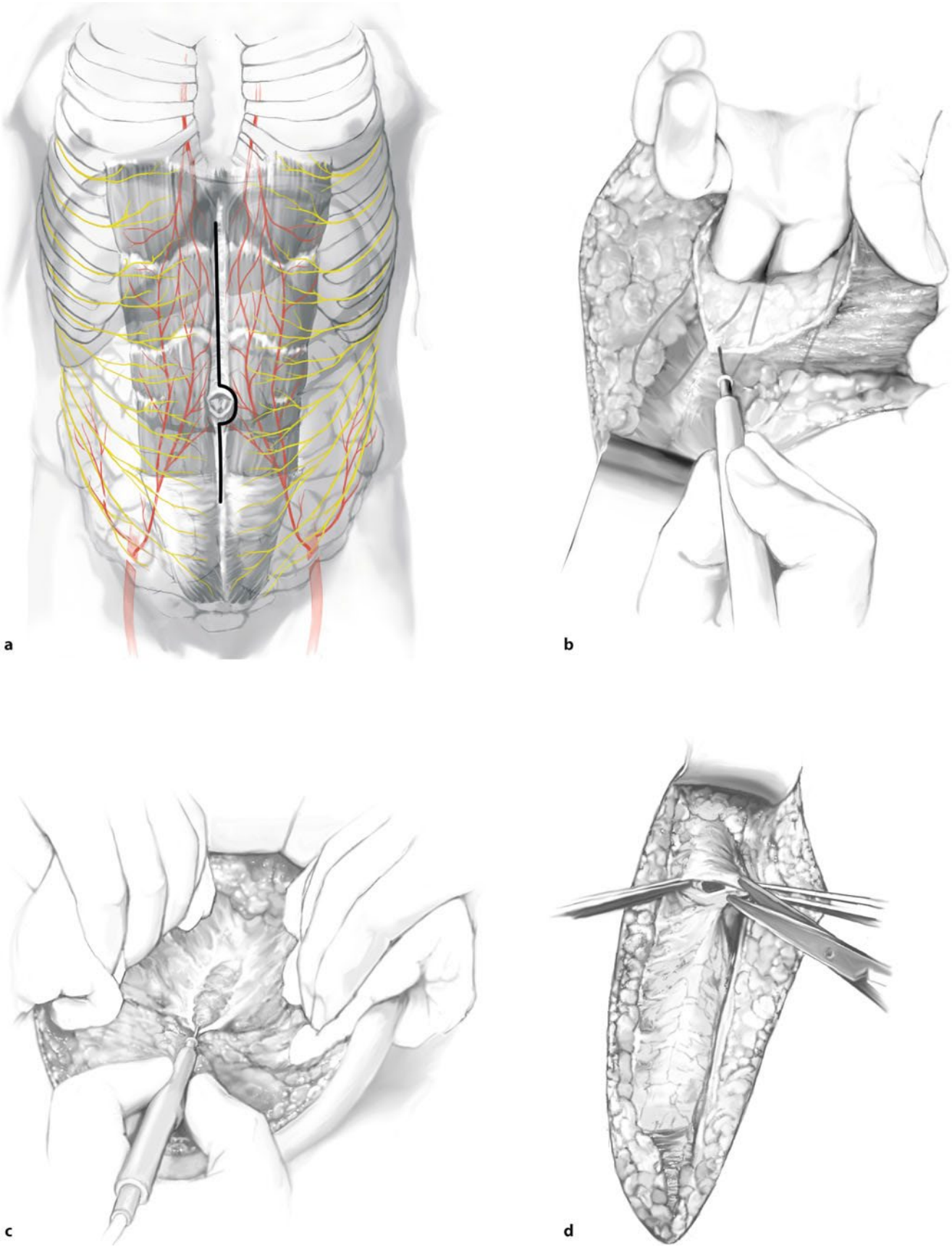


Fig. 2.6

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Subcostal Incision (Fig. 2.7a)

The subcostal incision is usually made for cholecystectomy or common bile duct exploration (right subcostal incision) and for elective splenectomy (left subcostal incision) (Fig. 2.7a). The major advantages of the subcostal incision over the upper midline incision are greater lateral exposure and possibly less pain. The disadvantage is that the operation takes longer, because there are more layers to close. The subcostal incision generally heals well with less risk of hernia formation.

The Steps

- Place skin incision two finger breadths caudal to the costal margin. This facilitates closure so that the incision line is not on or over the costal margin
- Incise the anterior and posterior sheet of the rectus muscle. The muscle is cut slowly with the cautery (Fig. 2.7b); care should be taken to ligate or cauterize the inferior epigastric vessels
- Laterally, the fascia of the transverse muscle may need to be cut
- Try not to incise the fascia in the midline, but if necessary, extend the incision medially

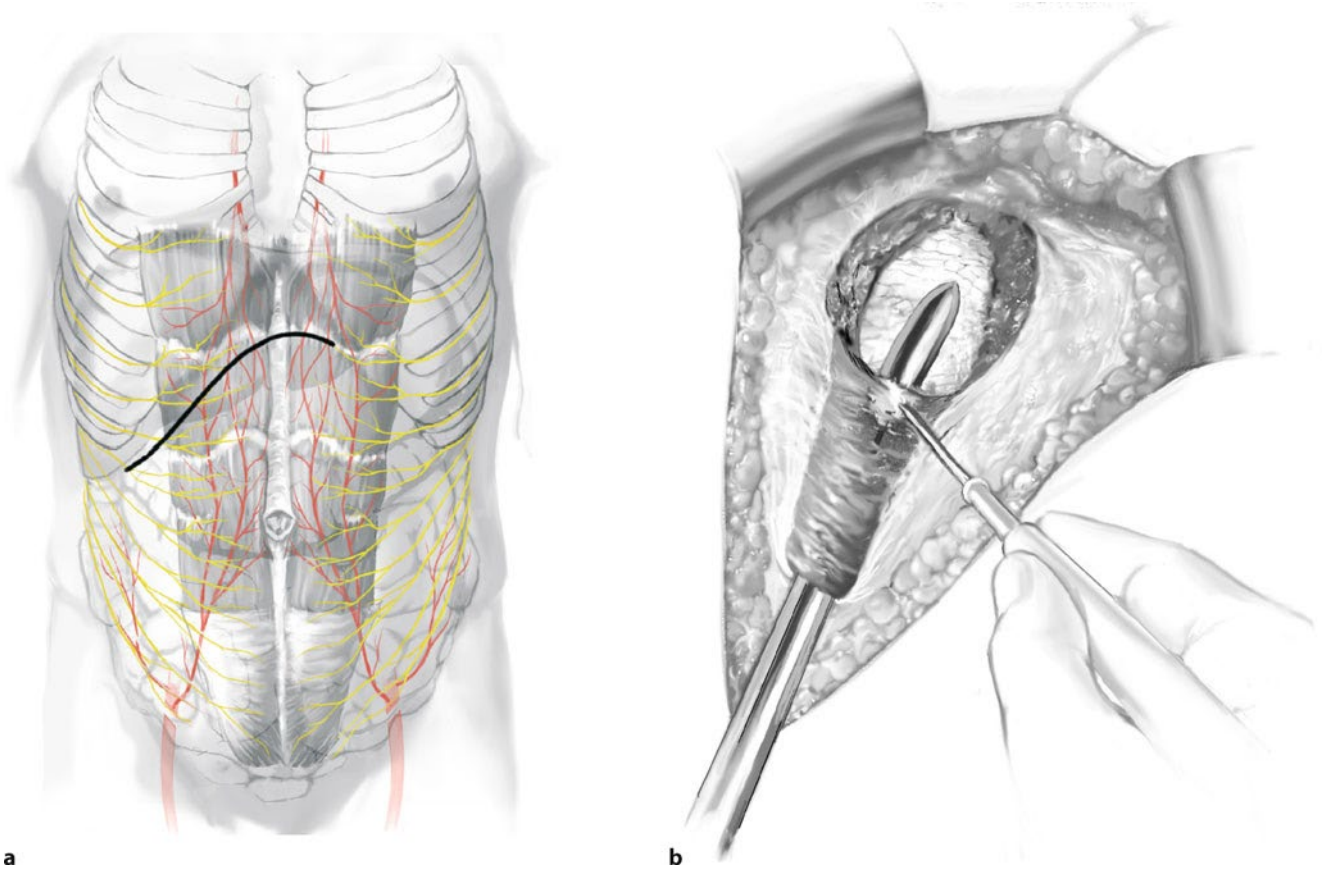


Fig. 2.7

Bilateral Subcostal Incision

The bilateral subcostal incision is used to access the liver for transplant and major liver resections. Also, most pancreas resections are performed with this incision. The exposure is often helped with a vertical extension to the xiphoid (the so-called "Mercedes star" incision).

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The Steps

- Incision of skin and fascia as described above
- For pancreas resections, the incision is generally placed three to four finger breadths below the costal margin
- Mobilization of the liver begins with the division of the falciform ligament as well as the liver's reflection of peritoneum with the anterior wall
- Division of the round ligament (a fibrous cord resulting from the obliteration of the umbilical vein), which should be ligated to avoid bleeding, particularly in the presence of portal hypertension
- It is preferable to mobilize the liver prior to the use of stationary retractors to reduce the necessity of frequent repositioning

J-shaped Incision

The J-shaped incision (Makuuchi incision) is used most frequently for surgery on the right liver. This incision provides a particularly good access to the area between the inferior vena cava and the right hepatic vein. The J-shaped incision can be extended laterally to a thoracotomy for better exposure.

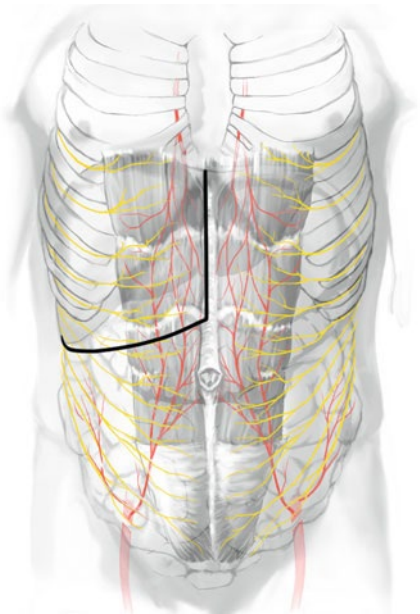


Fig. 2.8

Esophageal Surgery

Like the various positions used in esophageal surgery, there are different incisions used depending on the location of the disease, the level of the anastomosis, and the surgeon's preference. Most of the time, a combination of two or more of the following incisions are used:

a) *Upper midline laparotomy*

- As described in the previous section on the abdomen
- Can be combined with a transverse laparotomy for better exposure

b) *Thoracotomy*

- Anterolateral: skin incision usually in the fourth or fifth intercostal space
- Posterolateral: skin incision in the seventh intercostal space at the angle of the scapula (Fig. 2.9a). A paravertebral or anterior extension is possible

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- The intercostal muscle is freed from the upper border of the rib (avoids damaging the intercostal nerve and blood vessels, which lie just posterior to the inferior border of the rib) (Fig. 2.9b)
- The parietal pleura is opened with scissors, and the ribs are separated with a retractor

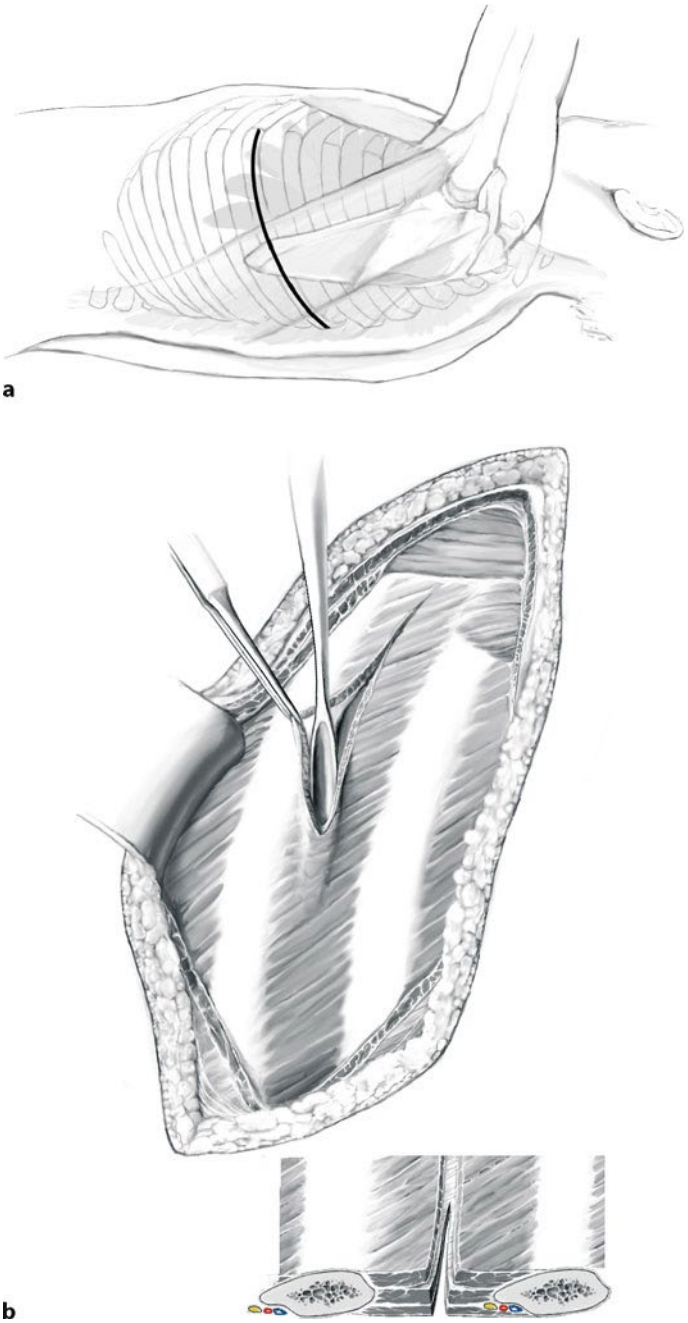


Fig. 2.9

c) *Cervical incision*

- Incision along the anterior border of the sternocleidomastoid muscle (Fig. 2.10a)
- Division of the platysma in the direction of the incision
- The omohyoid muscle (Fig. 2.10b) and, if necessary, the inferior thyroid artery and/or middle thyroid vein are divided to provide clear exposure
- The sternocleidomastoid muscle and carotid sheath and its contents are retracted laterally (Fig. 2.10c), and the trachea, larynx, and thyroid lobe are retracted medially (Fig. 2.10a)

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- No retractor should be placed against the recurrent laryngeal nerve in the tracheoesophageal groove during the entire cervical phase of the procedure
- For better exposure, the medial part of the sternocleidomastoid muscle can be cut inferiorly close to the clavicle bone if necessary
- Identification of the flat, decompressed esophagus can be helped by inserting a large tube into the esophagus by the anesthesiologist
- In patients with a "bull neck" habitus or with osteoarthritis preventing extension of the neck, a partial upper sternal split can provide the prerequisite access to the high retrosternal esophagus

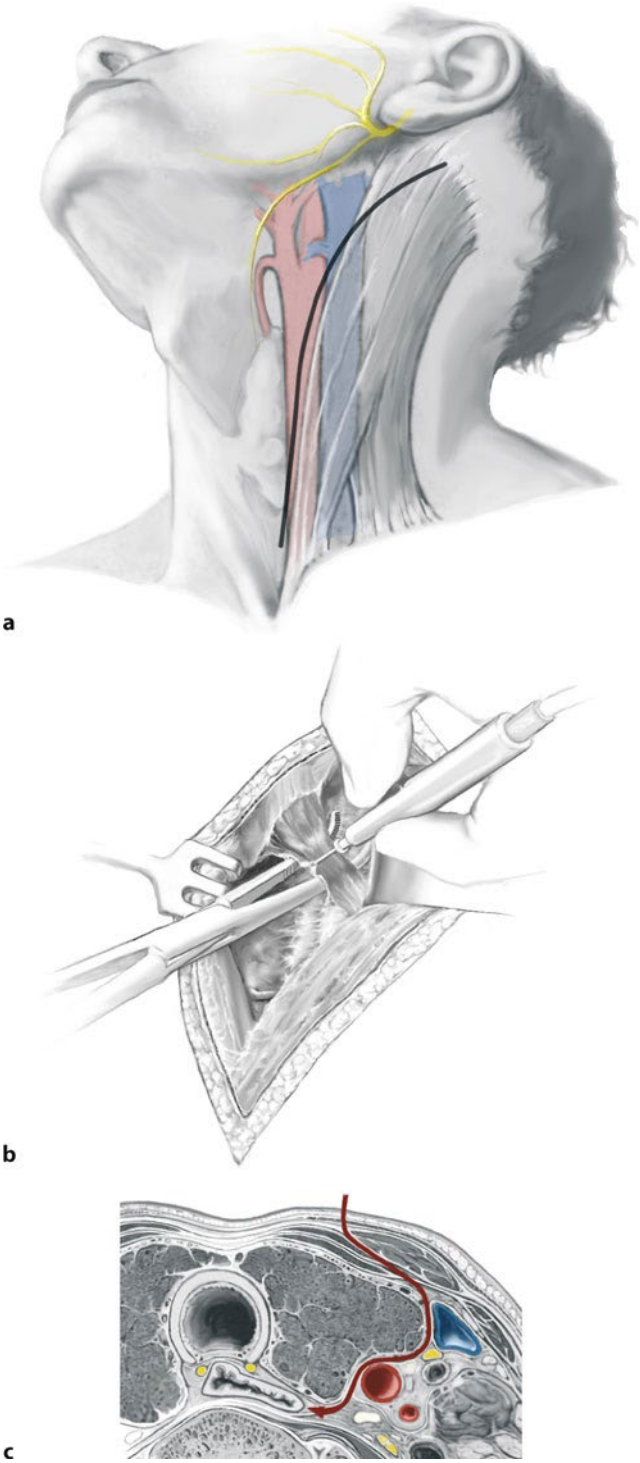


Fig. 2.10

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Laparoscopic Surgery

Establishing Pneumoperitoneum

Pneumoperitoneum can be established using a Veress needle, by an open approach using any modified Hassan trocars, or with EndoPath OptView trocar (Ethicon; Cincinnati, OH, USA). The open technique is generally preferred, as it minimizes the risks of inherent lesions to the bowel. However, in obese patients, the Veress needle is used, as the thick subcutaneous tissue does not allow visualization of the fascia through a 1–2 cm incision.

Gaining Access with a Veress Needle

- Incision of the skin (generally infraumbilical in the midline or just caudal to the left subcostal region) and blunt dissection of the subcutaneous tissue
- The fascia is grasped with a hook retractor or a Kocher clamp and is pulled anteriorly (Fig. 2.11a)
- Before inserting the Veress needle, its correct functioning must be checked
- Insertion of the needle at a 90° angle to the abdominal wall. As the needle's spring-loaded safety mechanism crosses the abdominal fascia and then the peritoneum, two clicks are heard and are usually felt
- Verification of the needle's intraperitoneal location by injecting 3 ml of saline with no resistance (Fig. 2.11b) followed by the "hanging drop" test (Fig. 2.11c) (i. e., a drop of saline is placed on the top of the needle, which is sucked into the needle when the abdominal fascia is lifted up anteriorly)
- Pneumoperitoneum. When a pressure of 13–15 mmHg is reached, the Veress needle is withdrawn, and a sharp-tipped camera trocar is blindly inserted through the same incision

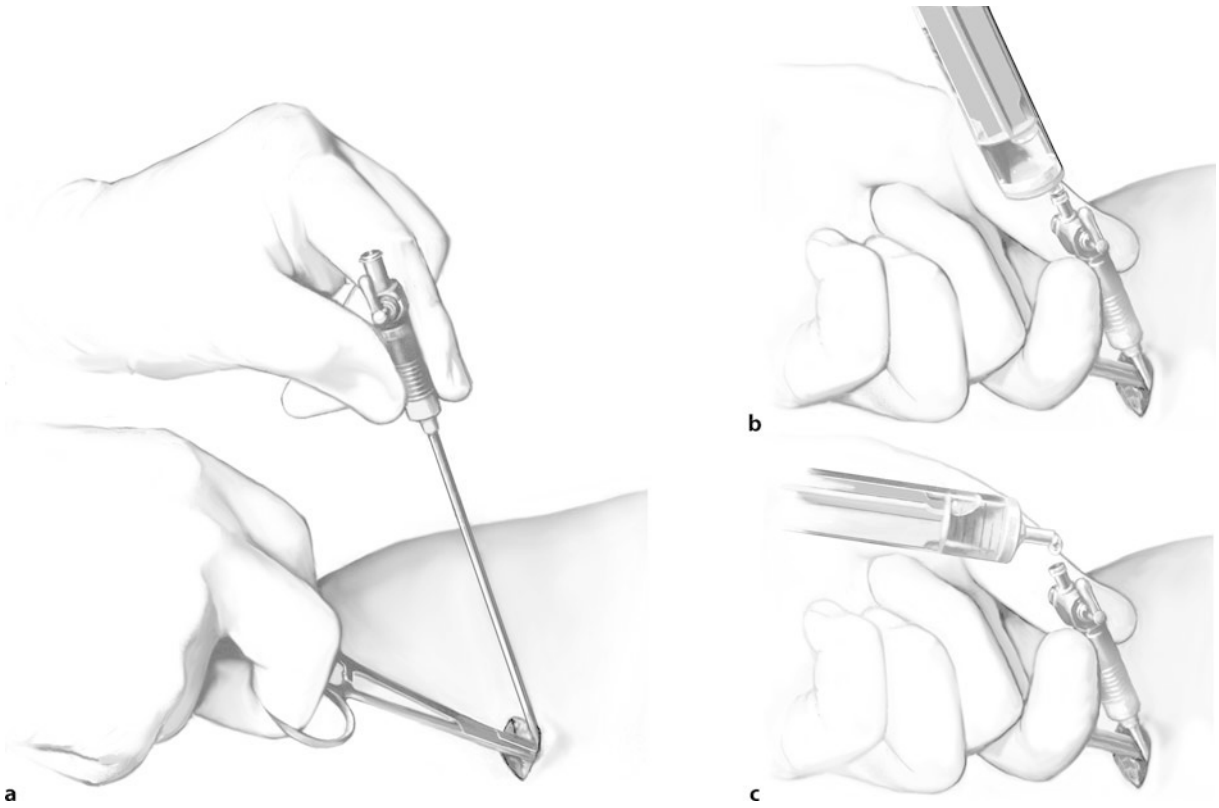


Fig. 2.11

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Gaining Access with the Open Technique

- Incision of the skin (generally infraumbilical in the midline) and blunt dissection of the subcutaneous tissue
- Incision of the fascia (1–2 cm) and opening of the peritoneum with scissors (two sutures can be placed to lift up the abdominal wall and to later secure the port)
- Entry into the abdominal cavity is confirmed easily by inserting a finger
- A blunt-tipped camera trocar is inserted and fixed with the two sutures if needed (Fig. 2.12a–b)

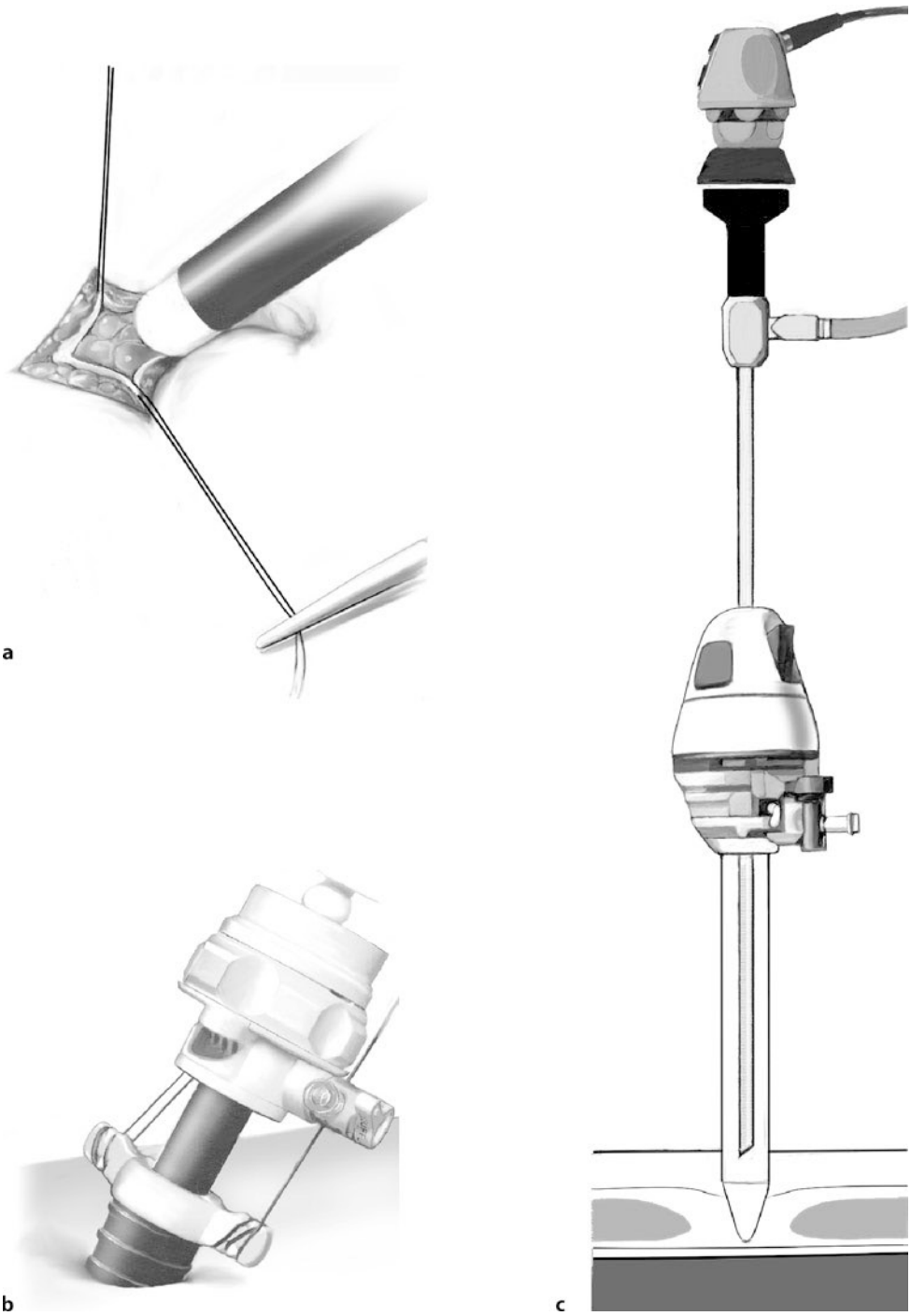


Fig. 2.12

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Gaining Access with the EndoPath OptiView Trocar

This trocar provides visualization of the transparent tip of the trocar as it traverses the anterior abdominal wall.

- Incision in the skin (generally in the left upper quadrant in midclavicular line 1 cm caudal to the left subcostal margin where the abdominal wall is less mobile)
- The camera is placed inside the trocar and the layers of the abdominal wall (fat, fascia, muscle, preperitoneal fat, and thin veil of peritoneum) are visualized as the trocar is advanced carefully (Fig. 2.12c)

Placement of Accessory Ports

Selecting the insertion sites of working trocars is dependent on the procedure to be performed and also depends on the surgeon's preference, the patient's body habitus, and the presence or absence of previous scars or intra-abdominal adhesions.

The Steps

- The size of the skin incision must be planned carefully. If the incision is too small, friction will develop between the skin and the port, and greater force will be required for insertion, which will increase the risk of uncontrolled insertion. If the incision is too large, gas may leak and the port may dislocate more easily
- Transillumination of the skin can help to avoid insertion of the trocar through major blood vessels (Fig. 2.13a)
- The trocar is inserted optimally by holding it between the index and the middle fingers. The shaft of the trocar should also be supported by the opposite hand as the body wall is traversed to avoid an uncontrolled, too rapid of an insertion (Fig. 2.13b)

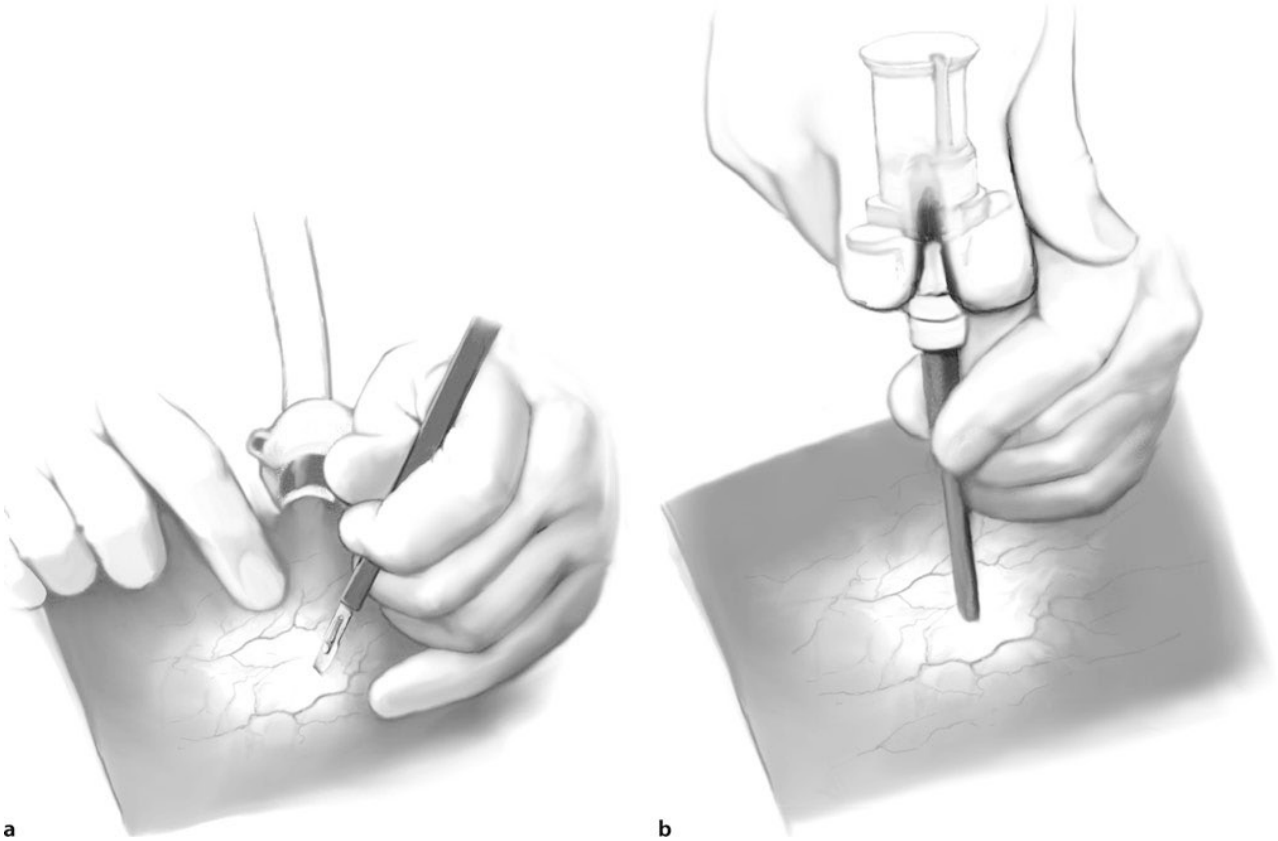


Fig. 2.13

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Closures

General

- The length of the suture material should be 4:1 to the length of the wound
- Avoid excessive tension on the suture closure of the fascial edges because it may compromise vascularization of the wound edges
- Caudal to the umbilicus, the posterior fascia (rostral to the semi-circular line caudal to which there is no posterior rectus fascia) and then the anterior fascia of the rectus abdominis muscle can be closed as separate layers
- Grasp the needle with the tip of the instrument

Midline Laparotomy

- The fascia is closed with a running loop of monofilament, absorbable suture material (e. g., PDS II-1 loop or Maxon-1 loop) with or without inclusion of the peritoneum
- The subcutaneous fatty layer is not closed and subcutaneous drains are rarely needed
- The skin is closed preferably with a running intracutaneous absorbable monofilament suture (e. g., Maxon 5-0 or 4-0 Monocryl) or with staples

Subcostal Incision

- In contrast to the midline laparotomy, the fascia should be closed in two layers

Trocar Wound Closure

- Ports are removed under direct vision with the camera; port sites should be watched routinely for 10 s to exclude port site bleeding
- All fascial defects of trocars greater than 5 mm are closed with absorbable sutures (e. g., Vicryl 0); this is also probably warranted with the 10-mm "blunt-tipped" "non-traumatic" trocars
- The skin is closed with interrupted mattress sutures (e. g., Dermalon 4-0) or with staples

Tricks of the Senior Surgeon

- The surgeon should personally check the correct positioning of the patient and the adequate protection of the extremities before draping.
- Marking the incision site before the beginning of the procedure is useful for teaching and prevents malpositioning.
- The incision should always be large enough to guarantee good visualization of the operative fields and to guarantee a safe and efficient operation.
- Avoid extending the midline incision all the way to the xiphoid-stay 1–2 cm caudal; this avoids a more difficult closure and potential ectopic bone formation from disruption of xiphoid cartilage. These last 2 cm do not provide increased exposure.
- Avoid extensive traction on the wound edges, as it may compromise healing.
- Place trocars carefully according to the operative need and according to the body habitus of the patient (e. g., obesity).
- Do not hesitate to place another trocar if better exposure is needed.
- Visualize the port site for at least 10 s after removal of the trocar to check for bleeding.

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Retractors and Principles of Exposure

Tim Gessmann, Markus Schäfer

Principles of Surgical Exposure

Adequate exposure of the target organ represents a laudable prerequisite of every successful operation. Therefore, it is worthwhile to be equipped with different retractors and to invest enough time intraoperatively to optimize exposure. Basic principles of exposure have been challenged recently by the advent of minimally invasive surgery. However, minimally invasive surgery has only changed the means of surgical access; the procedures performed at the target organs remain largely unchanged. In contrast to open surgery, exposure during laparoscopy is achieved predominantly by patient position and trocar placement. Retractor systems are less important.

Retractor Systems

In general, a retractor system needs to fulfil the following requirements for an ideal surgical exposure:

- Broad, unrestricted view into the abdominal cavity
- Wide access to the target organ
- Illumination provided or available if needed
- Stable retraction of the abdominal wall and surrounding organs
- Careful tissue retraction, preventing local ischemia
- Freeing up the hands of the surgeon and assistants
- Adaptability in usage (e. g., different patients, different incisions)
- Various type of accessories to retract the abdominal wall and organs

Hand-held retractors have the main disadvantage of losing "free hands" of the surgical team. Self-retaining retractors are used most commonly to keep open the abdominal and thoracic cavity.

Two types of self-retaining retractors are available:

1. *Closed ring retractors*:

Ring system retractors are self-stabilizing by the retaining force of the different retracting devices and do not necessarily need to be fixed to the operating table (e. g., Kirschner, ◘ Fig. 3.1a) although several types can be fixed to the table. The best exposure is achieved by placing one retracting device strictly opposite to the other. In some systems, stabilization and exposure can further be improved by attaching the ring to the operating table by a rail arm.

2. *Arm retractors*:

Arm retractors need to be fixed to the operating table. They allow for an asymmetric exposure (e. g; Thompson, ◘ Fig. 3.1b).

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
DOI 10.1007/978-3-662-46546-2_3, © Springer-Verlag Berlin Heidelberg 2016

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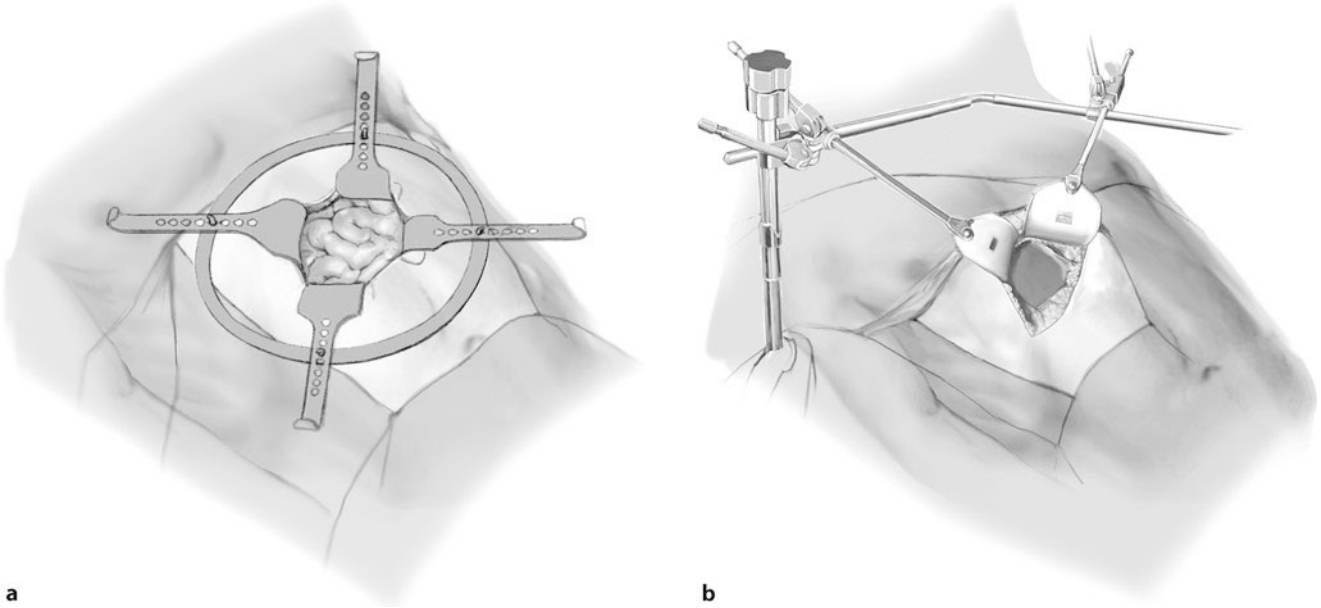


Fig. 3.1

Overview of Different Self-Retaining Retractors

Thompson (Fig. 3.2a)

The basic components of this very stable retracting system are the rail arm, the two rods, and the different retracting paddles that are attached to a retaining arm. The Thompson retractor is favored for uni- and bilateral subcostal incisions, which are often used for hepatobiliary procedures, in which most of the retraction required is oriented cephalic and anteriorly. The exposure of the lower abdominal parts is limited. There is a wide range of blades and paddles available as accessories.

Bookwalter (Fig. 3.2b)

This system has a frame (closed ring) fixed by a rail arm attached to the operating table. Different retracting accessories, such as blades and paddles, are available that can be clamped to the frame. The Bookwalter retracting system is used for both longitudinal and transverse abdominal incisions. Although some training is necessary to achieve a safe installation, fine adjustment is possible in three dimensions. Cleaning and sterilization need substantial effort due to the rather complex single components.

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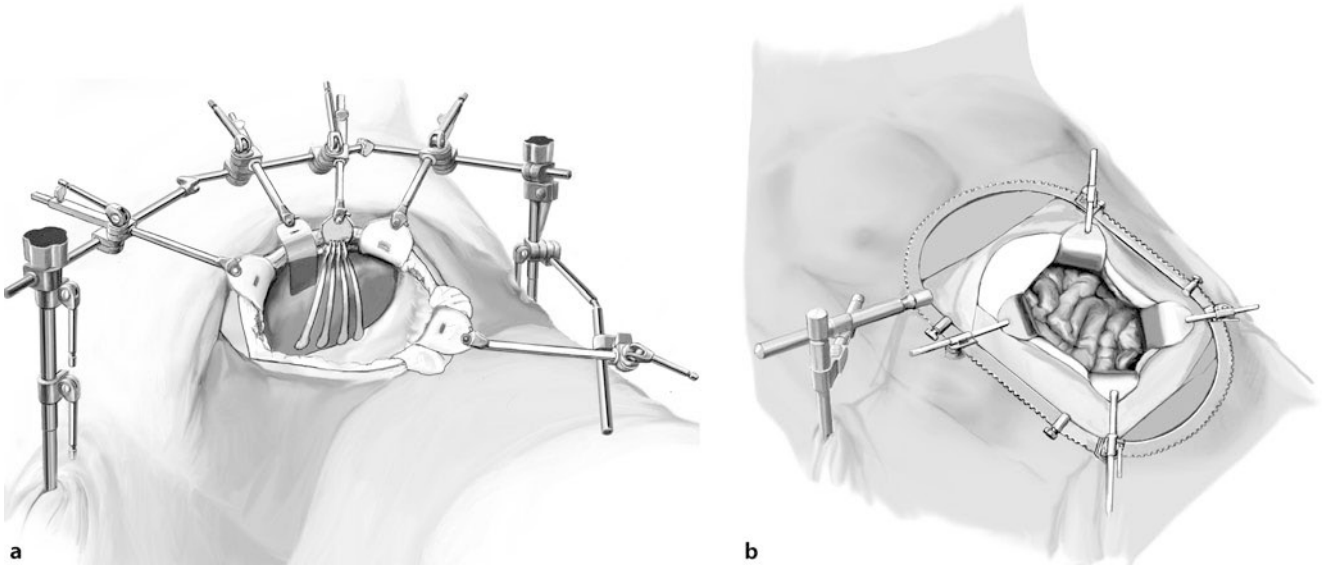


Fig. 3.2

Omnitract

Although this retractor system needs careful installation, it offers excellent access for most incisions. The open frame system can be utilized as easily as a closed ring. This retractor can be used widely for intraperitoneal and retroperitoneal operations. Maintenance and cleaning are not too elaborate. The figure shows longitudinal (Fig. 3.3a) and transverse (Fig. 3.3b) laparotomy using the Omnitract system.

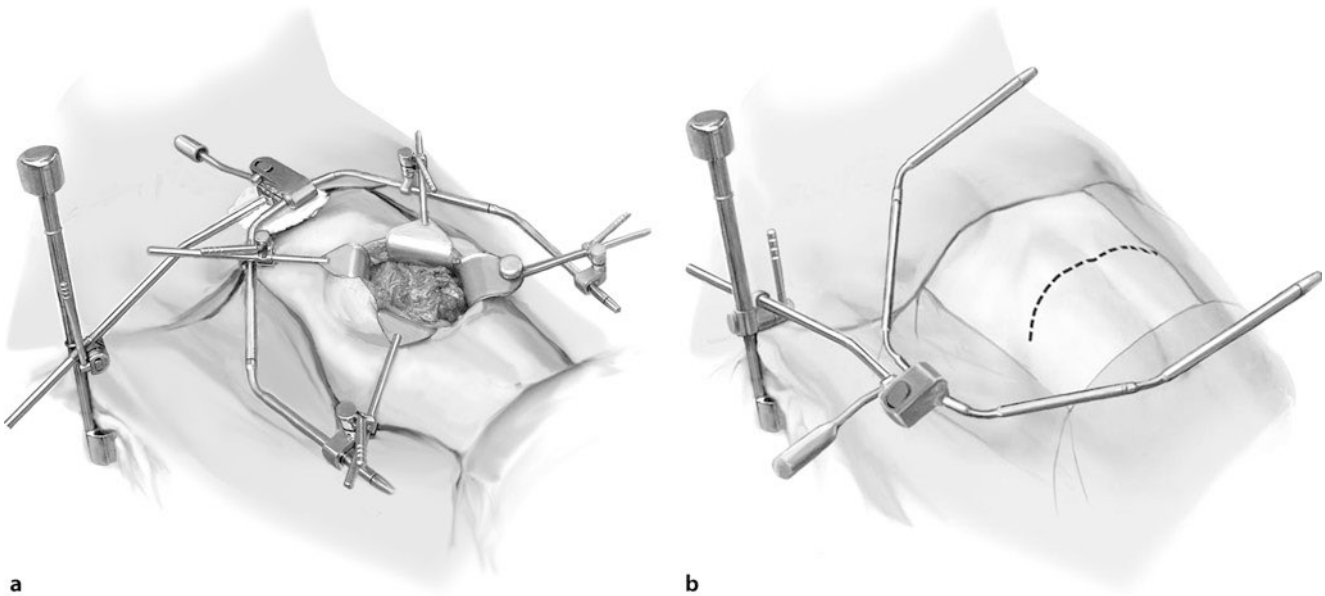


Fig. 3.3

Rochard

The Rochard retractor (not shown) is a single blade retractor that is mainly used for upper GI surgery. A large semicircular blade retracts the abdominal wall, and is attached to a fixed arm at

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the operating table. The main disadvantages are the unidirectional tension and the lack of anterior lifting the abdominal wall.

Kirschner, Balfour, O'Sullivan-O'Conner (Fig. 3.4)

The Kirschner frame (Fig. 3.4a) and the Balfour retractor (Fig. 3.4b) are good examples of systems that do not need any form of rail arm. However, retraction is not as stable and tension in the vertical dimension is not possible. They are rapidly usable, readily available, and are preferred when only lateral exposure is desired.

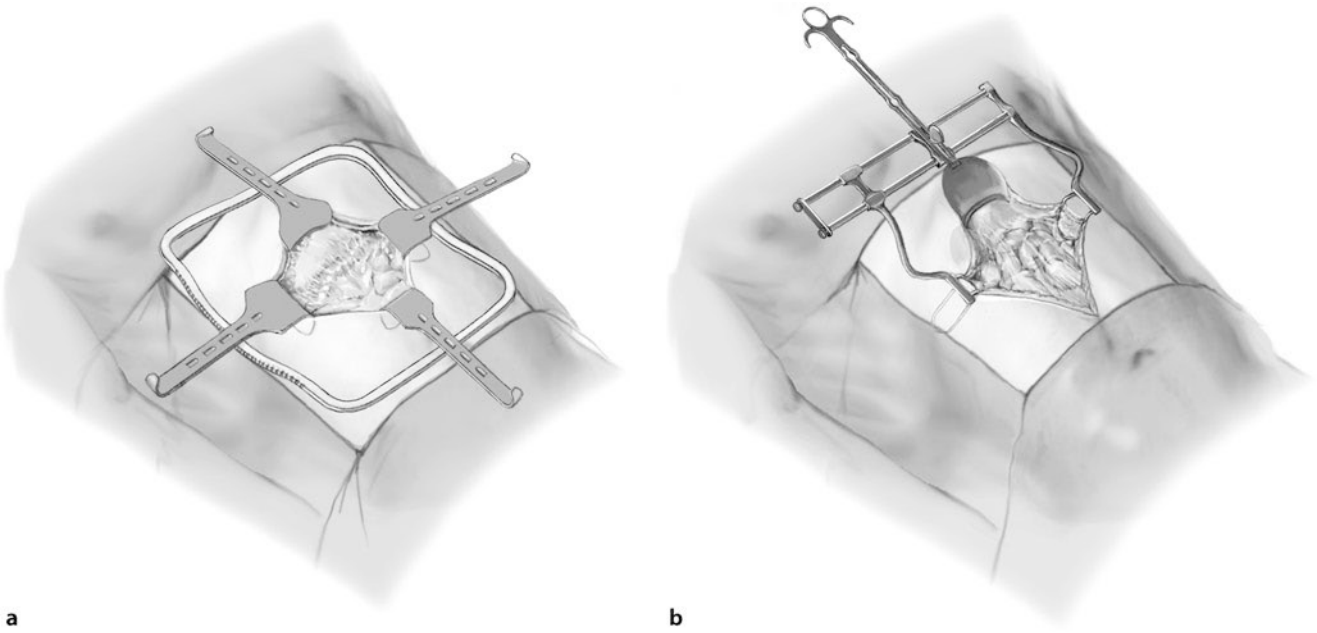


Fig. 3.4

Recommendation

Many factors and aspects influence the choice of a specific retractor. Some commonly used retractors are compared in Table 3.1. More than one type of retractor should be available to obtain the best possible exposure of the different parts of the abdominal cavity.

Table 3.1 Comparison of Different Retractor Systems

System	Construction	Installation	Adjustment	Accessories	Maintenance
Bookwalter	Closing ring + fixation	Complex	Three dimensions	+++	Elaborate
Thompson	Arm	Complex	Three dimensions	+++	Elaborate
Omnitract	Arm	Complex	Three dimensions	+++	Elaborate
Rochard	Arm	Complex	Tension only in 1 direction	+	Elaborate
Kirschner	Closing ring	Quick	Limited	++	Easy
Balfour	Closing ring	Quick	Limited	+	Easy

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Retractors in Laparoscopic Surgery

Whereas the abdominal wall is expanded anteriorly by the pneumoperitoneum, intra-abdominal exposure to facilitate different aspects of the operation is achieved primarily by patient positioning and trocar placement. There are several devices that may be used to retract the liver during upper GI operations, such as laparoscopic fundoplication, gastric bypass, or adrenalectomy (Fig. 3.5).



Fig. 3.5

Tricks of the Senior Surgeon

- For optimal use, be familiar with several retractors and have a good knowledge of their individual advantages.
- Slow, incremental retraction prevents rib fractures and postoperative pain.
- Intermittent release of the retraction during long-duration operations prevents local ischemic complications.
- Attention to the need for cranial retraction (exposure of esophagogastric junction) versus anterior retraction (for hepatectomy) will facilitate exposure.

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Surgical Staplers

Christian E. Oberkofler, Antonio Nocito

Since the turn of the century, surgeons have been stimulated to develop devices to close off a hollow organ or to join two hollow organs. Early devices by the Hungarian surgeons Hültl and Petz and later by the Germans Friedrich and Neuffer were pioneering efforts. But the current prototypes of mechanical staplers originated from Russia in the 1950s.

Linear and circular staplers were engineered to perform standardized surgical procedures safely (e. g., gastrectomies and bowel resection). The American surgeons Ravitch and Steichen subsequently brought these devices to the United States in the 1960s and focused on their improvement in terms of applicability and reliability. In collaboration with industry, preloaded plastic cartridges with double-staggered staple lines of different lengths were developed. In the mid-1970s, the first single-use stapling devices were developed and subsequently spread worldwide. Recently, mechanical staplers are used increasingly for closure of large vessels (vascular staplers), especially during laparoscopic surgery.

Types of Mechanical Staplers

Modern surgical staplers are disposable, made of plastic, and loaded using disposable cartridges. There are currently two major types of mechanical stapling devices in clinical use for open and laparoscopic surgery: linear and circular staplers.

The principles and prerequisites of mechanical stapling remain largely unchanged:

Principles of mechanical stapling

- Tissue compression
- Tissue stapling using metallic wire as staples
- Configuration of the closed staples in the shape of a "B"
- Staggered positioning of the staple lines

Aims of surgical stapling

- Creating an adequate lumen
- Preserving adequate tissue vascularization
- Preventing tension of adapting tissues
- Avoiding leakage and fistula formation
- Providing good hemostasis
- Ensuring mechanical reliability/uniformity of stapling devices

Linear stapler

Two basic types of linear stapling devices exist: devices with and without an integrated scalpel. Devices with an integrated scalpel fire two (open surgery staples) or three (laparoscopic staples) staggered lines of staples on both the patient and the resected tissue side, with the scalpel cutting through the tissue in between. The stapling device without an integrated scalpel fires two stapler with no transection of the tissue between the staple lines.

Linear stapling devices are applied in open and in laparoscopic surgery and are available as mono- and multiple-use instruments (Figs. 4.1 and 4.2). They are used to close partially or totally hollow organs. Depending on the purpose, different stapler cartridges ranging from 30–90 mm of length are available, as well as staples ranging in height from 3.5–4.8 mm before being fired and assuming the B shape.

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For closure of arteries and veins, three stapler lines are staggered. The staples used are 2.5 mm in size.

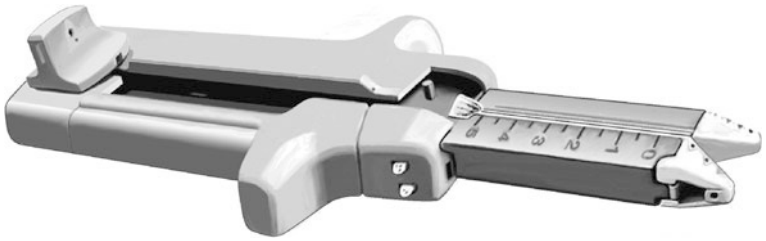


Fig. 4.1

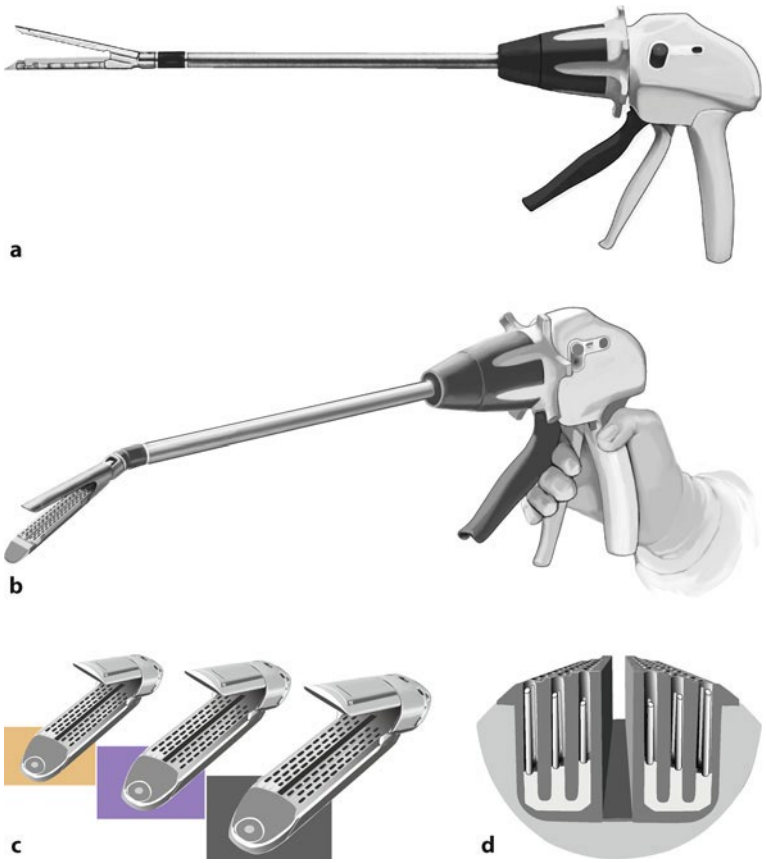


Fig. 4.2

Circular stapler

Circular stapling devices fire two staggered circular lines of staples (Fig. 4.3). After "firing" the stapler, an integrated circular scalpel resects overlaying tissue as "rings" or "donuts" of tissue and creates a circular anastomosis. Circular stapling devices are applied in general surgery as well as in thoracic and colorectal surgery. They are used for end-to-end anastomosis after bowel resection or in esophagogastric surgery.

Using circular staplers, a "tobacco pouches seam" or "purse string suture" is mandatory to approximate the intestinal lumen close to the anvil or device.

Diameters between 21–34 mm are available, whereas staple length is usually 5.5 mm in size, but can also vary with the thickness of the tissues.

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Circular staplers for vascular anastomosis were developed in the 1960s and 1970s but never had a significant impact on the standard hand-suture technique and are not used today.

Table 4.1 Approved Indications for Use of Staplers in Gastrointestinal Surgery

Organ area	Application
Oesophagus	Resection of or incorporation of a Zenker diverticulum Gastric tube formation Intrathoracic esophagogastrostomy
Small bowel	Resection of Meckel diverticulum or the appendix
Stomach	Closure of the stomach Closure of the duodenal stump Esophagojejunostomy intraabdominal and intramediastinal Formation of a jejunum or ileal pouch
Colon/rectum	Deep colorectal, coloanal, and ileoanal anastomosis partly in "double-stapling technique" Formation of an ileal pouch Formation of a colonic pouch

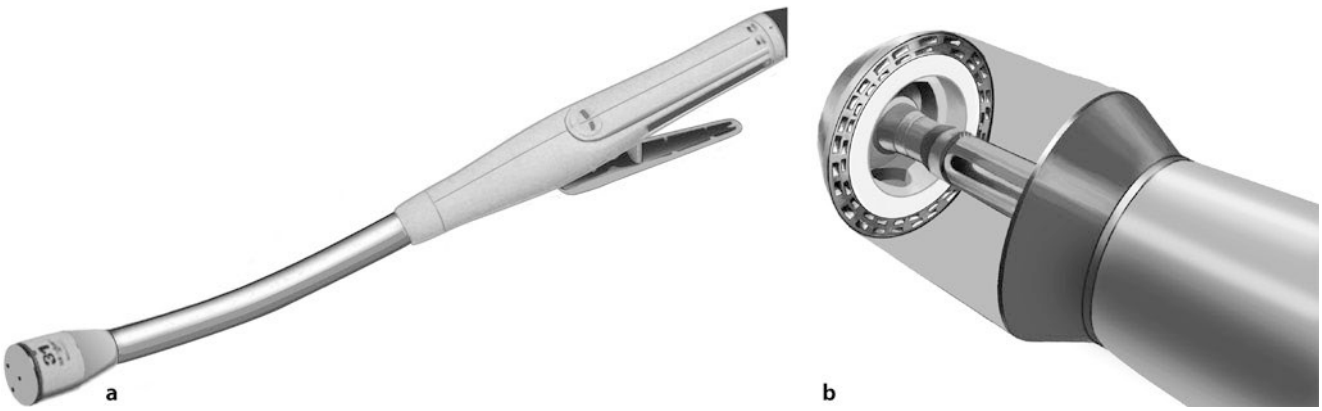


Fig. 4.3

Types of Staples

Current staples assume the shape of the letter "B" (Fig. 4.4). This special shape guarantees hemostasis and permits the tissue edges to be supplied sufficiently by blood. This shape supports wound healing and prevents necrosis. Absorbable and nonabsorbable staples are available. Note that the different stapler companies have multiple different size of staplers according to tissue thickness and whether a hollow viscous or a vascular vessel is being stapled; consult each manufacturer for their recommendations.



Fig. 4.4

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Currently, nonabsorbable staples are made of titanium, which have the following key benefits:

- Minimal artifacts in computed tomography (CT)
- Not magnetic and thus cause only minimal distortions in magnetic resonance imaging (MRI)
- High resistance and lighter, than stainless steel
- Corrosion resistant
- Biocompatible; can be safely used in patients who suffer from chromate-nickel allergy

Absorbable staples are made of a copolymer (lactomer) and are broken down to glycol and lactic acid and absorbed through hydrolysis. The copolymer still shows adequate tear resistance in tissue 14 days after deployment. Their absorption starts after 4 weeks and is completed after 180 days.

Table 4.2 Pros and Cons of Mechanical Stapling Devices

Pros
Less operating time
Less tissue manipulation
Less tissue trauma
Less tissue edema
Less risk of contamination and infection
Minimizes the time of open bowel
Treated organ gets closed first then resected
Less blood loss compared with hand-made suturing
Less anesthesia time
Stapling devices often decrease the need of a protective stoma
Cons
Bleeding from the anastomosis into the lumen
More expensive than suture material

Tricks of the Senior Surgeon

- After firing the stapler, wait 20–30 seconds to allow the tissue to be squeezed together which helps to prevent bleeding from the stapler lines
- The anastomosis should never be under tension
- Before resecting tissue using a mechanical stapler, make sure to have an adequate blood supply of the remaining tissue
- Check every anastomosis for leak-tightness

Acknowledgments

We would like to acknowledge Nicolas Attigah and Markus Schäfer who were the authors of this chapter in the first edition of the Atlas.

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Principles of Drainage

Henrik Petrowsky, Stefan Wildi

Drains are designated to evacuate intraperitoneal fluid collections. They can be used for diagnostic, prophylactic, or therapeutic purposes. In upper gastrointestinal surgery, diagnostic drains are placed to assess intraperitoneal fluid collections in order to establish a diagnosis. These drains are seldom left in place for an extended duration and are, therefore, of minor importance. In contrast, prophylactic drains placed at the end of an operation are used frequently with two intentions: first, to prevent fluid accumulations which could be harmful (i. e., pancreatic juice or bile) or to prevent or evacuate expected fluid collections that can become infected and lead to the formation of intra-abdominal abscesses; second, prophylactic drains may be used to detect early postoperative complications, such as intra-abdominal bleeding or anastomotic leakage. Sometimes, fluid collections become infected and develop into abscesses; the management of these collections requires therapeutic drainage either by the percutaneous route or by reoperative surgical irrigation or postoperative lavage.

Types of Drains

Drains can be divided into passive and active drains.

Passive Drains

Passive drains (Fig. 5.1), such as the Penrose and Easy Flow devices, serve to evacuate fluid passively by providing a route of access secondary to the natural pressure gradients, such as gravity flow, muscle contraction, and overflow. The opening in the abdominal wall for these drains should be made large enough, because passive drains are potentially collapsible. Easy Flow drains have intraluminal corrugations to prevent complete collapse (inlay). Passive drains cannot be sealed and are open systems with the potential risk of retrograde infections. The advantages and disadvantages of open and closed-suction drains are outlined in Table 5.1.



Fig. 5.1

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Table 5.1 Advantages and Disadvantages of Open and Closed-Suction Drains

	Open drain	Closed-suction drain
Advantages	Generates pathways for bulky or viscous material	Lowers risk of retrograde infection
	Lowers risk of mechanical erosion and pressure necrosis	Accurate measurement of drainage
		Facilitates radiographic studies Skin protection from irritating discharge
Disadvantages	Retrograde infection	More vulnerable to obstruction by small tissue fragments or ingrowth of surrounding tissue

Closed Suction, Active Drains

Jackson-Pratt and Blake drains (Fig. 5.2) are commonly used radiopaque, silicone products for closed-suction systems. The Jackson-Pratt drain is oval-shaped with numerous orifices and intraluminal corrugations (inlay). The Blake drain has four channels along the sides with a solid core center. In contrast to passive drains, active or suction drains maintain a negative pressure gradient.

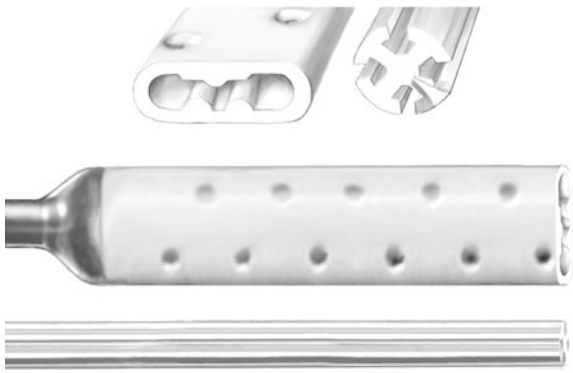


Fig. 5.2

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Sump Drains

Sump drains (Fig. 5.3) are usually double-lumen tubes with a larger outflow lumen and a smaller inflow "sump" lumen. The larger lumen is connected to a suction system and evacuates intra-abdominal secretions. The smaller lumen serves as a venting tube, allowing air to enter the larger lumen. This principle should help to break the vacuum in the large draining tube, maintaining the drain in a productive patent state, without the surrounding tissues continually occluding the drainage holes in the tube. Sump drains are often used when large fluid volumes or more particulate or thick collections have to be evacuated. The occlusion of the smaller venting tube by tissue debris due to retrograde inflow demonstrates a potential disadvantage of sump drains that occurs especially when the suction is disconnected. Some sump drains have an additional third lumen that allows the instillation of a lavage solution.

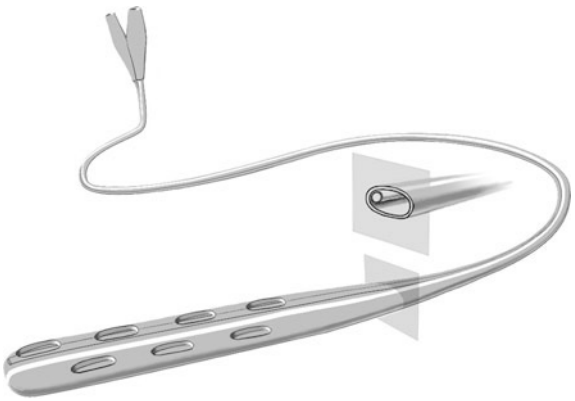


Fig. 5.3

Complete Drainage System

Collapsible devices connected to the drain tubes generate automatically a negative pressure gradient and keep the system "sealed", which is believed to have resulted in a substantial decrease in retrograde infections (Fig. 5.4).



Fig. 5.4

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Prophylactic Drainage

Drain Orifice

The drain exit site through the skin is created by a penetrating cut with a scalpel (Fig. 5.5a). A Kelly clamp is inserted into the orifice (Fig. 5.5b) and penetrates the abdominal wall diagonally (Fig. 5.5c). The underlying hand prevents bowel injury. This technique creates a tunnel that helps to seal the abdominal cavity after drain removal. After clamping the drain tip, the Kelly clamp and drain are pulled through the abdominal wall from inside outwards (Fig. 5.5d). Others prefer to create the tunnel from inside out and pull the drain into the abdomen. Finally, the drain position is secured by a non-reactive skin suture, and the drain tube is connected to the suction device.

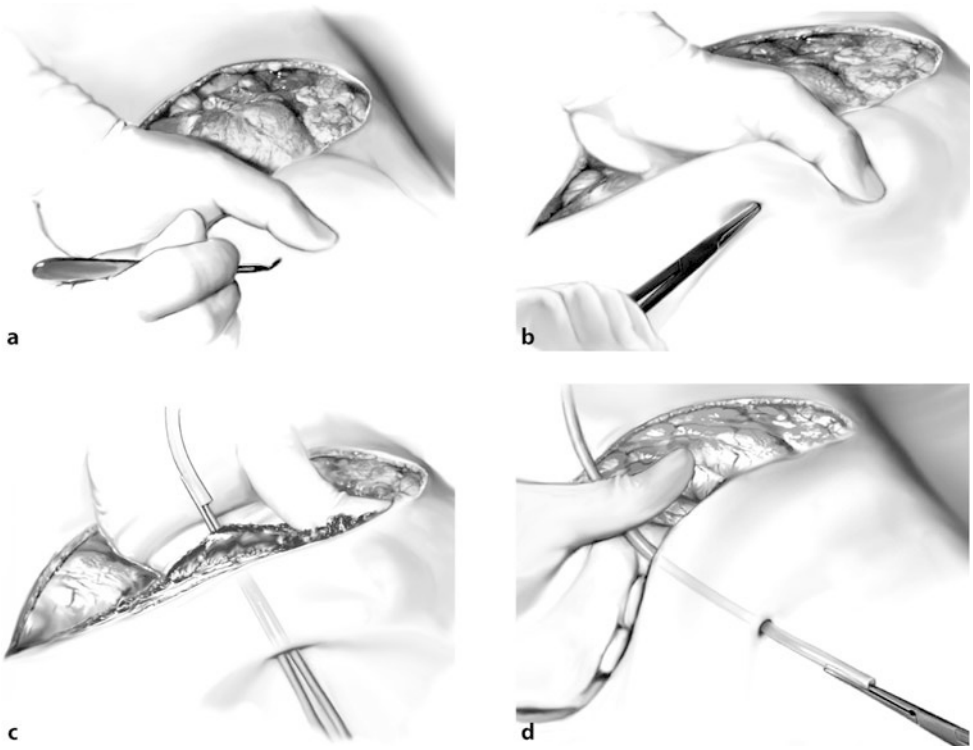


Fig. 5.5

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Prophylactic Drains

Prophylactic drainage after upper abdominal operations is used to evacuate intra-abdominal fluid that may develop, such as ascites, blood, chyle, bile, pancreatic, or intestinal juice, that are either harmful/toxic for adjacent tissue or might become infected. Therefore, drains are placed in spaces that tend to accumulate fluid, such as the subhepatic (1), right subphrenic (2), left subphrenic (3), and parapancreatic (4) spaces (Fig. 5.6).

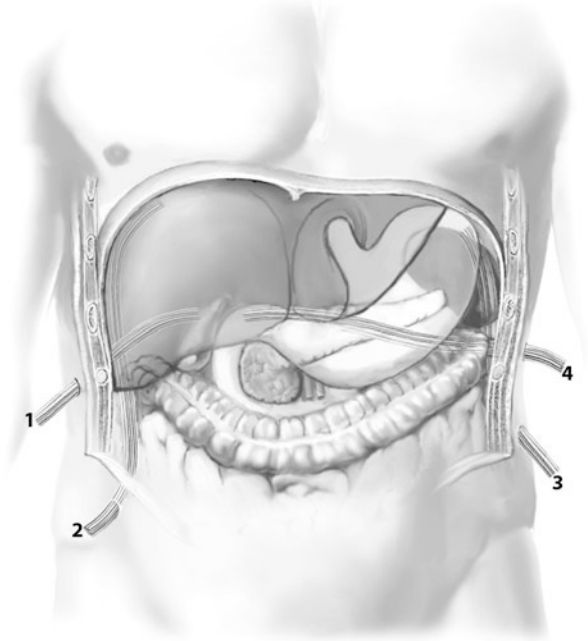


Fig. 5.6

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Perianastomotic Drains

Another proposed function of prophylactic drainage is the early detection of anastomotic leakage. If drains are to be used near a high-risk anastomosis, they should not be placed in direct contact with the anastomosis, but, rather, with a safety margin in between to prevent drain-related erosions. This principle is illustrated for a biliodigestive anastomosis, where the drain is placed posterior to the anastomosis (Fig. 5.7).

Although routine use of prophylactic drainage was often considered necessary to prevent complications, there is growing evidence that this practice may be associated with adverse effects. Retrograde drain infections or drain-related complications are known adverse effects. Several randomized, controlled trials are available investigating the routine use of prophylactic drainage for selected procedures (Table 5.2).

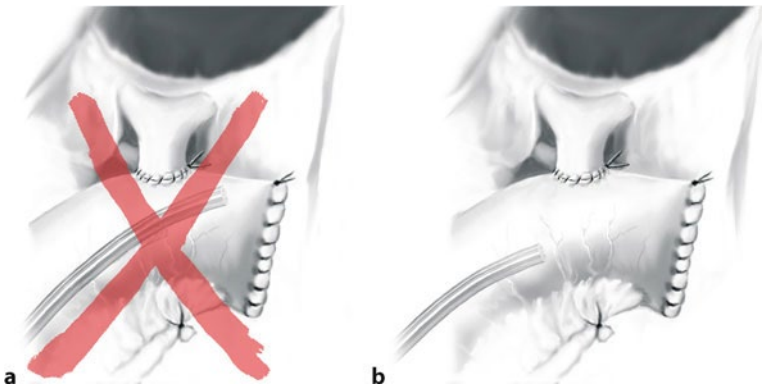


Fig. 5.7

Table 5.2 Evidence-based Recommendations for Prophylactic Drainage Practice

Gastrointestinal surgery	Procedures	Evidence-based recommendation
Hepato-pancreatico-biliary	Hepatic resection without biliodigestive anastomosis	No drain
	Cholecystectomy (open, laparoscopic)	No drain[a]
	Pancreatic resection	Controversial[b]
	Biliodigestive anastomosis	NA
Upper GI tract	Esophageal resections	Intrathoracic drain for any approach
	Total gastrectomy	Controversial
	Distal gastrectomy	No drain
	Roux-en-Y gastric bypass	No drain
	Duodenotomy with omental	No drain
	patch for duodenal perforation	

NA, not assessed
[a] Only one randomized controlled trial in pancreatic cancer
[b] Controversial even in centers where a prospective randomized trial suggested no benefit

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Therapeutic Drainage

Predisposed Spaces for Collections

Infected collections, such as abscesses or infected bilomas, are known complications after upper abdominal surgery and require drainage by operative or radiologically guided drain placement. The right subphrenic space (1), left subphrenic space (2), Morison's pouch (3), left subhepatic space (4), and omental sac (5) are anatomic spaces that predispose to abscess development (Fig. 5.8).

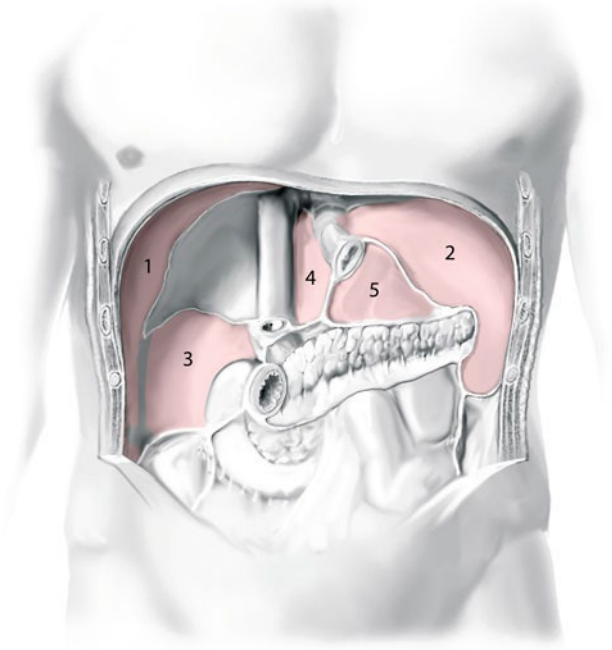


Fig. 5.8

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Catheters

The majority of postoperative collections in the upper abdomen are manageable by means of percutaneous drainage by interventional radiologic techniques using standard aseptic technique and local anesthesia. Thereby, collections are drained percutaneously under ultrasonographic or CT guidance using the Seldinger or trocar techniques. This figure illustrates a typical percutaneous drainage catheter, the MAC-LOC (Fig. 5.9a) that can be inserted by the introduction cannula (Fig. 5.9b) or the trocar stylet (Fig. 5.9c). The catheter has large, oval side ports to increase the drainage capability, as well as a radiopaque band that identifies the proximal area of the loop. This type of "self-locking" loop catheter has "memory" to prevent later displacement, i. e., the loop at the end can be straightened during insertion by introducing a stylet intraluminally. After the catheter is positioned in place, the stylet is removed, and the loop reforms.

Some fluid collections may require surgical drainage with repeated abdominal lavage and second-look procedures (Table 5.3).

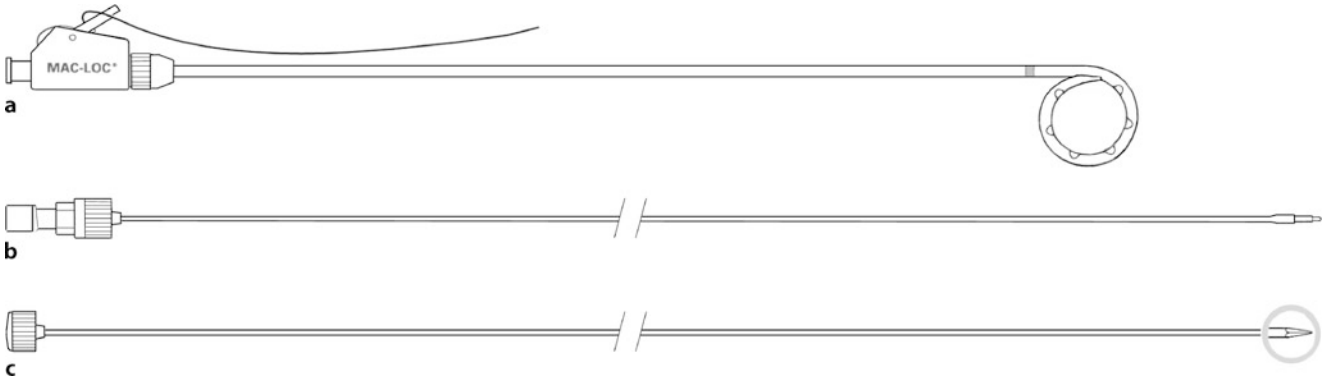


Fig. 5.9

Table 5.3 Criteria for Percutaneous and Surgical Drainage of Infected Collections

Percutaneous drainage	Surgical drainage
Unilocular collection/abscess	Multilocular collections/abscesses
Low viscosity of drain fluid	Multiple, non-communicating collections
Drain route not traversing intra-abdominal organs or thorax	High viscosity of drain fluid Percutaneous drain route traversing intra-abdominal organs or thorax

Tricks of the Senior Surgeon

- Whenever indicated, always use closed drain systems and keep drains as short as possible to minimize the risk of retrograde infections.
- Place drains near but never in direct contact to the anastomotic sutures to prevent drain-induced erosions or drain-induced anastomotic leaks.
- When drains are not productive, do not rely on them! Drains could be occluded or obstructed by tissue despite an adjacent fluid collection.
- Try to position intraperitoneal drains such that the drain does not rub against or lie in direct contact with blood vessels or hollow organs in an attempt to prevent drain erosions.
- These drains often can be manipulated and positioned better under fluoroscopic guidance by interventional radiologists.
- Drains may not effectively evacuate bleeding, especially when there are thick or older blood clots.

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Surgical Energy Devices or Devices for Hemostasis

Lukasz Filip Grochola, René Vonlanthen

Surgical Devices: Hemostasis, Sealing, and Dissection

Surgical energy devices that provide adequate hemostasis and allow accurate dissection of tissue are essential during surgical procedures. Unreliable tools can lead to bleeding, cause injury to adjacent organs, and jeopardize visualization. Modern energy devices have seen a rapid development in the past few years, leading to a striking improvement in both the control of hemostasis and the precision of tissue dissection, therefore minimizing operation time, collateral damage to surrounding tissue, and blood loss, and resulting in strikingly improved outcomes in both laparoscopic and open surgical procedures.

Requirements for surgical energy devices

In general, an energy surgical device used for control of hemostasis, sealing, and tissue dissection should fulfill the following requirements in order to enable safe and efficient surgery:

- Provide reliable hemostasis
- Minimize collateral damage to surrounding tissue
- Permit fast dissection of tissue to minimize operation time
- Provide flexibility in usage allowing unrestricted access to the operating field
- Be easy to handle by trained staff
- Be cost-effective

There are five types of widely used general surgical devices:

1. Basic energy-based devices: Instruments that utilize high-frequency monopolar or bipolar electric current to cut or coagulate biologic tissue. They lack highly sophisticated additional technical features designed to improve the control of dissection and hemostasis.
2. Advanced energy-based devices: Tools that utilize bipolar or ultrasonic energy combined with sophisticated features, such as tissue sealing mechanisms, temperature feedback control, and other features designed to control lateral thermal spread for simultaneous tissue dissection and hemostasis control.
3. Argon plasma coagulator (APC): A noncontact monopolar electrocoagulation device designed to deliver a high-frequency current through a jet of ionized argon gas for the purpose of hemostasis control.
4. Topical hemostatic/sealant devices: Assist in the control of diffuse oozing and minor bleeding. Provide hemostasis by contact activation of coagulation or induction of the last steps of the coagulation cascade, mechanical tamponade, or synthetic sealing.
5. Clips: Provide fast and reliable vessel and tissue sealing by mechanical compression.

Overview of devices

Basic energy-based devices

Monopolar electrosurgery

Monopolar electrosurgery devices revolutionized surgery after their development in the 1920s and are the mainstay of surgical dissection techniques and control of hemostasis. They generate a high-frequency (HF) electrical current, which flows from the active electrode in the hand-piece

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to the target tissue and subsequently through the patient to the passive electrode, grounding pad (Fig. 6.1, top; Tab. 6.1). This flow heats the tissue and causes a small area of tissue to vaporize through rapid tissue heating to temperatures reaching 400 °C (CUT mode) or coagulate through a slower heating process to temperatures approximating 100 °C (COAG mode). Those two modes are generated by distinct types of electrical current, which differ with regard to the wave form, frequency, and voltage. Monopolar current can be applied to the target tissue using a wide variety of surgical tips attached to a pencil-shaped hand-piece (Fig. 6.1, bottom, left to right). Such tips include the blade, effective in both the cutting and the coagulation of tissue; the Colorado needle (an ultrasharp tip), used for precise tissue dissection; the ball electrode for coagulation of a larger tissue area; and the monopolar forceps. In addition, the surgeon can choose different configurations of electrosurgical pencils, such as the rocker switch and push button configurations, as well as foot control pencils. Although monopolar electrosurgery is highly useful and effective, the surgeon should be aware of its potential safety hazards, such as unintended burns to the patient, malfunction of implanted electronic devices (e. g., pacemakers, cardioversion devices, sacral/spinal cord stimulators) or superheating of prosthetic conductive joints.

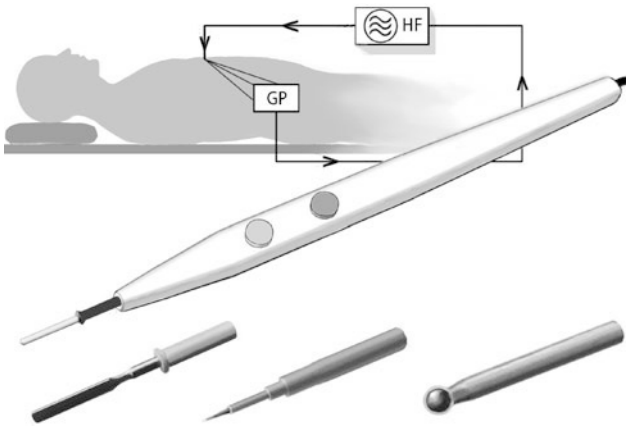


Fig. 6.1

Bipolar electrosurgery

Bipolar electrosurgery devices utilize an active and a return electrode, which are part of a single instrument, most often a surgical forceps (Fig. 6.2; Tab. 6.1). Current flows from one tip of the tool and only through the targeted tissue. This feature reduces lateral thermal spread and creates less smoke compared with monopolar equipment. However, this technology leads to less penetration of current density, which can be a disadvantage for hemostasis in certain areas. The lateral thermal spread as well as the sticking of tissue debris can be further decreased by a bipolar forceps, which incorporates a water irrigation system that causes a cooling of the forceps tip as well as of the targeted tissue. This feature, as described in more details in ▶ Chap. 3, makes it particularly useful in hemostasis control and dissection of liver parenchyma.

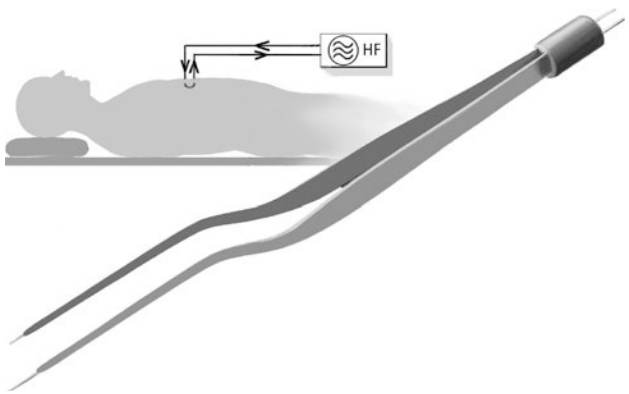
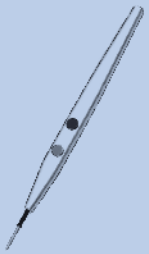
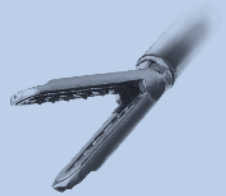
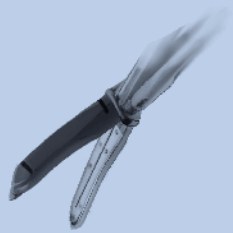


Fig. 6.2

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Tab. 6.1

Device	Monopolar pencil	Bipolar forceps	Harmonic ACE	Enseal	LigaSure	Thunderbeat
						
Principle	Monopolar	Bipolar	Ultrasonic	Pressure, bipolar, integrated blade	Pressure, bipolar, integrated blade	Combined: ultrasonic, pressure, bipolar
Sealing function	Yes	Yes	Yes	Yes	Yes	Yes
Transecting function	Yes	Yes	Yes	Yes	Yes	Yes
Haemostasis (w/o cutting)	Yes	Yes	Yes	Yes	Yes	Yes
Open + laprascopic surgery	Yes	Yes	Yes	Yes	Yes	Yes
Technical specifications	Maxim. Power: 300W (CUT) 200W (COAG)	Maxim. Power 180W	Amp: 50–100 µm Freq: 55 kHz	Maxim. Power: 135W	Maxim. Power: 150W	Amp: 50–80 µm Freq: 47 kHz Power: n.a.
Burst pressure (5–7 mm vessels)*	n.a.	n.a.	450 mmHg	720 mmHg	615 mmHg	730 mmHg
Lateral thermal spread	++++	++	+++	+	++	+++
Maximum size of vessel*	2–3 mm	2–3 mm	5 mm	7 mm	7 mm	7 mm
Tissue compression	n.a.	Not uniform	Not uniform	Uniform	Not uniform	Uniform
Comment	Cost-effective device, highest propensity for collateral tissue damage	Cost-effective device, optionally available with integrated water irrigation to cool down tip and reduce lateral thermal spread	Fast dissection, high prospensity for collateral tissue damage	Temperature is controlled at tissue interface. Offset electrode further reduces lateral thermal spread	Temperature is controlled at tissue interface, low lateral thermal spread; optionally available with additional monopolar tip	Fastest dissection in class, highest burst pressure, relatively high prospensity for collateral tissue damage

* approximate values

Advanced energy-based devices

Advanced bipolar devices

Advanced bipolar devices, such as Enseal (Fig. 6.3; Tab. 6.1) and LigaSure (Covidien), first introduced in 1998, use pulsed bipolar energy and a feedback control of the energy output during tissue coagulation. Thus, heat production is low compared with that of basic and other advanced electric-based surgical devices, minimizing tissue sticking, smoke, and lateral thermal spread.

Enseal (Ethicon) utilizes a positive temperature coefficient (PTC) polymer compound within the jaw to modulate energy flow (Fig. 6.3c). This compound contains a large number of nanometer-sized conductive particles organized in chains, which polymerize at temperatures approximating 100 °C, allowing energy flow through this bipolar device. Once the tissue temperature reaches 100 °C during the sealing process, the particles depolymerize owing to their physical properties and thus disrupt the energy flow. After the sealing step, an integrated cutting blade divides mechanically the tissue (Fig. 6.3d). In addition to the low sealing temperatures, the electrode designs of advanced bipolar devices contain energy flow within the jaw and decrease the lateral thermal spread and the propensity for collateral or proximity thermal damage.

Advanced bipolar devices simultaneously seal and transect relatively thick vessels up to 7 mm and large tissue bundles. Seal strengths are comparable with techniques of mechanical ligation, such as ligatures and clips and are greater than other energy-based techniques such as standard bipolar or ultrasonic coagulation.

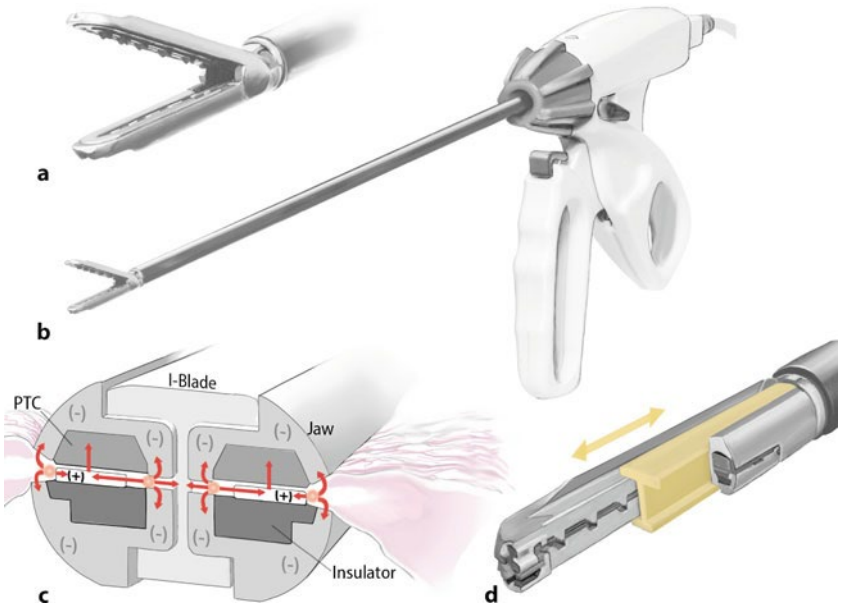


Fig. 6.3

Ultrasonic dissection systems

Ultrasonic dissection systems that cut and coagulate tissues were introduced in the early 1990s and have been applied with great success in hepato-pancreato-biliary (HPB) and upper gastrointestinal surgery (see also ▶ Chap. 3). The most widely used systems, such as the Harmonic scalpel (Fig. 6.4; Tab. 6.1), generate a high vibration frequency in the ultrasonic range of approximately 55 kHz at the functional tip of the device over a 50- to 100-µm arc through piezoelectric transducers that convert electrical into mechanical energy. This energy results from the ultrasonic frequency shearing of the bottom against the upper tip of the functional end and creates frictional heating as well as cell disruption during tissue compression between the blades (Fig. 6.4c). This process leads to the denaturation of proteins, such as collagen in the walls of hollow structures (e. g., vessels), which in turn results in reliable sealing and cutting of the lumen of vessels up to 5 mm in diameter. Depending on the setting, this Harmonic device can increase the longitudinal movement of the blades to deliver faster cutting and less hemostasis or decrease the longitudinal movement and provide slower cutting but more hemostasis. Ultrasonic devices carry advantages over high-frequency electrosurgery in that they transect tissue faster and do not generate smoke.

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However, they lead to higher maximum temperatures of up to 200 °C at the tips and, therefore, may disperse substantially greater amounts of energy to surrounding tissue during activation.



Fig. 6.4

Integrated bipolar and ultrasonic devices

Integrated bipolar and ultrasonic devices deliver the benefits of both advanced bipolar and ultrasonic energy in a single tool. This integration of energy modalities combines the advantages of safe hemostasis from advanced bipolar energy with the speed of ultrasonic dissection. In the Thunderbeat device (Olympus) (Fig. 6.5; Tab. 6.1), bipolar heat energy is applied laterally while additional sealing and cutting is achieved by ultrasonic energy in the central part of the device (Fig. 6.5c). The energy device can achieve high burst pressures even in large vessels while having the fastest cutting speed of all commonly used advanced energy-based devices. However, similar to other ultrasonic devices, heat production and the dispersal of greater amounts of energy to surrounding tissue can lead to lateral thermal damage and potential injury to adjacent organs.

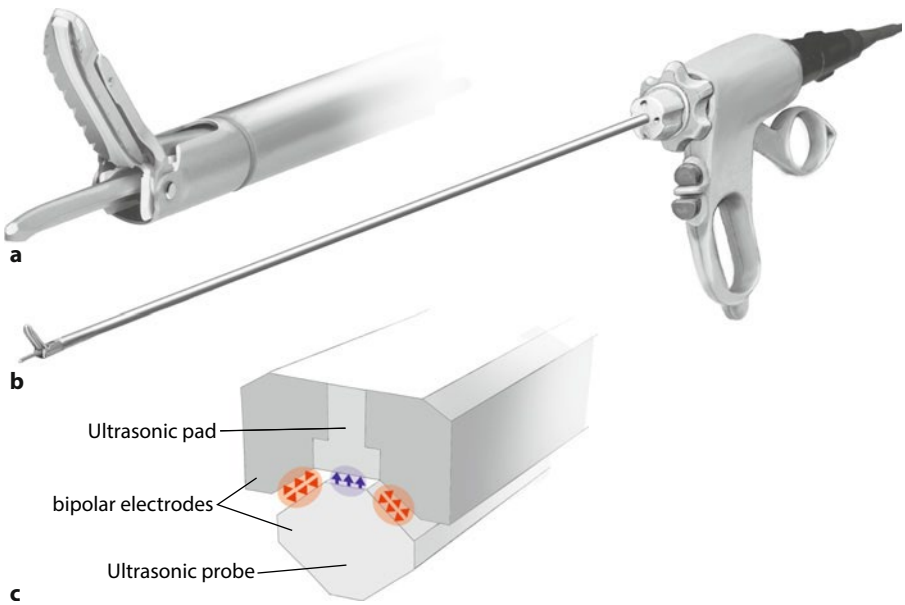


Fig. 6.5

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Argon plasma coagulation (APC)

APC (ConMed) has been applied during surgical procedures since the 1970s and is a noncontact electrocoagulation device that delivers high-frequency monopolar current through a column of ionized argon gas to achieve hemostasis control (Fig. 6.6). Electrons flow through this channel of gas from the probe electrode to the targeted tissue to cause coagulation. The thermal coagulation of tissue results in a thin and superficial, electrically insulated zone of desiccation, which produces an increased electrical resistance in the targeted area, prompting the current to move to another point on the tissue surface where resistance is lower, which in turn limits the depth of coagulation to only a few millimeters. Coagulation depth is dependent on the generator power setting, flow rate of the argon gas, duration of application, and distance of the probe tip to the target tissue. APC can be used in both open and laparoscopic surgery as well as during endoscopic procedures. Potential complications caused by the use of APC include those found with basic monopolar devices, such as unintended tissue damage due to factors such as insulation failure as well as argon gas embolism, which is a very rare but potentially serious complication.

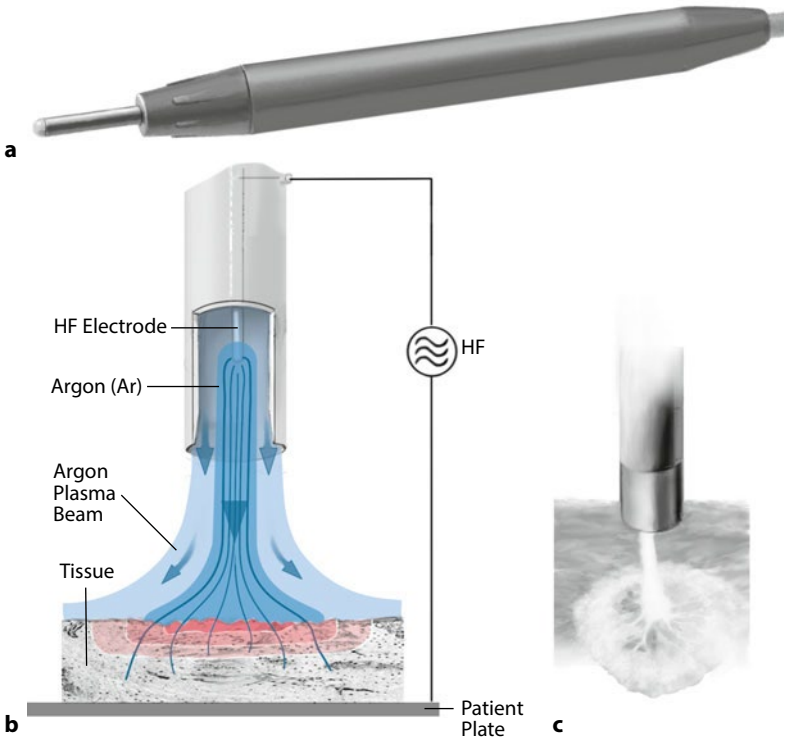


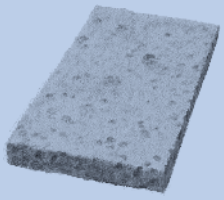
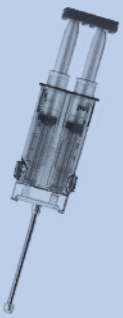
Fig. 6.6

Topical hemostatic and sealant devices

Topical hemostatic agents are designed to provide a useful adjunct to assist in the control of diffuse oozing blood and minor bleeding. They can be divided into three categories: the active and passive hemostatics as well as the synthetic sealants (Tab. 6.2). In principle, the first group consists of agents that are activated by mixing two components, human purified fibrinogen and thrombin, that are involved at the end of the coagulation cascade (e.g., Evicel Fibrin sealant [Ethicon], Tisseel Fibrin sealant [Baxter Healthcare Corporation]). Thrombin is the already active form of prothrombin that catalyses the conversion of fibrinogen to fibrin, one of the last steps of the coagulation cascade that induces a clot at the site of bleeding. The passive hemostatic agents, such as collagens, cellulose, and gelatins, act through physically restricting the flow of blood, as well as the promotion of platelet aggregation and contact activation of the coagulation cascade. Devices such as Tachosil Absorbable Fibrin sealant (Baxter Healthcare Corporation), which consists of a collagen sponge coated on one side with thrombin and fibrinogen, and Floseal Hemostatic Matrix (Baxter Healthcare Corporation), which is composed of a gelatin matrix

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Tab. 6.2

Device	Evicel, Tissel	Tachosil	Floseal	Coseal
				
Principle	Active: fibrinogen and thrombin, transexamic acid	Active and passive: collagen sponge coated on one side with thrombin and fibrinogen	Active and passive: gelatin matrix and thrombin	Synthetic sealant: polyethylene glycol polymers
Open surgery	Yes	Yes	Yes	Yes
Laparascopic surgery	No	Yes	Yes	Yes
Preparation and application	Reconstitute components immediately before use, spray on target tissue	Ready-to-use sponge	Reconstitute components immediately before use, apply gel on target tissue	Reconstitute components immediately before use, spray on target tissue
Maximum bleeding intensity	Oozing	Oozing	Oozing to minor pulsatile	Oozing to minor pulsatile
Comment	No bovine components: minimal risk for allergetic reaction	Easy preparation	Conforms well to irregular tissue surfaces; contains bovine components	Fast and realiable haemostasis; no bovine components

and thrombin, incorporate both active and passive hemostatic components to improve bleeding control. Lastly, the synthetic sealants (also known as adhesives) such as CoSeal Surgical sealant (Baxter Healthcare Corporation) are low-viscosity liquids that do not have any intrinsic hemostatic activity but polymerize in a few seconds, forming a solid film that connects adjacent tissue surfaces, making them fast and effective hemostatic agents.

Clip applicators

As a mainstay of both laparoscopic and open surgery, clip applicators combine fast and cost-effective vessel and tissue sealing even in areas that are difficult to reach using traditional wound closure equipment. Clips create a seal by mechanical compression and pose little risk to surrounding tissues when applied accurately. In principle, three categories of clips are in wide use: titanium, plastic, and absorbable. All can achieve reliable seals with high, supraphysiologic bursting pressures comparable with those of advanced bipolar devices and standard surgical techniques. However, they carry the risk of dislodgment with tissue manipulation, which is greatest with the titanium clips (Fig. 6.7a) and minimized in plastic clips designed with a toothed grasping surface and locking device (Fig. 6.7b). In addition, metallic clips carry the disadvantage of interfering with CT and MRI as well as of being electroconductive. Conversely, metallic clips are cheaper and narrower than other types of clips and thus easier to place in narrow sites. A further disadvantage of nonabsorbable clips is the reported, albeit rare, migration of the clip, for example, into the common bile duct, causing its obstruction and the induction of stone formation. The surgeon can choose different clip applicators, including single-fire and multi-fire applicators, varying sizes, 360°-rotating devices or applicators with an angled head, depending on the intended use.

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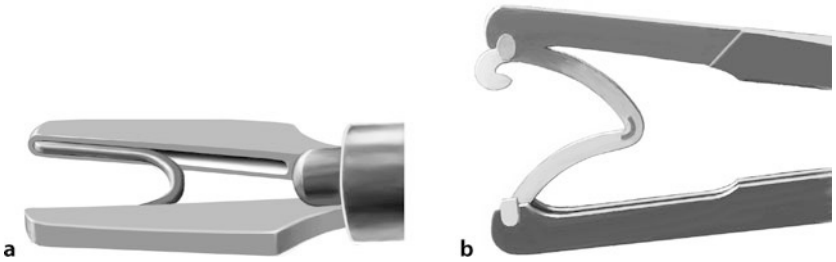


Fig. 6.7

6

Tricks of the Senior Surgeon

1. Surgical devices facilitate hemostasis, tissue sealing, and dissection. However, there is no substitute for placing stitches, tying knots, and using standard tissue dissection techniques, key skills that every surgeon must possess.
2. For optimal use, be familiar with several surgical devices and have a good knowledge of their individual advantages, biophysics, ranges of effectiveness, and application methods. Familiarity with the products facilitates their optimal use.
3. Lower power settings and short application times of all electrosurgery instruments is advised in order to prevent thermal injury to nearby anatomic structures.
4. Topical hemostatic agents are envisioned to provide a useful adjunct to assist in the control of diffuse oozing blood and minor bleeding but not to supplant ligation or surgical repair of major vascular disruption.

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Introduction to Robotic Surgery

Justin Ady, Vincent P. Laudone

Introduction

The history of robotic surgery started in the 1980s with the PUMA 560 robot. It was used in 1985 to increase the precision of neurosurgical biopsies. That same robot was then used later to perform a transurethral resection of the prostate. This lead to the development of PROBOT, a robot designed specifically for transurethral resection of the prostate. Around the same time another robot called ROBODOC was designed to machine the femur with greater precision in hip replacement surgery and eventually went on to become the first surgical robot approved by the FDA.

A number of medical robots are available currently in the United States. These medical robots include the Mako robotic system, which is a single-purpose robot currently used for orthopedic prosthetic implantation. They also include the Perfint Maxio Robot, which is used for image-guided biopsy and ablation procedures coupled to a CT scanner.

In the 1980s, both NASA and the U.S. Army began work on telesurgical systems. This work resulted in two commercially available systems, the da Vinci surgical system (Intuitive Surgical) and ZEUS (Computer Motion). In 2003, the two companies owning these products merged and ZEUS was phased out in favor of the da Vinci surgical system. The da Vinci surgical system is a master-slave surgical robot with multiple arms that are operated remotely from a console by a surgeon. It is the only robot approved currently by the U.S. FDA for soft tissue procedures. In that capacity, over 1 million surgical procedures have been performed using this surgical robotic system worldwide. In this chapter, we outline the principles of use of this robot. In subsequent chapters, we present the common upper gastrointestinal surgical applications of this robot, including cholecystectomy, splenectomy, distal pancreatectomy, gastrectomy, and hepatectomy.

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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Room Setup

The setup of the general operative suite for upper gastrointestinal surgery is shown in Fig. 7.1. With the recent introduction of the Xi model, the patient side cart of the robotic system can be brought in toward the patient from any angle. The overhanging arm design allows for equal access to all quadrants. In contrast, with the Si or older models, it is very important to orient properly the patient side cart to the patient for each operation. With these models, redirecting the robotic components requires undocking and moving the cart and often times the patient as well. This can be both difficult and time consuming. In general, cholecystectomy and right liver operations will require docking the patient side cart from the patient's right (Fig. 7.2a). Gastrectomies, central pancreatectomies, and left liver operations can be approached by docking directly overhead or from the left (Fig. 7.2b).

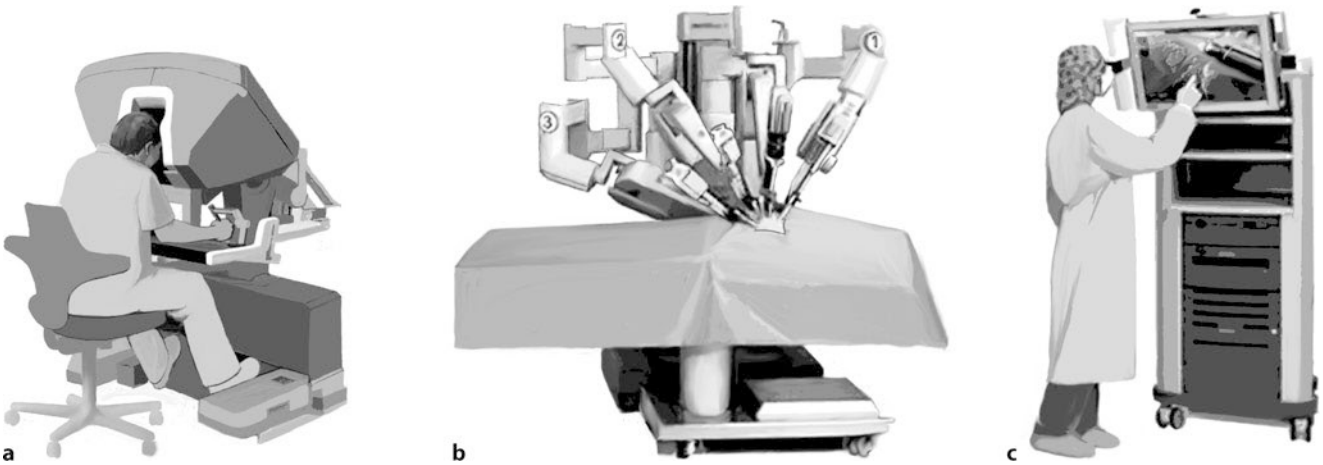


Fig. 7.1

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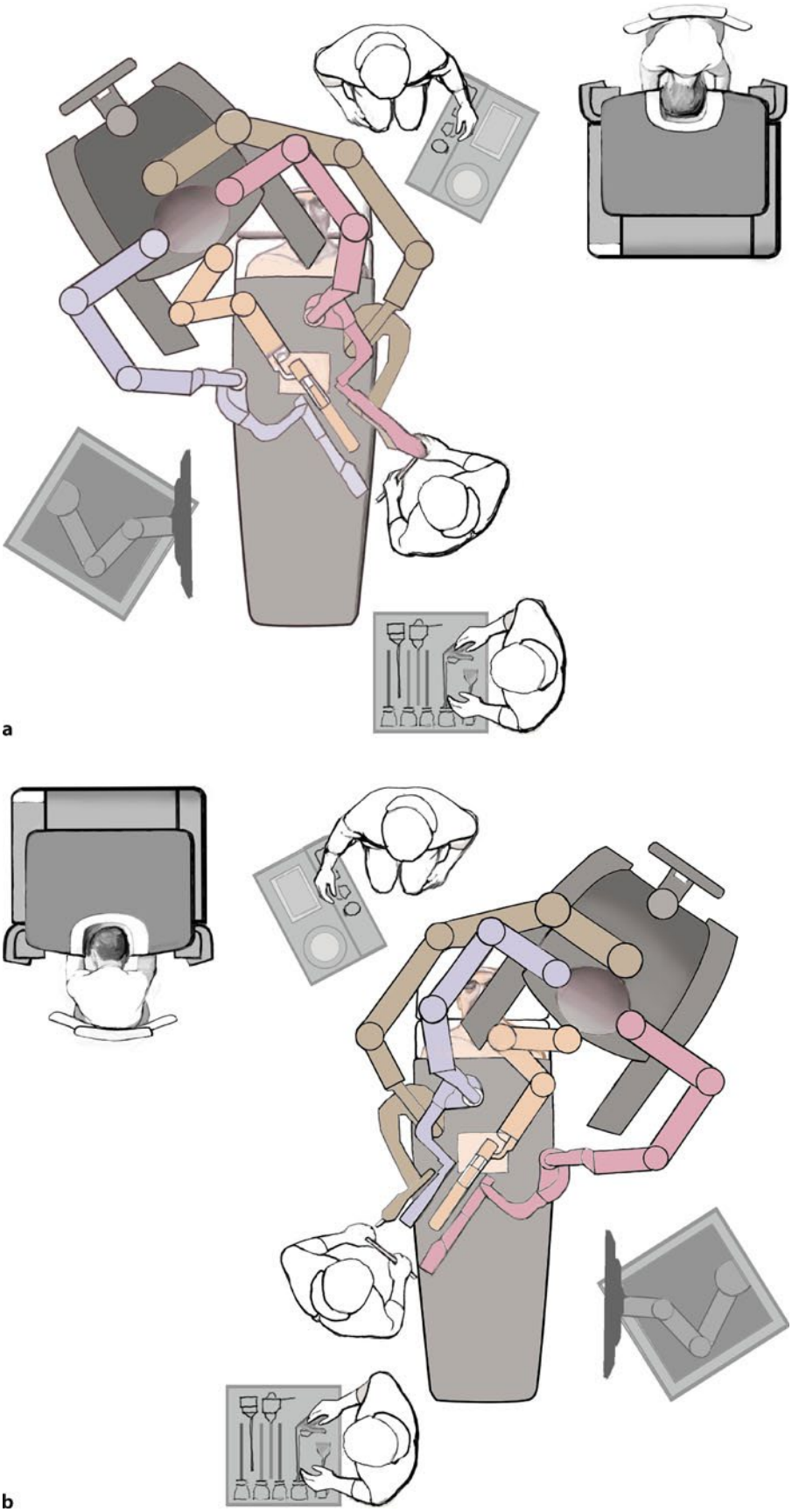


Fig. 7.2

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The general principles of room setup are:

- Once docked, access to the patient's arms will be limited. Thus all intravenous and intra-arterial access lines need to be placed before positioning and docking.
- There needs to be a stopcock on the intravenous line close to the patient to allow administration of emergency medications and blood products without going through a long length of intravenous tubing.
- The tubing for ventilation needs to be long.
- Standard table-attached retractors cannot be placed, because they will be obstacles for docking.

Patient Positioning

For most upper gastrointestinal operations, the patient will be positioned in a supine position. For a splenectomy, the patient may be positioned in a right lateral decubitus position. For right posterior liver operations, a left lateral decubitus position may be chosen (Fig. 7.3)

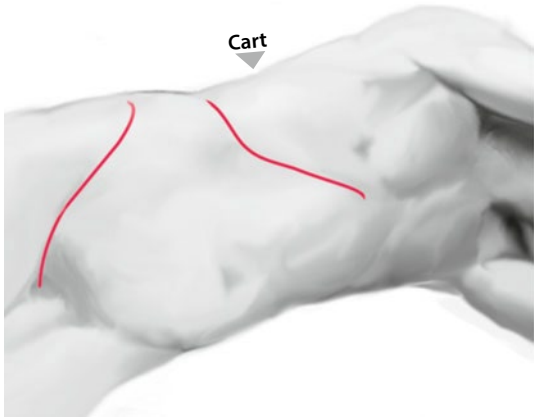


Fig. 7.3

The general principles of positioning are:

- Most cases will require the patient to be in a supine position in reverse Trendelenburg position.
- A foot board is helpful for limiting the sliding of the patient during the surgery.
- Some surgeons prefer a split leg position, although that is more helpful for pelvis procedures.
- Pad all pressure points.
- Need to commit to choice of degree of rotation and Trendelenburg, because the patient cannot be moved with the robot docked.
- In some cases such as splenectomy, the patient will need to be in right lateral decubitus position, similar to the laparoscopic approach.
- For a right posterior liver operations, a left lateral decubitus position is helpful.
- Set a time limit for the case: the longer the case, the more likely a positioning/pressure injury.

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Port Site Placement

Port placements for individual operations are described in individual chapters. One option for port placement for distal pancreatectomy is shown in Fig. 7.4 as an example. Three types of ports can be used.

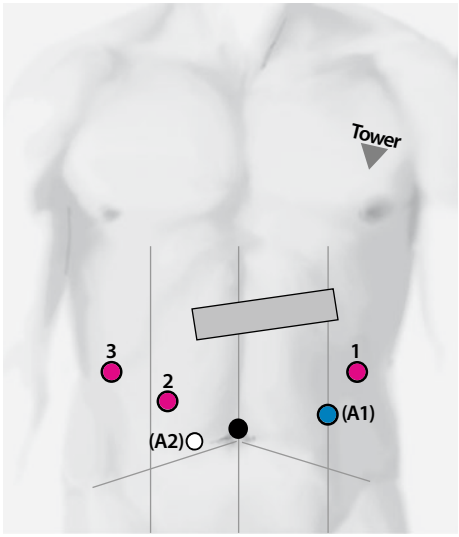


Fig. 7.4

- Dedicated robotic ports. These are generally 8 mm in diameter and have a marked isocenter to minimize trauma to the abdominal wall. These come in short and long (bariatric) lengths.
- Standard laparoscopic ports.
- A gel port can also be used. This port can be used for extraction of large specimens and for palpation of intra-abdominal organs. The gel port will also allow rapid access for those operations in which life-threatening hemorrhage is a possible complication. Laparoscopic and robotic ports can be placed through the gel port.

The general principles of port placement are similar to laparoscopic port placement, with some exceptions listed below:

- Ports should be and could be further from the intended surgical field than in laparoscopic surgery.
- A 7-mm robotic port can be placed within a 12-mm laparoscopic port for use. This "port-in-port" configuration allows the flexibility of using this port as a backup camera port, a robotic port, and an assistant port.
- An assistant port should be 12 mm if it is anticipated that staplers will be needed.
- 5- and 8-mm port sites do not generally need to be closed.
- The patient side cart (tower), target organ, and camera port (black) should be roughly in line with each other.
- Working ports (red) and assistant ports (white, blue) are placed around the target or set in a fashion so as to not conflict in position.

Instrumentation

The wide range of instrumentation used for robotic surgery falls into four categories:

a) Articulated instruments designed specifically for robotic surgery:
   - Graspers including ProGrasp, Cardiere, DeBakey, Tenaculum
   - Forceps including right-angle, Maryland, fenestrated bipolar
   - Dissectors including cautery hook, spatula
   - Scissors
   - Needle drivers

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- Sealers including PK dissecting forceps, Vessel Sealer
- Staplers
- Clip applier

b) Straight instruments designed specifically for robotic surgery:
- Harmonic scalpel
- Suction/irrigator
- Fluorescence imaging

c) Laparoscopic instruments used through an assistant port:
- Graspers
- Retractors
- Suction
- Staplers
- Ultrasound probe

d) Instruments used percutaneously:
- Sutures for retraction
- Ablation devices
- Biopsy devices

Contingency Plans for Emergency Conversion

One concern in robotic surgery is making an emergency conversion to an open procedure if severe hemorrhage occurs. It generally will take longer to convert to open surgery from robotic than laparoscopic surgery, because (1) the robot is docked and is an obstacle to conversion, (2) the primary surgeon is not at the surgical table, (3) anesthesia personnel are generally more remote from the patient, and (4) the open surgical instrumentation may not be nearby and is not open for use.

Having a contingency plan for conversion to an open procedure increases the likelihood of a favorable outcome. Implementing and rehearsing such a plan is essential. Having a "Robotic Emergency Timeout" as part of every robotic case ensures availability of emergency instruments and blood products and that all personnel involved understand the plan for emergency conversion and their role in the process.

- There should be an instrument set available for emergency conversion that should include standard open surgical instruments and vascular surgical instruments.
- There should be self-retaining retractors available to provide exposure such as a Thompson or Goligher retractor.
- There should be a list of standard vascular sutures and staplers that are made immediately available.
- In cases in which hemorrhage is likely, consideration should be given to placing a gel port at the start of the operation to allow for rapid, manual tamponade of bleeding. Such a gel port insertion site can be used for specimen extraction.

Emergency Conversion Timeout should be performed at the beginning of each robotic surgical case, and should include the following elements:

- Delineation of personnel responsibility including who will maintain tamponade, perform resuscitation, undock the robot, and make the open incision.
- Check to be sure emergency conversion instruments, retractors, vascular sutures, and staplers are readily available or in the room.
- Check that necessary blood products for potential resuscitation are available.
- List other personnel who may be called to assist in an emergency such as vascular surgeons.

Laparoscopic Versus Robotic

In the past two decades, laparoscopic surgery has transformed modern surgery dramatically. Numerous studies have shown these techniques to have resulted in decreased length of hospital stays, improved postoperative pain, better postoperative immune function resulting in fewer surgical infections, and improved cosmetic results when compared with similar open procedures. For these reasons minimally invasive techniques have become accepted by surgeons, patients, and insurance companies.

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Nevertheless laparoscopic surgery has limitations. There is a decreased freedom of movement within the abdominal cavity and surgeons are forced to watch a two-dimensional video representation of a three-dimensional operative field. In addition laparoscopic instruments provide surgeons with decreased haptic feedback and poor ergonomics. These limitations make complex dissections and anastomosis difficult. There is also a substantial learning curve to develop and maintain advanced laparoscopic skills. The shortcomings of laparoscopic surgery were the driving force behind the development of robotic surgery.

Unlike laparoscopic surgery, robotic surgery allows surgeons to perform advanced laparoscopic procedures with greater ease and less technical training. The robot's articulating instruments allow laparoscopic instruments to move with handlike motions. Performing delicate dissection and intracorporeal suturing is made possible by the steady camera platform, three-dimensional imaging, resting tremor filtration, the removal of tremor and motion artifact, and comfortable ergonomics provided for the surgeon. The significant advantages of robotic surgery are expanding the scope of surgical procedures being performed through minimally invasive techniques. The robot, however, as currently designed, provides much less haptic feedback to the surgeon because of the computer interface between the surgeon's hands and the patient. Visual experience with tension and force during formal laparoscopy is essential for the robotic surgeon.

Table 7.1 Advantages and Disadvantages of Open, Laparoscopic, and Robotic Surgery

	Open Surgery	Laparoscopic Surgery	Robotic Surgery
Advantages	Long track record	Well-developed technology	3D visualization
	Most affordable	Widely deployed	Improved dexterity
	Easy control of bleeding	Proven indications	Tools with multi-degrees of freedom
	Easy sewing	Established teaching/credentialing	Elimination of fulcrum effect
			Elimination of tremors
			Adjustable scaling
			Telesurgery
			Ergonomic
Disadvantages	Large incision	Loss of touch sensation	Loss of touch sensation
	Evaporative losses	Fulcrum effect	Very expensive
	Divided cutaneous nerves	Expensive	High start-up cost
	Compromised muscular function	Amplified tremor Learning curve	Requires skilled assistant Unproven benefit
	Compromised post-op respiratory function	Difficult sewing	Training and credentialing not uniform Difficult emergency conversions

Tricks of the Senior Surgeon

- Transcutaneous sutures may be used to retract various organs and minimize the number of ports required.
- Using a smoke evacuator is very helpful in cases in which many energy devices are used for hemostasis and maintains the advantages of clear, three-dimensional vision.
- "Port in port" and "port in gel port" strategies allow flexibility of use of alternating between robotic and laparoscopic instrumentation while minimizing number of ports.
- Drop-in ultrasonography probes allow facile delineation of target lesions and may mitigate the loss in tactile sensation.
- Use of a skilled assistant can be crucial for exposure.

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Introduction: Esophagus, Stomach, and Duodenum

Jakob Izbicki, Michael G. Sarr

This section presents the ambitious field of open and laparoscopic surgery in benign and malignant diseases of the esophagus, stomach, and duodenum.

Attempts to treat esophageal cancer surgically emerged at the beginning of the twentieth century. Torek successfully resected the thoracic esophagus in 1913, but real progress came as a result of the development of thoracic surgery during and after the Second World War. The concept of extensive lymph node resection in combination with en bloc esophagectomy was proposed by Logan in 1963 but with considerable morbidity and mortality.

Surgical procedures, pre- and postoperative management and treatment, and prognosis after surgical treatment have improved considerably in the past three decades. Expertise of the surgeon and the institution, patient selection, choice and radicality of operation, and pre- and postoperative care are the most important parameters for outcome.

For this reason, the first eight chapters present a comprehensive survey of the different open and laparoscopic surgical procedures, indications, and choice of operation in esophageal cancer. They give clear guidelines as to how and when to operate with regard to the biological characteristics of the tumor. The focus then turns to benign esophageal diseases such as diverticula, strictures, and achalasia.

The following chapters address the techniques of subtotal, total gastric resections in benign and malignant diseases, respectively. Four chapters then outline the open and laparoscopic strategies in the case of palliation such as gastroenterostomy and gastrostomy. Next the laparoscopic procedure is described as the gold standard for gastroesophageal reflux, and then the open approach is covered followed by different laparoscopic techniques for hiatal repair in paraesophageal hernia. Another chapter comprehensively covers the available strategies for morbid obesity, and the last chapter in the section deals with the ambitious pancreas-sparing duodenectomy.

The section has been prepared by experts in their surgical fields, and we hope that it will provide the reader with a comprehensive overview of current surgical standards for the various procedures.

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Cervical Esophagectomy

Rainer Schmelzle, Phillip Pohlenz

Esophagectomy for neoplasia includes removal of the cervical part of the esophagus combined with cervical lymphadenectomy and reconstruction by interposition of a free jejunal transplant with microvascular anastomoses.

Resection of a segment of up to 3 cm can be performed with primary anastomosis of the esophagus after adequate mobilization.

Indications and Contraindications

Indications

- Cervical esophageal neoplasia
- Benign esophageal stricture

Contraindications

- Local irresectability (infiltration of larynx, trachea, or vertebrae)
- Multifocal lesions
- Distant metastasis
- Florid gastroduodenal ulcer
- Crohn's disease

Procedure

Access

For the cervical part, a unilateral or bilateral (U-) incision at the medial margin of the sternocleidomastoid muscle is performed. It extends from the margo inferior of the mandible to the jugulum, where it meets with the contralateral side. For cervical-mediastinal lymph node dissection, the incision is combined with a partial or complete median sternotomy. For harvesting the transplant, a small upper abdominal transverse incision is sufficient.

Exposure

Retraction is performed by hand-held retractors of different shapes and sizes according to the anatomy. If available, a self-retaining retraction system will help.

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Step 1

Preparation of the Cervical Region

After transection of the platysma, the sternocleidomastoid muscle is retracted and the omohyoid muscle is divided. Along with the internal jugular vein, the common carotid artery and the vagal nerve are identified along the entire length of the incision and a lymphadenectomy around these structures is performed. The superior thyroid artery can be preserved for reconstruction. From the carotid artery, the anterior longitudinal ligament is reached and the posterior dissection of the cervical esophagus is completed under vision.

After mobilization of the left (or right) thyroid lobe, the recurrent nerve and the parathyroids are identified and preserved. Injuries to the recurrent nerve should be repaired immediately. Autotransplantation of dissected parathyroids should be performed in the forearm if radiation therapy is an option.

Quite frequently a hemithyroidectomy facilitates the further procedure significantly. Now the posterior aspect of the trachea is dissected, and after identification of the contralateral recurrent nerve, the cervical esophagus is completely mobilized from the hypopharynx to the upper thoracic aperture or below.

Occasionally the identification of important blood vessels can only be guaranteed using intraoperative Doppler ultrasound. Especially following extensive tumor resections of the oropharyngeal region, vast alterations of the typical anatomy must be expected. Injuries of the thoracic duct can lead to the development of persistent fistulas associated with significant fluid loss, protracted by a previous radiotherapy.

In cases of extensive tumor growth that warrant resection, more extensive procedures may become necessary (e. g., larynx or trachea).

Before resection, place retaining sutures on the potential proximal and distal stump (Fig. 9.1).

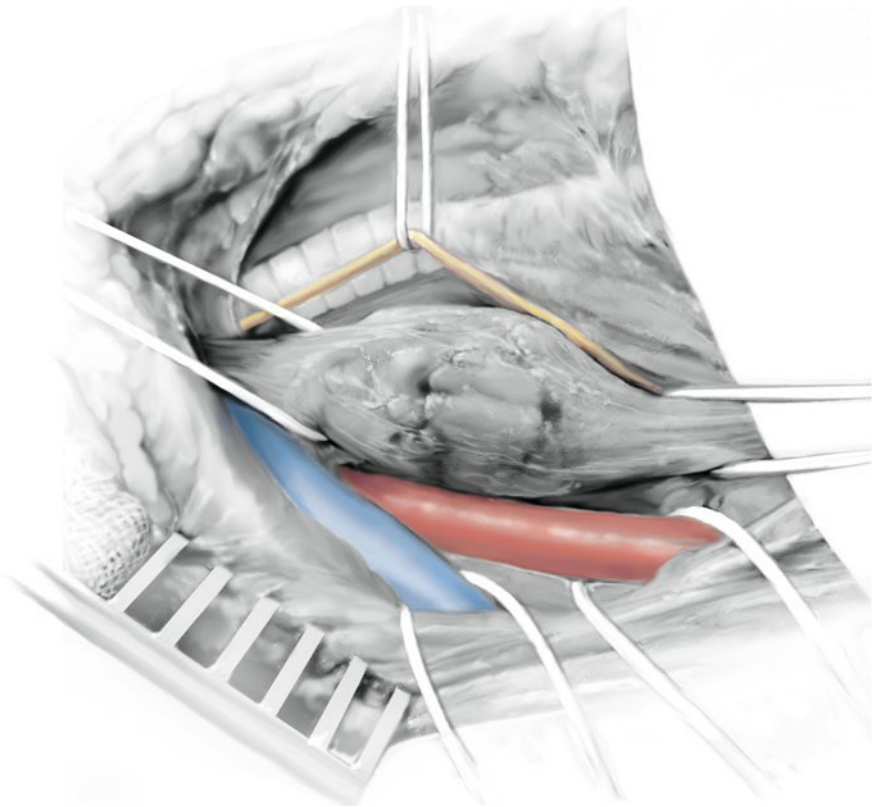


Fig. 9.1

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Step 2

Transection of the Esophagus

The cervical esophagus is transected and the nasogastric tube withdrawn to the level of the neck so that the specimen can be removed. Confirm free margins by frozen section on both sides. In case negative margins cannot be achieved, an esophagectomy should be performed (Fig. 9.2).

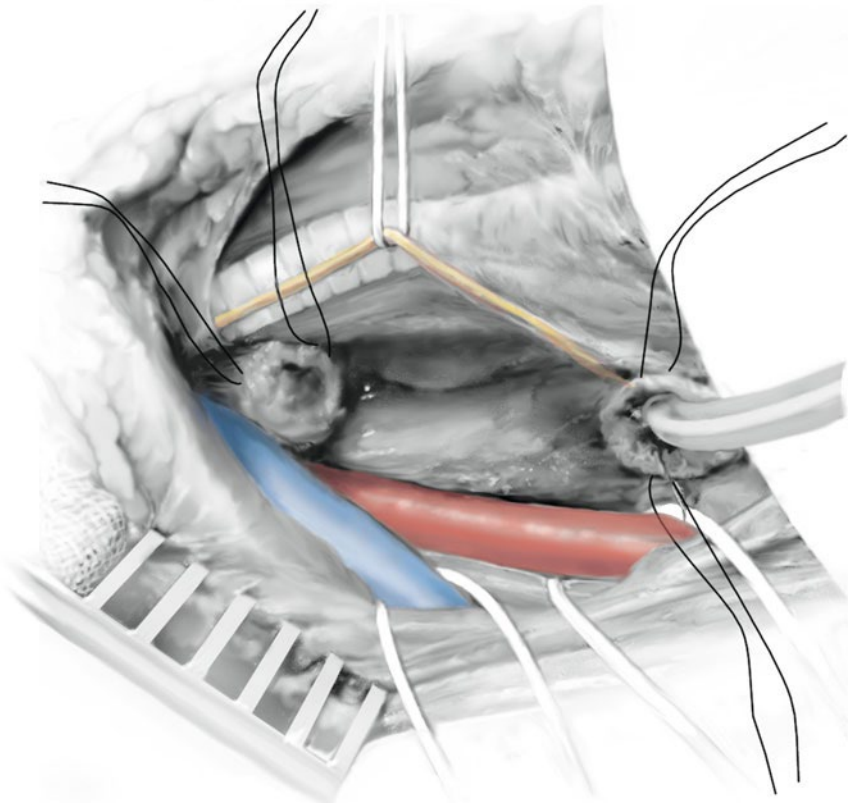


Fig. 9.2

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Step 3

Preparation of the Jejunal Loop

The jejunal loop is harvested after exploration of the abdominal cavity with sufficient arterial and venous length and lumen. If the mesentery is very thick, a meticulous removal of fatty tissue may enable diaphanoscopy. However, under diaphanoscopy, an artery and a vein of sufficient length and lumen are identified. After clamping on the mesenteric side and excision of the graft, the artery is flushed with heparinized saline until the venous outflow is clear.

If the vascular pedicle or one of the vessels is too short, it becomes necessary to harvest a venous or arterial interponate. The primary source for viable venous interponates is the forearm, whereas for the artery the saphenous vein can be employed. Vessels harvested from the arm or foot region are equally suitable for the arterial interponate whereas the saphenous vein, owing to its dimension and susceptibility to spasm, proves to be hardly suitable for venous interpositioning and should thus be reserved only for arterial lengthening. At times it is very difficult to differentiate between the artery and the vein in the intestinal flap. To avoid confusing the two, prior to harvesting, the artery or vein should be unmistakably marked.

An end-to-end jejunostomy is performed to reconstruct the bowel, and the abdomen is closed without drainage (Fig. 9.3).

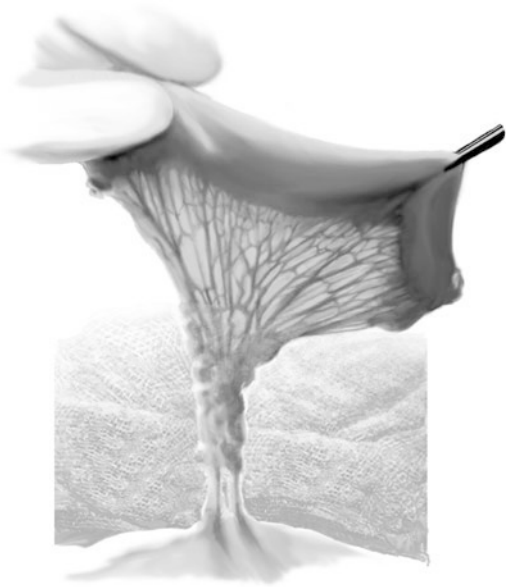


Fig. 9.3

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Step 4

Vascular Anastomoses

The venous and arterial anastomoses are now performed. First the vein is anastomosed. Preferably a confluens of the major mesenteric vein with a smaller contributing vein is used on the side of the graft and the internal jugular vein on the other side. The incision in the internal jugular vein should be at least 3 to 4 mm long. The anastomosis is performed under a magnification of at least ×4, preferably with a microscope. Running sutures with non-resorbable, monofilament material, 8-0 or 9-0, are used. Before closure, the anastomosis is rinsed with heparinized saline.

The vein should be anastomosed before the artery only if an expedient progression of the operation is evident. Should delays occur (e. g., difficulties during the preparation or unforeseen anesthesiological circumstances in conjunction with unstable cardiovascular parameters), the artery should be anastomosed prior to the vein, allowing a perfusion of the intestinal flap with nutrient-rich blood until peristalsis returns. If the nature of the delay prevents the anastomoses, the harvested intestinal flap should be stored in moist dressings. If desired, the metabolic rate of the temporary non-perfused flap can be decreased by cooling the flap. Routinely, there is no necessity for the use of organ preservation solutions.

The same technique is used for the artery. The anastomosis can be performed on the superior thyroid artery, the thyrocervical trunk, or the common carotid artery directly. Rarely other cervical branches like the lingual or facial artery are used.

It is extremely important to avoid kinking and compression especially on the vein during placement of the graft into the neck, and during closure of the neck.

If the vascular reconstruction fails, either a second loop can be harvested or a gastric tube can be fashioned (Fig. 9.4).

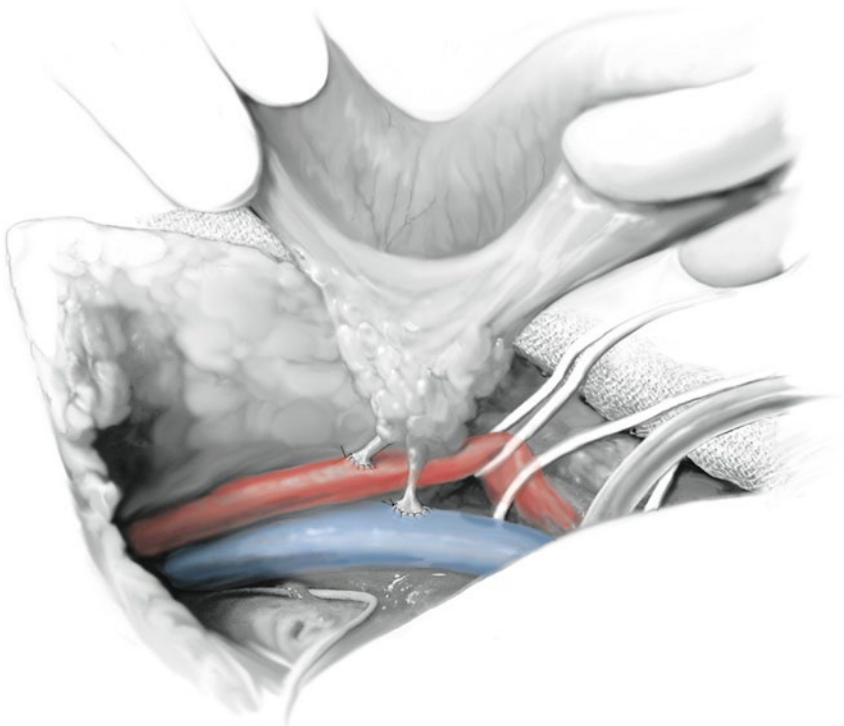


Fig. 9.4

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Step 5

Esophagojejunal Anastomoses

After reperfusion an adequate flow is confirmed. Then the lower and finally the upper esophagojejunal anastomoses are performed end-to-end or end-to-side after shortening the graft to an adequate length. These anastomoses are performed using 3-0 or 4-0 absorbable sutures in a single layer. It is important to grasp the entire thickness of the pharynx or esophagus, whereas the stitches in the jejunum are extramucosal. If the anatomy is demanding (e. g., a very low intrathoracic anastomosis), the suture can be performed in an interrupted fashion. The nasogastric tube is then placed through the graft into the stomach.

It is important to implant the graft in an isoperistaltic fashion to facilitate swallowing. Even under optimal conditions, it can take weeks before the graft gains normal transplant function (Fig. 9.5).

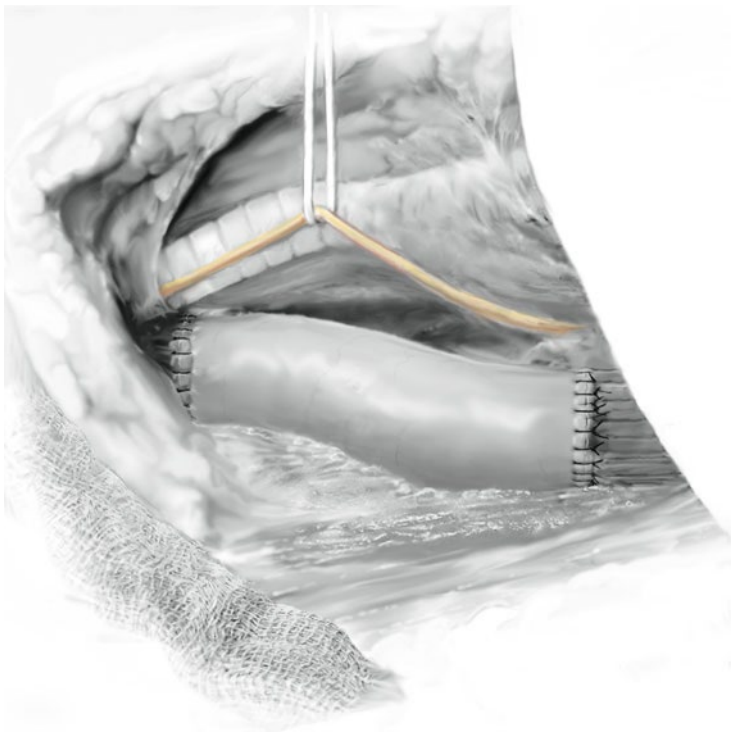


Fig. 9.5

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Step 6

Final Aspects

The neck is drained sufficiently from both sides with at least one soft easy-flow drain on each side. The neck is closed by loose interrupted subcutaneous and skin stitches.

For the postoperative follow-up, it is advantageous to ensure that parts of the jejunal graft are clinically visible. This can be achieved either by placing a few sutures in a manner such as to allow a division of the covering tissue or by configuring the flap so as to leave parts of the flap uncovered, serving as a "monitor" during the postoperative surveillance. Verification of the blood flow can be performed using Doppler ultrasound. As an adjunct, various tissue probes are available, facilitating the measurement of the oxygen partial pressure.

Standard Postoperative Investigations

- Anticoagulation (PTT 60–70s)
- Controlled systolic arterial blood pressure
- Monitoring of microcirculation and improved rheology
- Daily Doppler ultrasound
- Regular inspection of the flap on postoperative day 1 every hour

Postoperative Complications

- Venous thrombosis (reoperate immediately)
- Arterial thrombosis (reoperate immediately)
- Necrosis of the transplant (excise and drain by pharyngostomy or reconstruct with gastric tube or colon)
- Salivary leak (drain adequately)
- Lymphatic leak
- Recurrent laryngeal nerve injury
- Esophageal stenosis (dilate by endoscopy) (long term)
- Poor swallowing function (long term)
- Major bleeding

Tricks of the Senior Surgeon

- Be aggressive to reoperate if vascular status is questionable.
- Avoid kinking of the vein by keeping it short.
- Keep central venous pressure high and perform adequate heparinization to avoid vascular problems.
- Leave the neck open if the jejunum is congested after reperfusion but cover the vessels with tissue.
- If the exposure for vascular reconstruction becomes difficult, perform a hemithyroidectomy.
- Occasionally a partial sternotomy may enable a safer inferior esophageal anastomosis.
- Lymphatic leak can be managed conservatively; only rarely the lymphatic duct must be ligated.
- Exposure can be facilitated by division of the medial head of the sternocleidomastoid muscle.
- Previous surgery with resection of the internal jugular vein necessitates dissection down to the subclavian vein.
- Early tracheotomy.
- Avoid compression bandages, tapes around the neck or tracheal strips with extrinsic compression of the vascular pedicle.

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Left Thoracoabdominal Approach for Carcinoma of the Lower Esophagus and Gastric Cardia

Shoji Natsugoe, Takashi Aikou

Introduction

Tumors located aborally to the carina, i. e., Barrett's carcinoma or carcinoma of the esophagogastric junction, may be approached by a left-sided thoracotomy instead of the more usual right-sided access combined with an abdominal approach. The extent of lymphadenectomy is limited to the middle and lower mediastinum.

Indications and Contraindications

Indications

- Tumors of the infracarinal esophagus
- Tumors of the esophagogastric junction

Contraindications

See ▶ Chap. 11 *on "Subtotal Esophagectomy: Transhiatal Approach"*

- High-risk patients

Preoperative Investigation/Preparation for the Procedure

See chapter on "Subtotal Esophagectomy: Transhiatal Approach"

Procedure

- **Access**
  - Spiral positioning of the patient with 45° elevation of the left thorax
  - Rotating the operating table for the thoracic part/abdominal part

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Step 1

Thoracotomy

The skin incision is made obliquely from the epigastrium toward the sixth or seventh intercostal space, and a good exposure of the mediastinum or abdomen can be achieved by rotating the operating table. After 1 cm of costal cartilage is resected, the left side of the chest is opened. Distant and peritoneal metastases should be excluded prior to thoracotomy (Fig. 10.1).

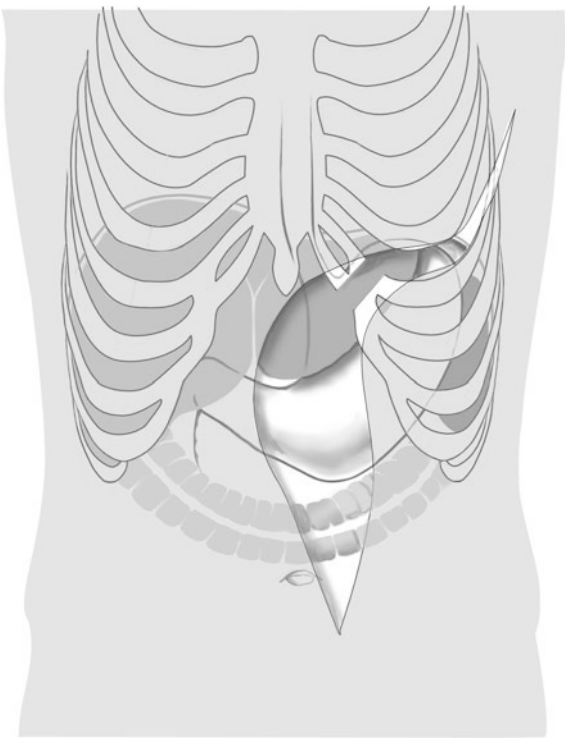


Fig. 10.1

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Step 2

Incision of diaphragm and mobilization of the colon

Para-aortic lymphadenectomy is performed by delivering the splenic flexure into the chest through a circumferential incision in the periphery of the diaphragm. The descending colon is then mobilized down the left paracolic gutter to the base of the sigmoid colon mesentery. After mobilization of the left kidney from the retroperitoneum as well as pancreas and spleen, the left renal vein is identified (Fig. 10.2).

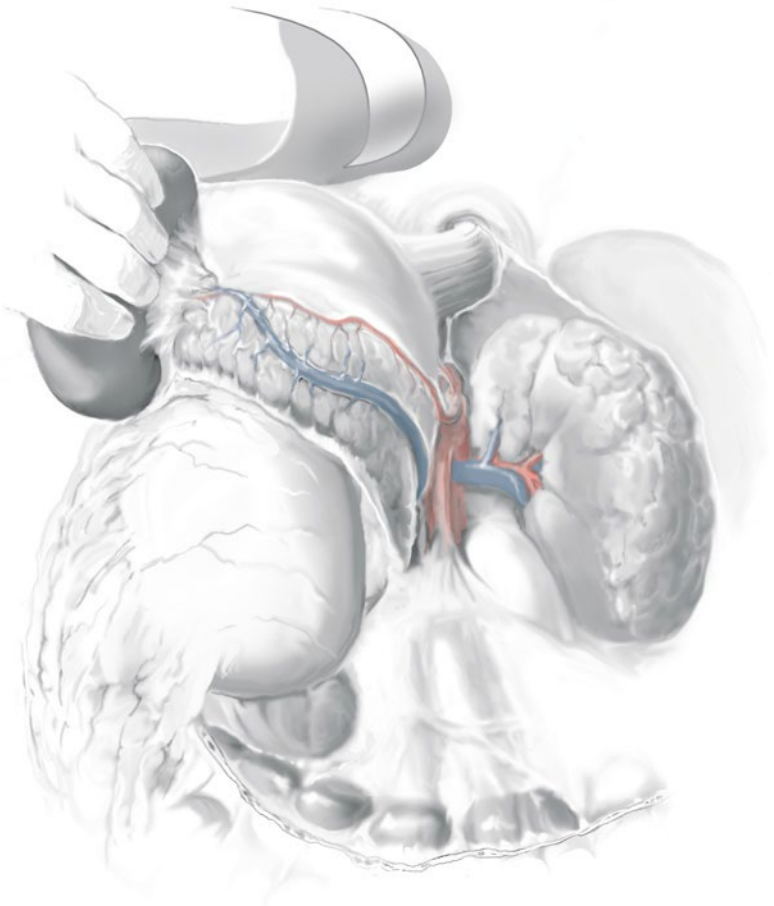


Fig. 10.2

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Step 3

Para-aortic lymph node removal

The para-aortic lymph nodes in the left lateral region are then dissected, and the right lateral para-aortic lymph nodes are removed after performing an extended Kocher maneuver (Fig. 10.3).

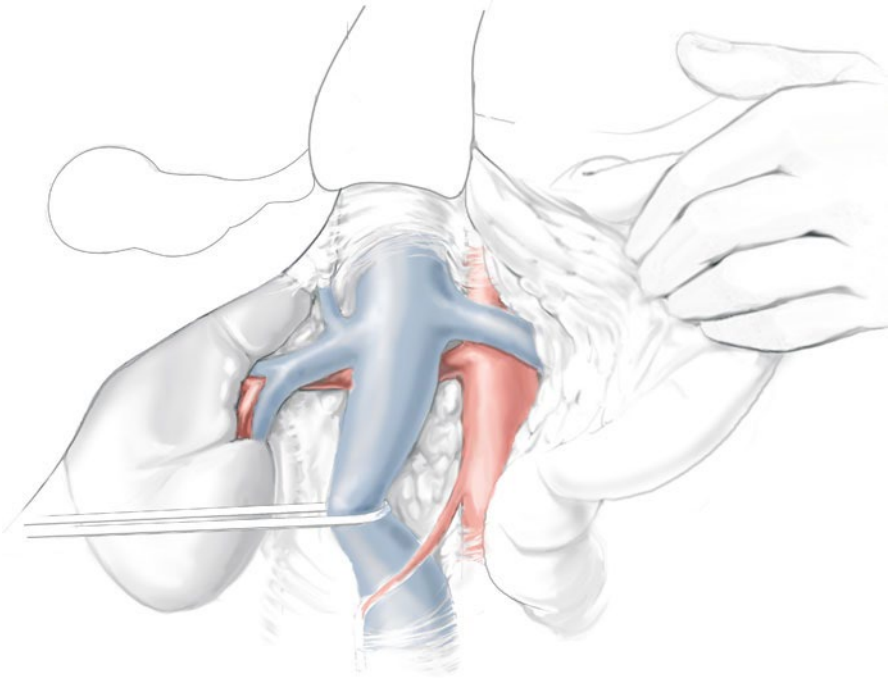


Fig. 10.3

Step 4

Lymph node removal of the upper abdomen

Lymph nodes of the hepatoduodenal ligament and around the common hepatic artery, left gastric artery and celiac trunk are dissected (Fig. 10.4).

Mobilization of the stomach and transection of the duodenum follows (see chapter "Total Gastrectomy with Conventional Lymphadenectomy")



Fig. 10.4

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Step 5

Lower mediastinal lymph node removal

Regarding the left intrathoracic approach, the left pulmonary ligament is divided and the mediastinal pleura is opened. The pleura covering the lower thoracic esophagus is incised, allowing the clearance of loose connective tissue together with the lower thoracic paraesophageal, supradiaphragmatic, posterior mediastinal and intradiaphragmatic lymph nodes (Fig. 10.5).

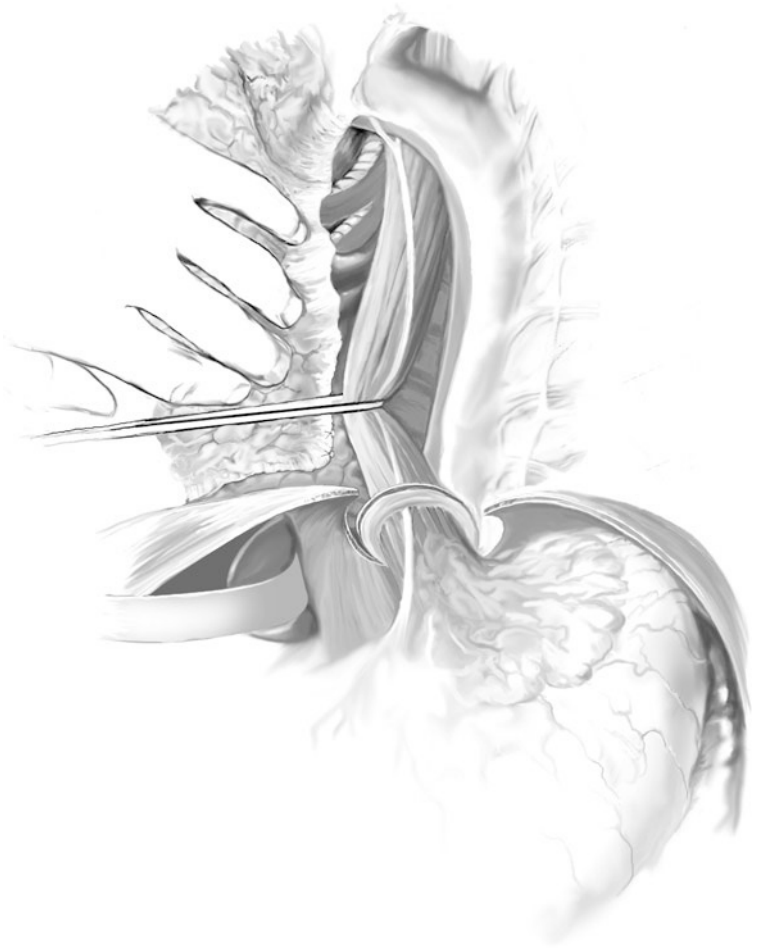


Fig. 10.5

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Step 6

Reconstruction

There are several methods of reconstruction according to the tumor location and extension. Roux-Y reconstruction by using an EEA stapler introduced through the end of the Roux limb (see ▶ Chap. 13, ◘ Fig. 13.5) or a hand sewn end to side anastomosis, as shown here, is an option for performing the esophago-jejunostomy (◘ Fig. 10.6).

See ▶ Chap. 11 *on "Subtotal Esophagectomy: Transhiatal Approach" for standard postoperative investigations and complications.*



◘ Fig. 10.6

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Tricks of the Senior Surgeon

- Kinking of the Roux limb: this is a rare but dangerous complication, due to clinical symptoms of difficulty passage due to relative obstruction of injested content through the Roux limb secondary to elongation, which requires surgical intervention and is performed by shortening of the Roux limb.
- If the trachea is injured, use direct suture and pericardial flap.

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Subtotal Esophagectomy: Transhiatal Approach

Matthias Reeh, Emre F. Yekebas, Jakob R. Izbicki

Introduction

The surgical trauma of the transhiatal approach is less pronounced as compared with a transthoracic approach. Conversely, the lymphatic clearance is less radical, at least for the mid and upper mediastinum. This is the reason why some surgeons are in favor of the transthoracic approach even for distal adenocarcinoma. Subtotal transhiatal esophagectomy is indicated for benign conditions and for distal carcinoma.

Indications and Contraindications

Indications

- Adenocarcinoma of distal esophagus (> T1 stage)
- Intraepithelial squamous cell neoplasia
- High-risk patients
- Extensive stricture (stenosis) due to erosion (chemical burns) unresponsive to nonsurgical treatment including bougienage and dilataton
- Extensive peptic stricture (stenosis)
- Relapse of megaesophagus after surgical repair of cardiospasm/achalaia combined with peptic strictures and failure of dilatation
- Extensive benign esophageal tumors (exceptional cases, usually local excision)
- Esophageal rupture or iatrogenic perforation with mediastinitis (primary repair not feasible)

Contraindications

- Florid Gastroduodenal Ulcer
- Infiltration of aorta by cancer
- Distant metastasis
- Adenocarcinomas of the esophagogastric junction type II
- Infiltration of upper or middle mediastinal anatomic structures

Preoperative Investigation/Preparation for the Procedure

History:	Previous gastric or colonic surgery
Risk factors:	Alcohol, nicotine, gastroesophageal reflux disease (GERD), Barrett's esophagus
Clinical evaluation:	Recurrent laryngeal nerve status, cervical lymphadenopathy
Laboratory tests:	CA 19-9, CEA, liver function tests, coagulation test
Endoscopy:	Esophagogastroduodenoscopy with biopsy – to exclude gastric infiltration of cancer
Colonoscopy:	If colonic interposition is likely
CT scanning (thorax + abdomen):	Staging
Abdominal ultrasound:	Staging

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Esophageal endosonography:	Staging, r/o aortic infiltration by cancer
Bronchoscopy (if tumor is localized in mid-third):	r/o bronchial infiltration by cancer
Bowel cleansing:	(If colonic interposition is likely)
Respiratory therapy	

Procedure

- **Access**

Upper transverse incision with median extension. Alternatively midline laparotomy.

Step 1

Laparotomy and inspection of the stomach, distal esophagus, liver, and regional lymph nodes

Placement of self-retaining retractor system for exposure of the epigastric region (Fig. 11.1a).

Mobilization of the left lateral liver by transection of the left triangular ligament. To prevent injury of adjacent structures, a pack is placed under the left lobe of the liver (Fig. 11.1b).

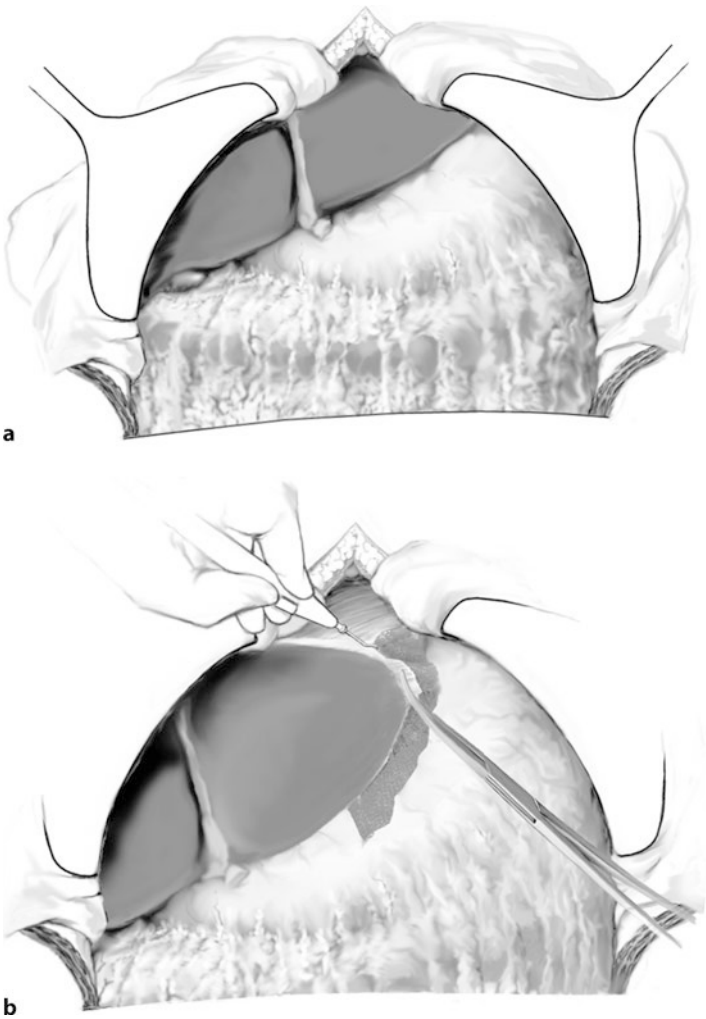


Fig. 11.1

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Step 2

Preparation and mobilization of the stomach with epigastric lymphadenectomy including para-aortic lymphatic tissue

Dissection of the greater curvature is commenced from below, thoroughly sparing the origin of the right gastroepiploic vessels and the arcade between left and right gastroepiploic vessels up to the level of the splenic hilum (Fig. 11.2a).

Dissection of the greater curvature is continued toward the spleen. The left gastroepiploic artery is transected directly at its origin at the splenic artery. Transection and ligature of the short gastric vessels is performed, thus mobilizing the fundus and the greater curvature completely. For esophageal carcinoma the parietal peritoneum is incised at the upper pancreatic margin and lymphadenectomy is begun along the splenic artery. The flaccid part of the lesser omentum is dissected. The cranial part of the hepatogastric ligament (hepatoesophageal ligament) is dissected from the diaphragm (Fig. 11.2b). An accessory left hepatic artery with strong caliber should be preserved. In this case the left gastric artery has to be diverted distally to the origin of this accessory/replaced left hepatic artery.

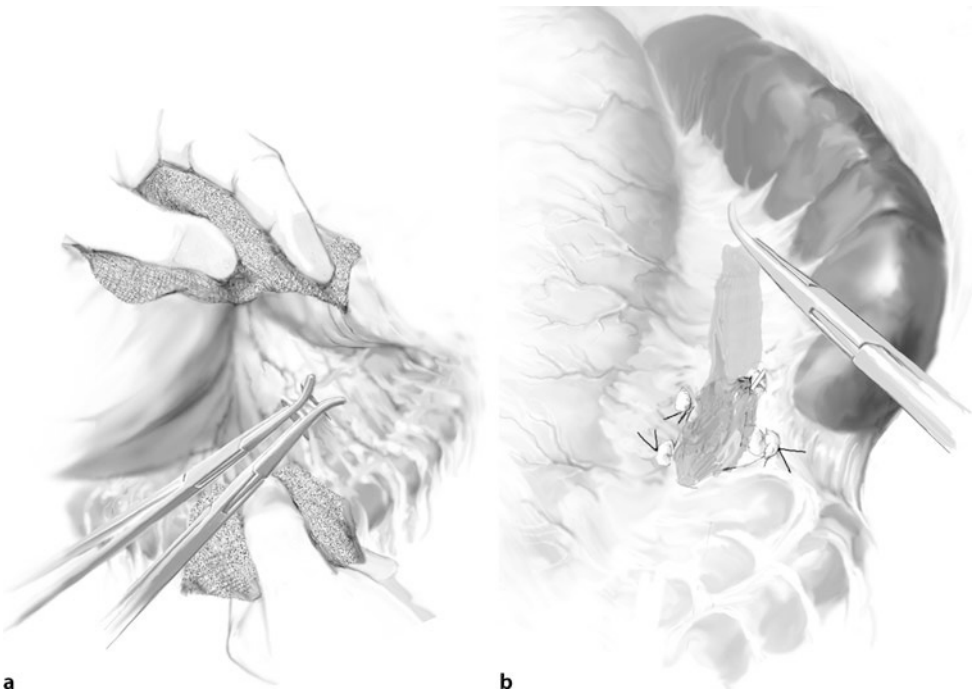
Preparation and mobilization of the stomach with epigastric lymphadenectomy including para-aortic lymphatic tissue.

Lymphadenectomy of the hepatoduodenal ligament is performed. Remove all lymphatic tissue around the hepatic artery up to the celiac trunk, the portal vein and as well as the lymphatic tissue around the common bile duct. Ligature and diversion of the right gastric artery are carried out close to its origin below the pylorus (Fig. 11.3a,b).

Transection of the left gastric artery. All lymph nodes along the left gastric artery, the splenic artery, the common hepatic artery, the celiac trunk, and para-aortic lymph nodes are removed as well (Fig. 11.3c).

In benign diseases, blunt dissection of the esophagus is performed without lymphadenectomy. The right gastric artery may be ligated below the pylorus.

The blood supply of the gastric tube after preparation is exclusively provided by the right gastroepiploic artery.



a b

Fig. 11.2

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Step 2 ***(continued)***

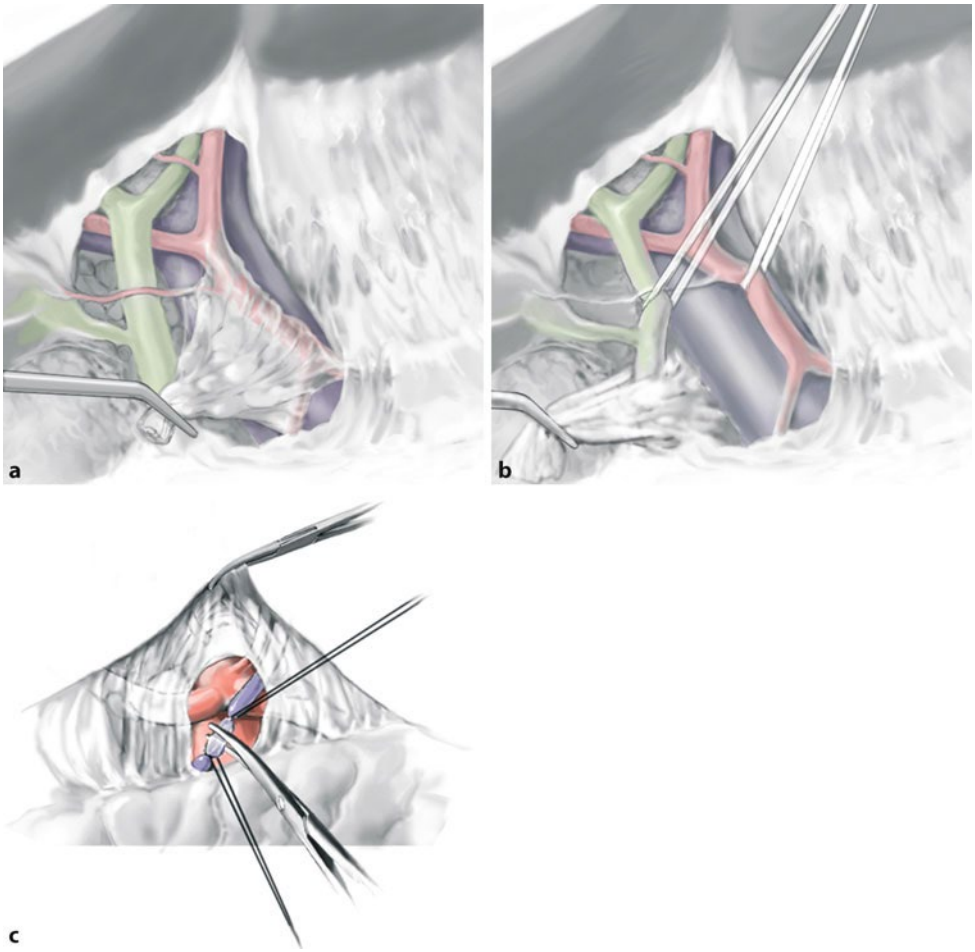


Fig. 11.3

Step 3

Mobilization of the abdominal part of the esophagus and incision of the esophageal hiatus

The lymph node dissection is continued along the celiac trunk to the para-aortic region. The lymphatic tissue is transposed to the lesser curvature and is later resected en bloc with the tumor.

For better exposure the diaphragmatic crura are incised with diathermia and the stumps may be ligated. Blunt mobilization of the esophagus is done with the index finger. During this maneuver connective tissue fibers between the esophagus, diaphragmatic crua, and abdominal aorta must be removed carefully (Fig. 11.4).

The abdominal esophagus is mobilized and pulled caudally with a rubber tube.

Mobilization of the abdominal portion of the esophagus and incision of the esophageal hiatus

The hiatus is incised ventrally following transection of the left inferior phrenic vein between ligatures (Fig. 11.5a).

Insertion of retractors. The retrocardial lymphatic tissue is removed en bloc with the specimen (Fig. 11.5b).

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Step 3 *(continued)*

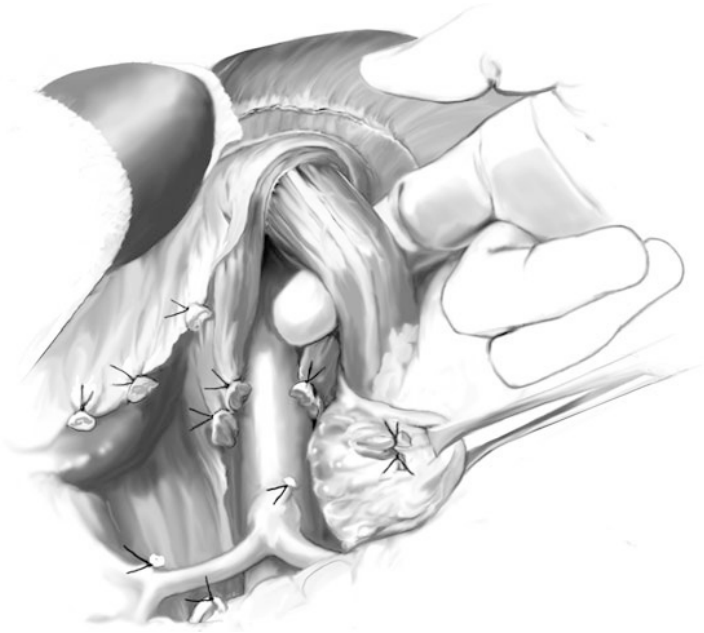


Fig. 11.4

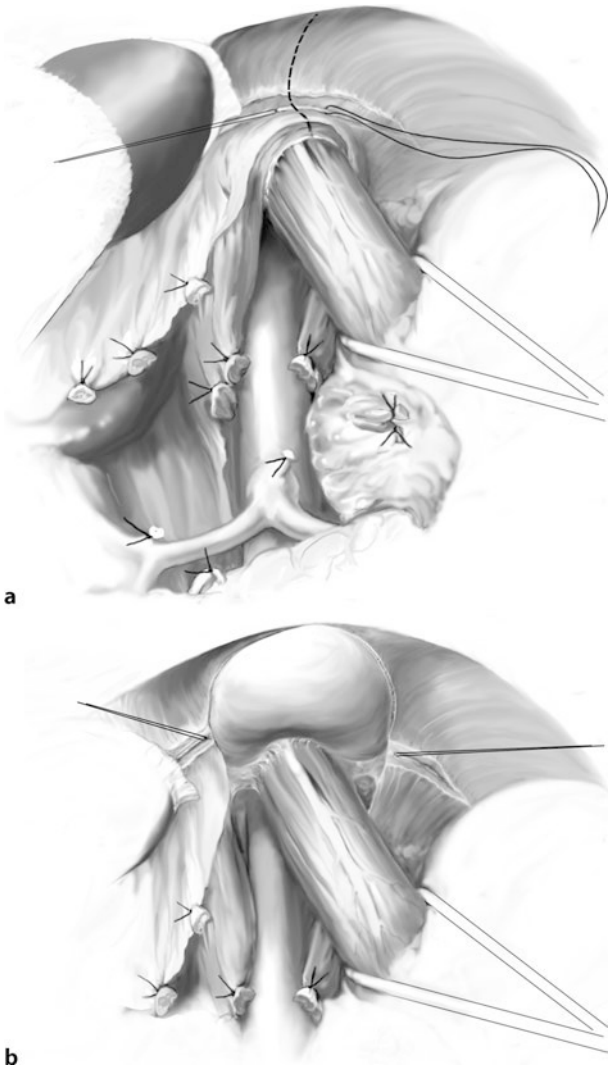


Fig. 11.5

۰۲۱-۶۶۱۹۸۵۱۴ www.myuptodate.com دریافت آخرین نسخه آپتودیت آفلاین

Step 4

Transhiatal esophageal dissection in the distal posterior mediastinum including para-aortic lymphadenectomy: mobilization of the distal esophagus

Dissection of the distal esophagus is performed by detachment of its anterior surface from the pericardium. Infiltrated pericardium can be resected en bloc. Sharp dissection is continued anteriorly up to the tracheal bifurcation and completed by blunt dissection cranially. The trachea and the brachiocephalic trunk are palpable anteriorly. Severe damage of the trachea, the azygos vein, the pulmonary vessels or the aorta, respectively, may occur especially in the case of extensive local tumor growth (Fig. 11.6).

After complete anterior and posterior mobilization, the esophagus is pulled caudally. The ligament-like so-called lateral "esophageal ligaments" consisting of branches of the vagus nerves, pulmonary ligaments and esophageal aortic branches should be transected sharply between clamps (clips may be used alternatively), thus avoiding bleeding, chylothorax or chyloperitoneum (Fig. 11.7).

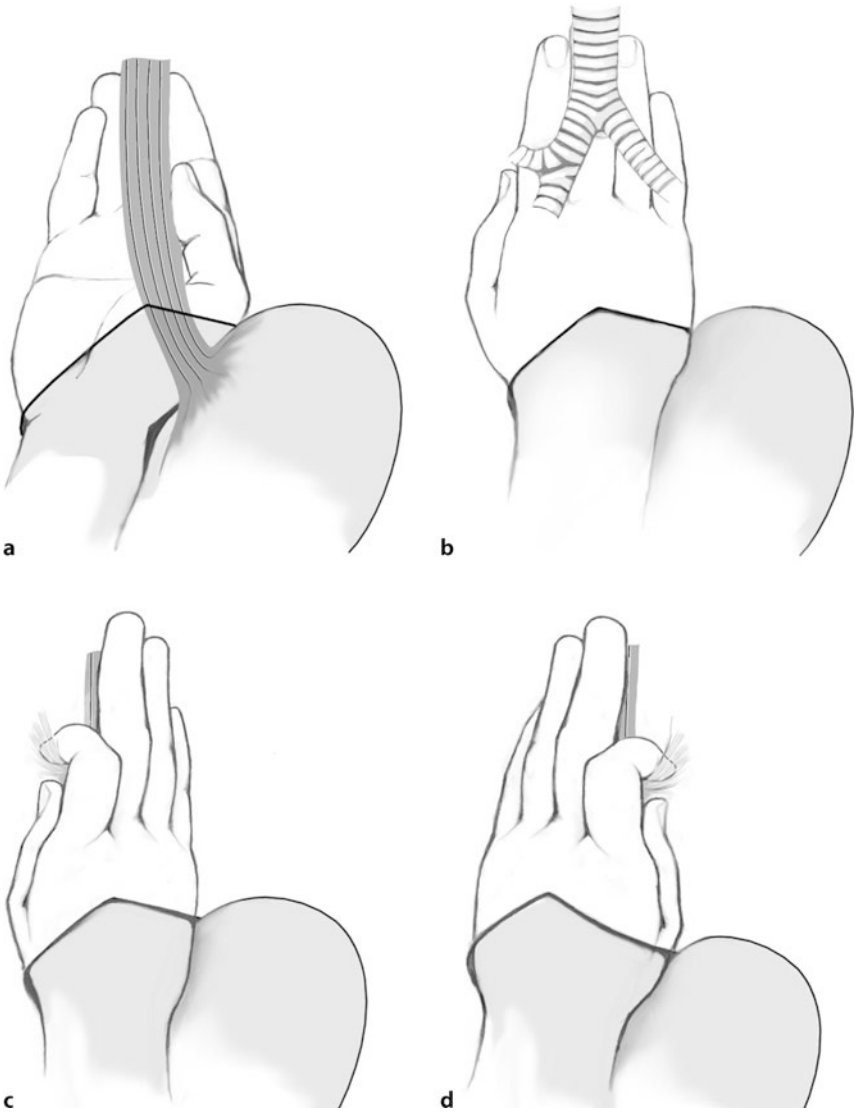


Fig. 11.6

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Step 4 ***(continued)***

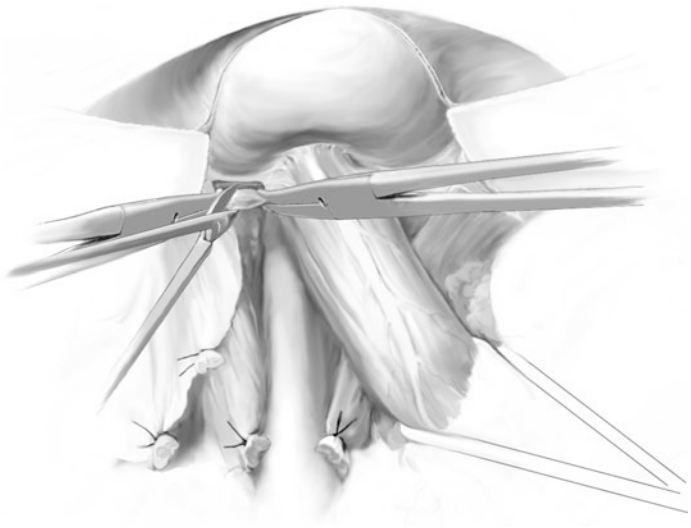


Fig. 11.7

۰۲۱-۶۶۱۹۸۵۱۴ www.myuptodate.com دریافت آخرین نسخه آپتودیت آفلاین

Step 5

Mobilization of mid-intrathoracic esophagus, posterior lymphadenectomy

Excision of parietal pleura. In the case of tumor infiltration of the pleura or lung, en-bloc resection of adherent tissue can be performed following enlargement of the diaphragmatic incision if needed (Fig. 11.8a).

Further dissection up to the tracheal bifurcation by division of the lateral ligaments. This step includes lymphadenectomy of the posterior mediastinum and posterior to the tracheal bifurcation (Fig. 11.8b,c).

For blunt dissection of the esophagus proximal to the tracheal bifurcation, the lateral ligaments should be pulled down and consecutively ligated.

If possible, blunt dissection is completed up to the upper thoracic aperture (Fig. 11.8d).

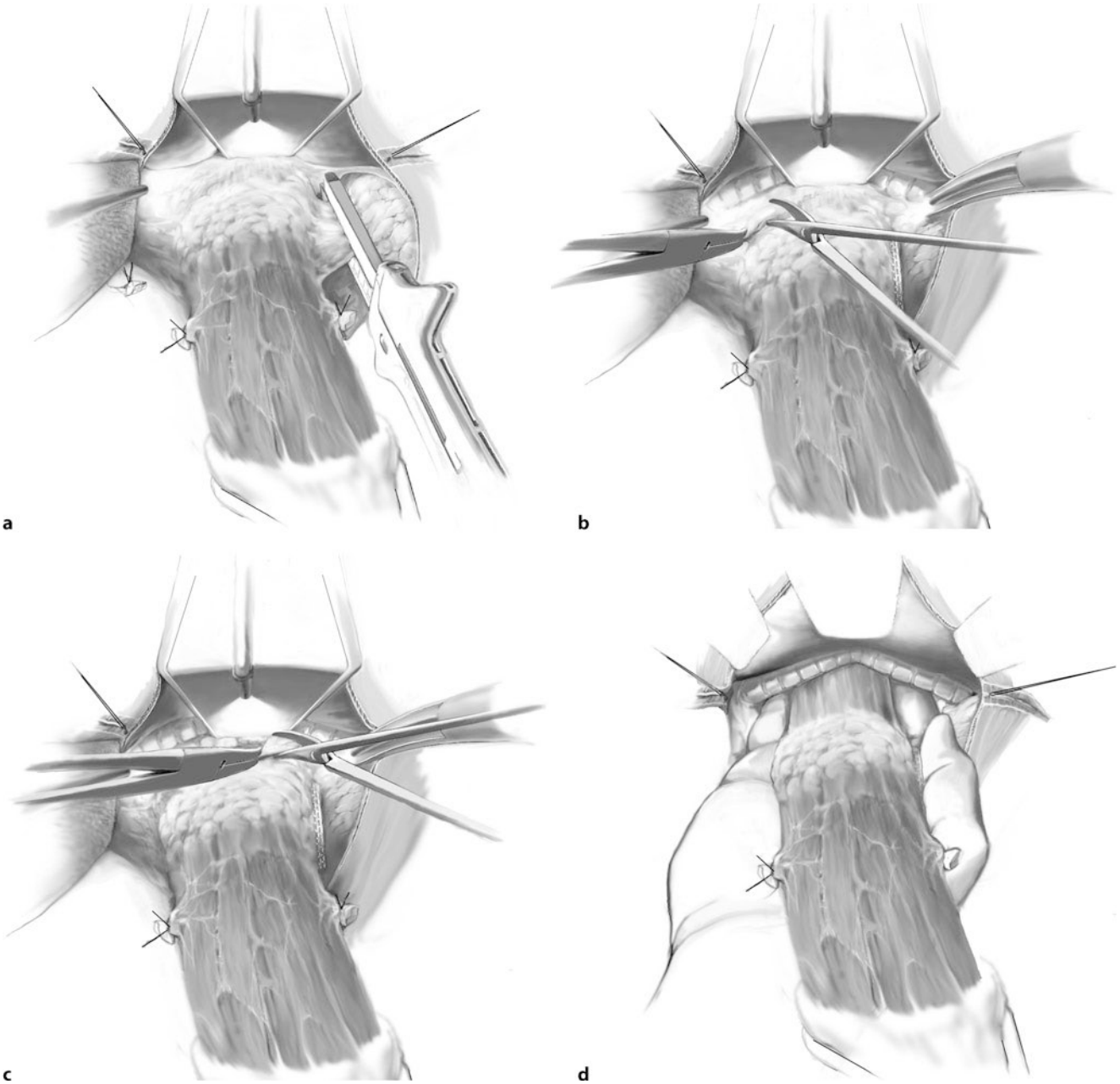


Fig. 11.8

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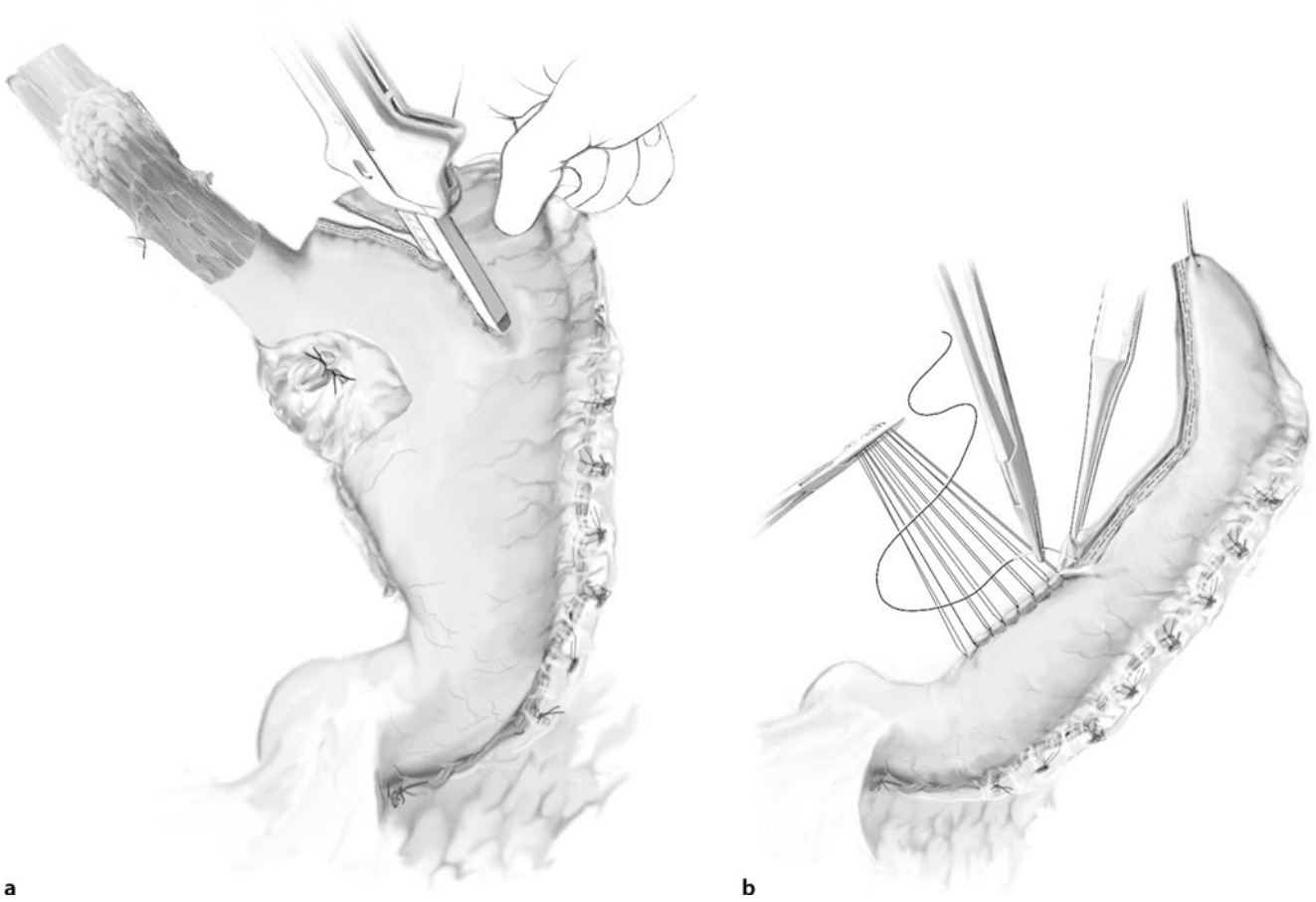
Step 6

Construction of the gastric tube

Starting at the fundus, the lesser curvature is resected using a linear stapler device.

Creation of the tube should follow the curvature of the greater curvature of the stomach; shortening of the gastric tube can be avoided by stretching the stomach longitudinally (Fig. 11.9a).

The staple line is oversewn by seromuscular interrupted sutures. The diameter of the gastric tube should be 2.5 to 3 cm following this procedure (Fig. 11.9b).



a b

Fig. 11.9

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Step 7

Mobilization and dissection of the cervical esophagus; resection of the esophagus

For better exposure the patient's head is turned to the right. A skin incision is performed along the anterior edge of the sternocleidomastoid muscle. Dissection of the platysma and blunt dissection between the cervical muscles and the sternocleidomastoid muscle are done followed by lateral retraction of the sternocleidomastoid muscle. Sharp dissection of the omohyoid muscle enables exposure of the lateral edge of the thyroid, the jugular vein and the carotid artery by retracting the strap muscles medially (Fig. 11.10a,b).

Displacement of the esophagus using a curved instrument. Dissection of the cervical esophagus and upper thoracic esophagus is completed by blunt dissection with the finger or dissector (Fig. 11.10c,d). The nasogastric tube is removed. Transection of the esophagus is performed with a stapler (Fig. 11.10e) or with scissors (Fig. 11.10c), after ligation of the aboral part of the esophagus. A strong thread or a rubber band is fixed at the aboral stump of the esophagus before the esophagus is transposed into the abdominal cavity. This facilitates later transposition of the gastric tube to the neck.

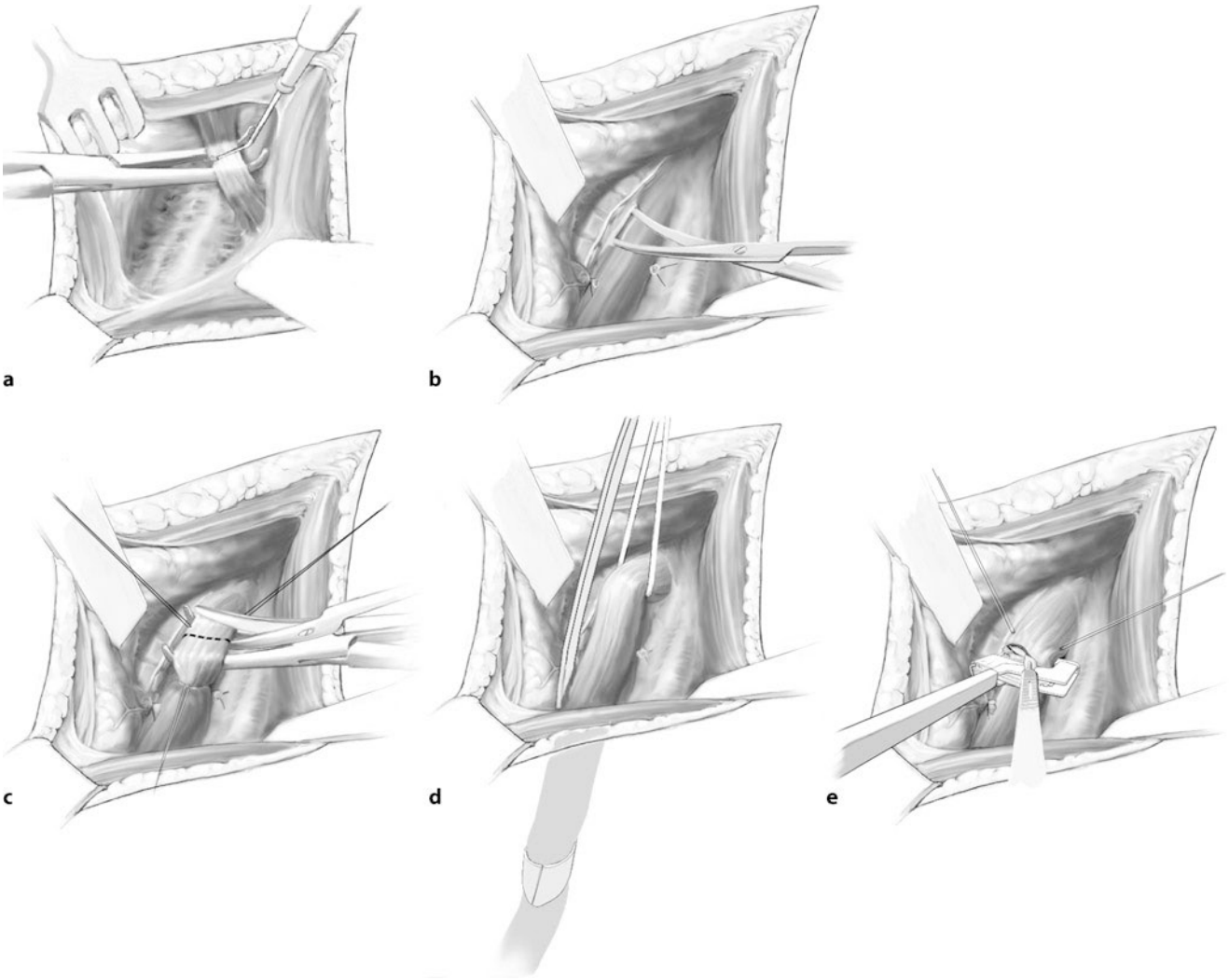


Fig. 11.10

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Step 8

Reconstruction

Gastric tube pull-through. In rare cases mobilization of the duodenum may be necessary (Kocher maneuver) to lengthen the gastric tube.

Optional methods of placement:

Esophageal bed (Fig. 11.11a)

Retrosternal (Fig. 11.11b)

Presternal (Fig. 11.11c)

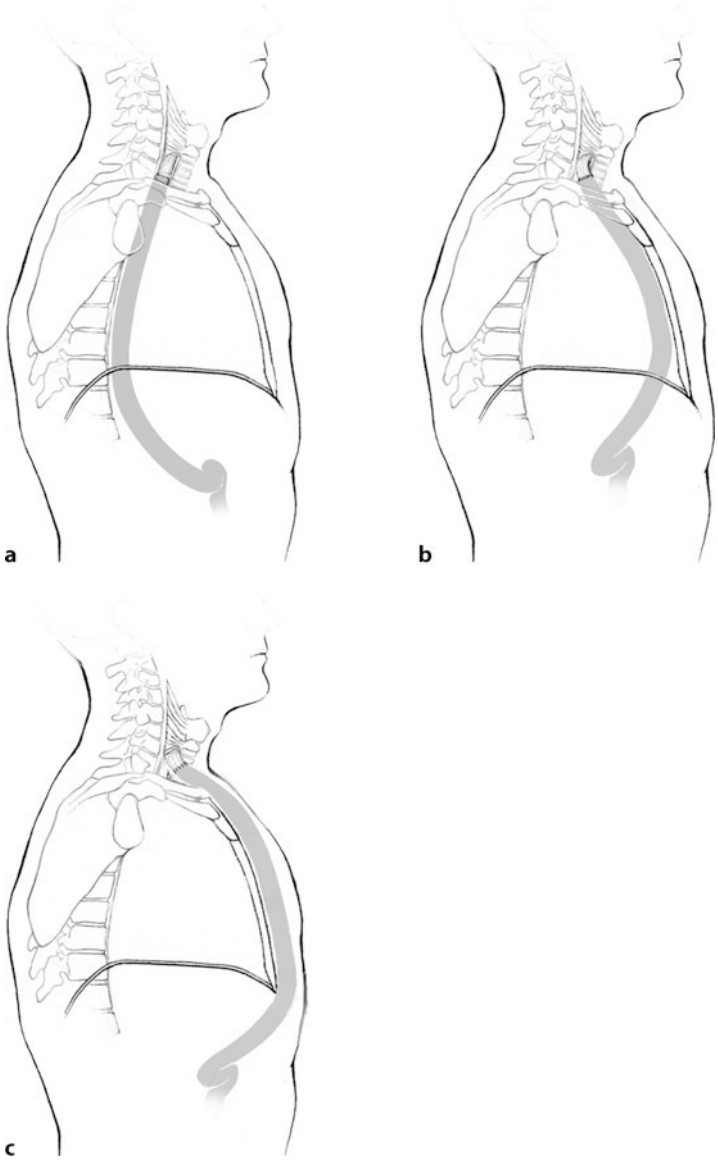


Fig. 11.11

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Step 9

Cervical anastomosis

A two-layer anastomosis of the gastric tube and the esophageal stump is performed. The first seromuscular suture line is performed in an interrupted fashion (Fig. 11.12a). The protruding parts of the esophagus and the gastric tube are resected (Fig. 11.12b). The second inner suture line of the posterior wall can be performed as a running suture (Fig. 11.12c). An enteral three-lumen feeding tube is then inserted through the anastomosis and placed into the first jejunal loop for postoperative enteral nutrition (Fig. 11.12d).

The anterior wall is completed with interrupted or running sutures. The second suture of the anterior wall can be performed in a U-shaped fashion. This may provide an inversion of the anastomosis into the gastric tube (Fig. 11.12e,f).

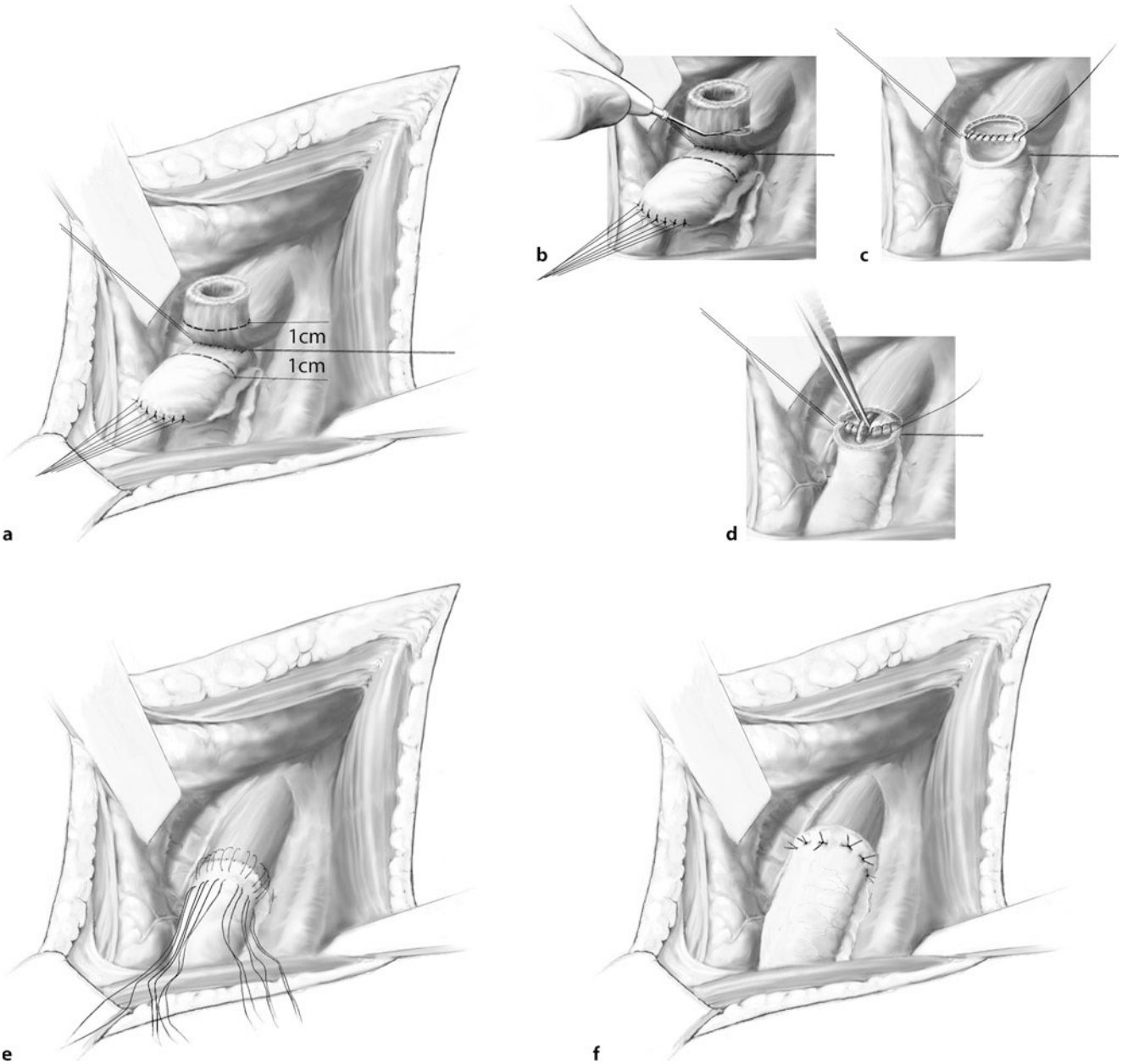


Fig. 11.12

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Step 10

Final situs

A soft drain is placed dorsal to the anastomosis, followed by closure of the skin. Drainage of the mediastinum is warranted by two soft drains placed transabdominally and entering the mediastinum through the esophageal hiatus (Fig. 11.13).

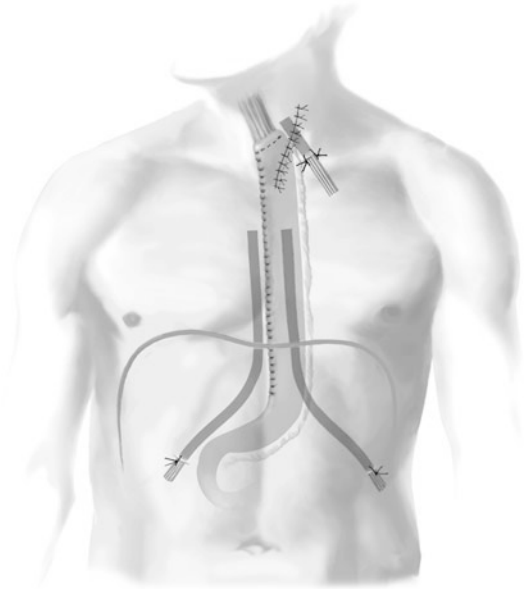


Fig. 11.13

Standard Postoperative Investigations

- Postoperative surveillance in intensive care unit
- "Generous" indication for postoperative endoscopy
- Daily check of the drainage for evidence of anastomotic leak

Intraoperative Complications

- Injury of the mediastinal visceral pleura
- Bleeding from esophageal branches of the aorta or directly from the aorta
- Bleeding from the azygos vein or cava inferior vein
- Injury of the thoracic duct or the trachea
- Injury of the intercostal arteries posteriorly or the artery of Adamkiewicz (Arteria radicularis magna)

Postoperative Complications

- Pleural effusion and pneumonia
- Anastomotic leakage
- Necrosis of the gastric tube
- Injury to recurrent laryngeal nerve (uni- or bilateral)
- Mediastinitis
- Chylus fistula
- Scarring of the esophageal anastomosis with stenosis (long term)

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Tricks of the Senior Surgeon

- Mobilization of the duodenum, on the one hand, may facilitate the placement of a feeding tube. On the other hand, it may include the possibility of shortening the length of the tube to get a better blood supply of the anastomotic region.
- Wide incision of the diaphragm crura provides optimal exposure of the posterior mediastinum to minimize risks of blunt mediastinal dissection.

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Subtotal Esophagectomy: Abdominothoracic Approach

Michael F. Nentwich, Asad Kutup

The goal of the operation is to remove an esophageal tumor with an adequate oncological lymphatic clearance including an upper abdominal D2-lymphadenectomy and radical mediastinal lymphatic clearance (two-field lymphadenectomy). Reconstruction is accomplished by gastric tube formation.

Indications and Contraindications

Indications

1. Thoracic esophageal carcinoma (cT1sm–cT3)
2. Benign stricture, if transhiatal resection is ill advised (e. g., adherence to trachea).

Contraindications

1. See ▶ Chap. 11 on the transhiatal approach
2. High-risk patients

Preoperative Investigation and Preparation for the Procedure

See ▶ Chap. 11 on the transhiatal approach

Procedure

- **Access**
  - Place the patient in the left lateral position for the thoracic part of the operation.
  - Anterolateral thoracotomy through the fifth intercostal space (ICS)
  - Reposition the patient in the supine position (see ▶ Chap. 11 on the transhiatal approach).
  - Upper transverse incision with median extension (see ▶ Chap. 11 on the transhiatal approach)

Alternatively, a modified approach without the need of intraoperative repositioning can be used.

- Place the patient on a vacuum-positioning device and establish the right thoracoabdominal position as follows:
  - Rotate the shoulders approximately 45°, the hips remain less rotated, and the right arm is elevated across the body, exposing the axilla.
  - Rotate the table for exposure of either abdominal or thoracic parts.

For the abdominal part, see ▶ Chap. 11 on the transhiatal approach.

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery*,
DOI 10.1007/978-3-662-46546-2_12, © Springer-Verlag Berlin Heidelberg 2016

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Step 1

Thoracotomy and incision of the pleura along the resection line

After thoracotomy through the fifth ICS (Fig. 12.1a), position two retractors stepwise. Single left lung ventilation is performed. The mediastinal pleura is incised along the resection line for the en-bloc esophagectomy. The incision starts from the pulmonary ligament, circumcising the dorsal part of the right hilum of the lung and along the right bronchus. It follows the right main bronchus at the lateral margin of the superior vena cava up to the upper thoracic aperture. Then the incision line changes direction caudally along the right lateral margin of the spine, down to the diaphragm along the azygos vein. It is of the utmost importance to identify and preserve the right phrenic nerve (Fig. 12.1b).

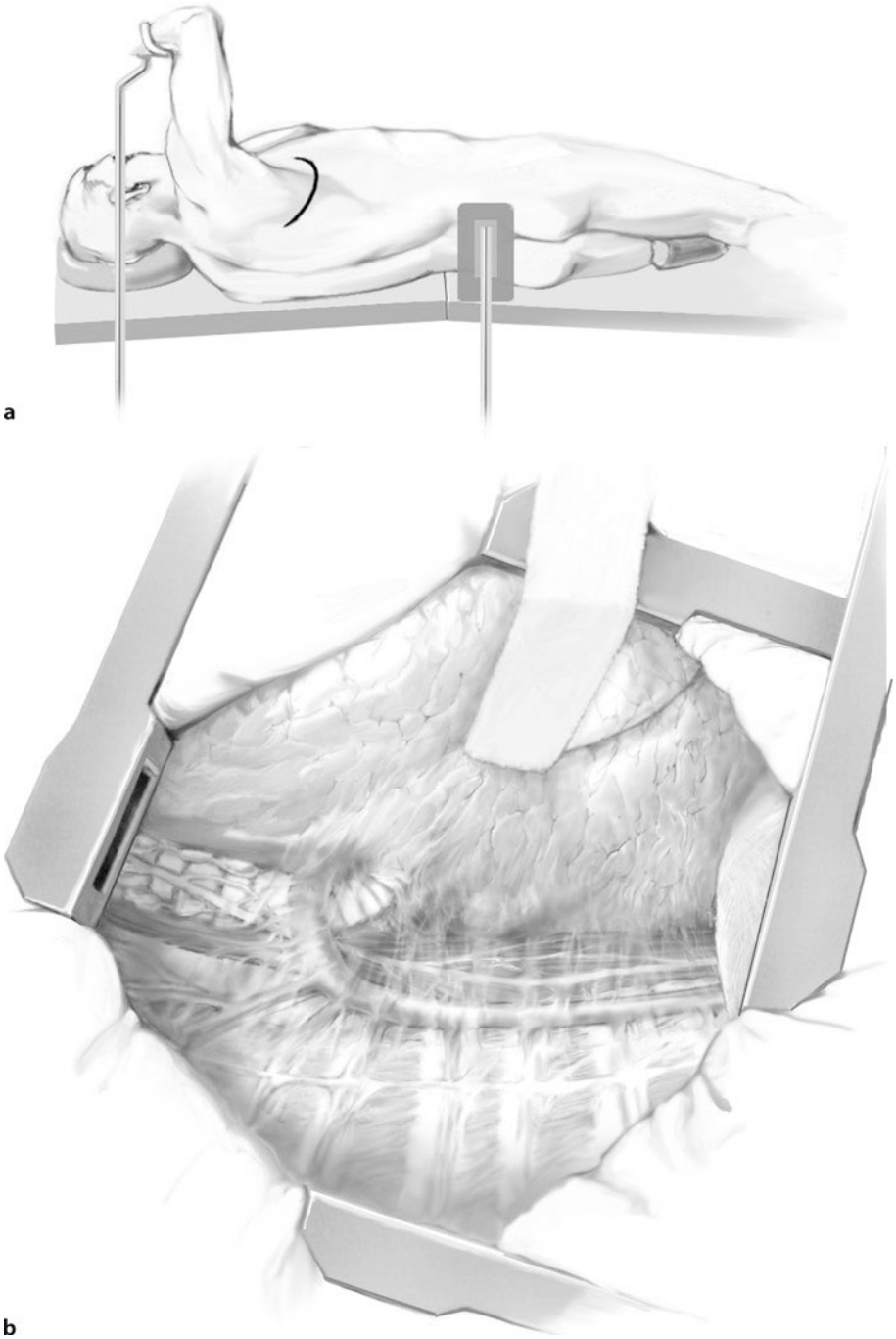


Fig. 12.1

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Step 2

Division of the pulmonary ligament

For exposure of the pulmonary ligament the lung is pushed cranially and laterally (Fig. 12.2). All lymphatic tissue should be moved toward the esophagus. Care has to be taken not to injure the pulmonary vein to the right lower lobe.

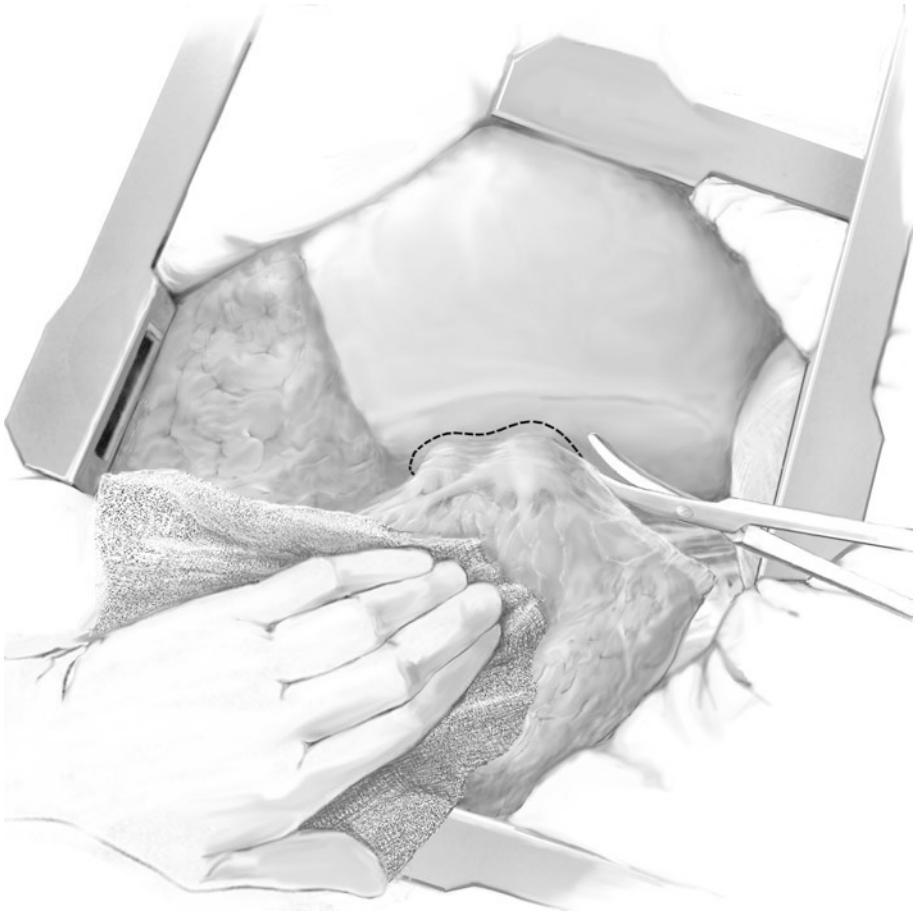


Fig. 12.2

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Step 3

Ligation of the azygos vein

The superior vena cava and the azygos vein are dissected and the lymph nodes between azygos vein and the anterior trunk are dissected. Suture ligation toward the vena cava and ligation of the azygos venal stump are performed (Fig. 12.3). Alternatively, transection of the azygos vein can be performed by using an EndoGIA device.

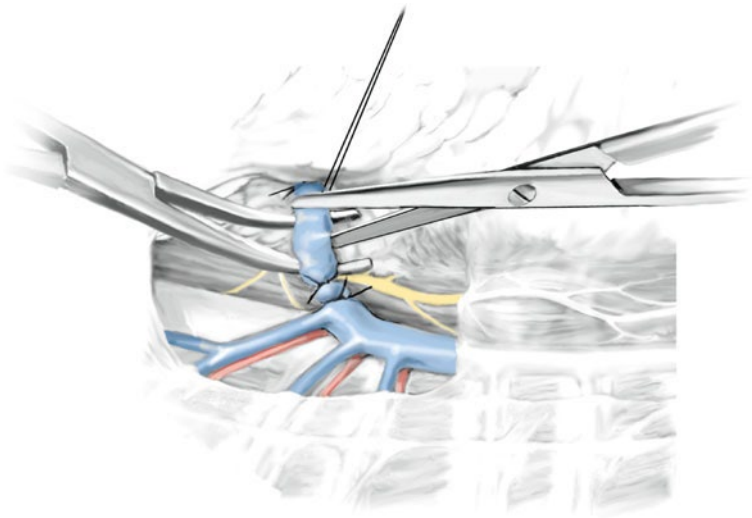


Fig. 12.3

Step 4

Radical en bloc lymphadenectomy

Lymphadenectomy starts from the superior vena cava up to the confluence of the two innominate and subclavian veins. Dissection of the brachiocephalic trunk and right subclavian artery is followed by dissection of the right vagal nerve after identification of the right recurrent laryngeal nerve. Caudal to the branching of the recurrent laryngeal nerve, the vagal nerve is transected and the distal part is pushed toward the en bloc specimen. Then lymphadenectomy is performed continuously along the dorsal wall of the superior vena cava (Fig. 12.4).

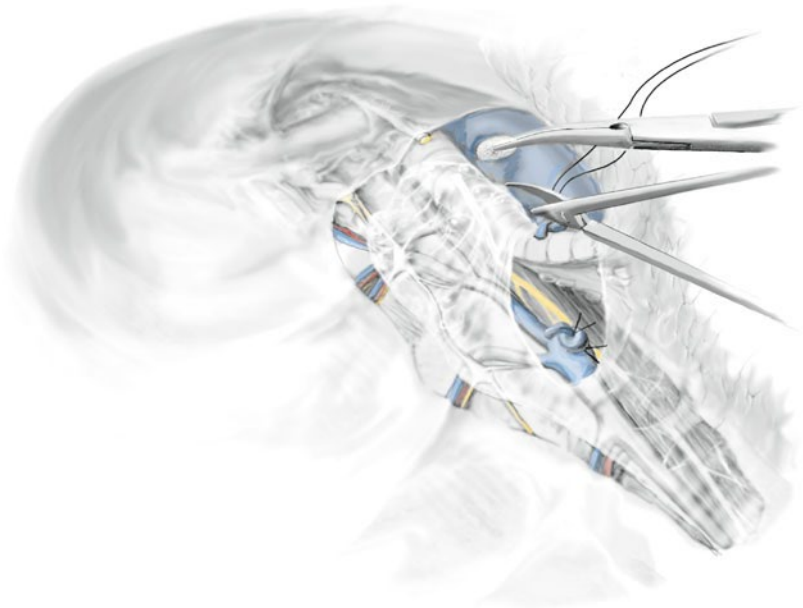


Fig. 12.4

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Step 4 ***(continued)***

Afterward, the trachea and the right main bronchus are completely freed from lymphatic tissue. The pre- and paratracheal fat and lymphatic tissue are dissected toward the esophagus (Fig. 12.5a).

Dissection of the retrotracheal lymph nodes is then performed. Injury of the membranous part of the trachea has to be carefully avoided while removing these nodes toward the esophagus (Fig. 12.5b).

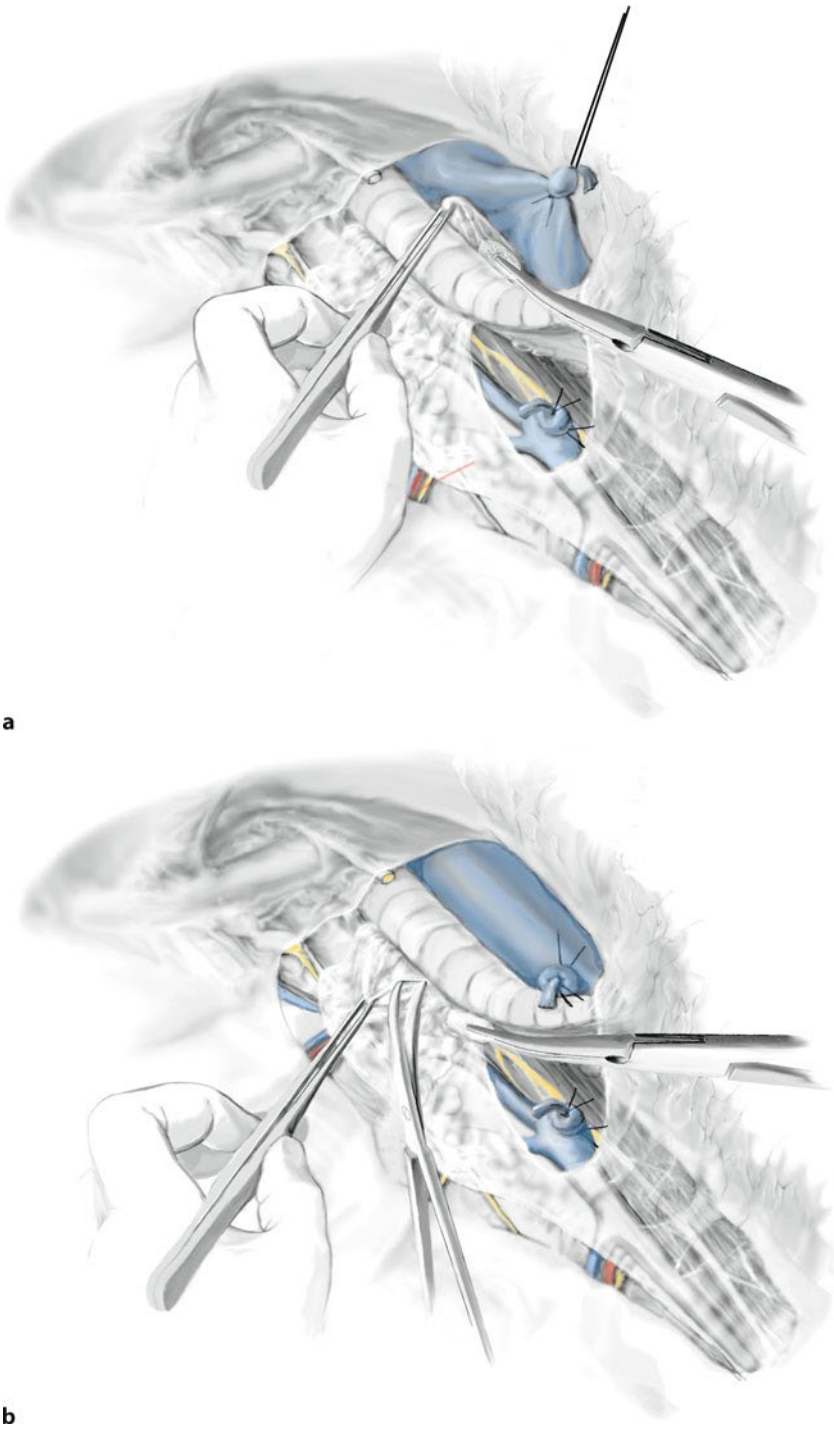


Fig. 12.5

۰۲۱-۶۶۱۹۸۵۱۴ www.myuptodate.com دریافت آخرین نسخه آپتودیت آفلاین

Step 4 ***(continued)***

Lymph node dissection continues with the upper paraesophageal lymph nodes (Fig. 12.6a).

All intercostal veins that drain into the azygos vein are ligated and divided. Lymphadenectomy of the subcarinal lymph nodes is then performed with dissection of the left main bronchus (Fig. 12.6b).

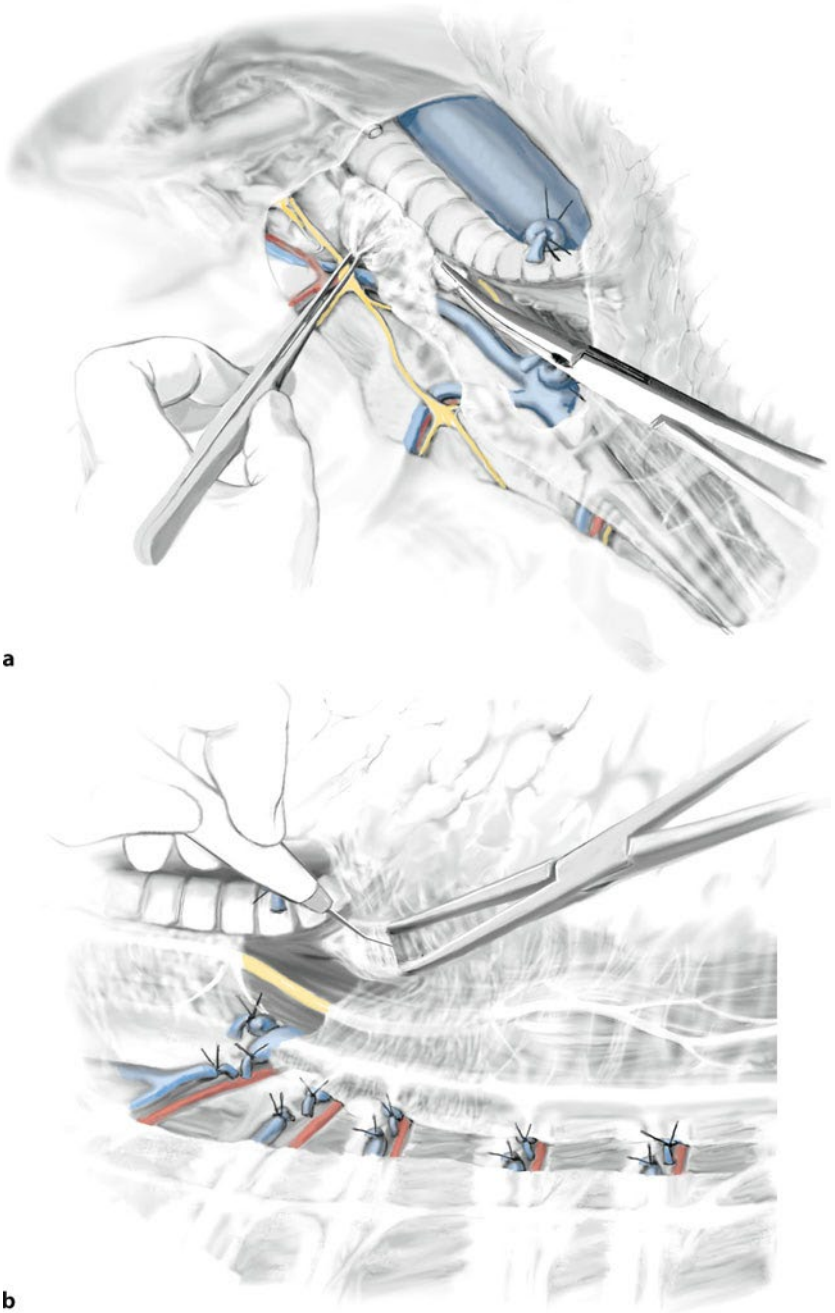


Fig. 12.6

۰۲۱-۶۶۱۹۸۵۱۴ www.myuptodate.com دریافت آخرین نسخه آپتودیت آفلاین

Step 4 ***(continued)***

Para-aortic lymphadenectomy is performed. The esophageal branches of the thoracic aorta have to be dissected very carefully and should be ligated with suture ligation (Fig. 12.7).

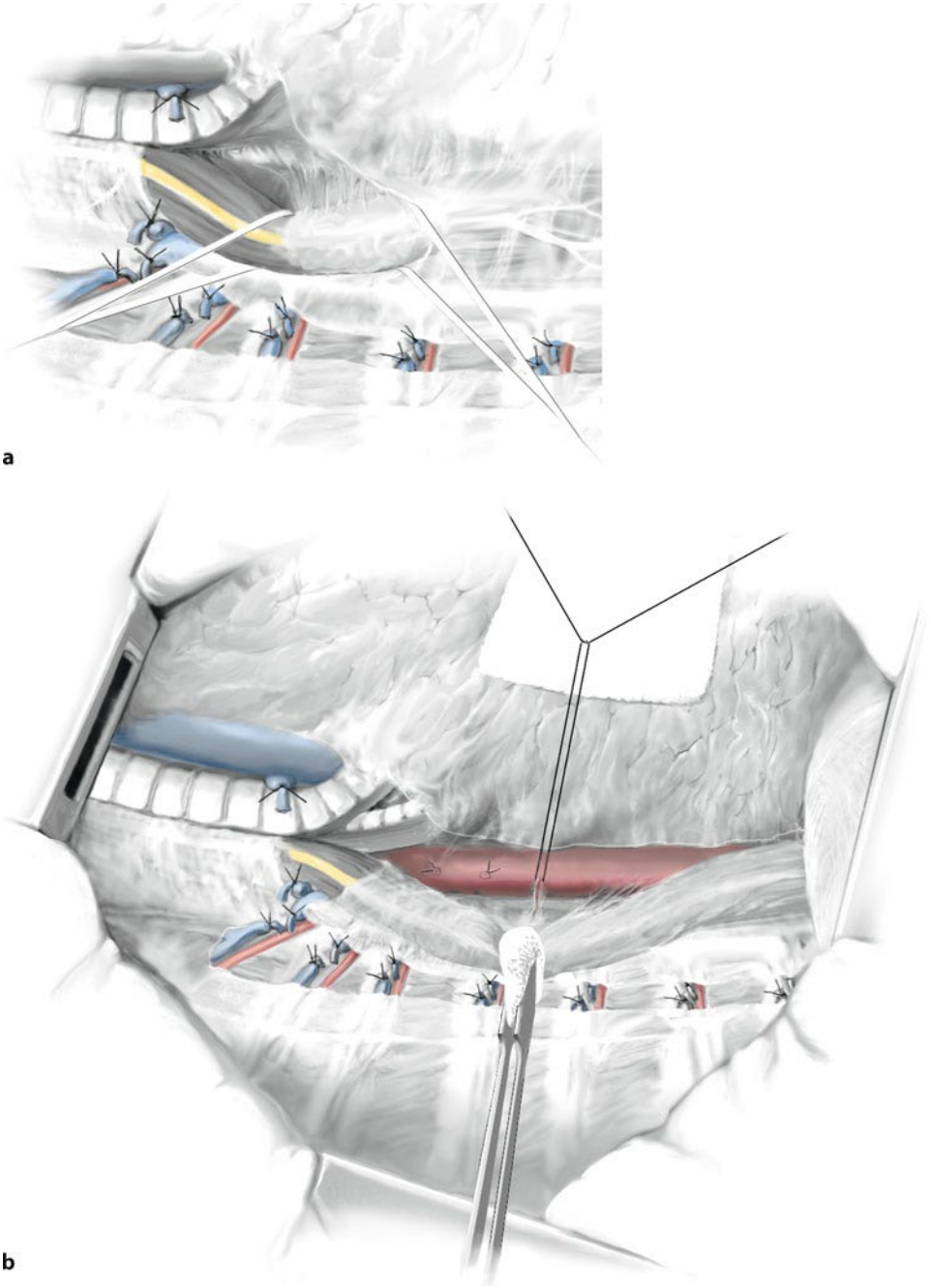


Fig. 12.7

۰۲۱-۶۶۱۹۸۵۱۴ www.myuptodate.com دریافت آخرین نسخه آپتودیت آفلاین

Step 4 ***(continued)***

Identification and careful dissection of the thoracic duct with double ligations directly above the diaphragm and at the level of the main carina (Fig. 12.8).

Mediastinal lymphadenectomy is completed with the removal of the left sided para-aortic and retropericardial lymph nodes, as well as the intermediate and lower lobe bronchus down to the esophageal hiatus.

After complete mobilization of the esophageal specimen, chest tubes are placed in the right thoracic cavity.

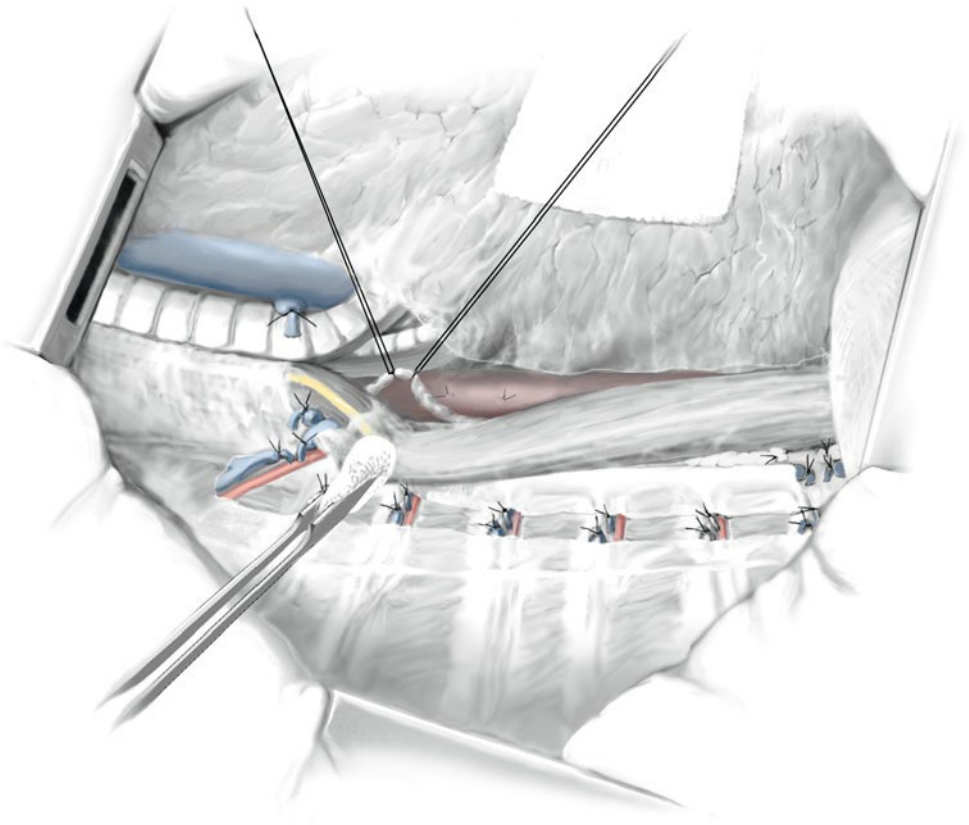


Fig. 12.8

For cervical part, see ▶ Chap. 11 on the transhiatal approach.

In case of a mid or lower esophageal carcinoma, an intrathoracic anastomosis can be accomplished.

High intrathoracic anastomosis

High intrathoracic anastomosis may be performed without compromising oncological requirements alternatively to a collar anastomosis for treatment of intrathoracic tumors, that is, if located distally to the tracheal bifurcation. The benefits of considerably shorter operating times are associated with the risk of developing mediastinitis when anastomotic leakage occurs.

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Step 5

High intrathoracic anastomosis

Transection of the esophagus is carried out 5 cm below the upper thoracic aperture over a Pursestring 45 clamp. Alternatively the esophagus is transected and a running suture (monofilament, 2-0) is applied as a pursestring suture.

Dilation of the proximal esophageal stump with a blunt clamp is performed. The anvil of a circular stapler (preferably 28 mm or larger if possible) is introduced into the esophageal stump and fixation is done by tying the pursestring suture.

Mobilization of the gastric tube through the diaphragmatic esophageal hiatus is performed, followed by resection of the apex of the gastric tube. The gastric tube is usually longer than required. Then introduce the stapler into the gastric tube and perforate the gastric wall at the proposed site of the anastomosis without tension with the head of the stapling device (Fig. 12.9a).

Connection with the anvil is followed by firing of the instrument (Fig. 12.9b).

Check for completeness of the anastomotic rings and for clear resection margins using frozen-section-analysis in suspected malignancy. The stapler is removed and closure and resection of the protruding part of the gastric tube are done with a linear stapler. A nasogastric feeding tube is then inserted through the anastomosis and placed into the first jejunal loop for decompression and postoperative enteral feeding. Thoracic drainage is placed into the right thoracic cavity.

Alternatively, this method can be performed in the same manner in the case of colonic interposition after esophagogastrectomy (Fig. 12.9c,d).

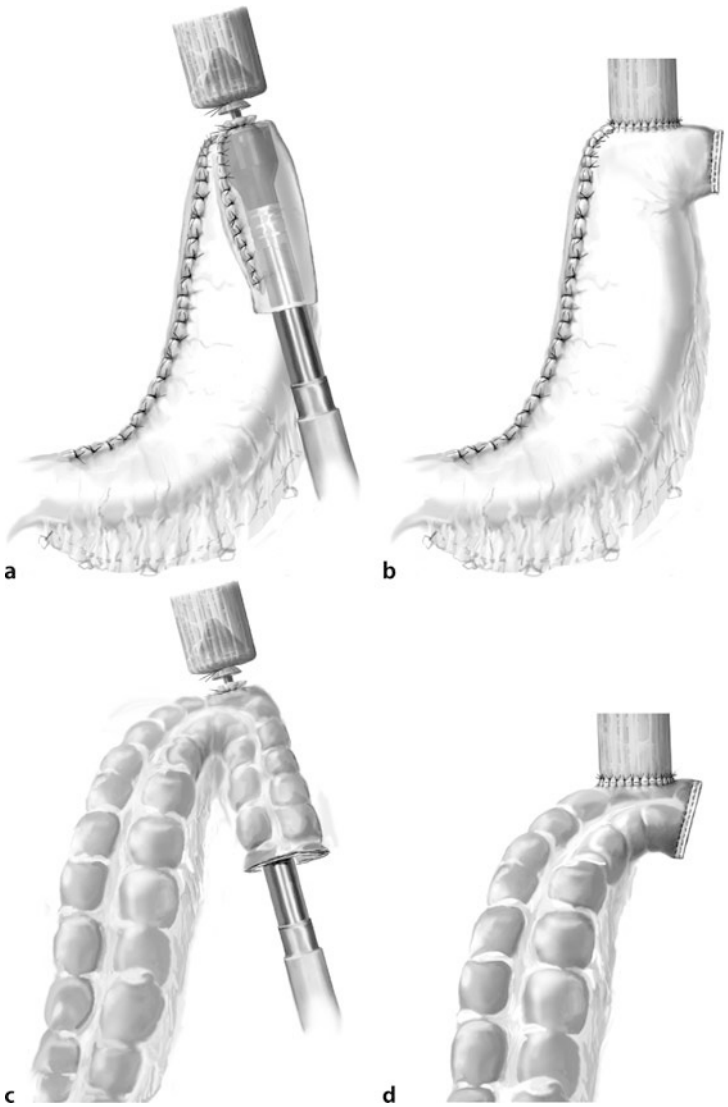


Fig. 12.9

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Standard Postoperative Investigations

See ► Chap. 11 on the transhiatal approach.

Postoperative Complications

See ► Chap. 11 on the transhiatal approach.

Tricks of the Senior Surgeon

- If the trachea is injured use direct suture and pericardial flap
- Injury of the gastroepiploic arcade necessitates colonic interposition.
- An additional length of the gastric tube is achieved by mobilization of the duodenum (Kocher maneuver). By this, the end of the gastric tube designated for the anastomosis is located closer to the gastroepiploic pedicle. The improved vascular supply reduces the risk of anastomotic leakage.
- In contrast to cervical esophagogastric anastomosis, in any case of suspected intrathoracic leakage, emergency endoscopy should be done. Even if an anastomotic leak cannot be definitely visualized, the indications for stenting should be very liberal as long as clinical signs suggest a anastomotic leak to prevent catastrophic mediastinitis.
- In case of limited length of the gastric tube with worry of tension at the anastomosis, the stapling device is inserted through a ventral gastrostomy and an end-to-end gastroesophagostomy or a hand-sewn anastomosis is performed.

■ **Acknowledgments**

The authors acknowledge the contribution of Stefan B. Hosch.

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Laparoscopic and Conventional Limited Resection of the Gastroesophageal Junction with Isoperistaltic Jejunal Interposition

Thorsten Dohrmann, Oliver Mann, Jacob R. Izbicki

Limited en-bloc resection of the gastroesophageal junction includes complete removal of the esophageal segment with metaplastic mucosa, the lower esophageal sphincter, and a part of the lesser gastric curvature and formation of a neofundus. Because even early adenocarcinomas of the distal esophagus (T1b) seed lymph node metastases in up to 20 % of patients, removal of the lymph nodes of the lesser curvature, the hepatic and splenic arteries, the celiac trunk, the paraaortal region, and the inferior mediastinum is an essential part of the operation.

In patients with early tumors, staged as uT1a or b on preoperative endosonography or severe dysplasia in the distal esophagus (Barrett's esophagus), a limited resection of the proximal stomach, cardia, and distal esophagus with interposition of a pedicled isoperistaltic jejunal segment offers excellent functional and oncological results.

Due to recent technical developments, laparoscopic surgery has become quite common even in more complicated operative procedures. The benefit of reduced postoperative pain, faster recovery, and shorter hospitalization is evident. In patients presenting with early stages of distal esophageal carcinoma or benign diseases as mentioned above, laparoscopic resection of the gastroesophageal junction should be taken into consideration as the technical results concerning lymphadenectomy and anastomosis are equivalent to the open procedure.

Indications and Contraindications

Indications

- Severe dysplasia in the distal esophagus (Barrett's esophagus)
- Distal adenocarcinoma of the esophagus (stage T1a and b)
- For palliative reasons (stenotic tumor with severe dysphagia or profuse hemorrhage in selective patients)

Contraindications

- Esophageal carcinoma staged T2 and more
- Long Barrett's segment above the carina
- Morbid obesity (laparoscopic approach)
- Prior major upper gastrointestinal surgery (laparoscopic approach)

Preoperative Investigations/Preparation for the Procedure

- Esophagogastroscopy with extensive biopsies
- Endosonography of the esophagus
- Computed tomography of the chest and abdomen
- Abdominal ultrasound
- Pulmonary function test

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Procedures

As the individual steps for this procedure are similar comparing open and laparoscopic surgery, only the differences for laparoscopic approach are mentioned.

Step 1

Positioning and Access

The patient is placed in supine position with hyperlordosis. An upper transverse incision with median T-shape is made to access the epigastric region. After placement of Rochard retractor or any other self-retaining retraction system to elevate the costal margin, thorough exploration of the abdominal cavity is carried out. Good exposition of the site is crucial, as access to the hiatus can sometimes be difficult.

Laparoscopic Surgery

The patient is placed in the beach chair position, as this enables best access to the hiatus. The operating surgeon stands between the legs, with the first assistant on the patient's left and the second assistant on the patient's right side. For trocar positions, see "Laparoscopic Gastrectomy". Open technique for gaining the pneumoperitoneum is favored.

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Step 2

Exposure of the inferior posterior mediastinum

The left liver lobe is mobilized completely and the lesser omentum is incised just medial to the anterior and posterior gastric vagal branches. The distal esophagus including the paraesophageal tissue is then mobilized beginning with dissection of the left crus. The right crus and gastrosplenic ligament and short gastric veins are separated. A longitudinal median diaphragmal incision enables better exposure of the inferior posterior mediastinum.

Intraoperative esophagoscopy identifies the cranial limit of the Barrett's segment. This also marks the proximal limit of resection. A lymphadenectomy around the splenic and hepatic artery is performed, the left gastric vein is divided, and the left gastric artery is divided at the celiac trunk. Then the celiac trunk and the para-aortic region above the celiac trunk are cleared from lymphatic tissue (Fig. 13.1).

Laparoscopic surgery

Vessel sealing devices or ultrasound dissectors reduce preparation time and allows reliable sealing of blood vessels during tissue dissection (Fig. 13.2).

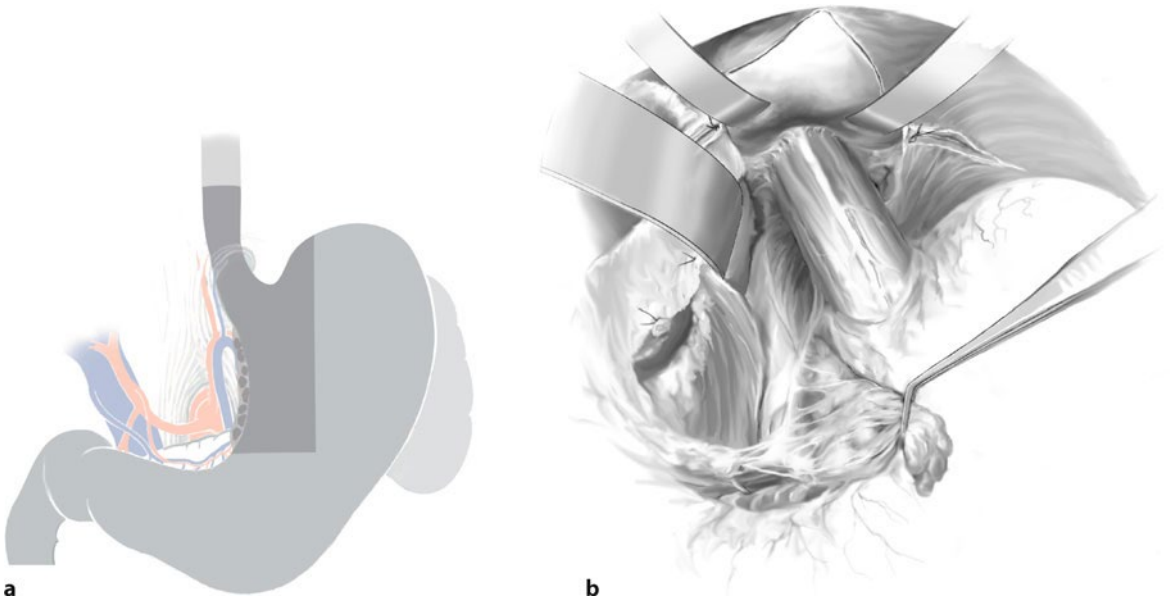


Fig. 13.1

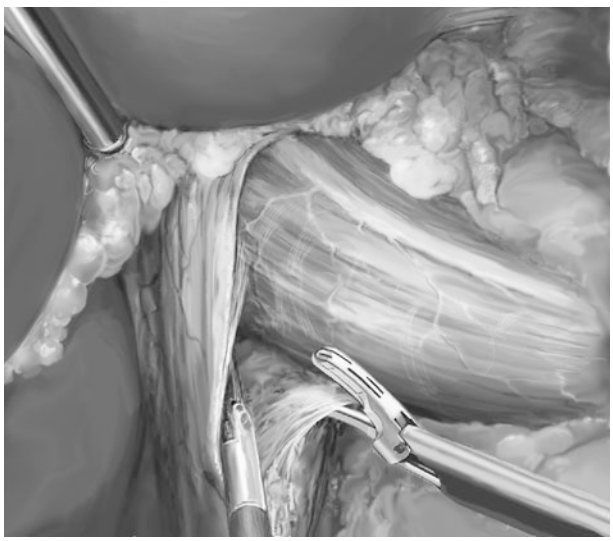


Fig. 13.2

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Step 3

Transection of the esophagus and stomach

Approximately 1 cm proximal to the cranial limit of the Barrett's segment, a purse-string clamp is placed and the esophagus is divided. Removal of the cardia and lesser curvature is performed by placing multiple linear staplers down to the border between antrum and body. Thus, a neofundus is formed. In case an advanced tumor stage is encountered, possible extension of the operation including transhiatal esophagectomy or esophagogastrectomy should be performed (Fig. 13.3).

Laparoscopic surgery

Transsection of the esophagus and cardia are performed using an articulating linear stapler. For transection of both esophagus and cardia, the best working angle is accomplished when inserting the stapler through the upper left trocar. The specimen is then recovered using a specimen-retrieving bag inserted through the upper right trocar. Enlarging the incision can be done at this point, as it is necessary later for stapling the esophagojejunostomy (Fig. 13.4).

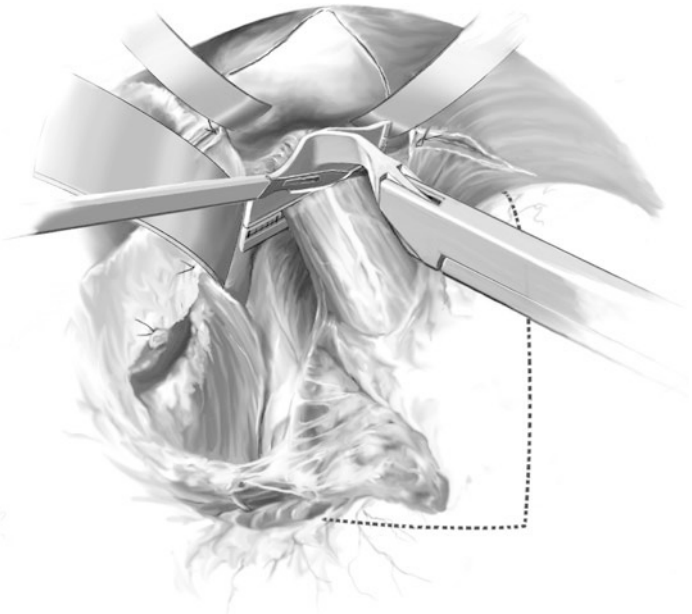


Fig. 13.3

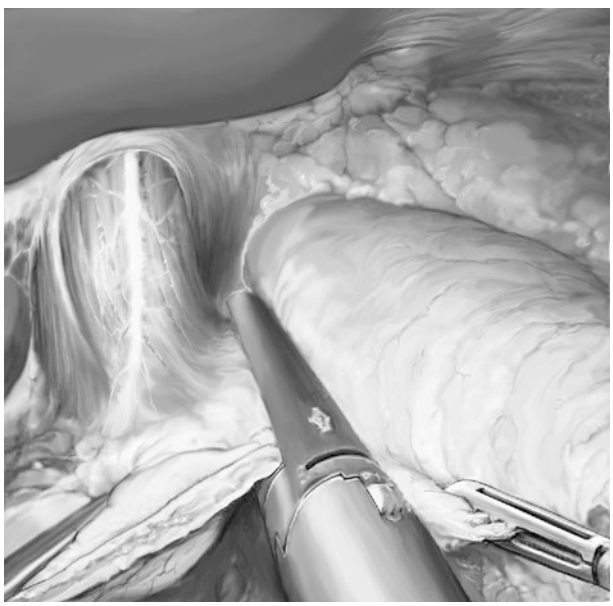


Fig. 13.4

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Step 4

Transposition of the proximal jejunum segment; esophagojejunostomy

A 15–20 cm segment of the proximal jejunum is isolated and is transposed with its mesenteric root to the diaphragmatic region through the mesocolon and behind the stomach. Care has to be taken to dissect the vascular pedicle of this jejunal interposition carefully to provide adequate length. It is imperative to form an isoperistaltic jejunal interposition, which should be pulled up retrogastric and retrocolic. The proximal anastomosis is then performed by a circular stapling device as a end-to-side esophagojejunostomy. The stapler is introduced into the end of the jejunal interposition (Fig. 13.5a). After firing the anastomosis, the blind end of the loop is resected by a linear stapler and then oversewn (Fig. 13.5b).

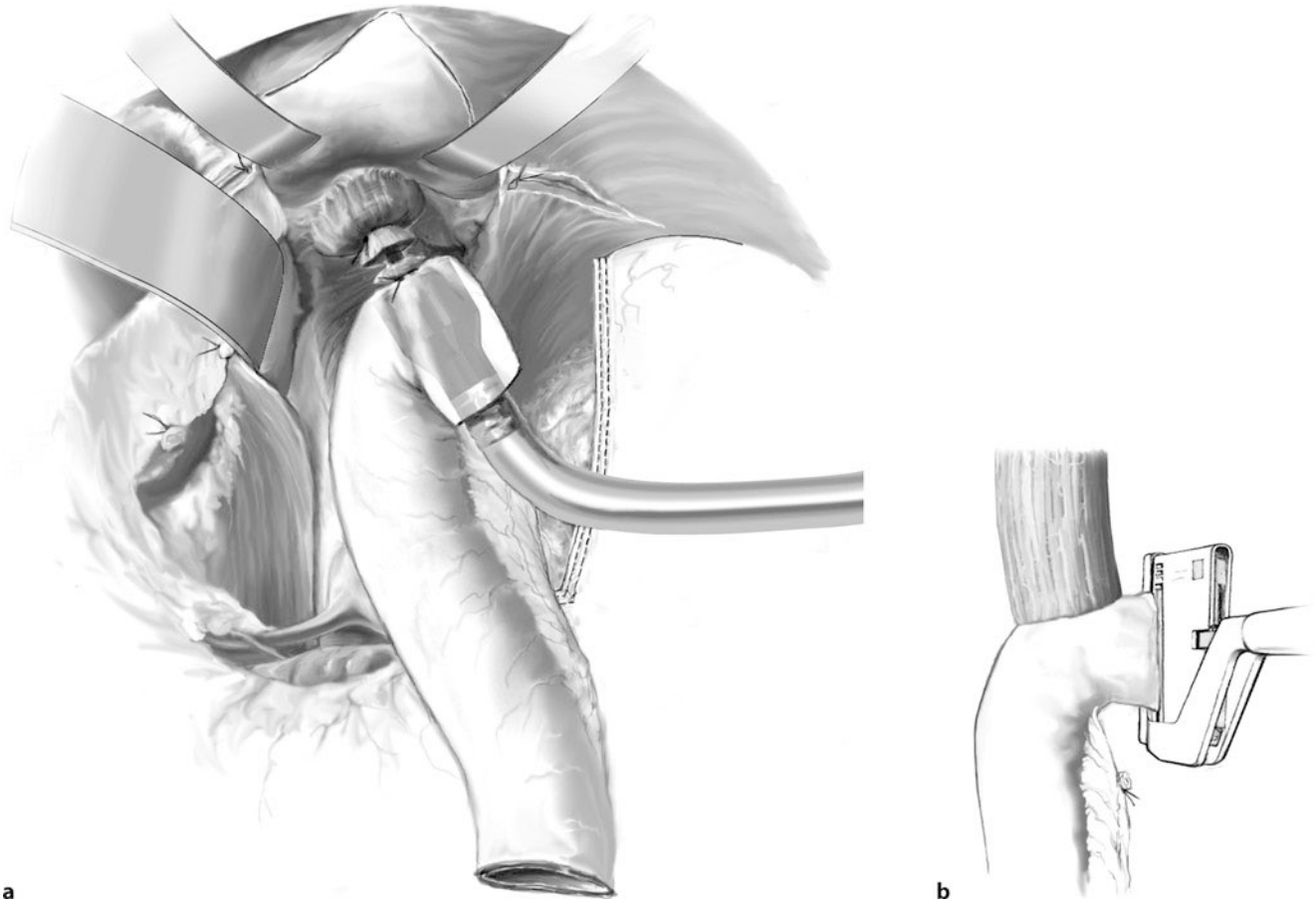


Fig. 13.5

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Step 4 ***(continued)***

Laparoscopic surgery

For anastomosis, the stapler anvil is placed in the esophagus by opening the stapler line and performing a manual purse-string suture. Alternatively, a pre-tilted anvil assembly for transoral insertion (OrVil; Covidien; Mansfield, MA, USA) can be used: a small incision is made in the center of the esophageal stapler line and the gastric tube with attached anvil is inserted transorally and pulled through (Fig. 13.6).

The circular stapler is inserted directly through the previously enlarged upper right incision after removing the trocar. As another alternative, a side-to-side esophagojejunostomy is also possible. Choice of technique performed depends on the surgeon's Laparoscopic skills.

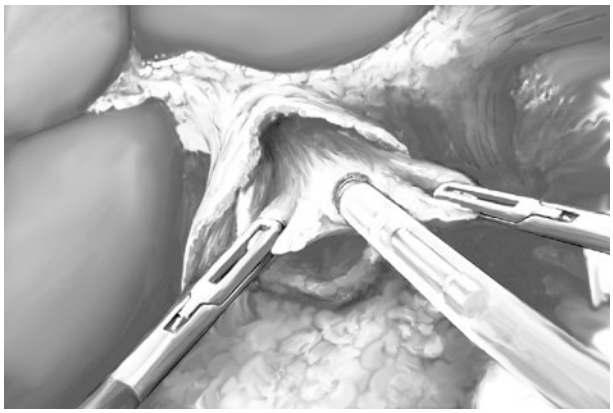


Fig. 13.6

Step 5

Jejunogastrostomy and reconstruction of enteric passage

13

Close to the base of the neofundus the gastric stapler line is removed over a distance of 3–4 cm and a end-to-side or laterolateral jejunogastrostomy is performed. The remaining gastric suture line is oversewn. A terminoterminal jejunojejunostomy reconstructs the enteric passage. Drainage of the mediastinum is warranted by two soft drains from the abdomen. Finally an anterior and/or posterior hiatal repair is performed (Fig. 13.7).

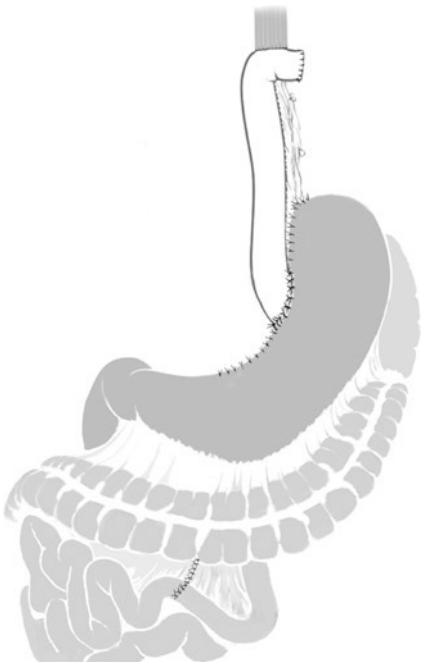


Fig. 13.7

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Step 5 ***(continued)***

Laparoscopic surgery

The anastomosis technique is slightly different. A typical side-to-side stapled anastomosis for jejunogastrostomy is performed. The linear stapler is inserted through two small incisions at the caudal end of the anastomosis. After stapling, the remaining defect is closed by manual suture. Side-to-side stapled jejunojejunostomy for reconstruction of the enteric passage is carried out in the same manner.

Standard Postoperative Investigations

Daily check of drains for leakage of the intrathoracic esophagojejunostomy

Postoperative Complications

- Leakage of the esophagojejunostomy or the intra-abdominal anastomosis
- Necrosis of the transposed jejunal segment
- Mediastinitis
- Peritonitis
- Pleural empyema
- Pancreatitis
- Postoperative gastroesophageal reflux
- Delayed gastric emptying

Tricks of the Senior Surgeon

- Use intraoperative endoscopy in any case of long-segment irregularities or evidence of multicentric lesions.
- Insertion of the stapler device through the oral end of the pedicled jejunal segment.

Laparoscopic Procedure

- Do not hesitate to place additional trocars if the exposure is insufficient or the working angle is not suitable.

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Three-Field Lymphadenectomy for Esophageal Cancer

Takashi Aikou

Introduction

Lymphatic drainage from the upper two-thirds of the thoracic esophagus occurs mainly toward the neck and upper mediastinum, although there is also some drainage to the nodes along the left gastric artery. In 1981, the first reported study of three-field lymphadenectomy in Japan noted that 10 of 36 patients with esophagectomy had skip metastases to the neck or abdominal lymph nodes in the absence of associated intrathoracic spread. In this chapter, we focus on the lymph node dissection of the upper mediastinal and cervical regions.

Indications and Contraindications

Indications

- Tumors of the supracarinal esophagus (> T1m stage)

Contraindications

- Superficial carcinoma (T1m stage)
- Severe comorbidity (heart disease, pulmonary and/or liver dysfunction)
- No evidence of cervical lymph node metastases preoperatively in high-risk patients (relative)
- Infracarinal tumors (relative)

Preoperative Investigation/Preparation for the Procedure

- See transhiatal approach
- Ultrasound plus computed tomography scan of the neck, consider PET scan
- In locally advanced tumors: primary radiochemotherapy and surgery is done secondarily

Procedure

- **Access**
  - Anterior-lateral thoracotomy through the right 5th intercostal space
  - Supine position and T-shaped incision in the neck

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Step 1

Exposure and lymphadenectomy of the right upper mediastinum

The arch of the azygos vein is resected, and the right bronchial artery is ligated and secured at its root to evaluate the tumor for its resectability. This procedure provides a good exposure of the upper and middle mediastinum. The brachiocephalic and right subclavian arteries are exposed in order to remove the nodes along the right recurrent laryngeal nerve and the right paratracheal nodes followed by carefully ligating the branches of the inferior thyroid artery (*arrow* indicates the direction of lymphadenectomy) (Fig. 14.1).

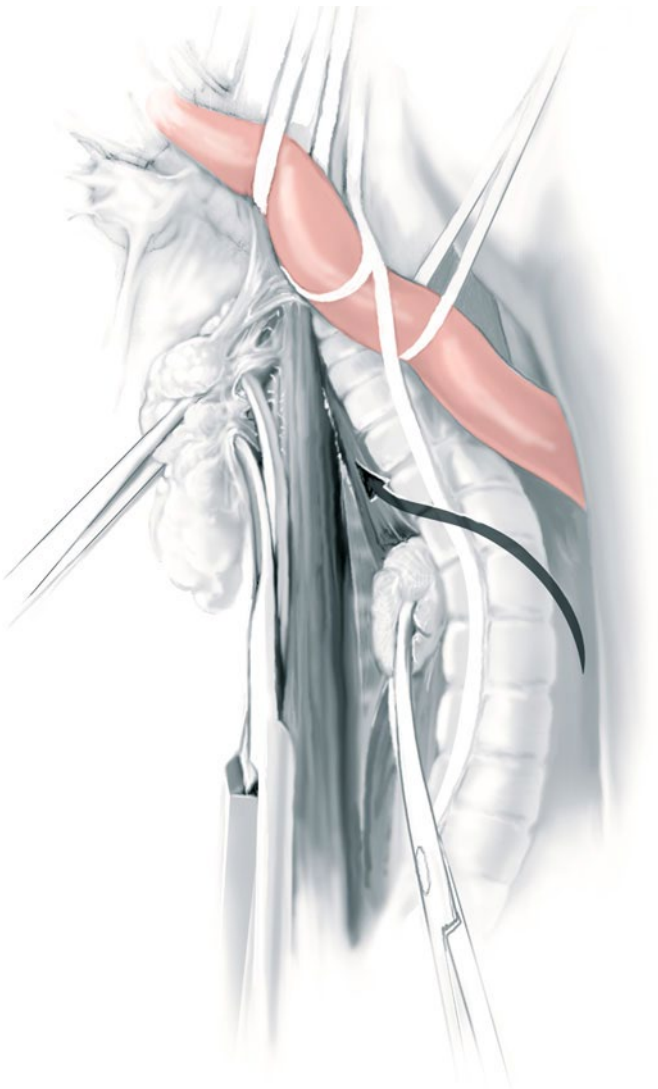


Fig. 14.1

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Step 2

Transection and resection of the esophagus and completion of lymph node clearance

After proximal transection of the esophagus at the level of the aortic arch, the nodes along the left recurrent laryngeal nerve (left paratracheal nodes) are removed. The middle mediastinal nodes, comprising the infra-aortic, infracarinal, and periesophageal nodes, are cleared in conjunction with the esophagus.

This exposes the main bronchus, the left pulmonary artery, branches of the vagus nerve, and the pericardium. Both pulmonary branches of both vagus nerves and the left bronchial artery originating from the descending aorta near the left pulmonary hilum are preserved. However, the esophageal branches of the vagus nerves are severed, and the thoracic duct is also ligated because it is removed together with the esophagus (Fig. 14.2).

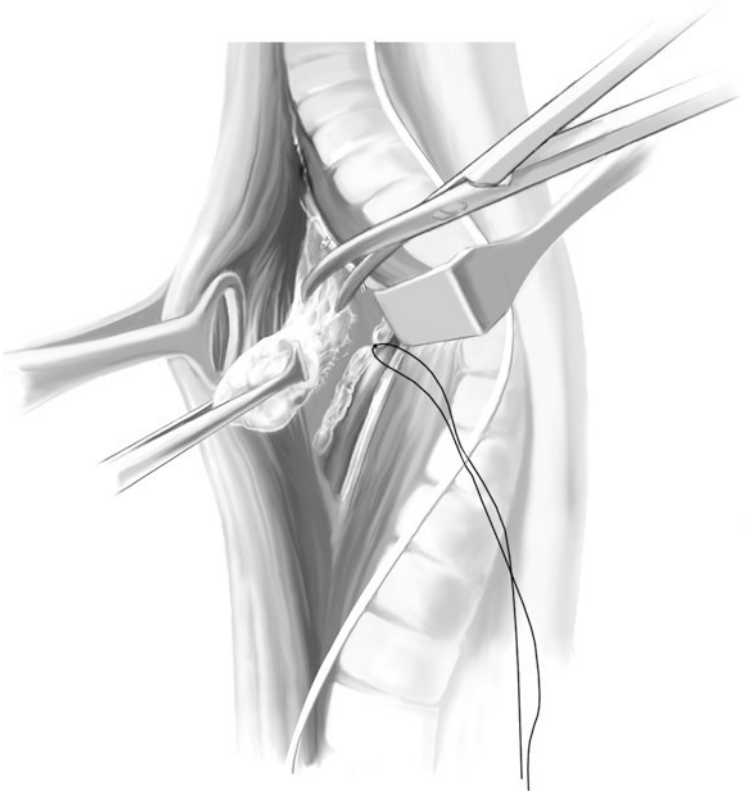


Fig. 14.2

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Step 3

T-shaped neck incision

A T-shaped neck incision is made and the sternothyroid, sternohyoid, and sternomastoid muscles are divided at the clavicle head and the fascia of the omohyoid muscle is incised. After identification of the recurrent laryngeal nerve, lymph nodes along this nerve (which are in continuity with the nodes previously dissected out in the superior mediastinum) are dissected. The inferior thyroid arteries are then ligated and divided. The para-esophageal nodes, including the nodes along the recurrent laryngeal nerve at the cervicothoracic junction, are classified as either cervical or upper mediastinal nodes, according to their position relative to the bifurcation of the right common carotid and right subclavian arteries (Fig. 14.3).

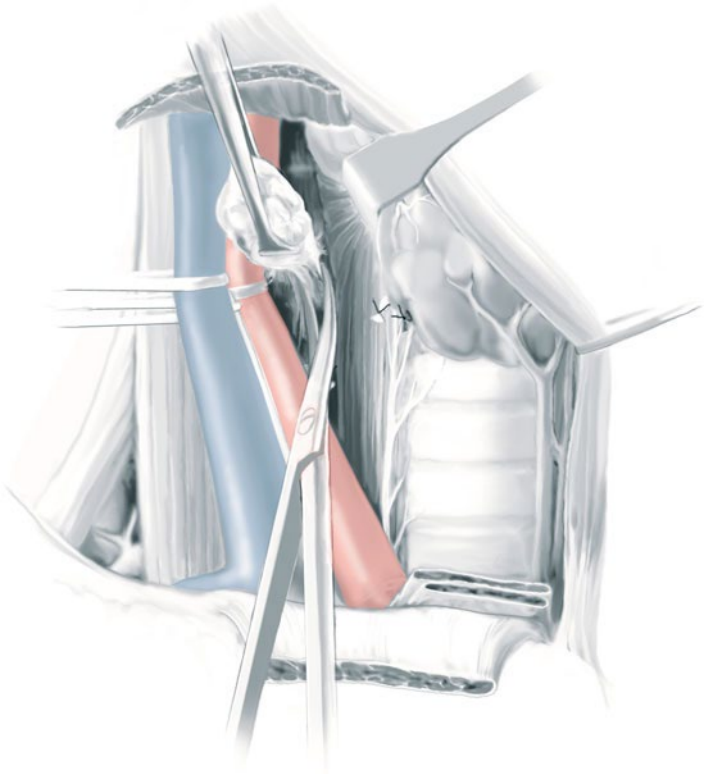


Fig. 14.3

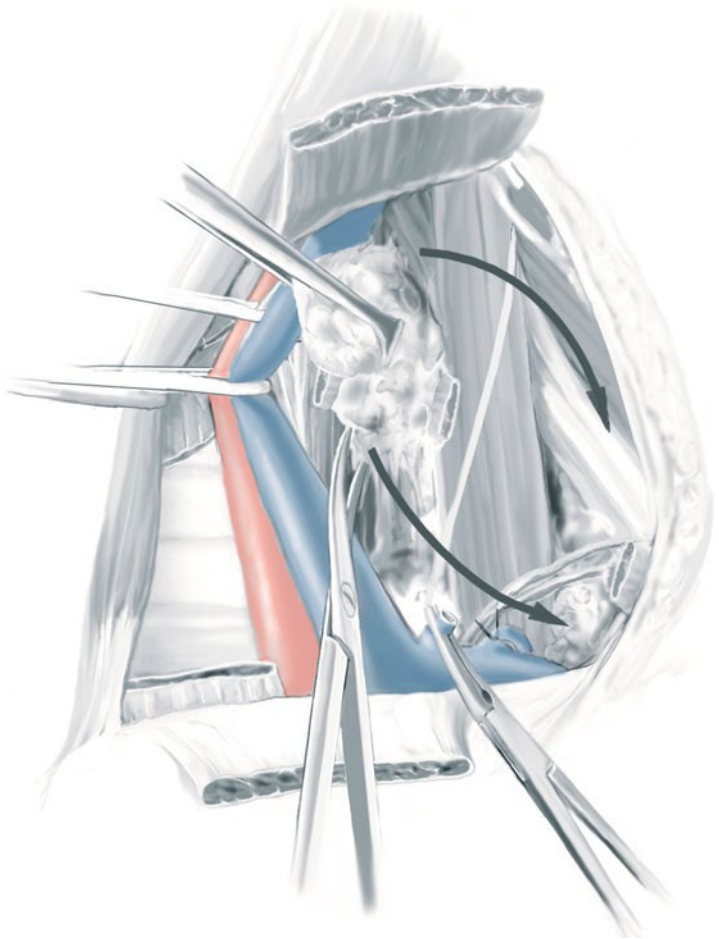
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Step 4

Cervical lymphadenectomy

The jugular vein, common carotid artery, and vagus nerve are subsequently identified and preserved. On the lateral side, after careful preservation of the spinal accessory nerve, lymph nodes situated lateral to the internal jugular vein are removed. The thyrocervical trunk and its branches and the phrenic nerve are then identified. In this procedure, the cervical nodes (internal jugular nodes below the level of the cricoid cartilage, supraclavicular nodes, and cervical paraesophageal nodes) are cleared bilaterally (arrow indicates the direction of lymphadenectomy) (◘ Fig. 14.4).

See transhiatal approach for standard postoperative investigations and complications.



◘ **Fig. 14.4**

Tricks of the Senior Surgeon

- A better exposure of the upper mediastinum requires transection of the medial head of the sternocleidomastoid muscle and/or partial upper sternotomy.

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Minimally Invasive Esophagectomy

Jonathan D'Cunha, David D. Odell, Ryan M. Levy, James D. Luketich

Over the past decade, minimally invasive esophagectomy (MIE) has become an accepted surgical approach for esophageal malignancy as well as certain benign conditions. When performed at high-volume centers, MIE results in morbidity, mortality, and oncological outcomes similar to those of open esophagectomy while offering the advantages inherent to minimally invasive surgery. MIE techniques have evolved from the intial hybrid approaches of thoracoscopy combined with laparotomy to the present combination of laparoscopy and thoracoscopy for a totally minimally invasive esophagectomy. Whereas the totally minimally invasive approach is technically demanding and associated with a significant operator learning curve, it is an excellent option for esophageal resection. In our experience, MIE is associated with a reduction in blood loss, decreased respiratory complications, improved pain cotrol, and a decrease in hospital length of stay.

At present, minimally invasive approaches for esophagectomy include laparoscopic-transhiatal, laparoscopic-thoracoscopic three-hole (McKeown), and laparoscopic-thoracoscopic Ivor Lewis esophagectomy. The choice between MIE approaches is largely based upon the preference of the surgeon. However, tumor location or other anatomical factors may influence the choice of surgical approach. The anticipated morbidity of the operation also varies with the choice of surgical approach. The creation of a cervical anastomosis has a higher incidence of recurrent laryngeal nerve injury. Cervical anastomoses may also be more prone to anastomotic leak, stricture, and pharyngoesophageal swallowing dysfunction. By comparison, transthoracic approaches have a higher incidence of cardiopulmonary complications and potentially greater morbidity if an anastomotic leak occurs.

Our initial approach to MIE utilized a modified McKeown (three-hole) technique that proved to have equivalent oncological outcome and morbidity to the open technique. Owing to concerns regarding cervical dissection and anastomosis, our preferred approach is now a completely laparoscopic-thoracoscopic (Ivor Lewis) esophagectomy with abdominal (celiac, left gastric, splenic) and mediastinal (paraesophageal and subcarinal) lymphadenectomy. The minimally invasive Ivor Lewis approach works well for most distal esophageal cancers, gastroesophageal junction tumors with gastric cardia extension, and short-to-moderate length Barrett's esophagus with high-grade dysplasia. In addition, when there is concern for the length of the gastric conduit, an intrathoracic anastomosis is preferable. In cases of primary gastric tumors with significant lesser curve extension that involve the incisura, we prefer a total gastrectomy with roux-en-Y reconstruction. Total laparoscopic and thoracoscopic Ivor Lewis resections should not be performed for upper third or mid-esophageal cancers with significant proximal extension owing to concern for adequate proximal resection margin. The following describes our current technique for laparoscopic-thoracoscopic Ivor Lewis minimally invasive esophagectomy.

Indications/Contraindications

Indications

1. Esophageal cancer
   a. Adenocarcinoma
      i. Primary treatment
      ii. Following induction chemotherapy and/or radiation treatment
   b. Squamous carcinoma
      i. Primary treatment
      ii. Following induction chemotherapy and/or radiation treatment
   c. Barrett's esophagus/high-grade dysplasia

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2. Benign disease requiring esophagectomy
   a. End-stage achalasia
      i. If not a candidate for Heller myotomy
   b. Megaesophagus
      i. Owing to primary dysmotility
      ii. Secondary to distal obstruction
   c. Multiple revision antireflux surgery
      i. In the setting of esophageal injury or inadequate esophageal length
   d. Caustic ingestion
      i. Failed dilation therapy
   e. Esophageal perforation
      i. If not amenable to primary reconstruction
      ii. Patient must be stable
      iii. Often a delayed approach

Contraindications

1. Anatomical
   a. Need for en-bloc resection of other organs
      i. Direct palpation of the lesion is often necessary to determine resection plane
   b. Concern for airway or major vascular injury or malignant involvement
      i. Determination of resectability
      ii. Evaluation and repair of injury
   c. Consideration of a non-gastric conduit (colon, jejunum)
      i. In order to preserve the vascular pedicle without tension
      ii. To facilitate a timely progression of the operation
   d. Locally advanced malignancy-unresectable disease
   e. Metastasis
2. Technical
   a. Inability to tolerate insufflation of the abdomen
   b. Hemodynamic instability
   c. Inability to tolerate single lung ventilation
   d. Prior gastric or mediastinal surgery (relative)

Preoperative Investigation and Preparation for Procedure

15

History and physical examination

- Focus on cancer risk factors, smoking history, dysphagia symptoms

Laboratory studies

- Complete blood count (CBC), electrolytes, coagulation studies, nutritional studies (albumin and prealbumin)

Upper endoscopy

- Direct evaluation of the extent of the tumor (or other pathology)
- Biopsies of the lesion for histopathological evaluation
- Assessment of the length of preserved proximal esophagus to allow for planning of the location of the proximal resection margin/anastomotic site.
- Assessment of the extent of gastric involvement and determination of the suitability of the stomach for use as a conduit in reconstruction.

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Barium esophagram

- Delineation of tumor anatomy
- Assessment of the degree of obstruction

Endoscopic ultrasound (EUS)

- Determination of ultrasonographic depth of invasion and more accurate T staging
- Visualization of periesophageal lymph nodes with the potential for biopsy of suspicious nodes to more accurately stage disease preoperatively
- May be unable to pass the scope in patients with larger tumors

Computed tomography-positron emission tomography (CT-PET)

- Evaluation for metastatic disease, especially useful in evaluation of celiac and perigastric lymph nodes not seen by EUS
- Assessment of direct tumor invasion of surrounding structures

Magnetic resonance imaging (MRI) of the brain

- Not routinely performed unless patients present with specific neurological symptoms

Pulmonary function testing

- Assessment of the suitability of the patient for thoracoscopy and the ability to tolerate single lung ventilation

Cardiac evaluation

- Electrocardiogram (ECG) and physician risk assessment in most patients
- Cardiology referral and formal stress testing for those patients with ECG abnormalities or identified risk factors for cardiac disease.
- Echocardiogram may be considered to evaluate for undiagnosed pulmonary hypertension (decision guided by history and physical).

Bronchoscopy

- Useful to rule out the presence of airway involvement prior to proceeding to surgery in patients with upper esophageal tumors, especially squamous carcinomas

Laparoscopic staging

- Comprises the initial step in the operation for all patients; however, it can also be performed as a stand-alone procedure in patients with a concern for an advanced (i. e., inoperable) disease state on the basis of preoperative imaging or endoscopic evaluation.
- Two- to three-port technique allows for direct visualization of the peritoneum and liver capsule and biopsy of nodal stations that may be inaccessible by EUS.
- May divide the left gastric artery with minimal dissection for ischemic preconditioning of the gastric conduit.

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Surgical Technique

Anesthetic Considerations

Anesthetic management during MIE poses specific challenges. Whereas all patients receive an arterial blood pressure monitoring line, central venous catheter placement is not routine. A double-lumen endotracheal tube is placed initially in anticipation of the thoracoscopic phase. In patients with midthoracic or upper thoracic tumors, a single-lumen endotracheal tube is initially placed for preoperative bronchoscopy to evaluate airway involvement.

Patients generally require significant volume loading during the laparoscopic phase secondary to the pneumoperitoneum and steep reverse Trendelenburg positioning. Given the high flow of CO_2 required, the patient can develop significant hypercarbia and acidosis. The surgeon must also be mindful of vasopressors administered by the anesthesiologist because these agents directly affect the viability of the newly created gastric conduit. Simple measures can be undertaken to help correct these problems. Maneuvers to increase preload include lowering the insufflation pressure, decreasing the degree of the reverse Trendelenburg position, and increasing volume loading. In addition to changes in the ventilator settings, hypercarbia can often be corrected by reversing the pneumoperitoneum, allowing the patient time to compensate and clear the excess CO_2. There must be clear and ongoing communication throughout the procedure between the surgeon and the anesthesiologist.

Endoscopic Evaluation

The operation begins with a careful esophagogastroduodenoscopy (EGD). The location of the tumor is confirmed along with precise measurements of the proximal and distal extent of the lesion. The surrounding esophagus is examined for evidence of Barrett changes proximal to the intended resection margin, with four-quadrant biopsies taken in areas of clinical concern. Careful endoscopic examination of the stomach is also imperative to assess its suitability for use as a conduit in esophageal reconstruction. Air insufflation should be kept to a minimum during the examination to reduce the degree of small bowel distention which may significantly decrease domain and heighten the difficulty of laparoscopy.

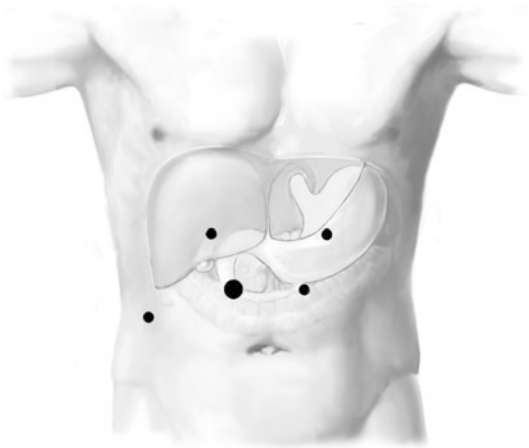
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Laparoscopic Phase

Positioning and laparoscopic port placement

The patient is positioned supine with the arms out at a 60°. A foot board is placed to allow steep reverse Trendelenburg positioning during the hiatal dissection. The costal margin is identified and a line is drawn from the xiphoid to the umbilicus. This line is then divided into thirds. The first port is placed using a direct Hassan cutdown approach in the right paramedian position roughly 2 cm lateral to the midline at the junction of the lower and middle thirds of the described line. A total of five abdominal ports are used for gastric mobilization (12-mm right and left paramedian, 5-mm right and left subcostal, and a second 5-mm right lateral subcostal port for liver retraction; ◘ Fig. 15.1) with the remaining ports placed under direct laparoscopic vision. A sixth port is placed in the right paraumbilical region to assist in placement of the feeding jejunostomy tube. All ports should be a hand's breadth apart so as to avoid interference between instruments. In addition, it is important to keep skin and fascial incisions small so as to avoid subcutaneous emphysema.

While working at the hiatus, the camera is placed in the left paramedian port position. The surgeon works from the right side of the table using the right paramedian and subcostal ports. The assistant, on the left of the table, controls the camera as well as a second grasper for retraction (through the left subcostal port). The liver retractor is brought in through the right lateral subcostal port and positioned to elevate the left lobe of the liver and expose the hiatus.



◘ Fig. 15.1

Gastric mobilization

Thorough inspection of the abdomen is performed to ensure that no injuries were caused during the process of port placement and to evaluate for intraperitoneal metastasis. The peritoneal lining, omentum, and liver are visually inspected for abnormalities with biopsies taken of any suspicious lesions for frozen-section evaluation. The gastrohepatic ligament is opened and the left gastric vascular pedicle identified (◘ Fig. 15.2). A complete lymph node dissection is then performed, leaving the left gastric and celiac lymph nodes with the specimen. This dissection is continued laterally along the splenic artery and the superior border of the pancreas and superiorly toward the crura along the preaortic plane. If there is a question of potential malignant involvement, these nodes are sent for frozen-section evaluation to aid in determination of resectability. Once ensured that no nodal disease is present, the right crus is dissected, allowing lateral mobilization of the esophagus. This dissection is continued anterior to the esophagus, transecting the phrenoesophageal ligaments and exposing the anterior hiatus. The left crus may be exposed either by the continuation of this anterior dissection along the medial crural border or by first mobilizing the fundus of the stomach by division of the short gastric vessels. Dissection of the left crus is continued posteriorly until the decussation of the right and left crural fibers is noted. This exposes the retroesophageal window and ensures complete mobilization of the superior portion of the lesser curvature and gastroesophageal junction.

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After identifying the gastrocolic omentum, the antrum of the stomach is retracted, and a window is created in the greater omentum, thus allowing access to the lesser sac. The remaining short gastric vessels are divided, taking care to preserve the right gastroepiploic arcade. The fundus is retracted to the right and this dissection is continued posteriorly, eventually exposing the left gastric artery and vein and joining the lesser curve dissection plane to complete mobilization of the stomach. Gastric mobilization is carried inferiorly to the pyloroantral region. Meticulous attention must be paid during this phase of the dissection because any injury to the gastroepiploic arcade at this level may render the gastric conduit unusable. This dissection may be especially difficult in patients who have had pancreatitis or a history of prior biliary surgery. Adequate mobilization has been achieved when the pylorus is able to reach the level of the caudate lobe of the liver, which may require either a partial or a complete Kocher maneuver. The left gastric artery and vein are then divided using an endovascular GIA stapler. Care should be taken to ensure that all nodes are swept toward the specimen side and to avoid narrowing of the splenic or hepatic arteries.

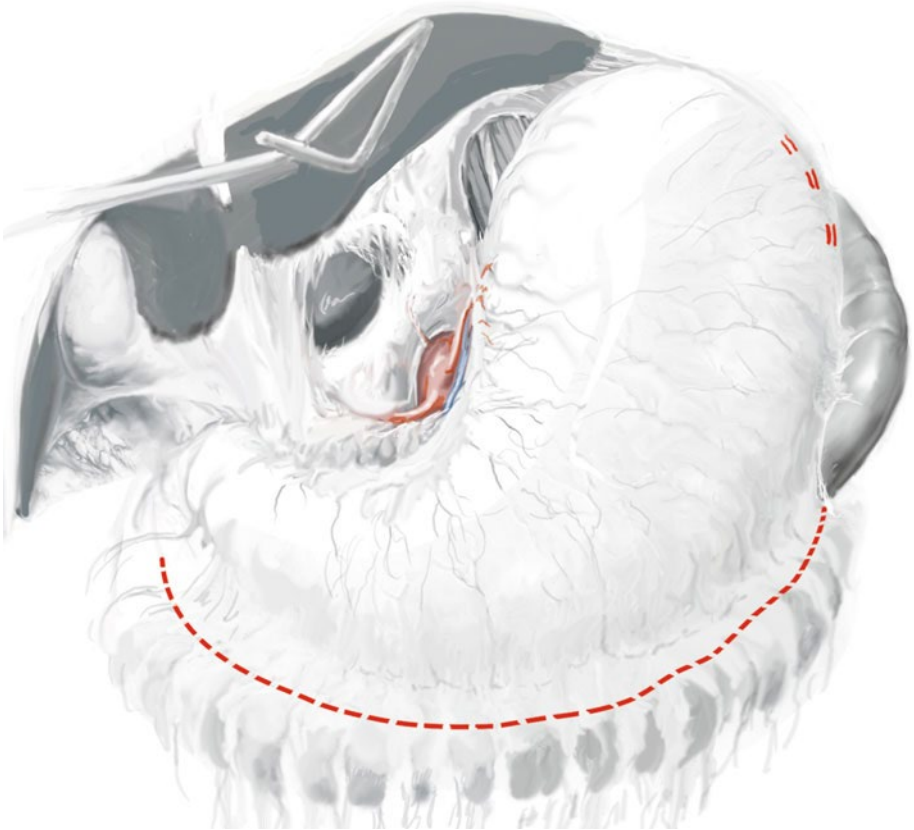


Fig. 15.2

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Creation of the gastric tube

The gastric tube is created prior to the completion of the pyloroplasty and placement of the feeding jejunostomy tube to allow for an assessment of the viability of the gastric conduit. The gastric tube follows the arc of the greater curve of the stomach and is based on the right gastroepiploic artery (Fig. 15.3). An endovascular stapling technique allows for a controlled creation of the gastric tube conduit. The first staple load is placed across the adipose tissue and vessels along the lesser curve, above the level of the right gastric artery. No stomach is divided in this initial staple firing, which is intended to provide hemostasis. The subsequent staple firings divide stomach. We prefer 45-mm staple loads for this process (purple loads; Endo GIA Reloads with Tri-staple Technology, Covidien, Mansfield, MA) because the course of the greater curvature can be followed more precisely, resulting in improved conduit length. An additional grasper is brought through the right paraumbilical port at this time to assist in the retraction of the stomach during creation of the gastric tube. It is important to keep the stomach on stretch during this process so as to create a straight conduit. The first assistant grasps the tip of the fundus along the greater curve and gently stretches it toward the spleen. A second instrument from the paraumbilical port grasps the antral area with a slight downward retraction. The stomach is first horizontally divided across the antrum. The staple line is then directed superiorly, toward the fundus, parallel to the line of the greater curve. A conduit width of 4 to 5 cm is preserved (Fig. 15.4). The length of the conduit is shortened if there is concern for extension of the tumor onto the gastric cardia. Sutures may be placed to reinforce the staple line if there is concern about its integrity, although this practice is not routinely necessary.

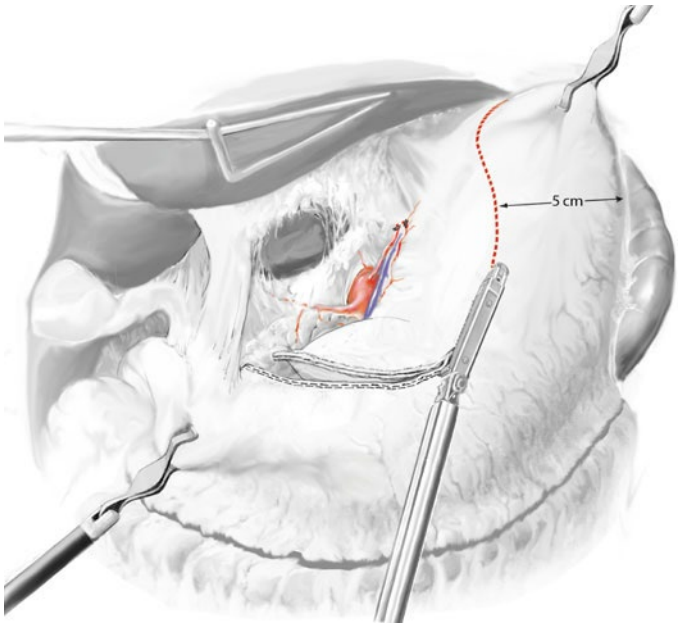


Fig. 15.3

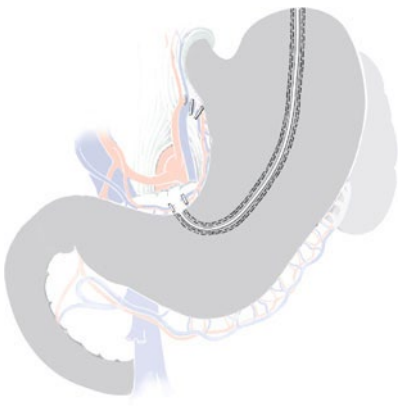


Fig. 15.4

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Pyloroplasty

The pylorus is visually identified and 2-0 Surgidac (Covidien, Mansfield, MA) stay sutures are placed on the superior and inferior aspects using the Endostitch device (U.S. Surgical, Norwalk, CT) to place it on stretch (Fig. 15.5). The anterior wall of the pylorus is then transected with an ultrasonic shears. The pyloromyotomy is then closed transversely in a Heineke-Mikulicz fashion using simple, interrupted 2-0 Surgidac sutures. An omental patch (with a vascular pedicle if the patient received neoadjuvant treatment) is placed over the pyloroplasty prior to termination of the abdominal portion of the operation.

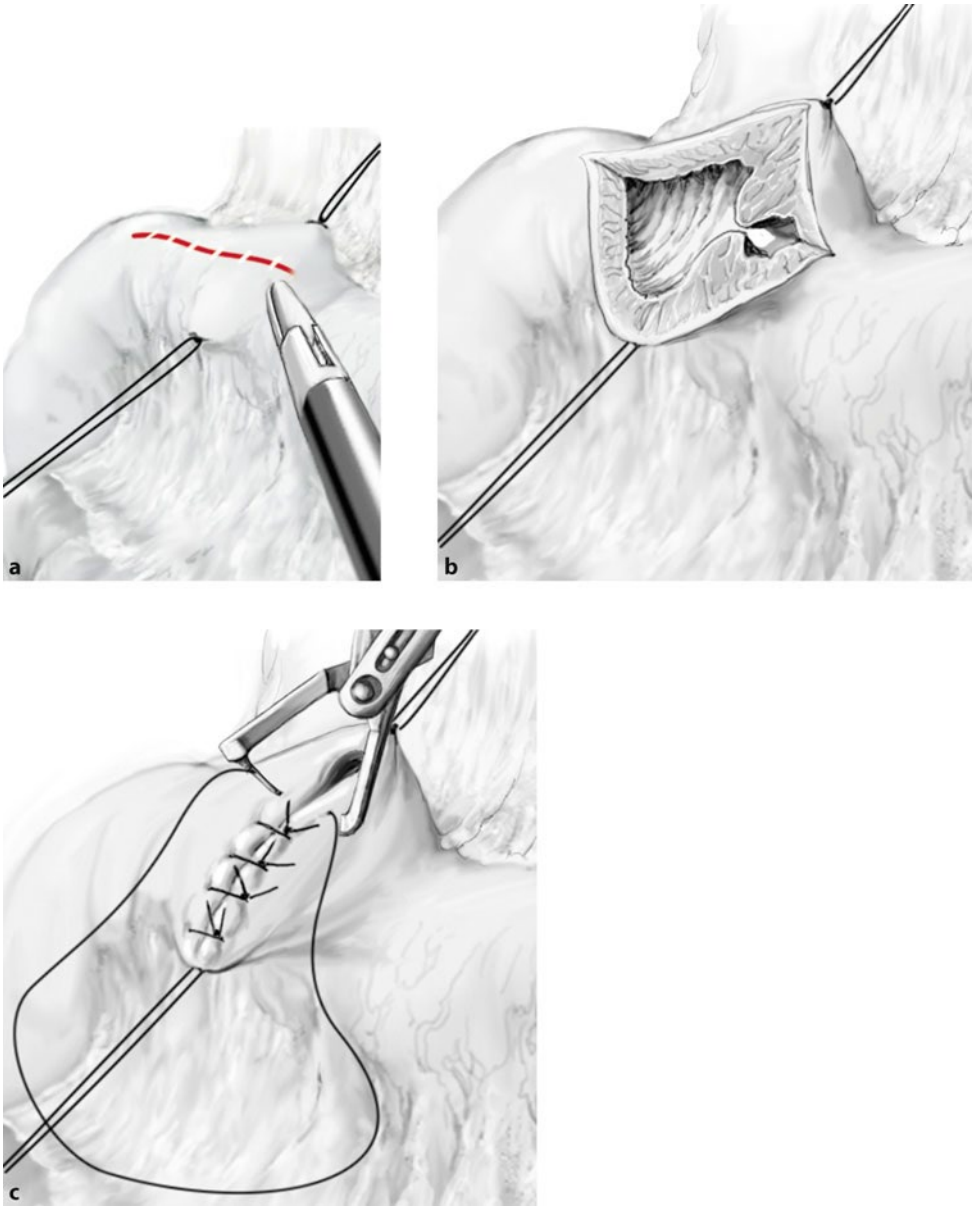


Fig. 15.5

Feeding jejunostomy tube placement

A 10-French jejunostomy catheter is placed in the left lower quadrant using a percutaneous technique (Fig. 15.6). The transverse colon is retracted superiorly to expose the ligament of Treitz and a position in the jejunum is identified 30 to 40 cm from this location. The antimesenteric border of the bowel is sutured to the abdominal wall with a 2-0 Surgidac suture. The 12-mm right paraumbilical port is used by the surgeon with the camera positioned in the right paramedian location. A Seldinger technique is then used to introduce the catheter into the jejunum under di-

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rect laparoscopic vision. Air insufflation via the catheter can be used to verify luminal placement. The jejunum is then tacked to the abdominal wall anterior to the catheter entry site to prevent leakage, and an additional suture to the abdominal wall is placed in the distal limb of jejunum to prevent rotation and obstruction.

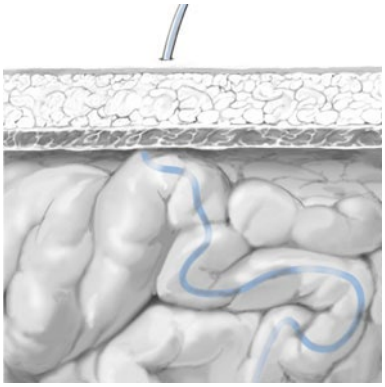


Fig. 15.6

Preparation for thoracoscopic phase

The gastric conduit is again assessed for viability and, if needed, resection of the nonviable portion and further mobilization with extension of the Kocher maneuver are performed at this time. Once viability of the conduit is ensured, the most superior portion of the gastric tube is stitched to the specimen (Fig. 15.7). It is imperative to maintain the alignment of the conduit so that twisting is avoided as the stomach is brought into the chest. We ensure this by suturing the greater curvature along the short gastric vessels to the staple line of the proximal gastric remnant. If an omental flap has been created, the distal end is sutured to the conduit tip. Clips are applied to the staple line as needed for hemostasis. The specimen and gastric conduit are then placed in the lower mediastinum, again taking care to preserve the proper orientation of the gastric conduit (Fig. 15.8). If the hiatal opening appears large, the crura are reapproximated with a stitch to prevent delayed thoracic herniation of the conduit. A nasogastric tube is then placed in the esophagus for decompression in preparation for the thoracic phase of the operation.

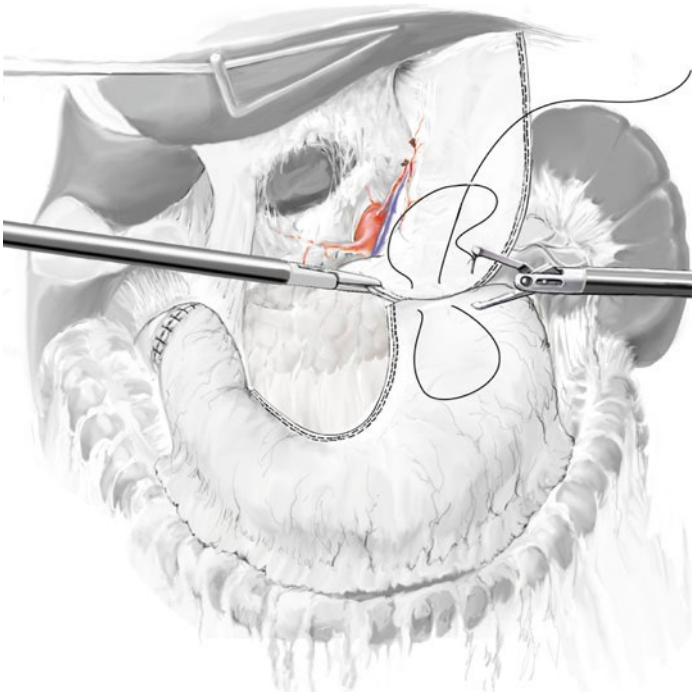


Fig. 15.7

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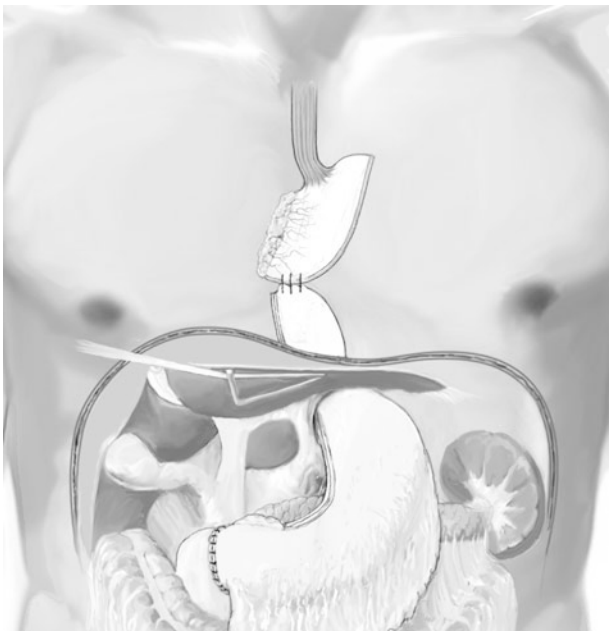


Fig. 15.8

Thoracoscopic Phase

Positioning and Port Placement

The patient is placed in the left lateral decubitus position and the placement of the double-lumen endotracheal tube is endoscopically reconfirmed. The operating surgeon stands on the right side of the table (facing the patient's back) while the assistant stands on the left side of the table. A total of five thoracoscopic ports are used (Fig. 15.9). A 10-mm camera port is placed in the eighth or ninth intercostal space, just anterior to the midaxillary line. The working port is a 10-mm port placed in the eighth or ninth intercostal space, posterior to the posterior axillary line. Another 10-mm port is placed in the anterior axillary line at the fourth intercostal space, through which a fan-shaped retractor aids in retracting the lung to expose the esophagus. A 5-mm port is placed just inferior to the tip of the scapula for the surgeon's left hand. A final 5-mm port is placed at the sixth rib, at the anterior axillary line for suction by the assistant.

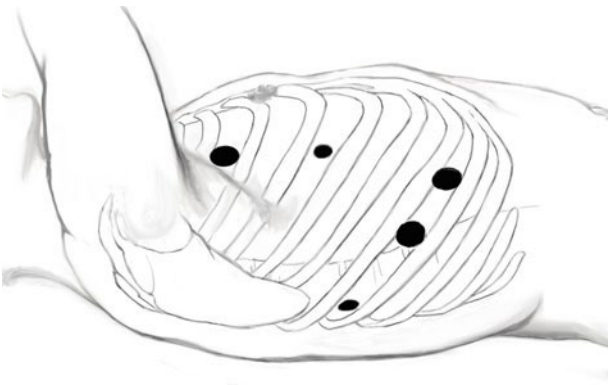


Fig. 15.9

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Thoracoscopic dissection and resection of the esophagogastric specimen

Adequate retraction of the diaphragm is essential to the thoracoscopic phase of the dissection. A 48-inch, 0 Surgidac suture is placed through the central tendon of the diaphragm using the Endostitch. The suture is brought out through the lateral chest wall at the level of the insertion of the diaphragm through a small stab incision, retracting the diaphragm inferiorly and exposing the distal esophagus. The inferior pulmonary ligament is divided to the level of the inferior pulmonary vein to allow for maximal retraction to the lung. This dissection is carried onto the avascular plane along the surface of the pericardium, which becomes the medial border of the dissection. This dissection is carried superiorly to the subcarinal space, with the lymph nodes kept en bloc with the esophagus (Fig. 15.10). Care must be taken to identify the membranous wall of the right mainstem bronchus because it is easily injured during this phase of the dissection. Removing any suction from the right lung during this dissection will prevent the membranous wall from collapsing and can aid in visualization. The lung is then retracted anteriorly and the pleura incised along the anterior border of the esophagus to the level of the azygos vein. The azygos vein and vagus nerve are divided to facilitate the dissection and prevent traction injuries to the recurrent laryngeal nerve during esophageal mobilization. Above the level of the azygos vein, dissection is kept close to the esophagus to avoid injury to the recurrent nerves. The extent of superior dissection and mobilization depends upon the location of the tumor and the intended site of resection. To facilitate lateral mobilization, the pleura is divided in the groove posterior to the esophagus. This dissection is kept superficial to avoid injury to the thoracic duct and underlying thoracic aorta. Bridging lymphatics and aortoesophageal vessels are controlled with endoclips and subsequently divided with the ultrasonic shears. A careful thoracic duct ligation should be considered if there is concern for trauma to the duct. This lateral dissection is carried along the length of the esophagus from above the azygos vein to the level of the gastroesophageal junction. The contralateral pleura marks the deep margin of the dissection. The left pleural space may be entered if needed to remove a bulky tumor. The insertion of a Penrose drain to encircle the esophagus can also be useful to provide traction and elevate the esophagus from the mediastinal bed.

Once the esophagus has been completely mobilized, the specimen and attached gastric conduit are delivered into the chest, preserving the orientation of the gastric tube. The conduit staple line should be directly facing the lateral chest wall. The stitch between the specimen and the conduit is cut and the tip of the conduit secured to the diaphragm with an Endostitch to prevent it from retracting into the abdomen. The specimen is then retracted anteriorly and superiorly, away from the esophageal bed, and the dissection completed along the contralateral pleural surface. Above the level of the azygos vein, this dissection again moves to the plane along the wall of the esophagus itself to avoid recurrent laryngeal nerve injury. Lymph node sampling is not routinely performed at this level.

Once mobilization of the esophagus is complete, a 4- to 5-cm minithoracotomy is made between the surgeon's working port and the tip of the scapula. A wound retractor (Applied Medical, Rancho Santa Margarita, CA) is placed to protect the skin and chest wall. The esophagus is then sharply transected using laparoscopic scissors at or above the level of the azygos vein as determined by the proximal extent of tumor. The nasogastric tube is pulled back into the proximal esophagus under direct vision as this is done. The esophagogastrectomy specimen is then withdrawn through the wound protector and sent for frozen section evaluation of the resection margins.

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Fig. 15.10

Creation of the gastroesophageal anastomosis

Attention is next turned to construction of the esophagogastric anastomosis. Our preferred technique utilizes an end-to-end anastomosis (EEA) stapling device (Fig. 15.11). The anvil of the stapler is placed in the cut proximal end of the esophagus and secured in place with two pursestring sutures of 2-0 Surgidac. All layers of the esophagus must be included in the suture to ensure a competent anastomosis. Typically, a 28-mm EEA stapler can be used without difficulty. This size will help to minimize stricture formation and potentially decreases the need for postoperative dilation. If the proximal esophagus does not appear large enough to accommodate the 28-mm anvil, a Foley catheter can be used to gently dilate the esophageal lumen in an attempt to facilitate placement of the anvil before electing a smaller stapler size. The gastric conduit is pulled further into the chest and the tip of the gastric conduit is opened using ultrasonic shears to the right side of the staple line. The EEA stapler is placed through the wound protector and positioned through the gastrotomy inside the conduit. The stapler spike is brought out along the greater curve of the gastric conduit to dock with the anvil. Prior to creating the anastomosis, we carefully estimate the amount of conduit that will lie in the chest. It is a common mistake to bring an excess stomach into the chest with the intent of minimizing tension on the anastomosis. A redundant conduit above the diaphragm can lead to significant problems with conduit emptying. In addition, ensuring proper orientation of the stomach is critical to prevent twisting. The stapler is then opened two complete turns and withdrawn. The tissue rings are inspected to ensure that they are complete prior to proceeding further.

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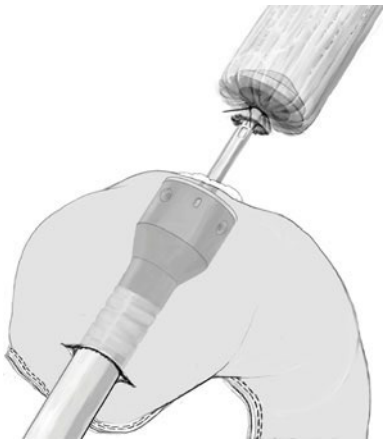


Fig. 15.11

After stapling, the remaining excess gastric tip, including the gastrotomy through which the stapler was introduced, is resected with two or three loads of the endovascular GIA stapler (Fig. 15.12). If an omental flap was created during the abdominal dissection, it is wrapped around the anastomosis and secured in place with two or three sutures. The chest is then thoroughly irrigated and inspected for hemostasis. Final anatomy of the reconstruction is demonstrated in Figure 15.13.

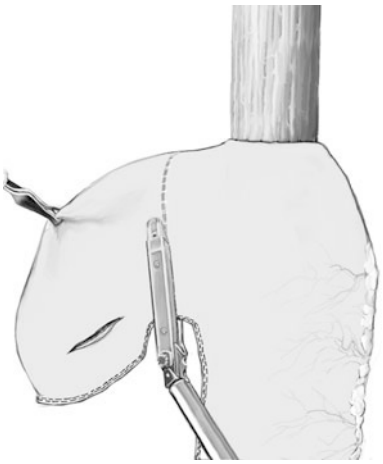


Fig. 15.12

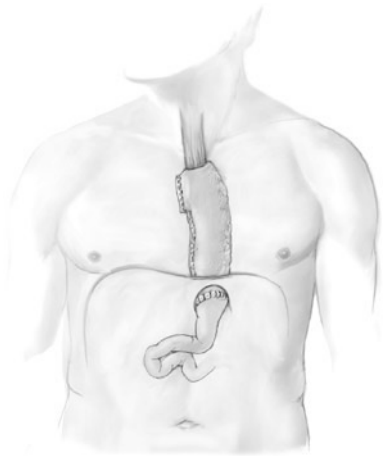


Fig. 15.13

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Drain placement and closure

Adequate drainage of the mediastinum and the area surrounding the anastomosis is imperative to mitigate complications related to anastomotic leak. A 10-mm Jackson-Pratt drain is placed posteriorly along the anastomosis and a 28-French chest tube is directed posteriorly toward the apex. The previously placed nasogastric tube is advanced past the anastomosis under thoracoscopic visualization. The gastric conduit is sutured to the right crus with a single 2-0 Endostitch to prevent torsion or delayed herniation of the conduit. A long aspirating needle is used to instill a multilevel intercostal nerve block to aid in postoperative pain control. The minithoracotomy is closed using pericostal sutures with a multilayer soft tissue closure. The Jackson-Pratt drain is secured with multiple sutures to prevent it from becoming dislodged. Once the patient is turned to the supine position, the oropharynx and nasopharynx are suctioned free of all secretions. The double-lumen endotracheal tube is withdrawn and the patient reintubated with a single-lumen endotracheal tube. Use of a tube exchange catheter should be discouraged because this device is placed blindly and may cause injury to the right mainstem bronchus, which is potentially vulnerable owing to the dissection of the thoracic esophagus. A toilet bronchoscopy is then performed using an adult bronchoscope. At this time, both right and left mainstem bronchi are examined for any evidence of airway injury.

Postoperative Care

Patients are taken to the intensive care unit postoperatively and typically remain there for the first postoperative day before transferring to the surgical floor. The typical hospital stay is 7 days in patients with an uncomplicated postoperative course. The nasogastric tube may be removed on day 2 and "trickle" (20–30 mL/h) jejunostomy tube feeds are started. A contrast esophagram is obtained on day 3 to 4 if the patient has adequate pulmonary toilet and a good cough. If there is no evidence of leak, oral intake is initiated in the form of 1 to 2 oz of clear liquids per hour. This is advanced over 2 days to full liquids, no more than 3 to 4 oz/h along with cycled tube feeds. The chest tube is removed when output low (< 150 mL/day) and the clinical course negative for leak. The Jackson-Pratt drain is pulled back 3 to 5 cm on postoperative day 5 and resecured. The drain is removed at the first postoperative clinic visit in 2 weeks' time.

Postoperative Complications

15

Early complications

- Anastomotic leak
- Anastomotic dehiscence
- Conduit necrosis
- Bowel obstruction
- Ileus
- Chylothorax
- Pleural effusion
- Recurrent laryngeal nerve injury: vocal fold paresis/paralysis
- Pneumonia
- Respiratory failure
- Pleural space infection

Late complications

- Stricture
- Bile reflux
- Poor conduit function (dilation, herniation, tortuosity)
- Recurrent cancer
- Weight loss
- Aspiration

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Management of Common Complications

Early

- Leak: ensure adequate drainage, operative repositioning of drains if necessary, nutritional support.
- Conduit necrosis: reoperate to drain infection and revise anastomosis with resection of dead tissue; diversion may be indicated depending on the clinical picture.
- Pleural space infection: early thoracoscopic drainage.
- Chylothorax: medical management if low-volume; thoracoscopic duct ligation and/or image-guided duct embolization if it fails to resolve conservatively.
- Pneumonia: aggressive pulmonary toilet for prevention; bronchoscopy and bronchoalveolar lavage for culture-directed antimicrobial therapy.

Late

- Stricture: serial endoscopic dilation
- Conduit dysfunction: careful evaluation for a correctable anatomical issue and consideration of operative conduit revision

Key Points

- Minimally invasive esophagectomy has become an established approach for the treatment of esophageal carcinoma.
- In our retrospective series of more than 1000 patients who underwent MIE, overall morbidity, mortality, lymph node yield, and oncological outcomes were similar to or better than most published series of open esophagectomy.
- Our favored approach is a laparoscopic-thoracoscopic Ivor Lewis MIE whenever oncologically appropriate.
- The Ivor Lewis approach for MIE significantly lowers the incidence of recurrent nerve injury compared with approaches requiring a cervical anastomosis.
- In the first randomized controlled trial of MIE versus open esophagectomy, MIE was associated with a shorter hospital stay, fewer pulmonary infections, less vocal cord paralysis, and better short-term quality of life compared with open esophagectomy. Oncological principles of resection and lymph node retrieval were not compromised using the minimally invasive approach.

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Treatment of Zenker Diverticulum

Yogesh Vashist, Stefan Groth, Uwe Seitz

Endoscopic Approach

The Zenker diverticulum (pharyngoesophageal diverticulum) arises from the triangle of mucosa located between the inferior pharyngeal constrictors and the cricopharyngeal muscle (Killian triangle). This type of diverticula is a false diverticulum and more common than true esophageal diverticula. The treatment options range from various endoscopic techniques to open surgical resection.

Treatment of Zenker diverticulum with a flexible endoscope provides an alternative to surgery or the intraluminal approach with a rigid endoscope (Weerda laryngoscope). The "septum" between the diverticulum and the esophagus is transected, thereby creating a common cavity of esophageal lumen and diverticulum, allowing easier food passage. It is not always necessary to divide the complete septum between the esophagus and the diverticulum because patients already have a good relief of symptoms after incision of one third to one half of the septum. That is why the aim of the endoscopic treatment is the relief of symptoms and not necessarily the complete separation of the septum.

Indications and Contraindications

Feasible in any patient including those not appropriate for general anesthesia.

Preoperative Investigations and Preparation for the Procedure

- Clinical examination
- Contrast swallow (water-soluble)
- Ultrasound
- A large gastric tube is carefully placed in the upper esophagus

Procedure

Intubation of the esophagus is often difficult in patients with a Zenker diverticulum. A pediatric endoscope can be used to facilitate intubation. If the diverticulum is filled with food, cleaning by using a large-channel endoscope should be first performed to avoid aspiration.

After intubating the esophagus, a Savary-Guillard wire is placed in the antrum, the endoscope is withdrawn, and a nasogastric tube is placed over the wire through the mouth.

The nasogastric tube indicates the entrance into the esophagus. This tube provides a better anatomical overview and simultaneously protects the esophageal wall during treatment (Fig. 16.1).

Alternatively a flexible diverticuloscope (Cook Endoscopy, Winston Salem, NC) can be introduced via the endoscope. It is designed as an overtube on the basis of the "Weerda" laryngoscope from otolaryngology. It has a double duckbill extremity, one to be placed in the esophagus and one for the diverticulum leaving the septum in the middle of the two bills. This device allows an excellent anatomical overview. Sometimes it can be quite challenging to get the device in position.

Once the endoscope is in position, there are different options on how to transect the septum. The most common ones are the treatment with argon-plasma coagulation and with a needle knife.

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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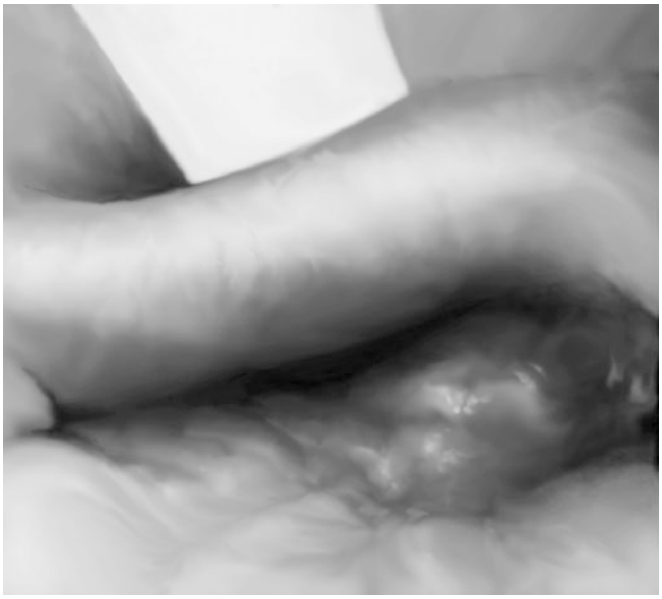


Fig. 16.1

Argon-plasma coagulation of the septum

The septum is treated with argon-plasma coagulation. The advantage of this method over conventional diathermy is the spray-like application. Bleeding from smaller vessels is avoided. In one session 1 cm of the septum is coagulated. The session is repeated after 4 weeks if required (Fig. 16.2a). The limitation of this method is that you can treat only the septum about a depth of 1 cm per session because the strong coagulation effect does not allow further treatment.

Figure 16.2b shows the effect of argon-plasma coagulation at the end of the first session.

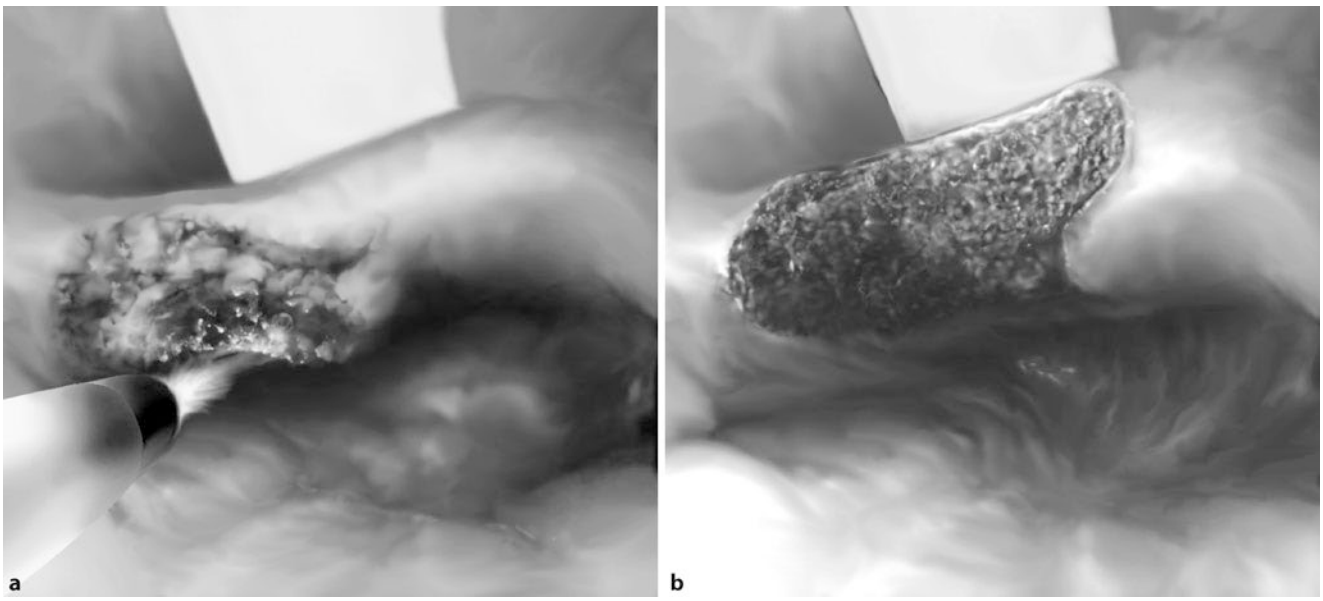


Fig. 16.2

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Needle knife incision

The beginning and the end of a session of needle knife incision are shown (Fig. 16.3). Fibers of the cricopharyngeal muscle are visualized. In our experience the risk of bleeding is slightly higher using the needle knife than using argon-plasma coagulation, particularly in the first session. Therefore fewer treatment sessions (on average, one) are needed for a good relief of symptoms. To avoid perforation on the distal end of the septum, one to two clips can be placed at the ground (at the distal end of the area treated).

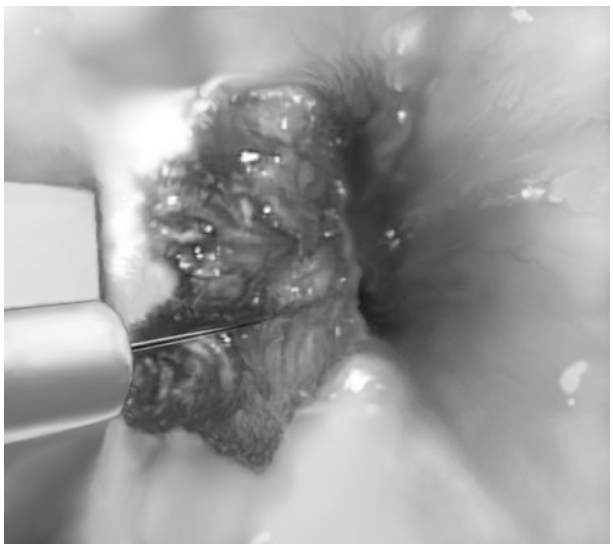


Fig. 16.3

Residual septum

- Residual septum after successful endoscopic treatment (Fig. 16.4)

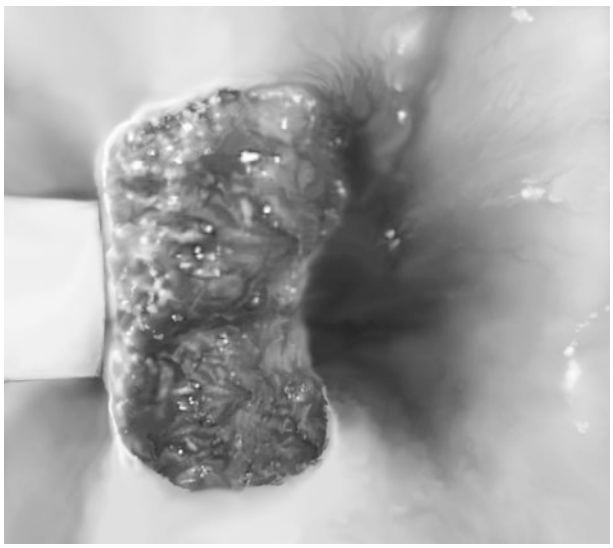


Fig. 16.4

Standard Postoperative Investigations

- No specific investigations are necessary.

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Postoperative Complications

- Bleeding
- Perforation
- Mediastinitis
- Sepsis

Tricks of the Senior Surgeon

- Control bleeding with hemoclips and injection of diluted epinephrine (1:20,000) or with a hot biopsy forceps.
- Pay attention to keep the incision of the septum central to avoid bleeding.
- Use CO_2 insufflation for the endoscope.

Open Approach

- Most Zenker diverticula are located left dorsolateral. This is due to the vertebra, which represents the posterior rigid plane; hence the Zenker diverticulum juts out to the left and follows a vertical growth parallel to the esophagus.
- Zenker diverticula are classified according to Brombart, Morton and Bartley and Lahey.
- Lahey classification differentiates between three stages:
  - Stage I: no symptoms, local mild inflammation
  - Stage II: dysphagia and regurgitation
  - Stage III: esophageal obstruction, dysphagia, and regurgitation.

Indications

- Progress over time. Treatment is recommended for patients who have moderate to severe symptoms/complications (pneumonia or aspiration).

Contraindications

- Severe physical constitution

Preoperative investigations and preparation for the procedure

- Clinical examination
- Contrast swallow (water-soluble)
- Upper gastrointestinal endoscopy
- Ultrasound
- Manometry
- A large gastric tube is carefully placed in the upper esophagus

Procedure

Access

The left arm should be adjacent to the patient's body and the patient placed in a supine position with the head rotated to the right.

Approach

The approach to the diverticulum for surgical therapy comes through a left cervical incision (most Zenker diverticula present on this side) at the level of the cricoid cartilage on the anterior aspect of the sternocleidomastoid muscle just above the clavicle. The anatomical overview of the access to the cervical esophagus is given in Fig. 16.5.

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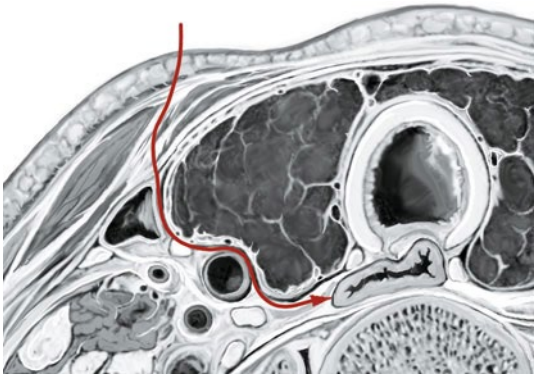


Fig. 16.5

Dissection

Dissection is performed between the medial aspect of the sternocleidomastoid muscle, which is pulled laterally, and the strap muscles by retracting the carotid sheath laterally and preserving the recurrent laryngeal nerve. The omohyoid muscle may be either retracted or transected. The thyroid gland is mobilized and vessels are dissected (Fig. 16.6).

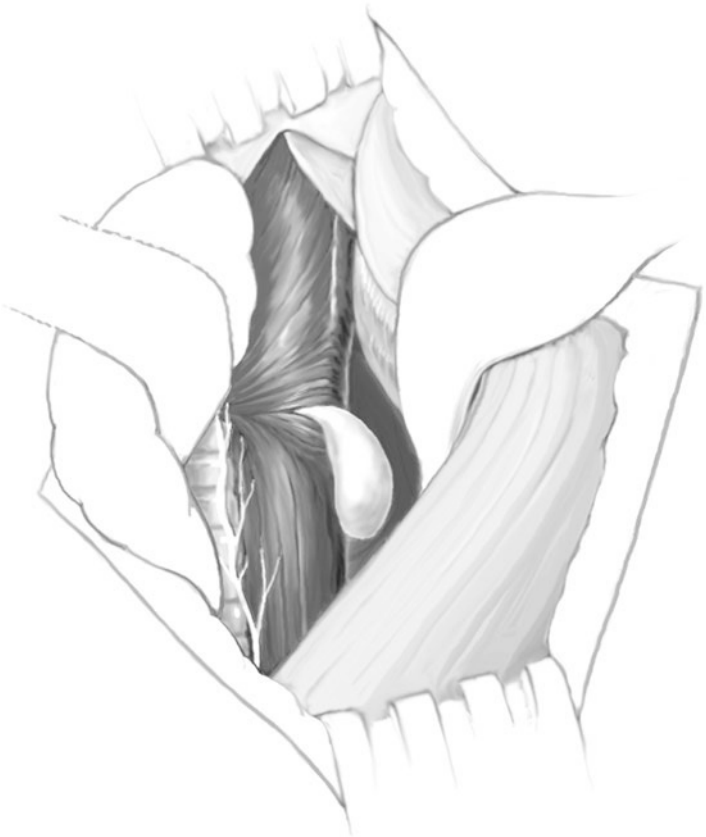


Fig. 16.6

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Mobilization of the esophagus and the diverticulum

The esophagus is mobilized from the prevertebral fascia, and the diverticulum is evident posterior to the esophagus. Large diverticula may extend into the mediastinum, but gentle traction and blunt dissection are sufficient to mobilize even the largest diverticula. Figure 16.7 shows the anatomy of the cervical diverticulum.

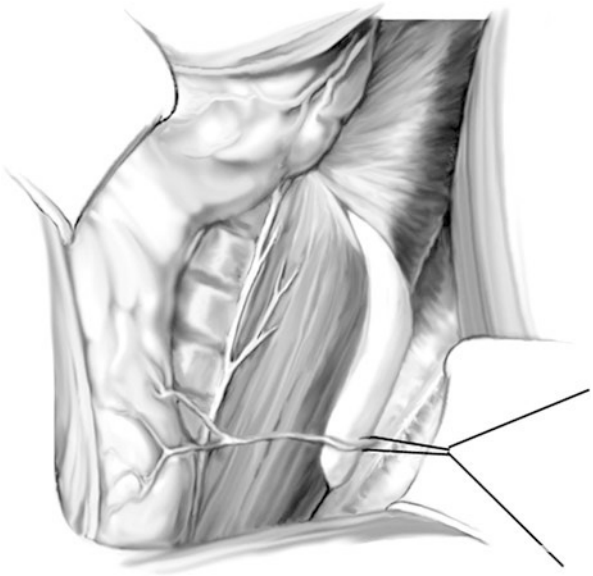


Fig. 16.7

Preparation of the diverticulum

The neck of the diverticulum is dissected. Gentle traction on the diverticulum exposes the fibers of the cricopharyngeus muscle. Oral insufflation of air may help to find the diverticulum.

Myotomy

The cricopharyngeus muscles are divided and bluntly dissected from the mucosa. Myotomy of the pars transversa and of the upper esophagus is performed and is essential.

After myotomy the diverticulum can be addressed differently, depending on the size of the diverticulum. Small diverticula measuring up to 2 cm virtually disappear after the myotomy is completed and may be left alone or fixed cranially with the apex. They may be inverted and sutured to the prevertebral fascia, which prevents food retention without necessitating creation of a staple line or suture line that is at risk for fistula formation. Larger diverticula are resected with a linear stapler parallel to the esophageal lumen, taking care not to compromise the diameter of the esophagus. Alternatively open resection and two-layer closure is performed (Figs. 16.8 and 16.9).

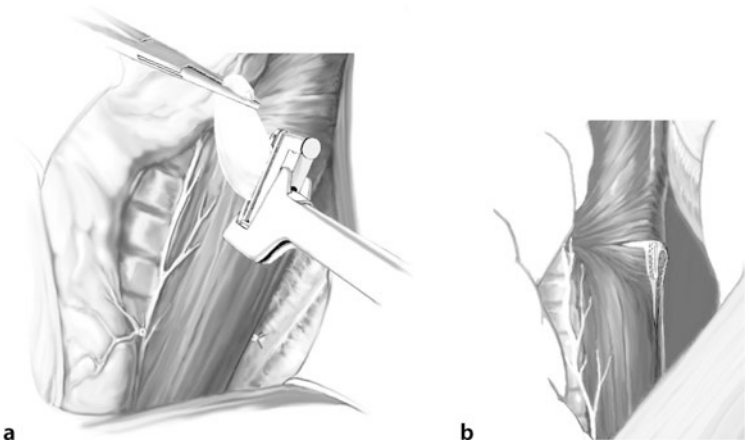


Fig. 16.8

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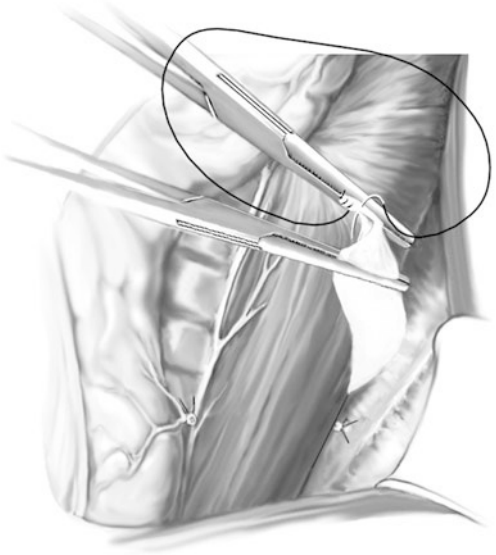


Fig. 16.9

Closure

A soft Penrose drain is placed at the resection line. The skin is closed after placing only a few subcutaneous sutures.

Standard postoperative investigations

- Contrast study of the upper gastrointestinal tract (not routinely performed before starting oral intake).
- Most patients may be started on a liquid intake within hours of the operation.
- The duration of hospitalization has been declining, and may be necessary for only 3 to 5 days.
- The drain is left *in situ* until solid food intake is possible.
- A solid intake should be started after the third postoperative day.

Postoperative complications

- Recurrent laryngeal nerve injury.
- Wound infection.
- Fistula formation/stump leakage – conservative treatment with drainage and opening of the wound is usually the appropriate treatment.
- Retropharyngeal abscess may require surgical intervention.
- Recurrence rates after resection of a cricopharyngeal diverticulum are low, if the cricopharyngeus muscle has been divided completely.

Tricks of the Senior Surgeon

- Placement of a large gastric tube helps to identify the esophagus and the diverticulum.
- Tension-free resection helps to avoid leakage.

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Epiphrenic Diverticula

Dedicated to the memory of Professor Gerald C. O'Sullivan – surgeon, scientist, mentor, and friend

Chris G. Collins

Introduction

An epiphrenic diverticulum is a herniation of a pouch of esophageal mucosa thought the musculature of the thoracic esophagus within 10 cm of the esophagogastric junction. The pathological process is thought to be the application of pulsion forces to the mucosa above a functionally obstructing region of abnormal esophageal motility. Investigations include endoscopy, contrast esophagogram and esophageal manometry. Operative interventions include laparoscopic, thoracic and thoracoscopic approaches in order to excise the diverticulum with a myotomy to address the underlying motility disorder.

Indications and Contraindications

Indications

- Dysphagia
- Pulmonary complications (recurrent pneumonia, aspiration pneumonitis, and lung abscess)

Contraindications

- Ongoing pneumonia or lung abscess (temporary)

Preoperative Investigation/Preparation for the Procedure

- **Clinical**
  - Full history and examination
  - Esophagogastroduodenoscopy (EGD): it is necessary to enter the diverticulum to examine the mucosa and exclude associated carcinoma
  - Esophageal manometry: it may be necessary to position the manometry probe distal to the diverticulum in order to accurately define the dysmotility. (High resolution manometry and twenty-four-hour recordings provide a more accurate diagnosis.)

- **Laboratory**

Routine biochemical profile to out rule any abnormality related to prolonged vomiting or forced fasting such as hypoalbuminia.

- **Radiology**
  - Plain chest radiograph
  - Contrast esophagogram (may need rotation to see smaller diverticulae)

Broad-spectrum antibiotics are given preoperatively (e. g., co-amoxiclav and metronidazole)

Treat complications of the diverticulum (aspiration pneumonia/lung abscess) prior to surgery.

Empty the diverticulum of retained secretions, food, or barium as completely as possible before anesthesia is induced to reduce the risks of aspiration.

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery*,
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What Not to Do

- Small asymptomatic diverticulae can be left alone. Regular follow-up is advised to detect malignant change or significant enlargement with regurgitation or aspiration.
- Failure to perform myotomy is associated with higher rates of recurrence and leak from the suture line.
- Candidates with an underlying motility disorder unfit or unwilling for surgery may benefit from endoscopic pneumatic dilatation.

Procedure

The focus of the procedure is on both the underlying motor disorder and the epiphrenic pouch. The main approaches are as follows:

- Laparoscopic abdominal approach (most common approach today)
- Thoracic approach mostly for larger and higher (> 10 cm from diaphragm) thoracic pouches
- Video-assisted thoracic approach

Laparoscopic Procedure

Access and Exposure

- The patient is placed in the lithotomy position with 20–30° reverse Trendelenburg ("French position") and the surgeon stands between the legs.
- Pneumoperitoneum is established and four ports inserted as shown (Fig. 17.1). The camera is inserted to the left of the midline 2–3 cm above the umbilicus (or higher depending on the size of the patient) and three additional ports are inserted under direct vision. The Nathonson retractor is inserted at the xiphisternum for liver retraction, left subcostal for traction on the stomach, and two working ports on either side of the midline.

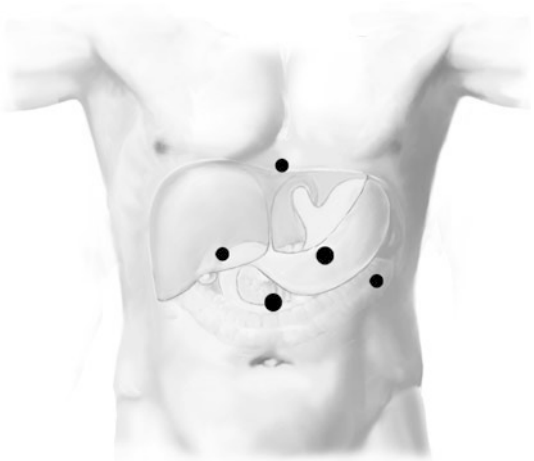


Fig. 17.1

Exposure

- The phrenoesophageal ligament is incised using endo-scissors or a harmonic scalpel.
- Dissection begins on the right crus and then moves to the left crus.
- The right crus is then dissected downward and the esophagus is encircled with a Penrose drain for traction, via the left subcostal port. The Penrose drain may be maintained in position for traction by approximation with a 3-0 endoloop.
- Mediastinal dissection is then carried out using blunt instruments and harmonic scalpel, staying close to the esophagus until the diverticular pouch is reached.

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Step-by-Step Procedure

Endoscopy and preparation of the diverticulum. An endoscope is inserted into the esophageal lumen to the level of the diverticulum and by using insufflation and transillumination the diverticular pouch is defined to allow safe dissection. The pouch is thoroughly dissected until the neck of the diverticulum is completely clear of all adherent tissue, with care to avoid injury to the pleural sacs (Fig. 17.2).

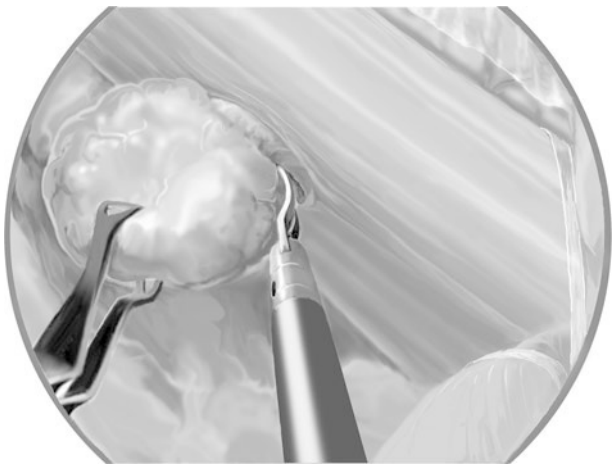


Fig. 17.2

Resection. An endoscopic stapling device is introduced through the operative trocar in the left upper quadrant and is advanced to the level of the diverticular neck (Fig. 17.3). The stapler jaws are closed under simultaneous endoscopic control; the endoscope is advanced into the stomach to prevent too much mucosa being excised, and it is then withdrawn. Once this is confirmed the stapler is fired and mucosal closure is verified. Additional stapler applications may be necessary to completely incise and close the diverticular neck. The pouch is removed and the staple line is inspected using the endoscope.

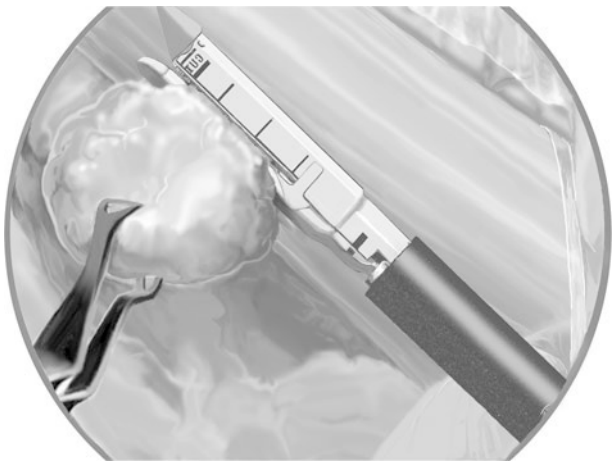


Fig. 17.3

Myotomy. A myotomy is performed on the opposite esophageal wall, with longitudinal and circular muscular fibers divided and the submucosal plane carefully dissected using a combination of blunt dissection and the harmonic scalpel. The myotomy is extended proximally above the upper limit of the diverticulum and distally for almost 1.5 cm onto the cardia using a combination of blunt dissection and either the harmonic scalpel or endoscissors (Fig. 17.4).

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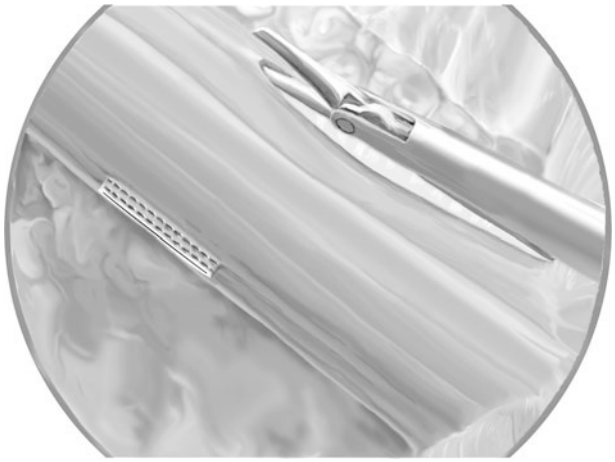


Fig. 17.4

Dor fundoplication. The hiatus is closed posteriorly with two or three interrupted sutures. The anterior wrap is performed by suturing the gastric fundus to the muscular edges of the myotomy (Dor type procedure) and the gastric fundus is also sutured to the superior part of the crura. The fundus is sutured to the right crus and to both the right and the left sides of the esophagus.

Thoracic Approach

Access

A standard left posterolateral thoracotomy through the seventh intercostal space (ICS). The lung and the pleural space are inspected thoroughly.

Exposure

The inferior pulmonary ligament is divided with diathermy to the level of the inferior pulmonary vein and the lung is retracted upward. The mediastinal pleura overlying the esophagus is incised longitudinally to expose the esophagus and diverticulum (Fig. 17.5).

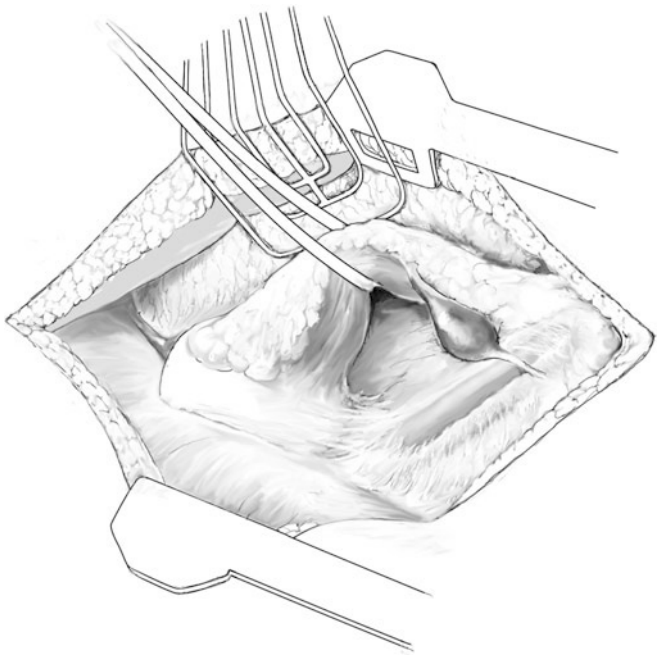


Fig. 17.5

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Step-by-Step Procedure

1. The esophagus is mobilized from its bed sufficiently to allow dissection of the diverticulum, which is most often located posteriorly.
2. The diverticulum is isolated, grasped with a Babcock type forceps, and carefully dissected from its attachments until the entire sac is free and attached to the esophagus only at the neck.
3. If the diverticulum has a wide neck a large bougie (60 F) is passed down the esophagus and the diverticulum is then stapled longitudinally using a stapling device (TA) and excised (Fig. 17.6).
4. The muscular layer is closed over the mucosal staple line with interrupted 3-0 sutures.
5. A 2–3 cm incision is made in to the abdomen through the phrenoesophageal ligament at the anterior margin of the hiatus along the midlateral border of the left crus. A tongue of gastric fundus is pulled up into the chest. This exposes the gastroesophageal junction and its associated fat pad. The fat pad is excised.
6. A longitudinal myotomy is performed along the anterior wall of the esophagus (opposite side to the diverticulum) from approximately 1 cm above the diverticulum extending down for about 1–2 cm into the musculature of the stomach (Fig. 17.7).
7. The cardia is reconstructed by suturing the tongue of the gastric fundus to the margins of the distal half of the myotomy for a distance of 4 cm using interrupted 3-0 Prolene sutures (Fig. 17.8). The fundus is then placed below the diaphragm and is sutured to the anterior lip of the crura.
8. A chest tube is left in situ and brought out through a separate intercostal stab wound in the lower thorax, and its outer end is connected to an underwater drain. The lung is expanded and the thoracotomy wound is closed in layers.

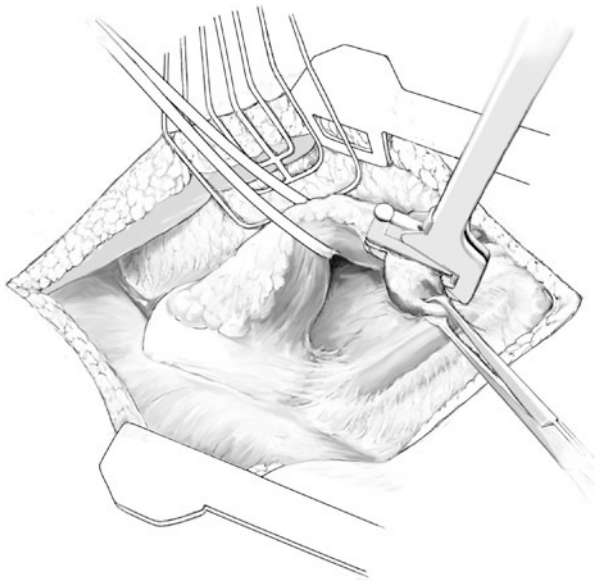


Fig. 17.6

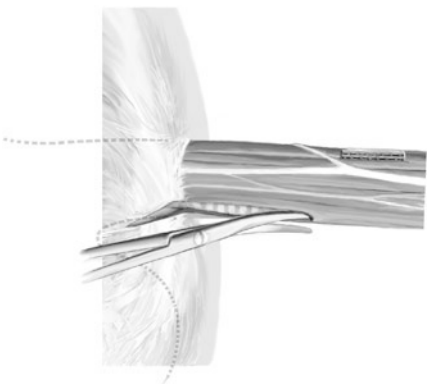


Fig. 17.7

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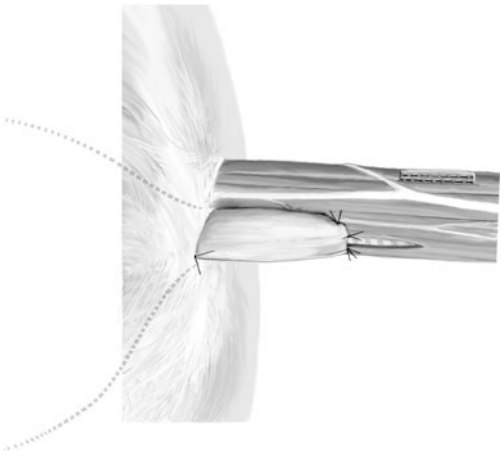


Fig. 17.8

Video-Assisted Thoracoscopic Approach

Access

The patient is positioned in a right lateral position as for left posterolateral thoracotomy. The left lung is deflated using a double-lumen endotracheal tube. Ports are inserted as follows:

- 10 mm at the sixth ICS at the posterior axillary line for the camera,
- 10 mm at the fifth ICS at the anterior border of the axillary line for retraction of the lung,
- 10 mm at the third ICS for the working cannula,
- 12 mm at the midaxillary line for the working cannula. The procedure is as for the open procedure.

Intraoperative Complications and Management

- Intraoperative hemorrhage is managed along standard lines.
- Perforation of mucosa at myotomy. This is tested for using insufflation with the gastroscope under saline. This most commonly occurs at the gastroesophageal junction. It is repaired using interrupted 4-0 suture and covered with the fundus of the stomach.
- The posterior vagus nerve is vulnerable when performing the diverticulectomy and should be isolated and protected. The anterior vagus is vulnerable during myotomy and should also be protected.
- Tension pneumothorax during laparoscopic repair should be monitored intraoperatively and if detected the insufflation pressure should be reduced and a chest drain inserted.

Postoperative Care

Thoracic approach only

- The chest drain is usually removed 48 hours postoperatively if the lung is completely expanded and there is no evidence of leak or infection.

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All Approaches

- The nasogastric tube is left on free drainage and aspirated every 4 hours for the first day and removed on the second or third postoperative day.
- Patients begin liquid oral intake following nasogastric tube removal, advancing to a full fluid diet as tolerated. Analgesics and antiemetics minimize nausea and vomiting.
- Once patients can tolerate a soft/puréed diet, they are allowed to go home with instructions about resuming a normal diet from 2 weeks postoperatively at home.

Standard Postoperative Examinations

A water-soluble non-ionic contrast swallow is performed on day 5 postoperatively:
- To exclude suture line leak
- To verify the position of the wrap
- To ensure that no significant obstruction has developed
- To provide an impression of gastric emptying

Carbonated beverages and very large meals must be avoided in the early postoperative period.

Postoperative Complications

Early (days to weeks)

- Hemorrhage. This usually occurs within 48 hours. This is managed along standard line with volume replacement and control of bleeding.
- Suture line leak. Early obvious leak is managed by thoracotomy. If symptomatic then proceed to thoracotomy and repair; if asymptomatic it is managed conservatively.
- Pleural effusion. Aspirate and evacuate to treat hemothorax or empyema.
- Empyema. This is managed by aspiration and the esophagus checked for suture line leak by upper gastrointestinal studies.
- Subphrenic abscess. This is managed by radiological guidance and suture line leak checked for by using upper gastrointestinal studies. These complications are rare.

Late (months to years)

- Recurrence of diverticulum. If symptomatic this is managed by open surgery.
- Gastroesophageal reflux with stricture (treated by dilatation and antireflux medication).
- Paraesophageal hernia (may require surgical therapy and repair of the hernia).
- Delayed gastric emptying or gastroparesis. This usually settles with prokinetic agents, but may require pyloroplasty.
- Post-thoracotomy pain. This is managed symptomatically.

Tricks of the Senior Surgeon
- Verification of impermeability of the suture line is confirmed using insufflation of air via the gastroscope in conjunction with insertion of saline via the laparoscope.
- Non-ionic contrast media is preferred to Gastrografin for the postoperative swallow as it provides superior images and is less reactive if aspirated or inadvertently leaks into thorax or abdomen.
- Small diverticulae may be treated by plication and myotomy.
- Intraoperative upper gastrointestinal endoscopy facilitates transillumination of the diverticulum, safe staple placement as well as suture line evaluation with insufflation.

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Techniques of Local Esophagoplasty in Short Esophageal Strictures

Asad Kutup, Emre F. Yekebas, Jakob R. Izbicki

Introduction

Local esophagoplasty is indicated for patients with short esophageal strictures when endoscopic therapies including bougienage and balloon dilatation are not effective.

Indications and Contraindications

Indications

- Short peptic stricture
- Short scarred stenosis

Contraindications

- Suspicion of malignancy

Preoperative Investigations/Preparation for the Procedure

- Esophagogastroscopy with multiple biopsies.
- Special preparation: no peculiarities compared to the previously mentioned operations.
- Anesthesia: endotracheal anesthesia; in case of intrathoracic stenosis, a double lumen tracheal tube with the possibility of separate ventilation should be used.

Procedure

Positioning and Access

These depend on the location of the stenosis.

- Cervical stenosis: left cervical approach with lateral rotation of the neck.
- Intrathoracic stenosis: right anterolateral thoracotomy using the fourth to sixth intercostal spaces (ICS).
- Stenosis of the abdominal part of the esophagus: "inverted T-incision" or median laparotomy.

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Step 1

Resection and technique of anastomosis

After resection of the stenotic segment, mobilization of the proximal and distal end of the esophagus restores the basis for reconstruction of the continuity with single layer end-to-end anastomosis in an interrupted suture technique. The distance of each suture should be 5 mm. Each stitch should be placed 5 mm distant to the anastomosis.

For stenoses less than 1 cm, stricturoplasty according to Heineke Mikulicz should be performed. Therefore a longitudinal esophagotomy is performed using a single-layer transverse closure with mattress sutures (Fig. 18.1).

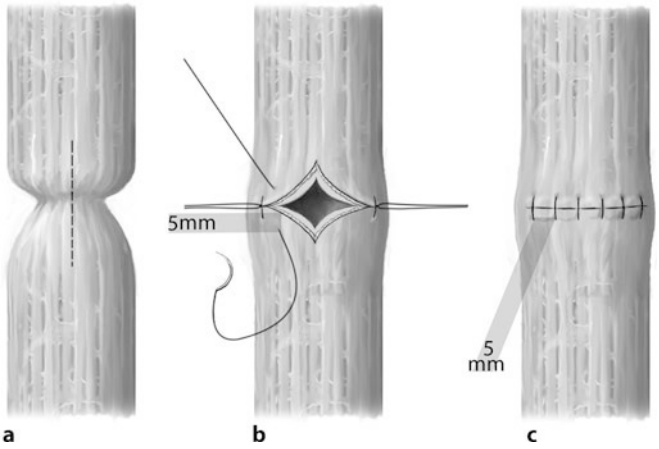


Fig. 18.1

Step 2

In case of limited stenosis

In stenosis limited to mucosa and submucosa, a transverse transection of the esophageal musculature over the stenosis suffices (Fig. 18.2a). The anterior part of the stricture is resected (Fig. 18.2b). Reconstruction of the continuity of the mucosa and submucosa in the posterior wall area (Fig. 18.2c) is done followed by transverse closure of the anterior wall with single-layer mattress sutures (Fig. 18.2d).

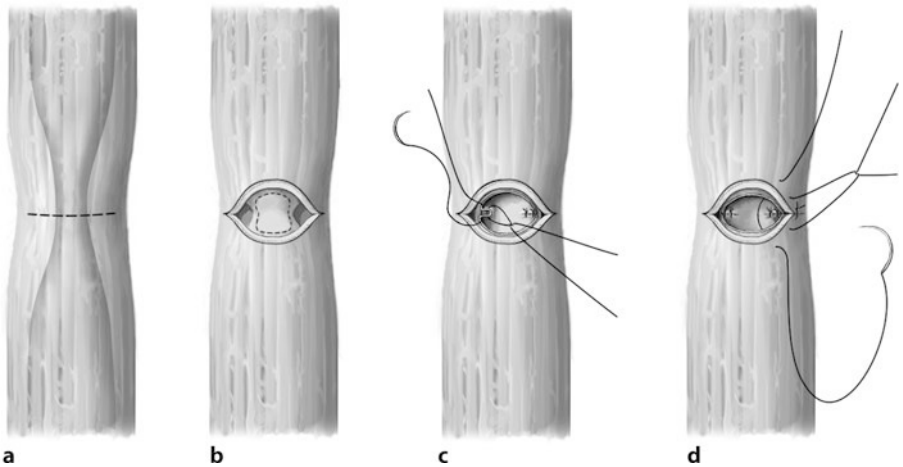


Fig. 18.2

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Step 3

In case of prestenotic dilatation

In case of a prestenotic dilation of the esophagus, side-to side esophagostomy of the pre- and poststenotic esophageal segment should be performed.

In all local esophagoplasties an intraluminally placed tube (large gastric tube) and abundant external drainage are obligatory (Fig. 18.3).

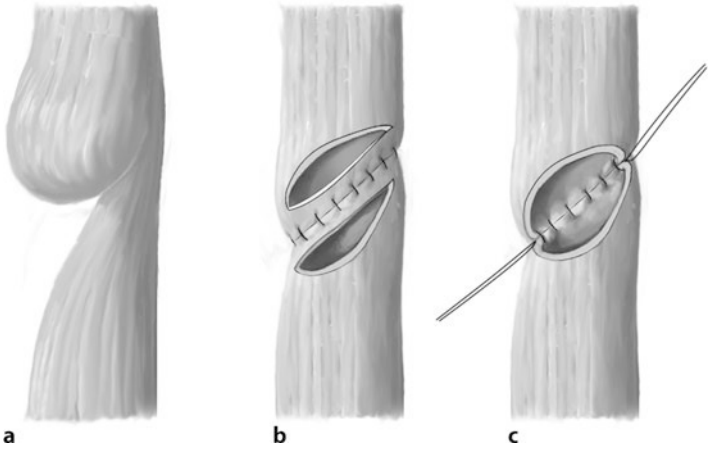


Fig. 18.3

Standard Postoperative Investigations

- Daily check for anastomotic leak of the esophagoplasty
- If problems occur after removal of the drain, a contrast study with water-soluble contrast is recommended
- In case of early detected anastomotic leak, esophagoscopy with the feasibility of endoluminal stenting

Postoperative Complications

- Leakage
- Mediastinitis
- Pleura empyema
- Peritonitis
- Re-stenosis

Tricks of the Senior Surgeon

- In case of caustic ingestions, organs adjacent to the esophagus (i. e., trachea) may be involved. In these instances, mobilization and repair of the esophagus has to be performed carefully.

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Operation for Achalasia

Luigi Bonavina, Alberto Peracchia

Introduction

In 1913 Heller reported the first esophageal myotomy for achalasia through a left thoracotomy. Over the years, the transabdominal approach has been extensively adopted, especially in Europe. More recently, laparoscopic Heller myotomy has emerged as the initial intervention of choice in several institutions throughout the world.

The operation consists of complete division of the two layers of esophageal muscle (longitudinal and circular fibers) and of the oblique fibers at the esophagogastric junction. A further step of the transabdominal procedure is the construction of an antireflux valve, most commonly an anterior Dor fundoplication.

Indications and Contraindications

Indications

In patients with documented esophageal achalasia, regardless of the disease's stage

Contraindications

Not deemed fit for general anesthesia and in those with:

- Significant co-morbidity
- Short life expectancy in whom pneumatic dilatation or botulinum toxin injection represents a more reasonable therapeutic option
- Extensive intra-abdominal adhesions from previous upper abdominal surgery can make the laparoscopic approach hazardous

Preoperative Investigation/Preparation for the Procedure

History and clinical evaluation:	Duration of dysphagia, nutritional status
Chest x-ray:	Atelectasis, fibrosis (s/p aspiration pneumonia)
Barium swallow study:	Degree of esophageal dilation and lengthening
Esophageal manometry:	Non-relaxing lower esophageal sphincter, lack of peristalsis
Endoscopy:	Rule out esophageal mucosal lesions, *Candida* colonization, associated gastroduodenal disease
CT scan and/or endoscopic ultrasound (EUS) in selected patients:	Rule out pseudoachalasia (malignancy-induced)

Insert a double-lumen nasogastric tube 12 hours before surgery to wash and clean the esophageal lumen from food debris

Short-term antibiotic and antithrombotic prophylaxis

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Laparoscopic Procedure

For details on access, see chapter "Laparoscopic Gastrectomy".

Instrumentation

- One monitor
- Three 5-mm trocars, two 10–12 mm trocars
- 30° laparoscope
- Standard laparoscopic instruments (Johannes forceps, needle holder, Endoclinch grasper, rod for liver retraction)
- Unipolar coagulation
- Ultrasonic scissors
- Gastroscope (optional, mostly used in redo procedures)

Step 1

Exposure

Incision of the phrenoesophageal membrane. Dissection is limited to the anterior surface of the esophagus and of the diaphragmatic crura to prevent postoperative reflux by preserving the anatomical relationships of the cardia. The cardia is mobilized only in patients with a markedly dilated sigmoid esophagus; in such circumstances, it is preferable to reduce the redundancy in the abdomen and to close the crura posteriorly.

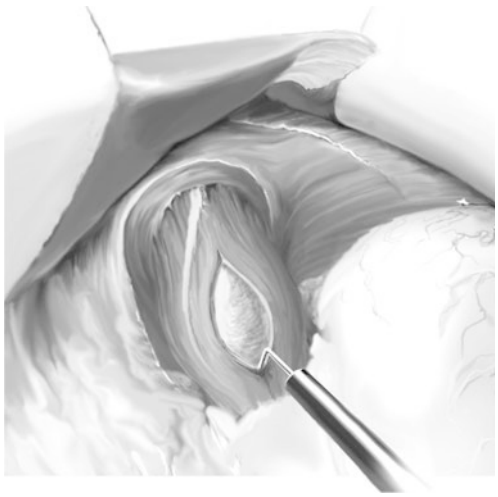
Step 2

Heller myotomy

The Heller myotomy is started on the distal esophagus using an L-shaped hook until identification of the submucosal plane.

The myotomy is extended on the anterior surface of the proximal esophagus for about 6 cm using insulated scissors, a harmonic scalpel, or Ligasure device.

The myotomy is extended onto the anterior surface of the gastric side including the oblique fibers for about 2 cm using the L-shaped hook (◘ Fig. 19.1).



◘ Fig. 19.1

Step 3

Intraoperative endoscopy

Intraoperative endoscopy aids in evaluating the length of the myotomy, dividing residual muscle fibers, and checking the patency of the esophagogastric junction and the absence of leaks. This is most helpful in patients previously treated by pneumatic dilatation or botulinum toxin injection.

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Step 4

Construction of the Dor fundoplication

The anterior wall of the fundus wall is sutured with three interrupted stitches (Prolene for extracorporeal knots, Ethibond for intracorporeal knots) to the adjacent left muscle edge of the myotomy. The most cranial stitch incorporates the diaphragmatic crus (Fig. 19.2).

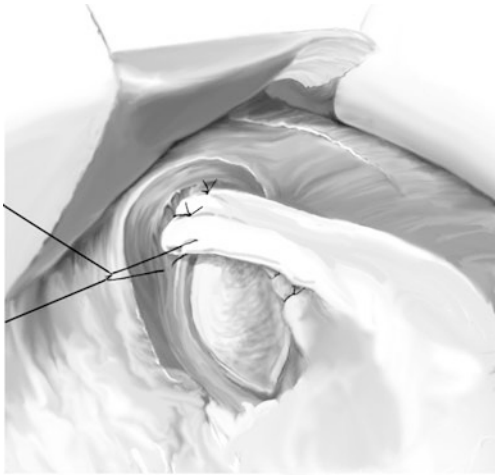


Fig. 19.2

Step 5

Security of the fundic wall

A more lateral portion of the anterior wall of the fundus wall is secured with three interrupted stitches to the right muscle edge of the myotomy and to the left diaphragmatic crus.

Standard Postoperative Investigations

Gastrografin swallow on postoperative day 1 to check for esophagogastric transit and absence of leaks

Postoperative Complications

- Persistent dysphagia
- Delayed esophageal emptying
- Recurrent dysphagia due to an incomplete distal myotomy or to an incorrect geometry of the Dor fundoplication
- Esophagectomy may be required in patients with decompensated sigmoid megaesophagus
- Gastroesophageal reflux
- Evidence of stricture may require mechanical dilatation followed by vagotomy and total duodenal diversion
- Leak after undetected perforation
- Consider revisional laparoscopy or endoscopic endoluminal stenting and percutaneous CT-guided drainage

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Tricks of the Senior Surgeon

- Once the submucosal plane has been identified, use a pledget swab or peanut to create a tunnel before cutting the muscle upward.
- Bleeding from the muscle edges of the myotomy is self-limiting; it is wise to avoid excessive electrocoagulation and to compress with a warm gauze for a few minutes.
- Be careful when the nasogastric tube or the endoscope is advanced into the stomach after the myotomy is performed to prevent iatrogenic perforation.
- Pay attention to include the sling fibers of the proximal stomach in the myotomy and to avoid tension in the construction of the Dor wrap to prevent twisting of the distal esophagus.

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Subtotal Gastrectomy, Antrectomy, Billroth II, and Roux-en-Y Reconstruction and Local Excision in Complicated Gastric Ulcers

Dean Bogoevski, Enrique Moreno Gonzalez, Carmelo Loinaz, Dr. Reeh Matthias

Subtotal Gastrectomy

In subtotal gastrectomy, at least 75 % of the stomach is resected. Gastrointestinal continuity is reconstructed using the proximal jejunum either as an omega loop or as a Roux-en-Y reconstruction.

Indications

- Gastric carcinoma of the intestinal type in the distal part of the stomach
- Complicated ulcers of the distal part of the stomach and the duodenum

Preoperative Investigations/Preparation for the Procedure

- In gastric carcinoma patients, the carcinoma should be clearly identified histologically as an intestinal type.
- The location of the carcinoma/ulcerative lesion should be clearly identified by means of endoscopy.

Procedure

Step 1

Abdominal incision and mobilization of the stomach

For laparotomy, a transverse epigastric incision should be chosen. In case of inadequate exposure, this incision should be extended with an upper midline extension (reverse T laparotomy). This approach provides adequate exposure up to the gastroesophageal junction. A valuable alternative is the midline laparotomy. Following the exploration of the whole abdominal cavity for metastatic disease in case of gastric cancer, the gastric lesion should be located.

The greater omentum of the stomach is dissected from the transverse colon, exposing the posterior wall of the stomach and opening the lesser sac (Fig. 20.1).

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Step 1 *(continued)*

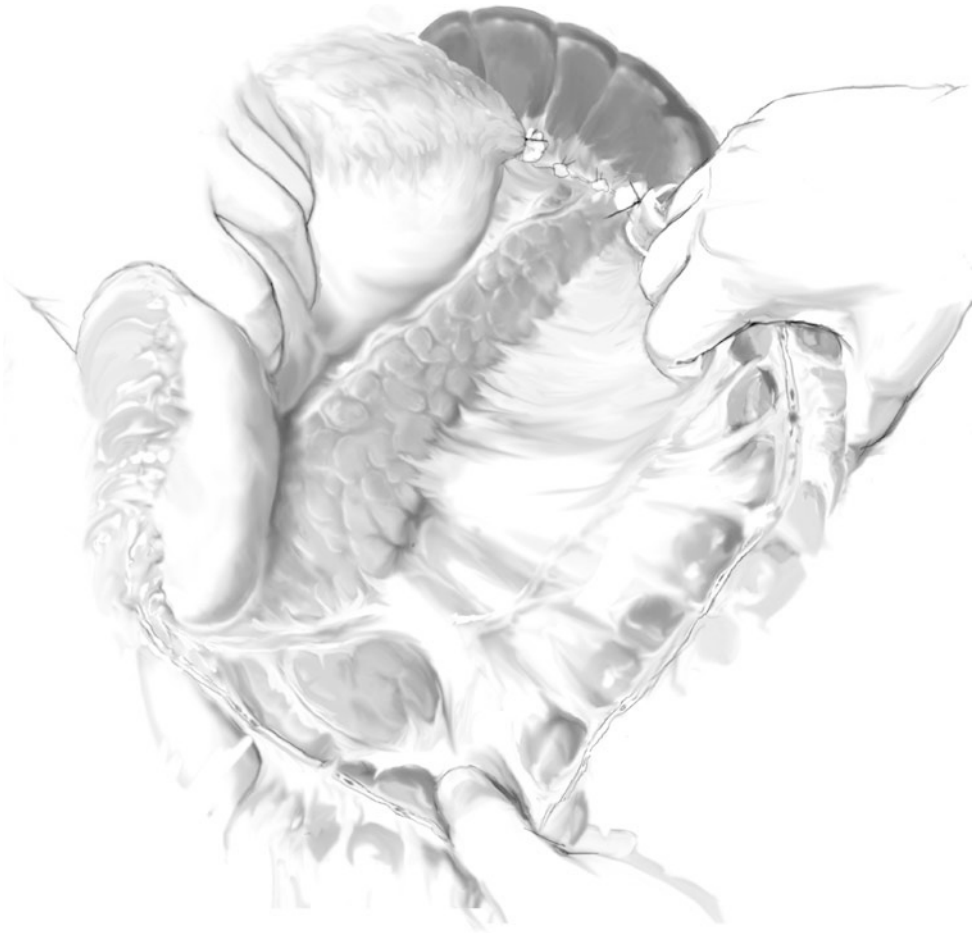


Fig. 20.1

The pylorus is freed from adjacent connective tissue (Fig. 20.2), and the lesser omentum is opened along the minor curvature. Care has to be taken not to overlook an accessory left hepatic artery. The left gastric artery is exposed at its origin as well as the coronary vein. Both structures are ligated and transected (Fig. 20.3). Thus, the lymphatic tissue along the lesser and greater curvature is included in the specimen. The right gastric artery and vein are ligated and transected as well as the right gastroepiploic artery and vein at the greater curve, preserving the arcade vessels of the proximal part of the stomach.



Fig. 20.2

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Step 1 *(continued)*

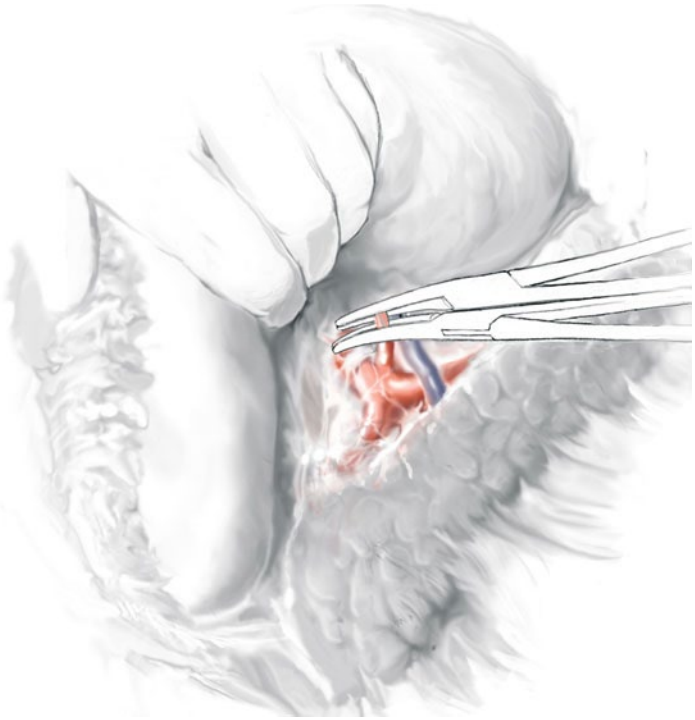


Fig. 20.3

Step 2

Resection

The resection margins are set about 1 cm distal to the pylorus and the proximal third of the stomach (Fig. 20.4). The duodenum is divided with the stapler device. It is recommended to make a single-layer closure of the gastric incision with a running suture or interrupted stitches. In case a stapler device is used, the serosa should be approximated with seromuscular stitches (Fig. 20.5). The duodenal stump should be treated with special care, avoiding any tension on the suture line. For its closure, the staple line is oversewn with interrupted seromuscular stitches (Fig. 20.6). For the gastrojejunostomy, an omega loop (i. e., the Billroth II reconstruction (Steps 1–3) or a Roux-en-Y reconstruction (Step 1) is used.

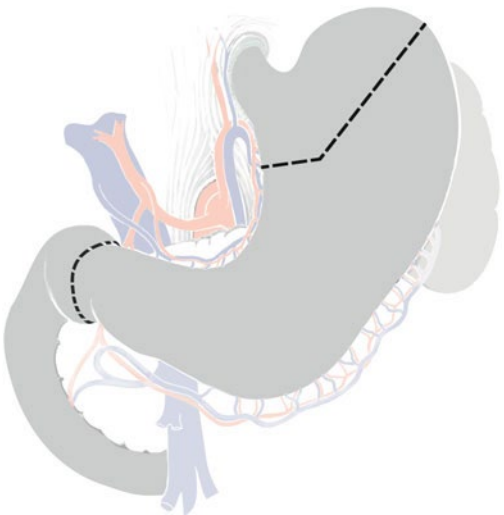


Fig. 20.4

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Step 2 ***(continued)***

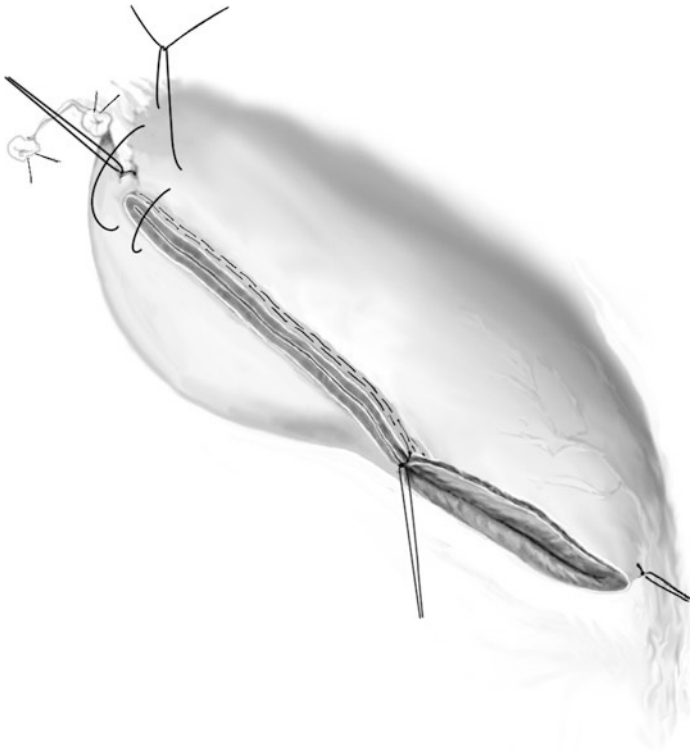


Fig. 20.5

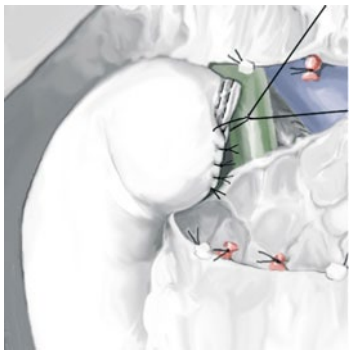


Fig. 20.6

Antrectomy

Indications

In antrectomy, the distal 25 to 40% of the stomach is resected.

- Complicated duodenal ulcers and ulcers of the prepyloric region. Antrectomy is performed in combination with bilateral selective vagotomy. This procedure reduces acid secretion by reduction of acetylcholine stimulus of the vagus nerve and gastrin production of the antrum.

Preoperative Investigations

- Endoscopic verification of the lesion
- Exclusion of gastrinoma and hypercalcemia as risk factors
- Exclusion of carcinoma (multiple biopsies)

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Procedure

Step 1

Mobilization of the stomach and vagotomy

As in subtotal gastrectomy, the stomach is mobilized and freed from the omentum, and the pylorus is isolated. The vagal trunks are identified on the distal part of the esophagus, with the anterior nerve lying to the left of the esophagus, and the posterior nerve lying on the back or to the right of the esophagus (Fig. 20.7). For truncal vagotomy about 2 cm of each nerve is resected, and the nerves are ligated about 5 cm proximal to the esophago-gastric junction; care should be taken to look for and transect any accessory vagal branches that have originated proximal to the site of vagal nerve transection. These nerves tend to innervate the proximal great curvature of the stomach. Also the esophagus should be isolated and any other branches going to the stomach arising from cranial to the point of ligation and excision of the segment should be sought for and also transected , especially the so called criminal nerve of Grassi. Alternatively, a selective vagotomy can be performed by transecting all the branches of the anterior and posterior vagus traveling to the esophagus and stomach starting about 7 cm proximal to the esophagogastric junction through the esophageal hiatus and then transecting the trunks of both the anterior and posterior vagus nerves distal to the takeoff of the intestinal branches that travel toward the celiac axis and the hepatic branch that travels with the left hepatic artery in the lesser omentum (Fig. 20.8). By a selective vagotomy the intestinal vagal fibers can be preserved (Fig. 20.8).

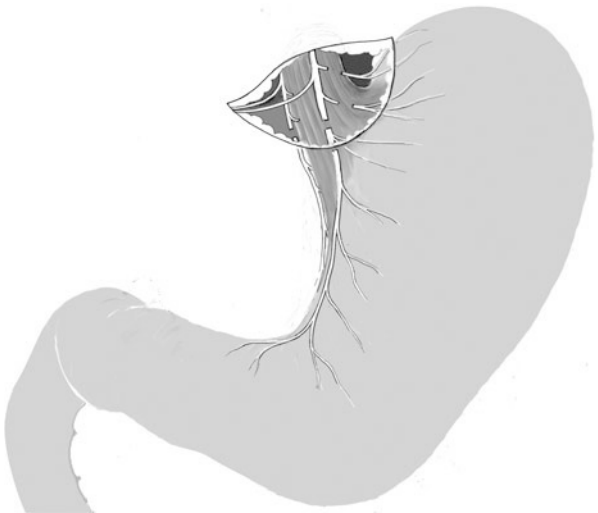


Fig. 20.7

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Step 1 ***(continued)***

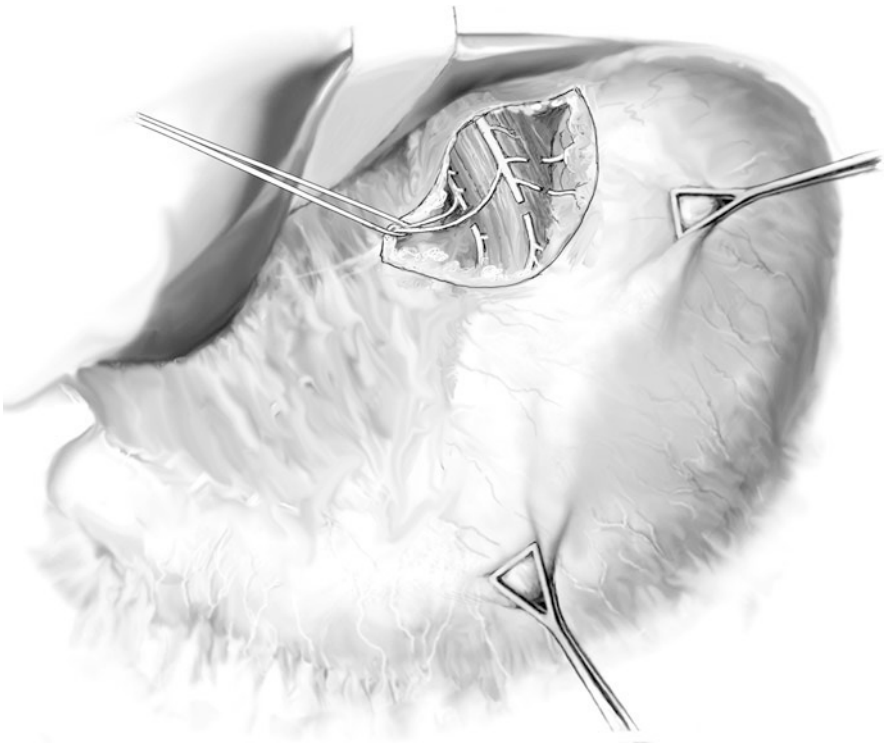


Fig. 20.8

Step 2

Exposure of the antrum

The pylorus (see "Subtotal Gastrectomy" Step 1) and the distal part of the stomach are transected, ligating the vasculature on the greater and lesser curvature. Using a stapling device is the most convenient way to perform the resection.

Step 3

Resection margins

The gastric resection line is positioned just proximal to the incisura on the lesser curvature and along the greater curvature at the junction of the right and left gastroepiploic vessels.

Step 4

Reconstruction of the passage

For reconstruction of gastrointestinal continuity, the Billroth II (Steps 1–3) or the Roux-en-Y procedure is used (Step 1).

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Billroth II Reconstruction

Procedure

The gastrojejunostomy is done with an omega loop.

Step 1

Placement of the omega loop

Choose a loop of the proximal jejunum that can easily be mobilized to the distal part of the posterior wall of the remnant stomach. The distance of the loop is kept short when a retrocolic route is chosen.

Prepare a small passage in the mesentery of the transverse colon and pull the omega loop through the defect in the transverse colonic mesentery. Keep in mind that no tension is applied on the mesentery when the loop is in place (Fig. 20.9).

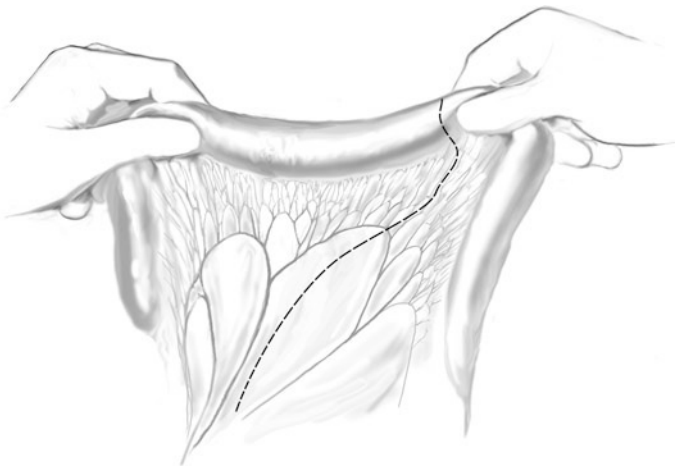


Fig. 20.9

Step 2

Gastrojejunostomy

Open the closure of the distal gastric remnant and the antimesenteric side of the omega loop. For the backward layer, use interrupted stitches or a running suture (Fig. 20.10).

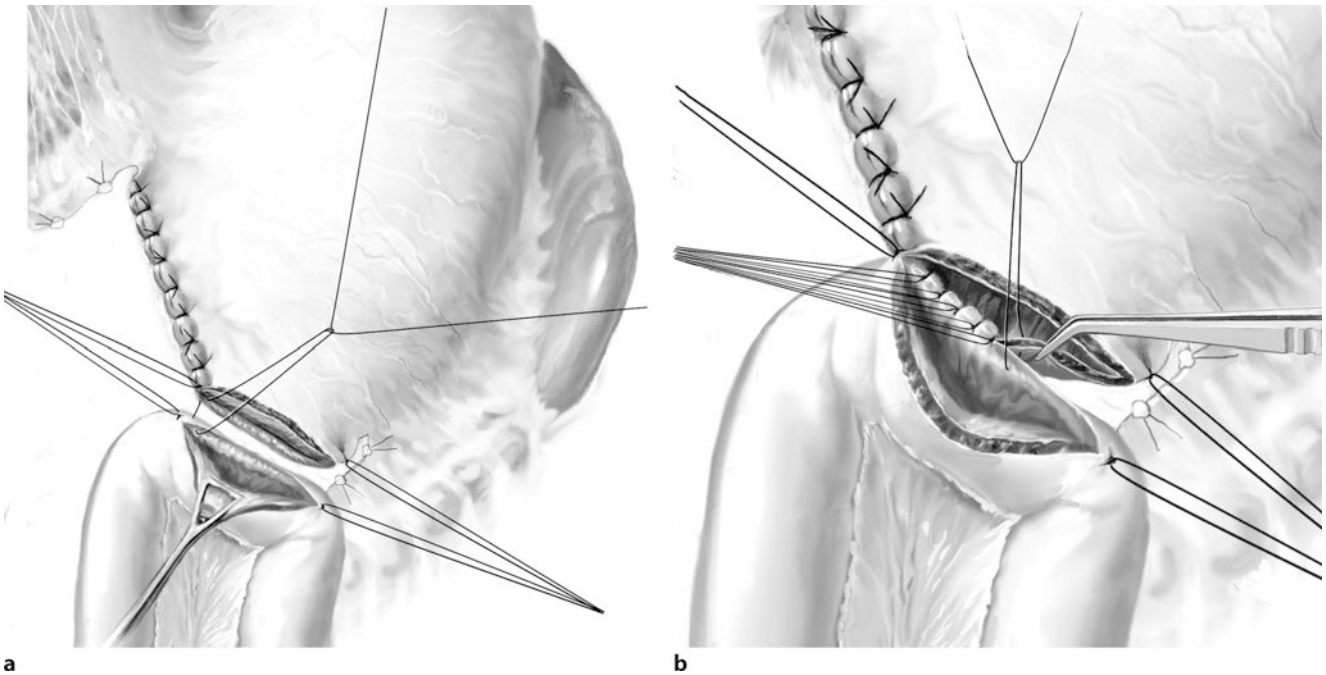


Fig. 20.10

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Step 2 ***(continued)***

For the anterior layer, a running inverting suture is adequate. However, a monolayer with interrupted stitches is also possible as well as the use of a stapling device (Fig. 20.11). To avoid anastomotic stricture, the gastrojejunostomy should be performed over a distance of at least 5–6 cm for a retrocolic gastrojejunostomy, after completion of the anastomosis, the stomach just proximal to the anastomosis should be sewn to the edges of the mesenteric defect to keep the anastomosis below the transverse mesocolon to prevent retraction of the anastomosis into the lesser sac and potentially leading to an obstruction at the defect in the transverse mesocolon.

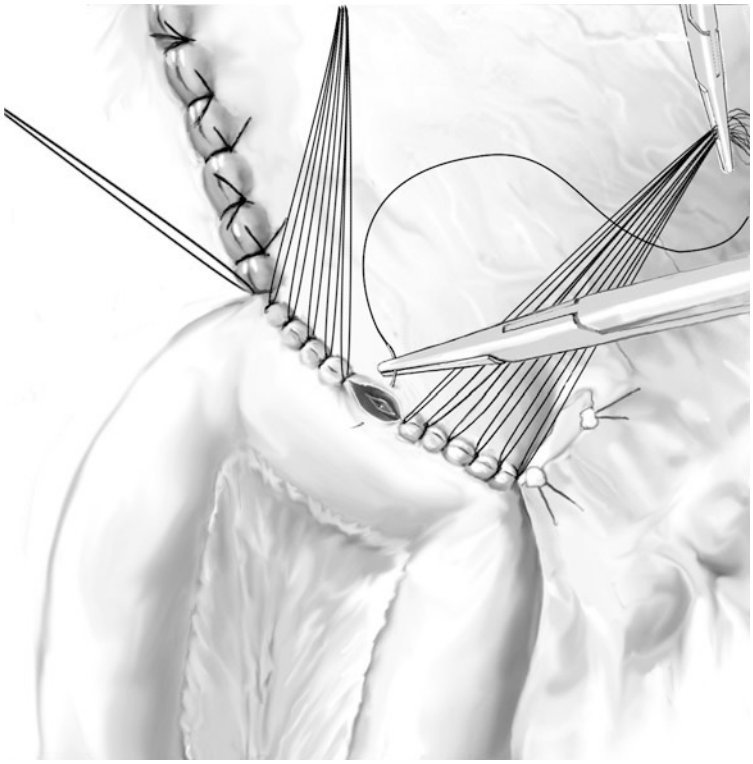


Fig. 20.11

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Step 3

Braun's anastomosis

Braun's anastomosis is performed as distal as possible (>40 cm) to avoid biliary reflux into the gastric remnant. Side-to-side jejunostomy is done either with interrupted stitches, a running suture, or a stapler device (Fig. 20.12).

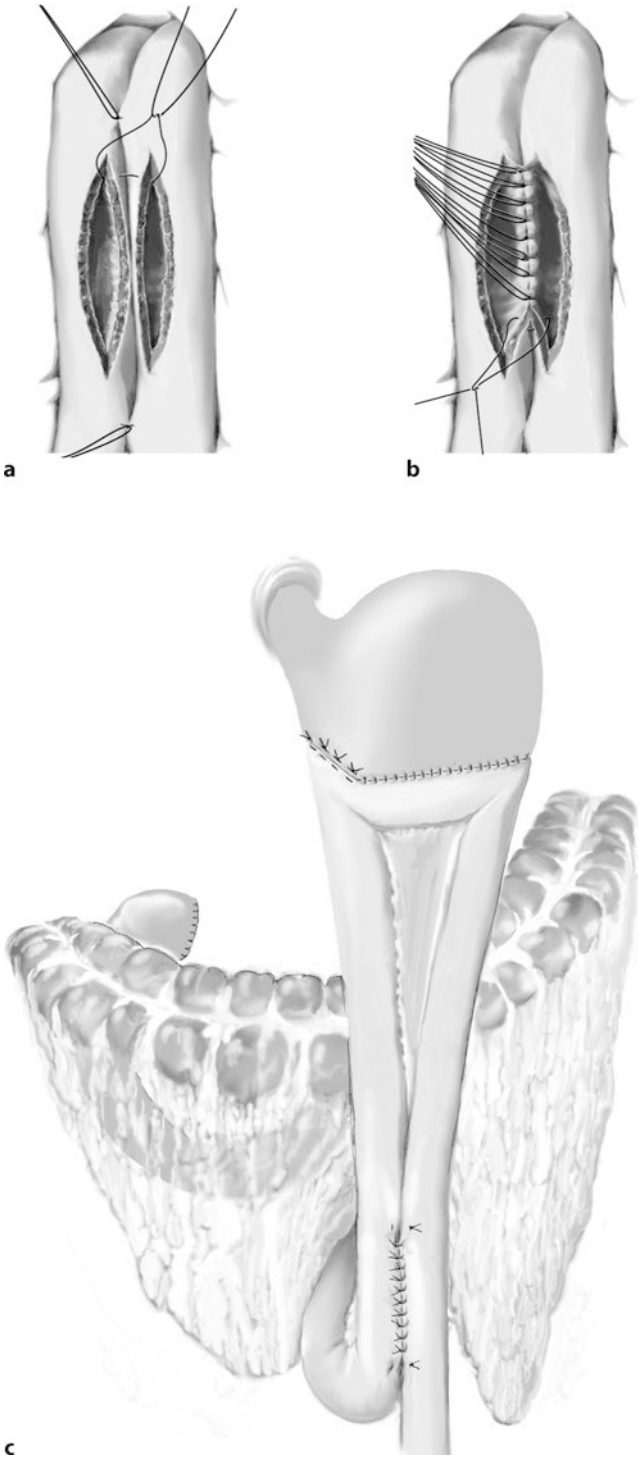


Fig. 20.12

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Roux-en-Y Reconstruction

Procedure

Step 1

Dissection of the jejunum

The ligament of Treitz is identified, and the jejunum is transected about 40–50 cm distal to Treitz' ligament (Fig. 20.13a). For convenience, a stapler device may be used. The blind end of the distal part is closed using a running suture or interrupted stitches. The distal loop is placed side-to-side to the posterior wall of the gastric remnant without exerting any tension on the mesentery. A retrocolic route is preferable. Before performing the anastomosis, the serosa of the jejunal loop is fixed to the serosa of the gastric remnant over a distance of 5–6 cm, thus building the outer layer of the backward suture (Fig. 20.13b).

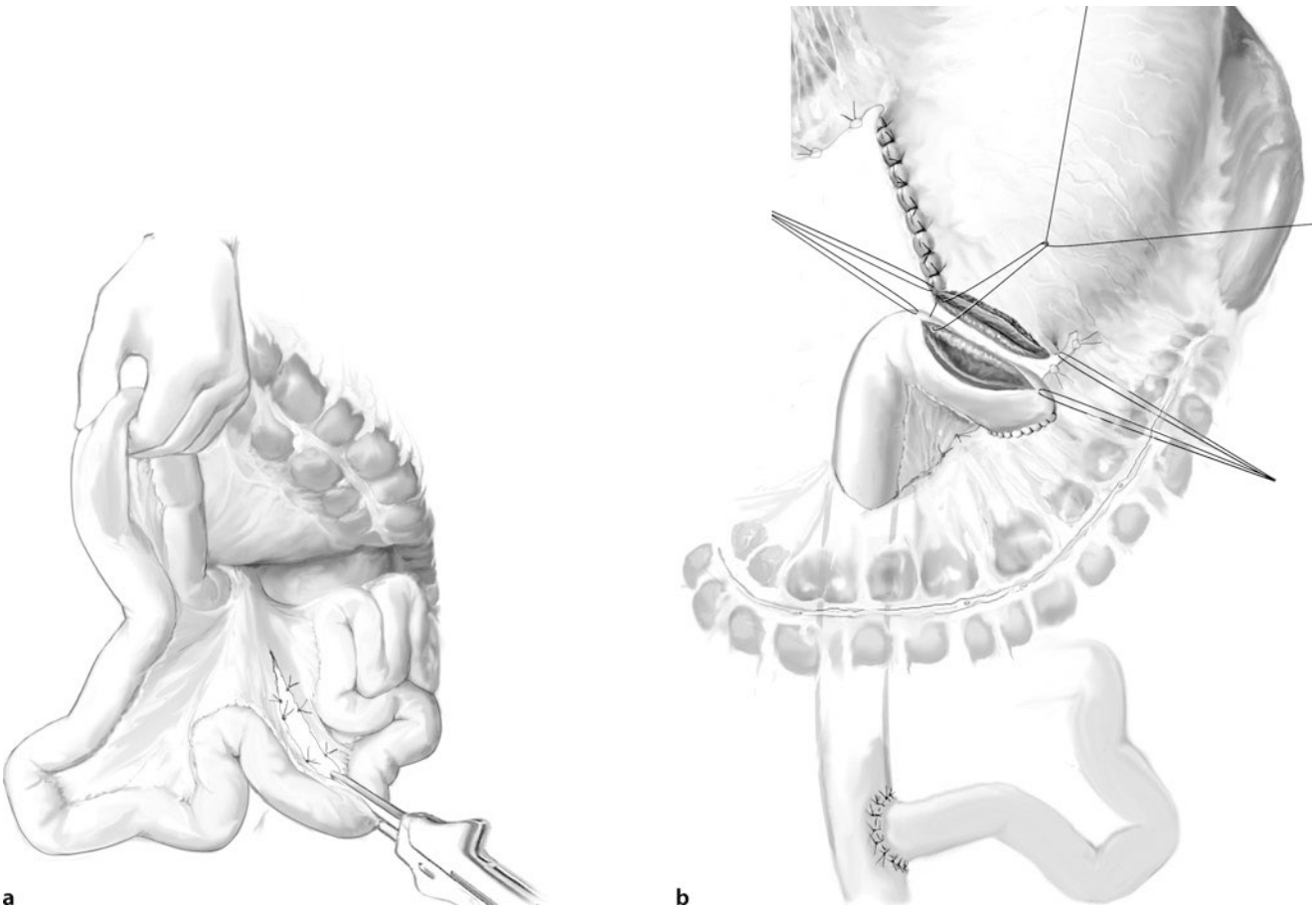


Fig. 20.13

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Step 2

Gastrojejunostomy

The jejunal loop and the gastric wall are opened along the antimesenteric border using electrocautery, and the posterior part of the anastomosis is done with a running suture representing the inner layer, completed by a running inverting suture on the anterior part of the gastrojejunostomy. However, interrupted stitches in monolayer technique as well as the appliance of a stapler device are also adequate. The technique is similar to the gastrojejunostomy in the Billroth II reconstruction (Step 2).

The transected limb of proximal jejunum is anastomosed end-to-side to the Roux-en-Y limb 40 to 60 cm distal to the gastrojejunostomy.

Postoperative Investigations

- We prefer to use a nasogastric tube to keep the stomach remnant decompressed for two days to facilitate healing of the gastrojejunostomy and until oral feeding can be started.

Postoperative Complications

- **Short term**
- Anastomotic leakage of the gastrojejunostomy
- Leakage from the duodenal stump
- Acute pancreatitis, pancreatic fistula
- Early dumping syndrome
- Biliary stricture

- **Long term**
- Biliary reflux
- Stricture of the gastrojejunostomy
- Stump carcinoma
- Late dumping syndrome

Local Excision in the Stomach

Ulcers that do not respond to medical treatment, perforation, or bleeding require surgical intervention. Gastric ulcers in bleeding, an endoscopic treatment is the first-line approach. If bleeding cannot be controlled by endoscopic means, surgical excision is the therapy of choice.

Local excision in the stomach is indicated when the extension of the ulcer allows for re-approximation of the edges of the excision without exerting any tension on the anastomosis. The test for Helicobacter pylori and the maintenance of antacid medications are mandatory. Work-up includes gastrin testing and testing for elevated serum calcium levels, both risk factors in complicated ulcers.

Indications

- Endoscopically uncontrollable bleeding and perforation are indications. for an emergency procedure.

Standard Preoperative Investigations

In Case of Bleeding

- Endoscopy with the identification of the bleeding site: active bleeding is identified by endoscopy or systemic hemoglobin values. Blood pressure and heart rate are recorded.

In Case of Suspected Perforation

- Standard x-ray of the abdomen in upright and left semiprone positions.
- Gas insufflation via a gastric tube may facilitate the diagnosis in conventional x-ray examination; in case of peritonitis without direct evidence of free abdominal gas, a CT scan should be obtained.
- Especially in retroperitoneal perforation of the duodenum, free gas may not be seen in standard x-ray films.

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Procedure in Perforated Gastric Ulcers

Step 1

Exposure of the ulcerative lesion

The ulcerative lesion is completely exposed. In case of perforation of the posterior gastric wall, the omentum of the stomach and of the colon is separated, and the omental bursa is exposed (see Fig. 20.2).

Step 2

Excision of the ulcer

In case of chronic granulation, the wall of the ulcer is excised longitudinally (Fig. 20.14).

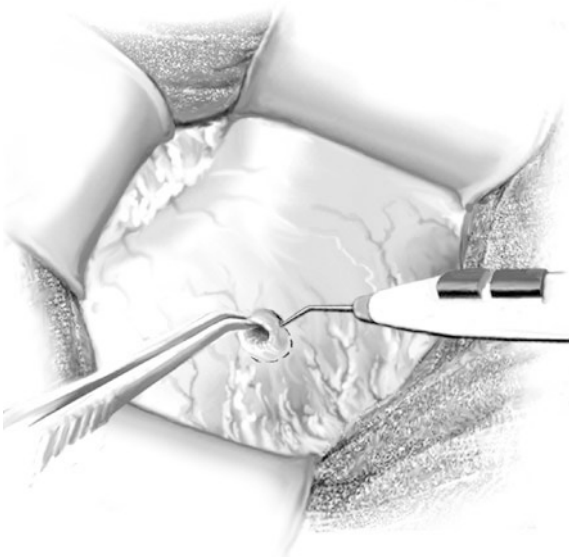


Fig. 20.14

Step 3

Closure

The ulcer is closed in a crosswise technique by single layer stitches with an absorbable suture (Fig. 20.15).

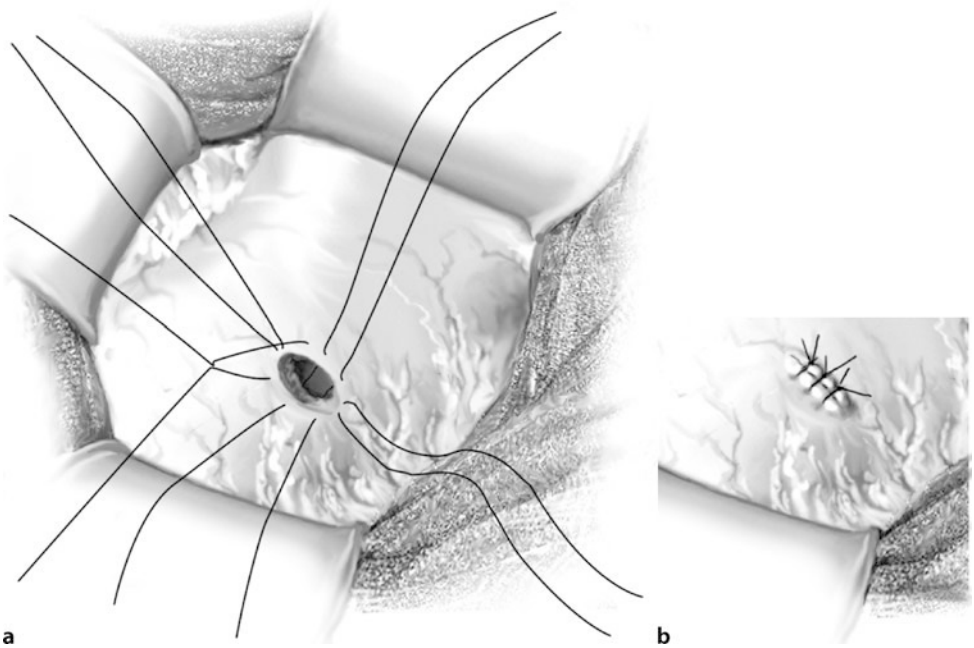


Fig. 20.15

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Procedure in Bleeding Gastric Ulcers Refractory to Endoscopic Treatment

Step 1

Gastrotomy and exposure of the bleeding site

In bleeding without perforation, gastrotomy is the exposure of choice. Use a longitudinal incision of the anterior gastric wall.

Step 2

Isolation of the bleeding

In bleeding of the posterior gastric wall, verify if the source of bleeding arises from an ulceration of the splenic artery. In this case, obtain proximal and distal control of the artery, ligate these regions and then address excision of the ulcer. Additional stitches placed around the ulcer wall on all four sides may help to control bleeding. The use of a nonabsorbable suture is preferable. Collaterals maintain blood supply to the spleen, and splenectomy is not required.

Step 3

Closure

Closure of the incision with the single-layer technique.

Local Excision in the Duodenum

In complicated duodenal ulcers, local excision is the therapy of choice. Depending on the size of the ulcer and its surrounding tissue, a duodenojejunostomy with a Roux-en-Y reconstruction may be indicated. Further, the gastroduodenal artery should be ligated in case of bleeding ulcers.

Indications and Preoperative Investigations

These correspond to those in gastric ulcers and bleeding (see "Local Excision in the Stomach", earlier).

Procedure in Complicated Duodenal Ulcers

Ventral Duodenal Wall

Step 1

Exposure of the duodenum

The duodenum is completely exposed and opened longitudinally on the lateral wall after a full Kocher maneuver.

In case of perforation, the ulcerative lesion is excised (Fig. 20.16).

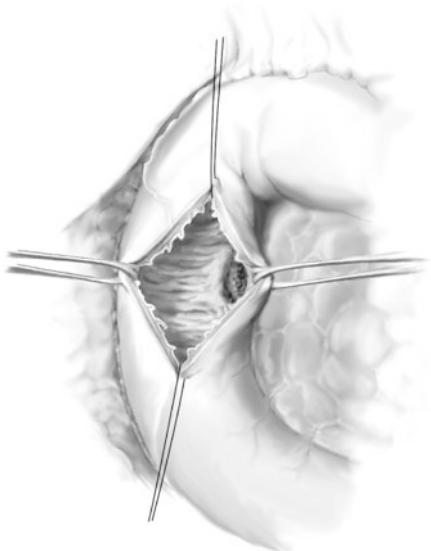


Fig. 20.16

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Step 2

Closure of the incision

The incision is closed crosswise using single stitches. Kocher's maneuver may lower the tension to the suture. Mind that the duodenal passage is not compromised. Depending on the extent of the excision, primary closure might not be advisable. In this case, a duodenojejunostomy is required using a Roux-en-Y reconstruction (Fig. 20.17).

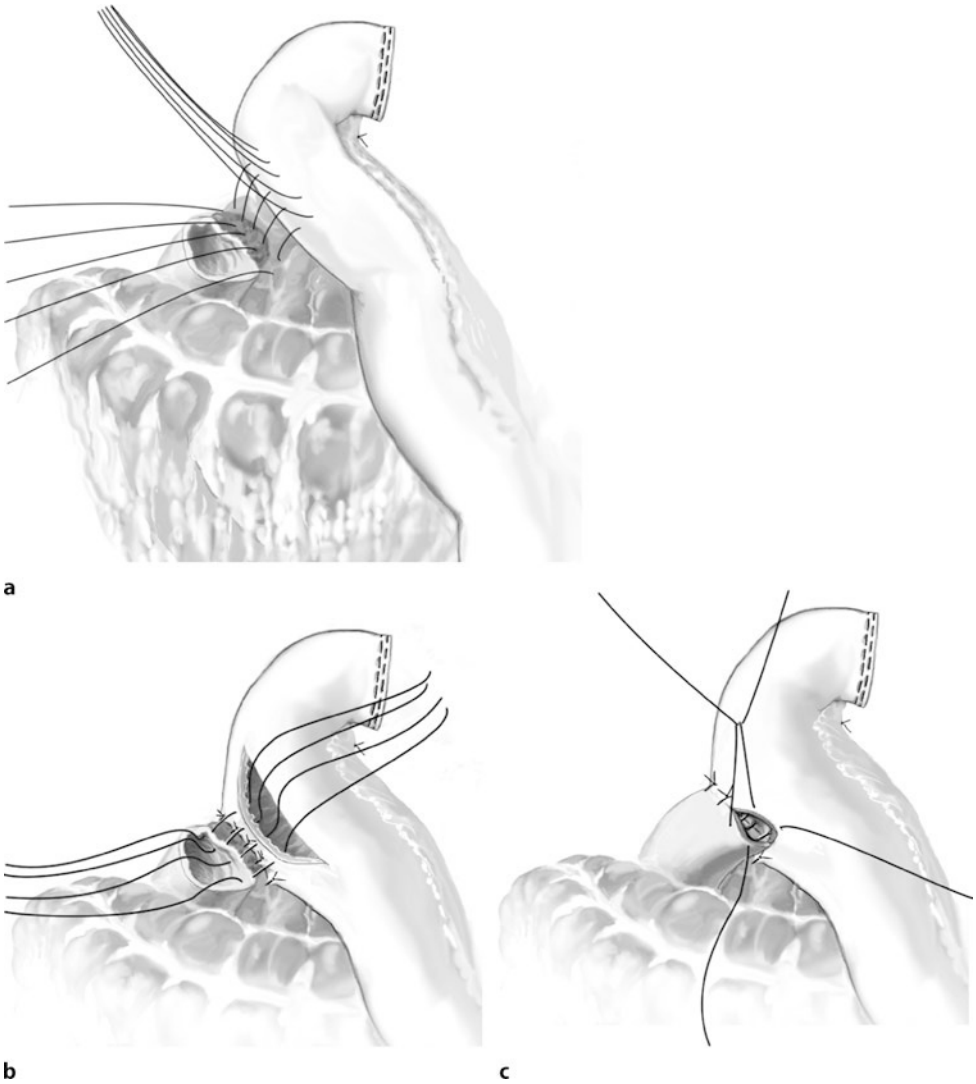


Fig. 20.17

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Posterior Duodenal Wall

Step 1

Exposure of the duodenum

After exposing the duodenum, Kocher's maneuver is performed, and the posterior wall of the duodenum is completely exposed in case of perforation. In case of bleeding, the anterior wall is opened, and interrupted stitches are placed on all four sides of the ulcerative lesion (Fig. 20.18).



Fig. 20.18

Step 2

Excision of the ulcerative lesion

The ulceration is excised (see "Local Excision in the Stomach", Step 2). As a rule, primary closure of the lesion may not be advisable, as mobilization of the posterior duodenal wall is limited. Hence, a duodenojejunostomy is put in place. The gastroduodenal artery is exposed and ligated at its origin. In case of bleeding ulcers, this step might be taken first, when the bleeding source has previously been identified in gastroduodenoscopy.

Standard Postoperative Investigations

The clinical course of the patient and the careful daily observation of the drains if placed are the key points in postoperative care.

Postoperative Complications

- Anastomotic leaks and abscess formation
- Peritonitis
- Anastomotic strictures
- Delayed gastric emptying
- Recurrence of bleeding and ulcerations
- Pancreatitis
- Lesion to the pancreatic duct/papilla Vateri with biliary congestion

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Tricks of the Senior Surgeon

- When mobilizing the minor curvature of the stomach, bear in mind that a replaced left hepatic artery may be present.
- Take care that the duodenal stump is closed without any tension on the wall.
- Mobilize the duodenum if required.
- The gastroduodenal artery should be carefully preserved to maintain adequate blood supply to the duodenum in case of Billroth II reconstruction.
- To avoid any biliary reflux, choose an adequate length of the jejunal limb > 40 to 50 cm distal to the gastrojejunostomy.
- Transillumination of the mesentery of the proximal jejunum will nicely outline the vascular arcade when constructing a Roux-en-Y limb.
- To avoid any stricture of the anastomosis, choose a length of the gastrotomy for the anastomosis of 5–6 cm in gastroenterostomy.
- In case of Roux-en-Y reconstruction, the blind end of the jejunal loop should be kept short to avoid the building of a reservoir within the blind end.
- In case of Billroth II procedure and an inadvertent injury to the spleen requiring a splenectomy, take care that the remnant part of the stomach is adequately supplied with blood as the short gastric arteries arise from the splenic artery. In case of hypoperfusion, resection of the gastric remnant is necessary, and an esophagojejunostomy should be done.

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Total Gastrectomy with Conventional Lymphadenectomy

Jürg Metzger

In 1884 Connor attempted the first total gastrectomy in humans, reestablishing continuity with an esophagoduodenostomy. His patient did not survive the operation. In 1897 Schlatter carried out the first successful total gastrectomy. In 1892, Roux described a new procedure where the jejunal loop was divided and the distal limb was joined to the esophagus. The proximal limb of the loop was anastomosed to the jejunum some 45 cm distal to the esophagus. A large number of gastric substitutes have been tried over the past century, grouped into large and small bowel procedures. Some operations preserve the continuity through the duodenum. Others bypass the duodenal passage. Some procedures include a pouch construction and/or an antireflux modification. Currently, Roux-en-Y reconstruction is still the most widely used procedure after a total gastrectomy.

Indications and Contraindications

Indications

- Adenocarcinomas arising in corpus or fundus of the stomach
- Malignant tumors arising in the antrum of the stomach and showing less well differentiated histology (high grade tumors)
- Zollinger-Ellison syndrome
- Mesenchymal tumors (e. g., gastrointestinal stromal tumors [GISTs])
- Palliative gastrectomy for severe bleeding
- Familial gastric carcinoma

Contraindications

- Peritoneal carcinomatosis
- Malignant infiltration into neighboring organs
- Child-Pugh B–C cirrhosis with severe portal hypertension

Preoperative Investigation and Preparation for the Procedure

History:	Cardiac disease, pulmonary disease, gastric outlet function, melena, alcohol, smoking, Helicobacter pylori infection, diet, geographic risk, genetic factors
Clinical evaluation:	Nutritional status (NRS: nutritional risk score)
Laboratory tests:	Hb, coagulation parameters, tumor markers, albumin, prealbumin
Gastroscopy:	To prove the diagnosis (biopsies), endoscopic ultrasound CT scan: assessment of resectability, distant metastases
Diagnostic laparoscopy:	If peritoneal carcinosis is suspected

Procedure

- **Access**

Midline incision or bilateral subcostal incision, division of round and falciform ligament (Fig. 21.1)

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Step 1

Exposure and exploration of the abdomen with focus on

- Liver metastases
- Peritoneal carcinosis
- Tumor localization and size
- Lymph node enlargement
- Penetration into pancreas, spleen, and transverse colon
- Mesentery of the proximal small bowel

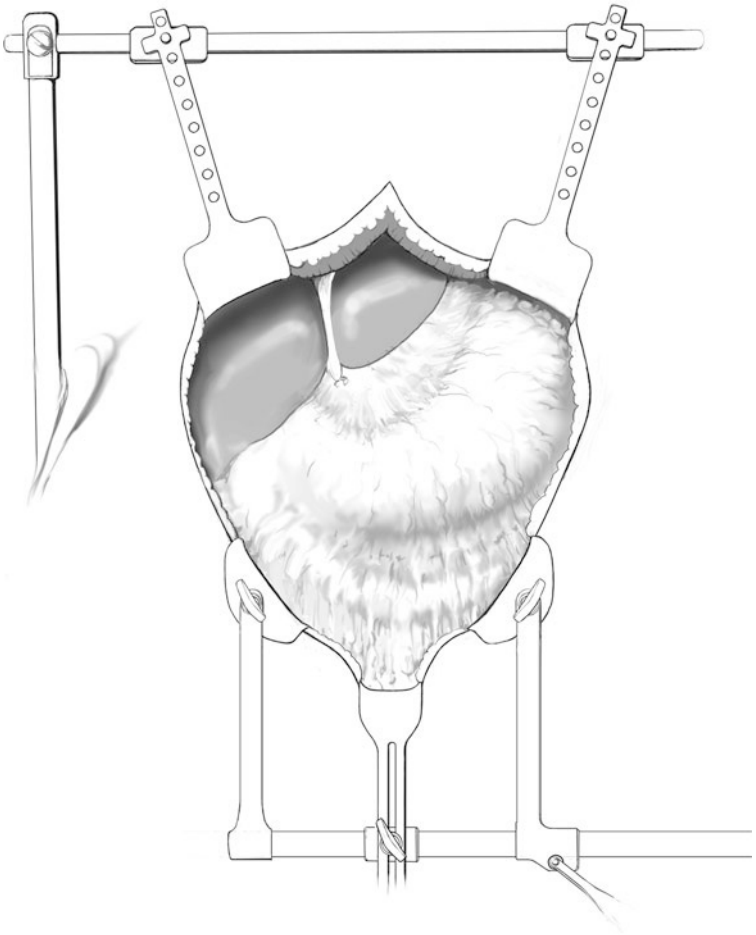


Fig. 21.1

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Step 2

Separation of the greater omentum from the entire transverse colon

The entire gastrocolic omentum is separated from the transverse colon by scissors dissection through the avascular embryonic fusion plane. It is tremendously helpful to be alert to the difference in texture and color of the fat in the epiploic appendices of the colon and that of the omentum. Bleeding will be avoided by keeping this important plane of dissection between these two different structures. The next step is to elevate the mobilized omentum from the transverse colon and to expose the anterior surface of the pancreas. As the omentum is mobilized, the venous branch between the right gastroepiploic and the middle colic veins is identified and ligated (Fig. 21.2).

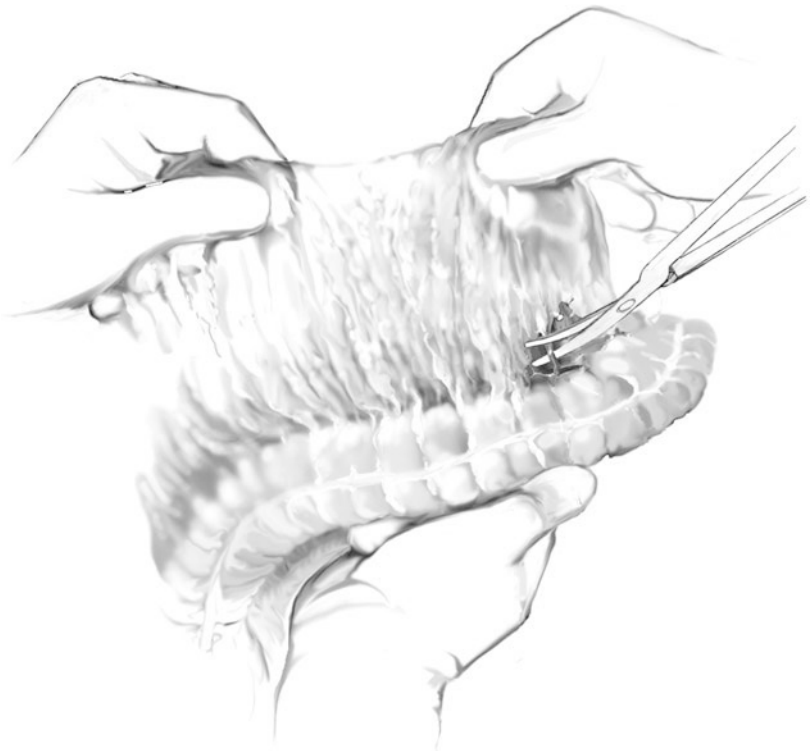


Fig. 21.2

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Step 3

View of the mobilized left liver lobe and the esophagogastric junction

Next mobilize the left lobe of the liver unless segments II and III can easily be retracted. The lesser omentum is divided. If present, a replaced left hepatic artery will be identified at this time and should be preserved. An additional liver retractor is used so that the abdominal part of the esophagus is visible. The stomach is then pulled in an inferior direction and the peritoneum and phreno-esophageal ligament are incised over the esophagogastric junction. Both crura of the diaphragm are identified and the lymph nodes at stations 1 and 2 are cleared. Using a large dissector, the esophagus is separated from the crura and is then encircled by a finger. A rubber band is placed around the esophagus and retained by a clamp. The vagal nerves are divided, which facilitates further mobilization of the distal esophagus (Fig. 21.3).

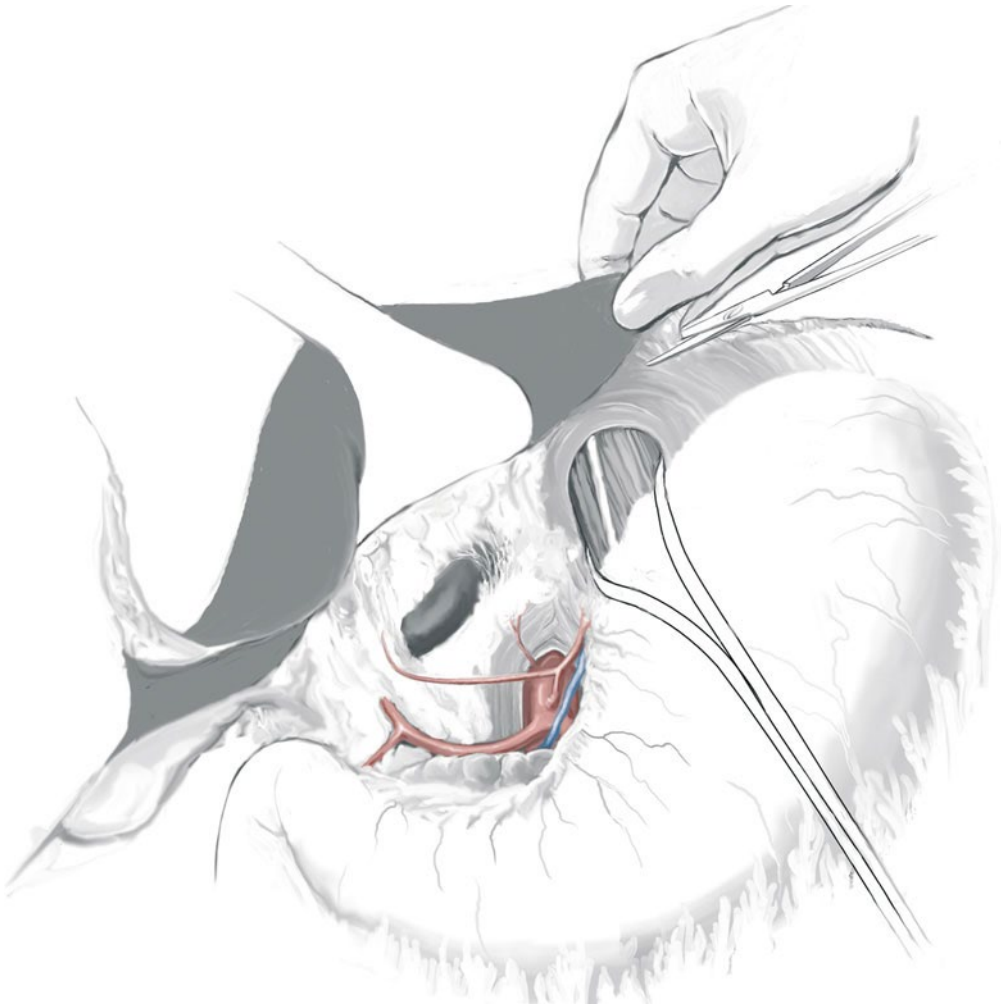


Fig. 21.3

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Step 4

Mobilization of the greater curvature

The greater omentum is released from the splenic flexure. The stomach is then gently pulled in an inferior and medial direction and the short gastric vessels are dissected at the point of contact with the greater curvature of the stomach (Fig. 21.4).

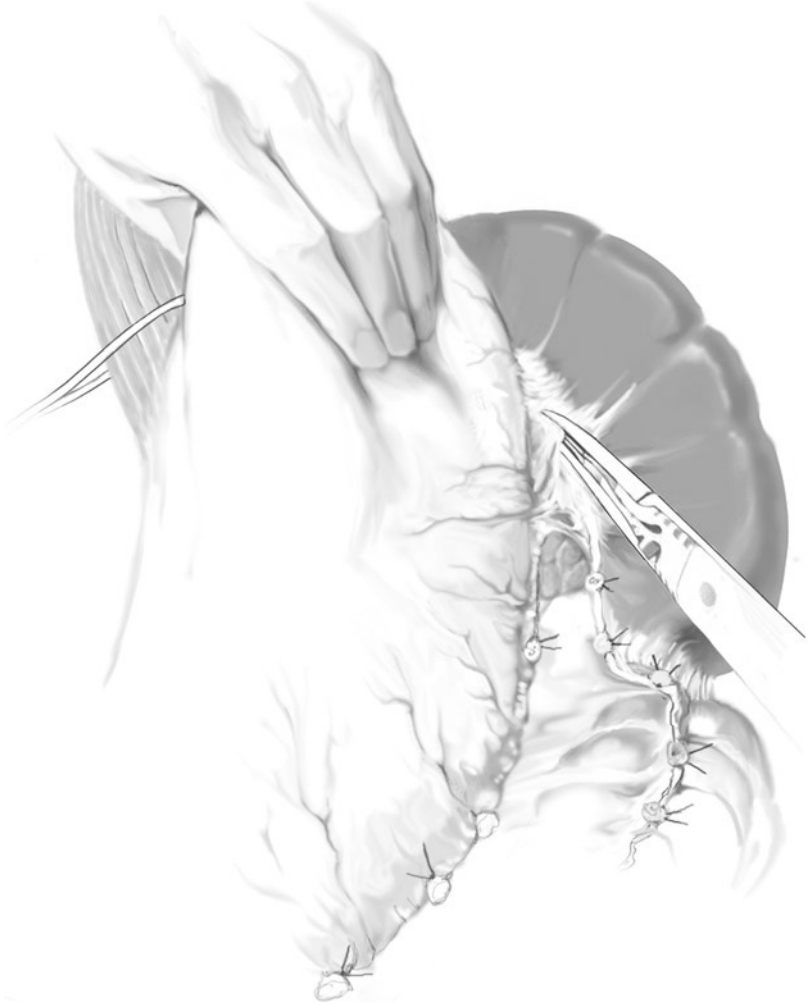


Fig. 21.4

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Step 5

Transection of the duodenum

The right gastroepiploic and the right gastric arteries are divided, and the posterior wall of the duodenum is freed. Extensive duodenal dissection is not necessary when the distal antrum is free of tumor. The duodenum is then transected with a linear stapler 1–2 cm distal to the pylorus. The stapler line is oversewn with a permanent, non-resorbable running suture. The distal end of the spicemen is covered with a gauze, which should be fixed in place with an additional umbilical tape ligature. In case of a D2-Lymphadenectomy, perform a cholecystecomy in order to reduce the risk of further gallstone formation (Fig. 21.5).

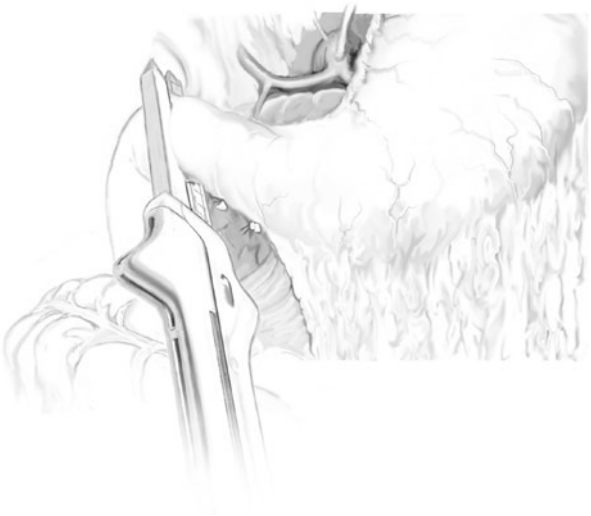


Fig. 21.5

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Step 6

D2 lymphadenectomy

The stomach is now held upward and to the left, which allows optimal exposure. A D2-lymphadenectomy (lymph nodes stations 1–12) is carried out. This involves removing all the nodes along the common hepatic artery, nodes behind and within the hepatoduodenal ligament, and nodes along and around the celiac artery, the trunk of the splenic artery and the cranial margin and surface of the pancreas. All the arteries are fully freed of areolar and lymphatic tissue and secured with vessel loops. It is important to clip or ligate all the remaining lymphatic vessels to avoid postoperative lymphorrhea (Fig. 21.6). If the spleen is not involved, do not excise lymph nodes (station. 10) at the hilus of the spleen. A splenectomy should be avoided to reduce the increased risks of postoperative morbidity.

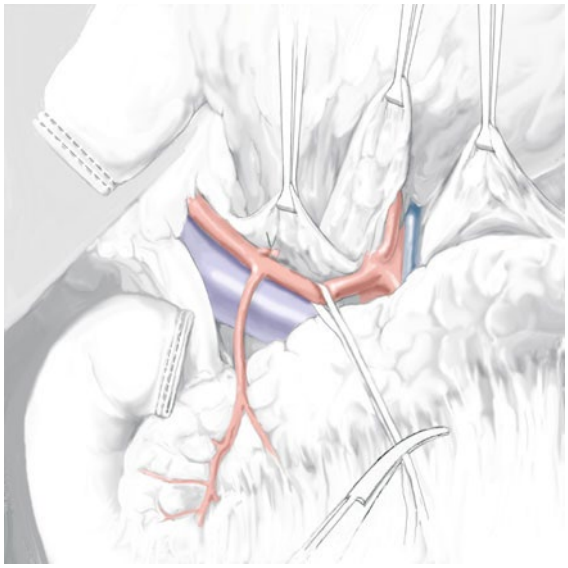


Fig. 21.6

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Step 7

Division of left gastric vessels

The left gastric vessels are identified and isolated from adjacent tissues by blunt and sharp dissection and are then ligated and divided. The coronary vein, which is situated just caudal to the artery, is often identified first in the course of dissection (Fig. 21.7).

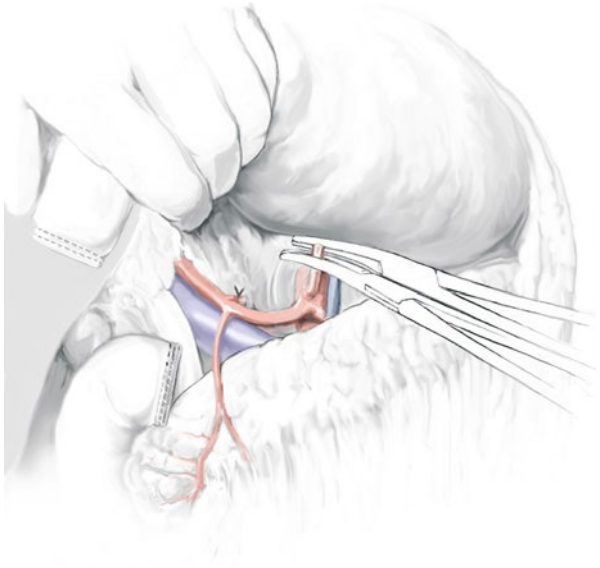


Fig. 21.7

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Step 8

Transection of the distal esophagus

After mobilization of the entire stomach, the esophagus is then divided just above the cardia. A right-angled clamp is placed distal to the lower esophagus and the esophagus is divided by electrocautery. The specimen, which consists of stomach, proximal 2 cm of duodenum, greater omentum, and regional lymph nodes, is sent to pathology to confirm the absence of tumor and the presence of duodenal and esophageal mucosa of the resected margins before reconstruction (Fig. 21.8).

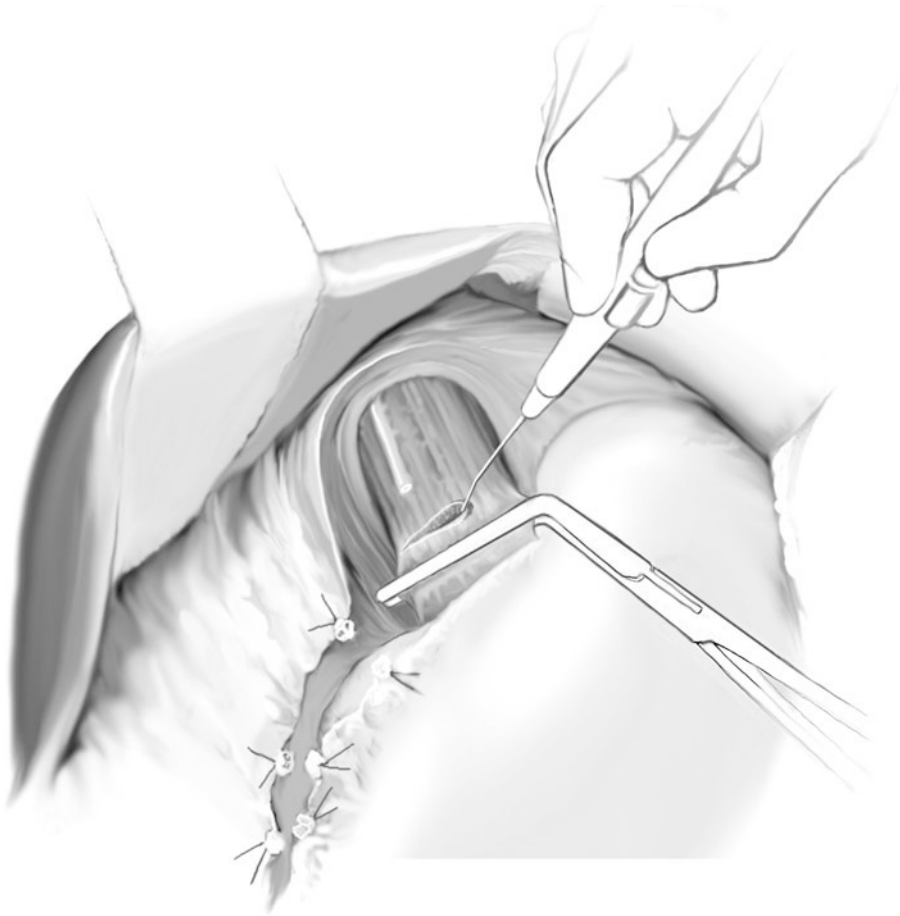


Fig. 21.8

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Step 9

Roux-en-Y reconstruction

Preparation of Roux-en-Y jejunal segment: A jejunal limb is elevated about 20–30 cm beyond the ligament of Treitz (Fig. 21.9a). Dissection of the mesentery is facilitated by transillumination. The peritoneum is incised along the resection line. The small bowel is divided with a linear stapler (Fig. 21.9b). To reach a sufficient length of the Roux-en-Y limb, it is sometimes necessary to further divide the main arcades, but it is crucial to preserve the peripheral arcades.

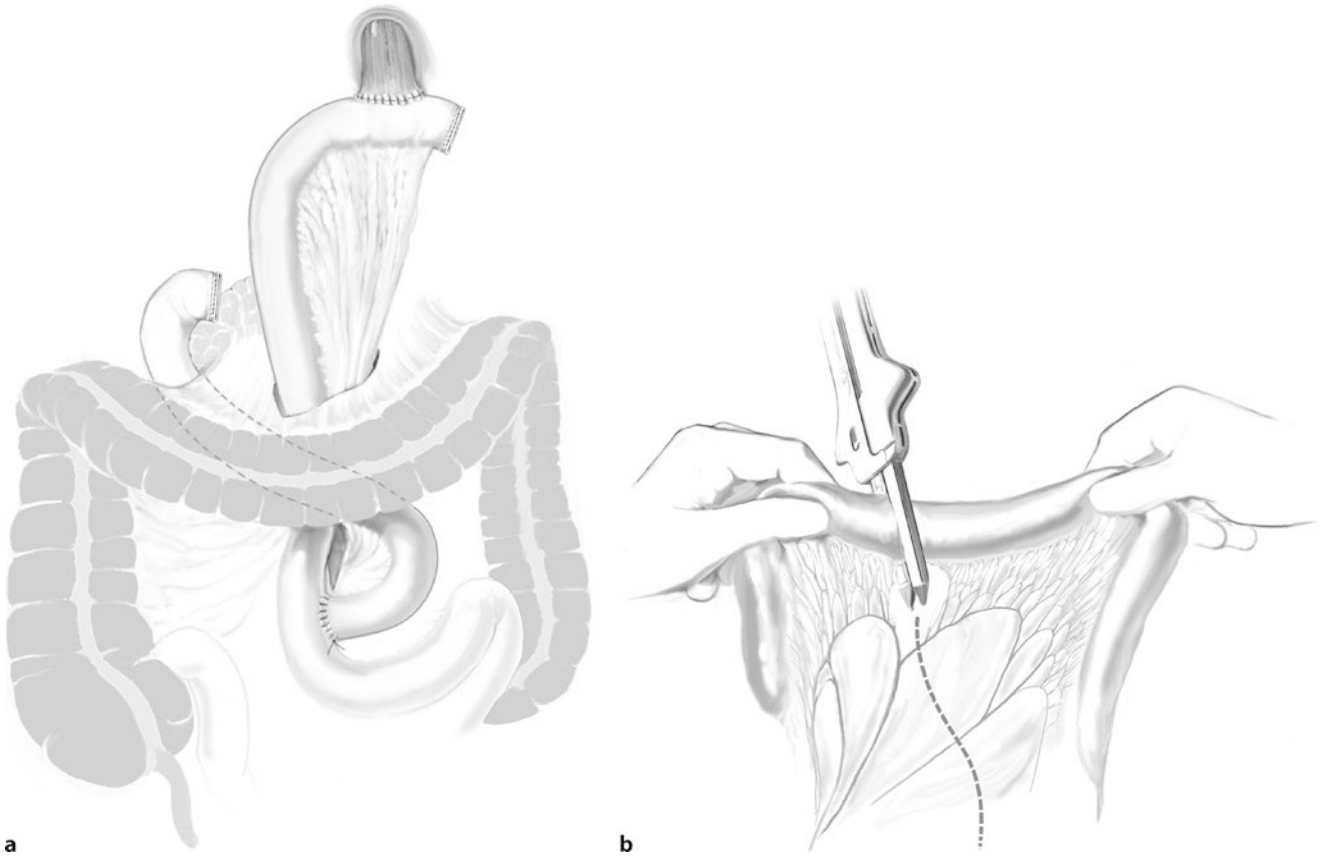


Fig. 21.9

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Step 10

End-to-side sutured esophagojejunostomy

There are two ways of performing the esophagojejunostomy, suturing either end-to-end or end-to-side. My preference is to use the latter because the end-to-end method carries an increased risk of compromising the circulation at the end of the jejunal limb. It is also easier to match the diameter of esophagus and jejunum in this way. The anastomosis is sutured by hand using a single-layer interrupted suture technique (lift anastomosis).

- An antimesenteric incision is made in the end of the jejunum, its length corresponding to the diameter of the esophagus. To avoid a blind loop syndrome, the incision is made close (1–2 cm) to the end of the jejunum closed earlier by the staples and oversewn with a permanent nonresorbable running suture (Fig. 21.10a).
- Two corner sutures are inserted and lightly retracted with Pean forceps. A further stitch is placed midway between the corner stitches on the posterior wall and the back line is completed using full-thickness mattress sutures (Fig. 21.10b).
- Alternatively, the esophagojejunostomy can be performed using a circular stapling device.

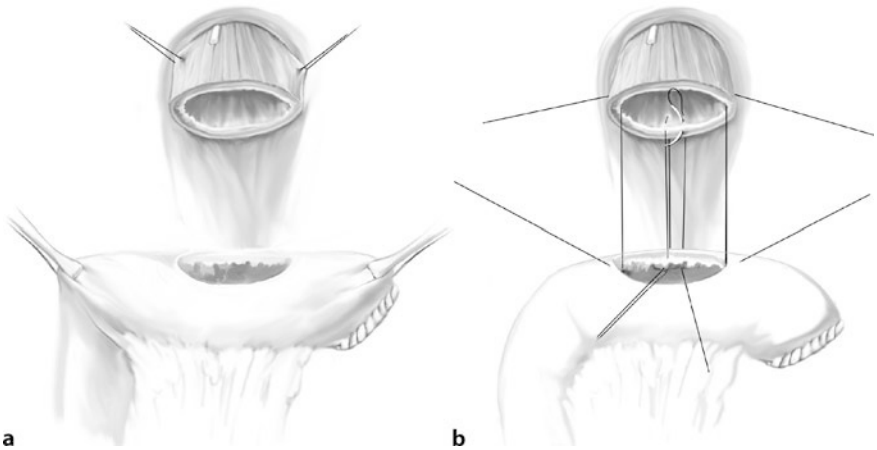


Fig. 21.10

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Step 10 ***(continued)***

- The sutures pass from the jejunal lumen outward through all layers and complete the circuit by passing through the wall of the esophagus from outside to inside. The needle is then turned around and the backstitch picks up only a small bite of mucosa on each side of the bowel lumen. The sutures extend approximately 5–8 mm from the wound margins, depending on the wall thickness, and the gap between the stitches is 4–6 mm (Fig. 21.11a).
- Threads are then held in a coil fixed to a Kocher clamp on the retractor hook (Fig. 21.11b).

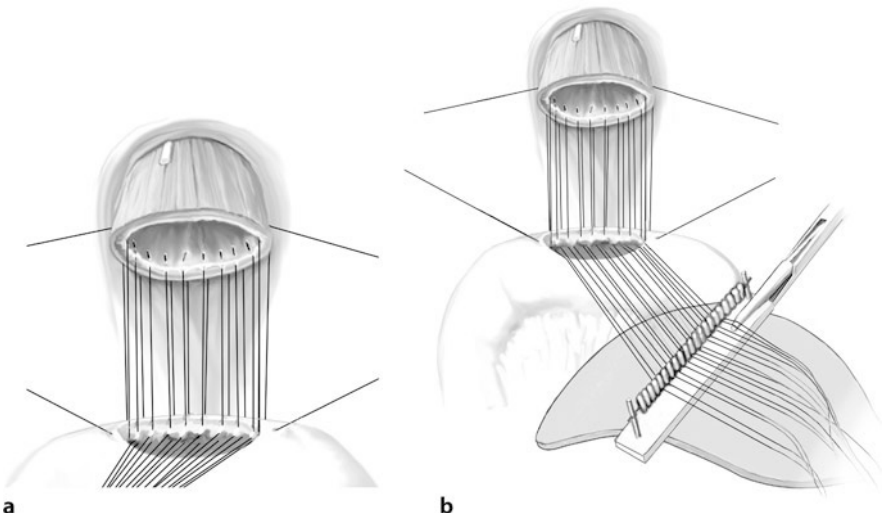


Fig. 21.11

- After insertion of all backwall stitches, they are then railroaded down to the anastomosis using a wet swab on a stick. It is very important to hold the ends of all threads under firm tension to ease this maneuver (Fig. 21.12a).
- The anterior wall of the anastomosis is closed with a continuous suture if there is a good view or with interrupted sutures when the view is less satisfactory. The anterior wall anastomosis is also begun at the far corner using an extramucosal stitch on the small bowel side and a full-thickness stitch on the esophagus wall. Before completing the front wall, the gastric tube is led down into the jejunum (Fig. 21.12b).

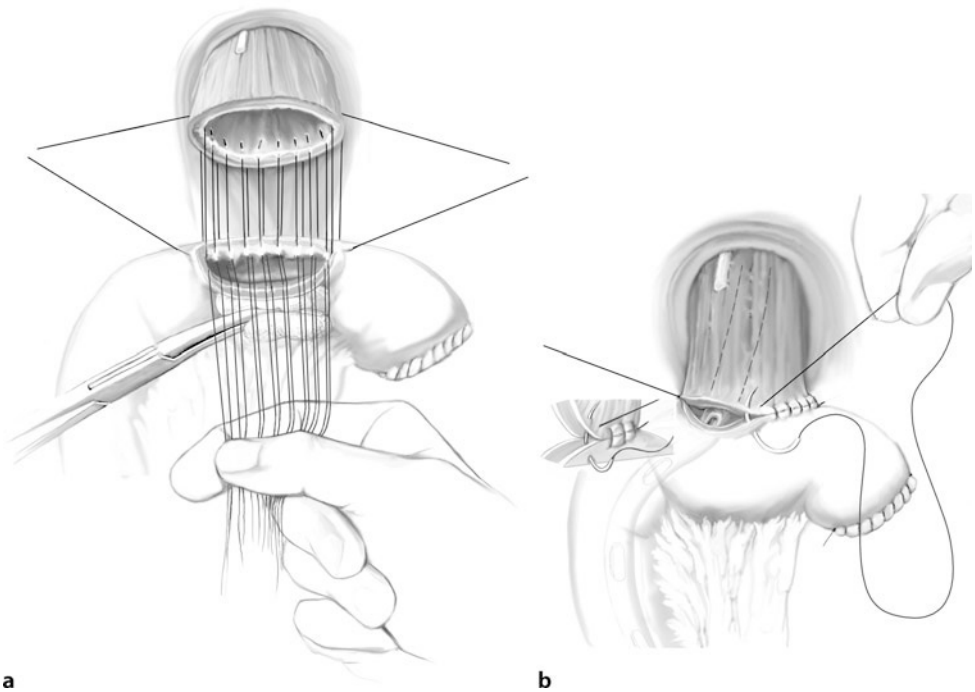


Fig. 21.12

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Step 11

Reconstruction of the intestine

At a point 50–60 cm below the esophagojejunostomy, an end-to-side jejunojejunostomy is performed using a continuous extramucosal suture technique.

All openings in the mesentery are closed by monofilament suture.

One drain is placed behind the esophagojejunostomy.

Standard Postoperative Investigations

- Hemoglobin
- Check daily for clinical signs of infection (anastomotic leak)
- In case of clinical suspicion of a leakage arrange an upper GI Endoscopy.

Postoperative Complications

- **Short term**
  - Intra-abdominal bleeding
  - Subphrenic abscess
  - Anastomotic leak
  - Pancreatic fistula
  - Duodenal stump leak
- **Long term**
  - Weight loss, decreasing nutritional status (reservoir capacity)
  - Diarrhea
  - Dumping syndrome
  - Alkaline reflux

Tricks of the Senior Surgeon

- Ask the anesthesiologist not to introduce a gastric tube before having completed the back-wall of the esophagojejunostomy. This may minimize the risk of esophagus spasm.
- Keep the dissection of the short gastric vessels closed to the great curvature of the stomach.
- Secure the duodenal stump (staples row) with a continuous suture.
- Use optical magnification to perform the lymphadenectomy.

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Total Gastrectomy with Radical Systemic Lymphadenectomy (Classic Japanese Style D2)

Mitsuru Sasako

Historically, total gastrectomy (TG) with radical lymphadenectomy included distal pancreatectomy and splenectomy and was favored by Brunschwig in 1948. Maruyama modified this procedure by preserving the distal pancreas, so-called pancreas-preserving radical TG. His initial report was published in Japanese in 1979. Initially he ligated both the splenic artery and vein near their origin, which often caused major congestion of the pancreas tail followed by massive necrosis. The first available English report was published in 1995 and described a modified technique of the original version. There he preserved the splenic vein up to the tip of the pancreas tail to preserve venous return.

The technique of pancreas preserving TG with radical systemic lymphadenectomy (D2) by preserving the splenic artery and vein as far as the branching-off of the major pancreatic artery (Sasako's modification) is described. After this original text was written, results of the JCOG0110 study, a RCT comparing this type of TG and spleen preserving TG, were reported in ASCO 2014, showing that spleen should be preserved unless tumors do not involve the greater curvature of the upper body or the pancreas tail or the spleen. Therefore indication of this technique should be limited mainly for T4a tumors of the greater curvature and T4b tumors involving the pancreas or spleen.

Indications and Contraindications

Indications

- Gastric carcinoma (T2–T4a, M0) involving the greater curvature of the upper third of the stomach or T4b involving the gastrosplenic ligament or spleen without involvement of the pancreas tail

Contraindications

- By invasion of the pancreas body or tail or the spleen or macroscopically evident lymph node metastasis at the splenic artery, an extended total gastrectomy with pancreatico-splenectomy (en-bloc resection) should be performed.
- Distant metastasis
- Severe cardiopulmonary insufficiency (relative)

Preoperative Investigations/Preparation for the Procedure

See ▶ Chap. 21 on "Total Gastrectomy with Conventional Lymphadenectomy."

Procedure

- **Access**

Upper median incision or upper transverse incision with median T-shaped extension.

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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Step 1

Exposure

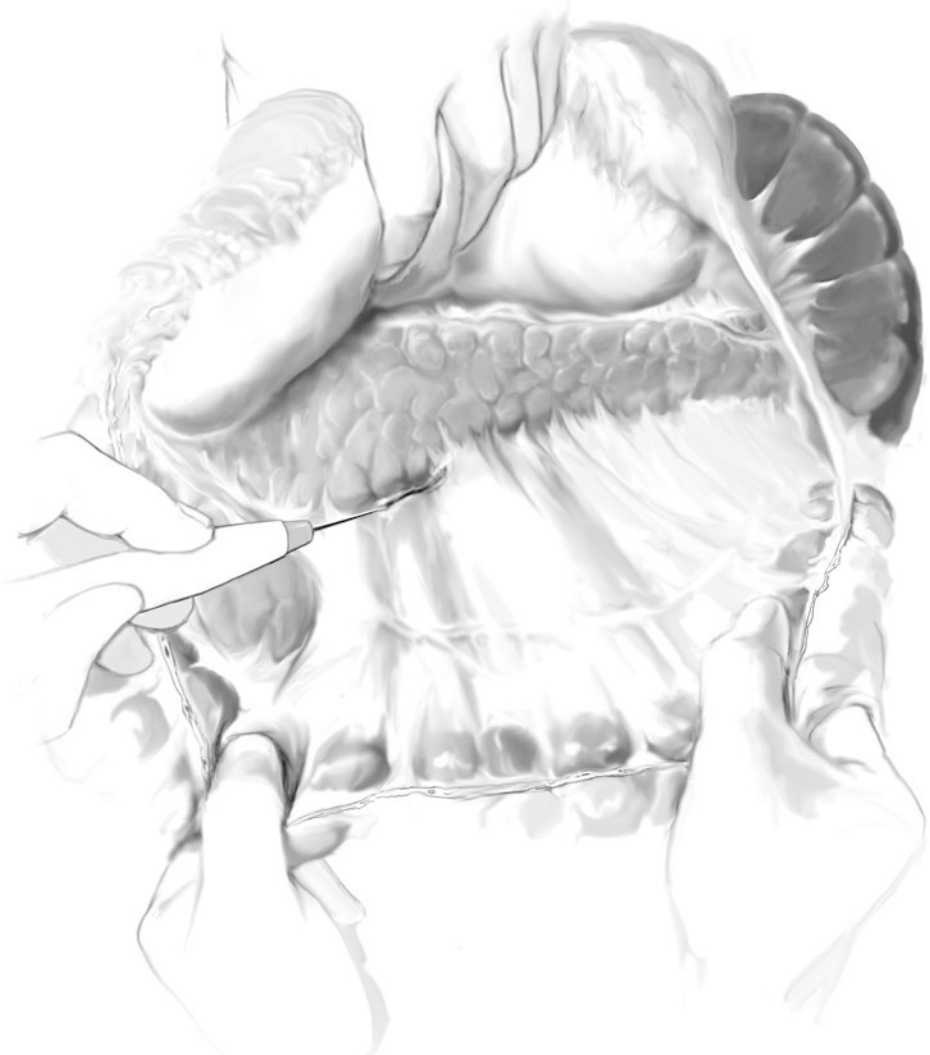
Laparotomy and inspection are performed of the peritoneum, liver, and, after mobilization of the duodenum by the Kocher maneuver, the para-aortic area. After cytological washings out of the Douglas space, one or two Kent-type retractors with one or two octopus retractors are inserted for best overall view of the epigastric region, especially the diaphragmatic esophageal hiatus. Excision of the xiphisternum is recommended.

Steps of the preparation of the gastrectomy are described in the ▶ Chap. 21 "Total Gastrectomy with Conventional Lymphadenectomy."

Step 2

Omentectomy

The transverse mesocolon is stretched by the second assistant. Dissection of the greater omentum together with the posterior wall of the omental bursa is performed. In the fetus the mesocolon is fused to the mesogastrium which comprises the greater omentum and two membranes of the posterior bursa. Between these two membranes, the tail of pancreas and the spleen exist. Along the inferior surface of the body and tail of the pancreas, dissection should be between the fused transvers mesocolon proper and the deeper membrane of the posterior bursa. Then leaving the deeper membrane going behind the pancreas, the superficial membrane of the posterior burse alone should be dissected on the pancreas. At this point, we cannot still see the stomach directly. Diathermy allows bloodless transection (◘ Fig. 22.1).



◘ Fig. 22.1

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Step 3

Dissection of infrapyloric lymph nodes

Following the right accessory colonic vein, Henle's surgical trunk can be found. The origin of the right gastroepiploic vein is ligated. Before going on to the third step, the dissection plane should be changed from the posterior to the anterior capsule of the pancreas (Fig. 22.2).



Fig. 22.2

Step 4

Ligation and division of the right gastroepiploic artery

By dissection of the anterior capsule of the pancreas toward the duodenum, the gastroduodenal artery appears on the anterior surface of the pancreas neck. Following this artery caudally, the origin of the right gastroepiploic artery can be found. After its ligation and division, the gastroduodenal artery should be followed cranially up to the bifurcation of the common hepatic artery (Fig. 22.3).

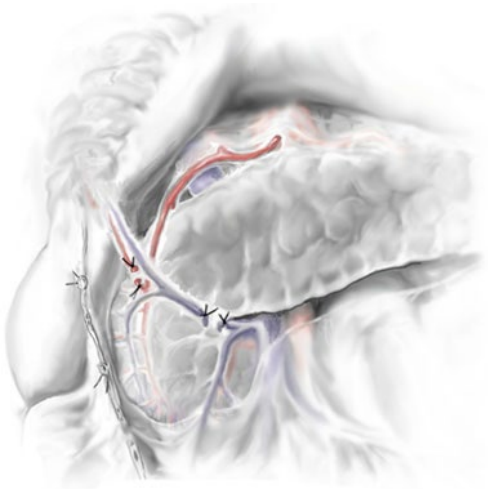


Fig. 22.3

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Step 5

Division of the lesser omentum

Close to the left liver lobe, the lesser omentum is divided from the left edge of the hepatoduodenal ligament toward the esophagus (Fig. 22.4).

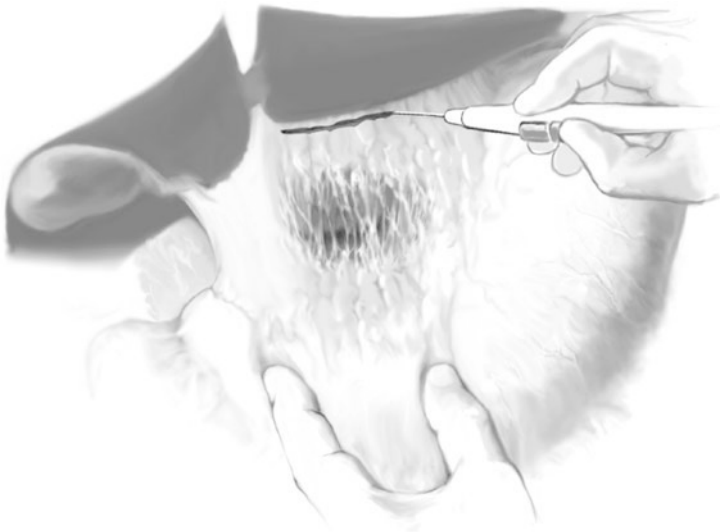


Fig. 22.4

Step 6

Division of the right gastric artery

The lesser omentum is incised along the hepatoduodenal ligament up to the left side of the common bile duct and caudally to the duodenum. After ligation and division of the supraduodenal vessels, the gastroduodenal artery is seen clearly on the pancreas.

The tissue defined by this incision is dissected from the proper hepatic artery and swept across to the patient's left. The gastroduodenal artery is followed to its junction with the proper hepatic artery and the latter is cleaned until the origin of the right gastric artery is found and ligated. The dissection to the left of the hepatoduodenal ligament should go deeper than the proper hepatic artery and clear the nodes from the left side of the portal vein (Fig. 22.5).

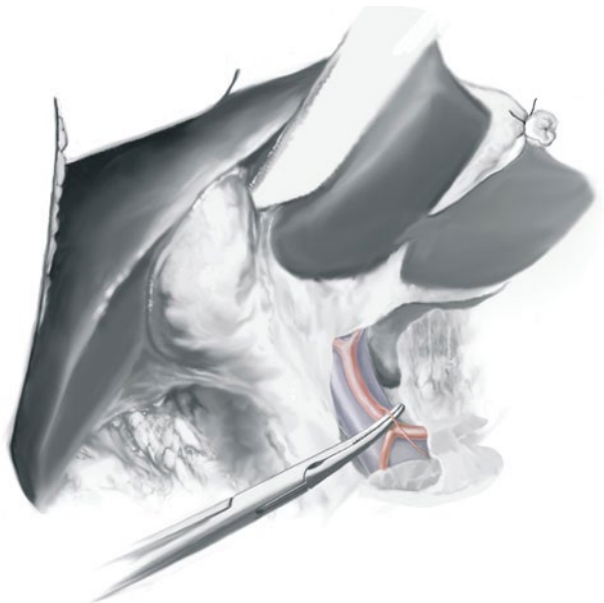


Fig. 22.5

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Step 7

Dissection of suprapancreatic nodes

The dorsal mesogastrium contains the celiac artery in the center, and common hepatic, splenic arteries and the pancreatic body and tail. All these structures are embedded in adipose tissue. Thus, inside of this mesogastrium, the adipose tissue contains many lymph nodes along the superior border of the pancreas. These arteries are surrounded by thick nerve tissue. This tissue should be preserved in case of no adherence of suspect lymph nodes. The left gastric vein is visible and therefore ligated and divided. Caudally it crosses the origin of either the common hepatic or splenic artery before entering the splenic vein in about 30–40 % of patients. In the majority the left gastric vein passes obliquely behind the hepatic artery to join the junction of the splenic and portal veins (Fig. 22.6).

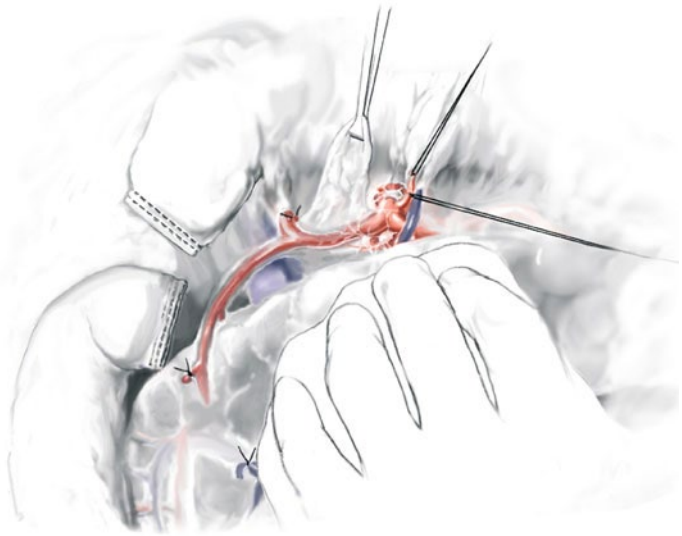


Fig. 22.6

Step 8

Dissection around the celiac artery and division of the left gastric artery

The celiac artery is covered by the celiac plexus. All the tissue around these nerve structures is dissected to visualize the celiac and left gastric artery. Ligation and division of the left gastric artery is performed near its origin (Fig. 22.7).

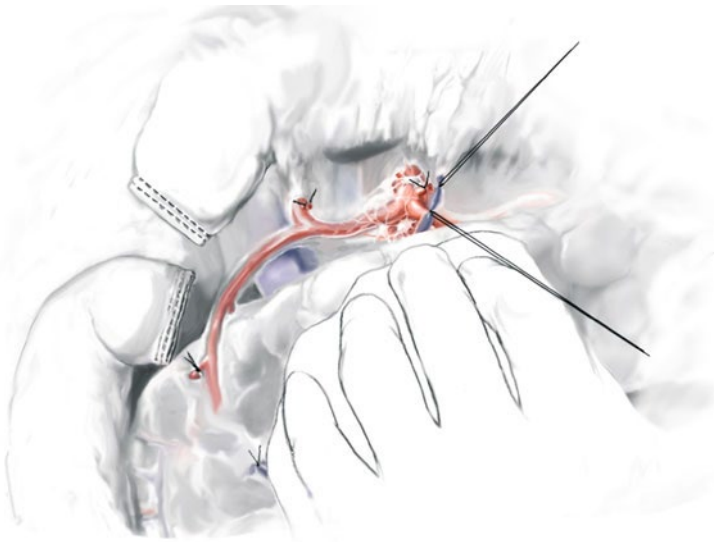


Fig. 22.7

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Step 9

Mobilization of the pancreas body/tail and the spleen

View from the patient's feet. To carry out the dissection of the splenic artery and hilar lymph nodes, the pancreas body/tail and spleen should be mobilized from the retroperitoneum and the Left Gerota's fascia, beginning at the pancreas body from the inferior toward the superior border and then toward the tail and spleen. After total mobilization of the spleen, the retroperitoneum is incised lateral of the spleen and divided. The pancreas body/tail and spleen are now completely mobilized for a meticulous dissection of lymph nodes around the pancreas tail (Fig. 22.8).

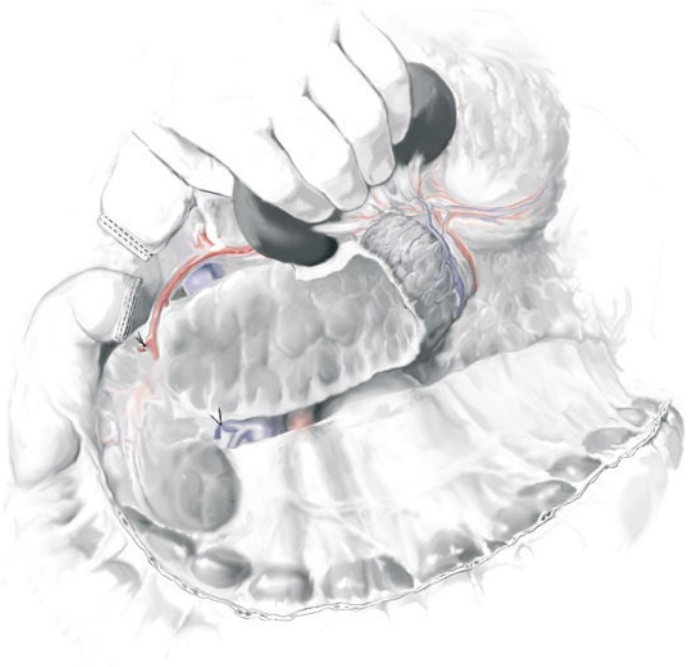


Fig. 22.8

Step 10

Division of the splenic artery

The splenic artery is divided near the pancreas tail at least after branching-off of the great pancreatic artery and possibly after branching-off of the pancreatic tail artery. In contrast to Maruyama's procedure in Sasako's modification (Fig. 22.9).

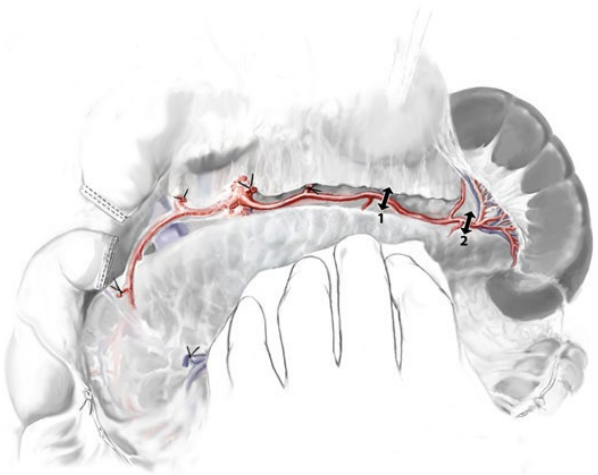


Fig. 22.9

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Step 11

Dissection of the splenic artery nodes

The issue around the distal portion of the splenic artery and vein is removed from the anterior and posteriors surfaces of the vessels. To avoid venous congestion, the splenic vein should be preserved as distal as possible. If there is a pancreas tail vein at the tip, it should also be preserved (Fig. 22.10).

See ▶ Chap. 21 "Total Gastrectomy with Conventional Lymphadenectomy" for postoperative investigations and complications.

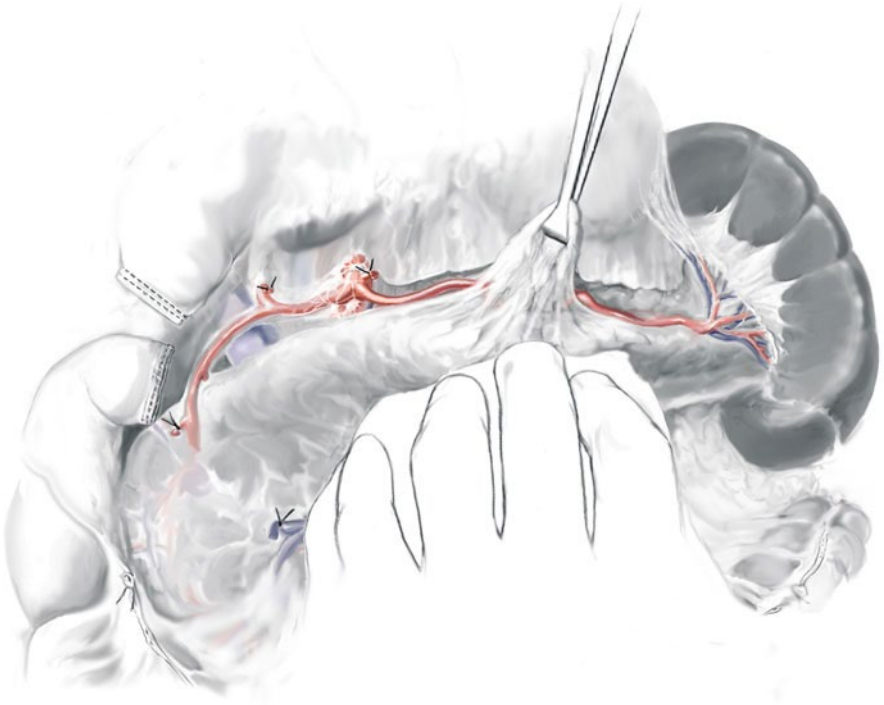


Fig. 22.10

Tricks of the Senior Surgeon

- Avoid transecting the postpyloric duodenum too close to the pancreatic capsule, making it much more difficult to confidently close the duodenal stump
- Meticulous dissection of the proper hepatic artery and the splenic artery is mandatory to prevent postoperative pancreatitis.

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Abdominothoracic Esophagogastrectomy

Enrique Moreno-Gonzalez, Carmelo Loinaz, Carlos Jiménez-Romero

Introduction

From the pathogenic and therapeutic point of view, adenocarcinomas of the esophagogastric junction (AEG) should be classified into adenocarcinoma of the distal esophagus (Type I), true carcinoma of the cardia (Type II), and subcardial carcinoma (Type III).

In patients with potentially resectable, true carcinoma of the cardia (AEG Type II), resection can be achieved by a total gastrectomy with a transhiatal distal esophagectomy and en-bloc removal of the lymphatic drainage in the lower posterior mediastinum and upper abdomen.

Indications and Contraindications

Indications

- Carcinoma of the distal esophagus with involvement of the proximal stomach
- Locally advanced carcinoma of the cardia
- Adenocarcinoma of the proximal stomach with extension into the distal esophagus
- Distal esophageal carcinoma after subtotal gastrectomy
- Esophageal carcinoma of the mid or upper third after subtotal gastrectomy (abdominothoracic esophagogastrectomy with cervical or high intrathoracic anastomosis)
- Caustic ingestion

Contraindications

- Extensive intra-abdominal spread to distant lymph nodes
- Severe or irreversible cardiopulmonary insufficiency

Preoperative Investigations/Preparation for the Procedure

- Esophagogastroduodenoscopy with histologic diagnosis
- Total colonoscopy to exclude second neoplasm or diverticula in the colon segment to be used
- CT scanning of the thorax and abdomen
- some surgeons suggest an abdominal angiography to examine the colonic arteries while others use a good quality CT-angiography; such studies are especially helpful if there is any question about blood supply or in patients with known vascular disease or prior colonic surgery
- Abdominal ultrasonography
- Esophageal endosonography
- Pulmonary function tests and blood gas analysis
- Echocardiography
- Ergometry and other cardiac investigations if necessary
- Entire orthograde bowel preparation

Procedure

- **Positioning**
  - Supine position with hyperlordosis

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery*,
DOI 10.1007/978-3-662-46546-2_23, © Springer-Verlag Berlin Heidelberg 2016

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- **Approach**
  - Upper transverse incision with median T-shaped
  - Insertion of Rochard retractor to elevate costal margin

Step 1

Laparotomy

See ▶ Chap. 11, "Subtotal Esophagectomy: Transhiatal Approach."

Step 2

Exposure

After mobilization of the left lateral liver lobe and dissection of the lesser sac close to the liver, the greater omentum is detached from the transverse colon. Lymphadenectomy begins at the site of the right gastroepiploic vessels.

The peritoneal sheath is incised above the right gastroepiploic vessels. The right epiploic vessels are suture-ligated as close as possible to the pancreas without injuring the pancreatic capsule.

Step 3

Lymphadenectomy: transection of the duodenum

Dissection of the surrounding lymph nodes is performed. For better exposure of these nodes, the stomach is held upward by ventral traction. The lymph nodes at the upper margin of the pancreas are dissected toward the duodenum to facilitate the later en-bloc resection. Injury of the serosa of the duodenum and of the capsula of the pancreas must be avoided.

The lymphadenectomy of the hepatoduodenal ligament is performed. In addition, the lymph nodes around the origin of the right gastric artery are dissected toward the stomach. The right gastric artery is then ligated at its origin. After circular dissection of the gastroduodenal junction the duodenum is transected 1–2 cm distal to the pylorus with a linear stapler and the stapler suture line is inverted with single sutures (see ▶ Chap. 21, "Total Gastrectomy with Conventional Lymphadenectomy," Step 5).

Step 4

Completion of the lymphadenectomy

The upper margin of the pancreas is now exposed by applying upward traction to the distal stomach. Lymphadenectomy continues from the hepatoduodenal ligament along the common hepatic artery down to the coeliac trunk. Lymphadenectomy at the splenic artery, the coeliac trunk, and the para-aortic space is performed (see ▶ Chap. 21, "Total Gastrectomy with Conventional Lymphadenectomy," Step 6).

Step 5

Mobilization of the stomach

Traction is applied to the stomach toward the right upper abdomen to expose the origin of the left gastroepiploic artery and the short gastric vessels. These vessels are transected and ligated between clamps or using an energy device. Mobilization of the greater curvature of the stomach is performed up to the gastroesophageal junction. During this step, the phrenicogastric ligament must be transected with electrocautery.

Step 6

Transhiatal esophageal resection

See ▶ Chap. 11, "Subtotal Esophagectomy: Transhiatal Approach."

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Step 7

Mobilization of the right and left colonic flexure

The gastrocolonic omentum is freed from the stomach all along the transverse colon. Next the right colon is mobilized along its lateral peritoneal reflection to allow anterio-medial mobility ant the hepato-colonic ligament is transected. The left lateral peritoneal reflection is finally mobilized by dissection of the peritoneum in the cranial direction. The colosplenic ligament and the phrenicocolic ligament are ligated and divided using cautery or scissors. Thus, the whole splenic flexure of the colon is mobilized.

Step 8

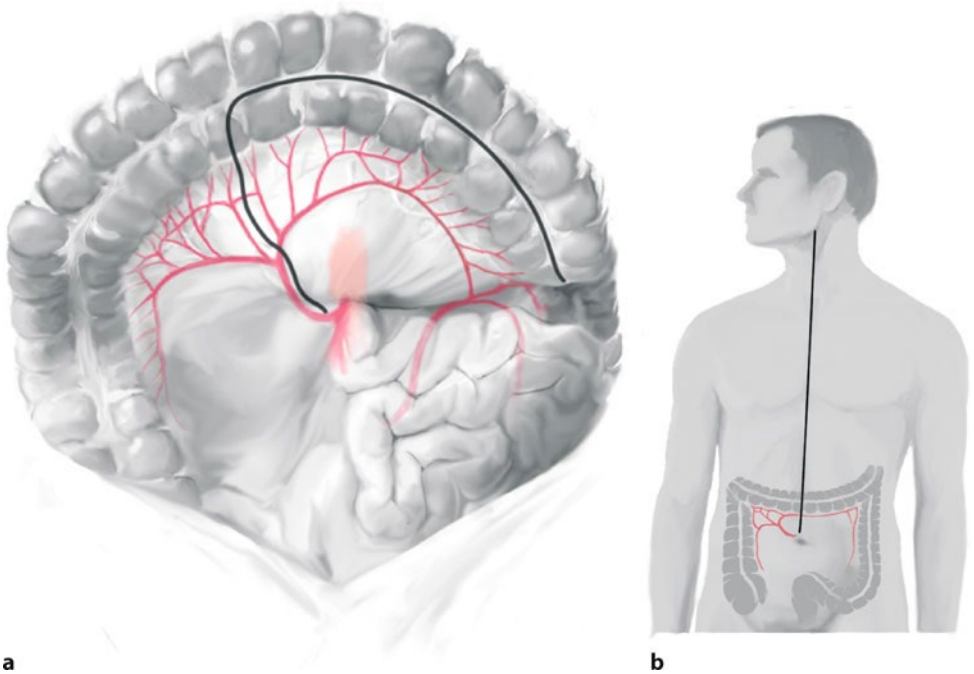
Mobilization of the sigmoid colon

Mobilization of the sigmoid colon is facilitated by performing mediocranial traction to expose the congenital adhesions between the colon and the retroperitoneum. Further dissection is done between the mesosigmoid and retroperitoneal fat, taking care of the left ureter and gonadal vessels.

Step 9

Determination of the essential length

A colonic segment is selected suitable for interposition. The appropriate length is determined as follows: elevation of the colon in front of the abdominal wall, and measurement of the distance between the abdomen and the angle of the mandible by a suture, fixed at the root of the feeding vessel of the colonic mesentery (Fig. 23.1). The length of the suture is finally transferred to the colon, and the resection margin is marked.



a b

Fig. 23.1

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Step 9 ***(continued)***

The black bars show alternative lines for transection of the colon. Resection of bluish margins on the right flexure of the transverse colon between the middle and the right colic artery should be performed with careful preservation of the paracolic arcades. Following this procedure, a better mobilization of the colonic segment can be obtained. To perform the pharyngocolostomy in carcinomas of the upper third of the esophagus, a long colonic segment is required. Therefore, parts of the sigmoid colon have to be used and the first (and probably the second) sigmoid artery has to be ligated close to the inferior mesenteric artery. Prior to dissection of the vessels, a clamp is applied temporarily to ensure the sufficiency of the vascular supply. Dark arrows point to the vascular resection margins. The arcade between the right and the middle colonic artery should be preserved for a better vascular supply of the colonic segment chosen for interposition (Fig. 23.2).

Advantages of using the left colonic segment are the following:

- The more predictably longer length and the smaller diameter of the left colon.
- Adequacy of the vascular pattern due to primary arteries with larger diameter, instead of vascular supply via several arcades as in the right colon.
- Using an antiperistaltic colonic segment has no clinical relevance, because the transit through the colonic segment is by gravity, not peristalsis.

The essential advantage of the left colon is the opportunity to obtain a longer colonic segment.

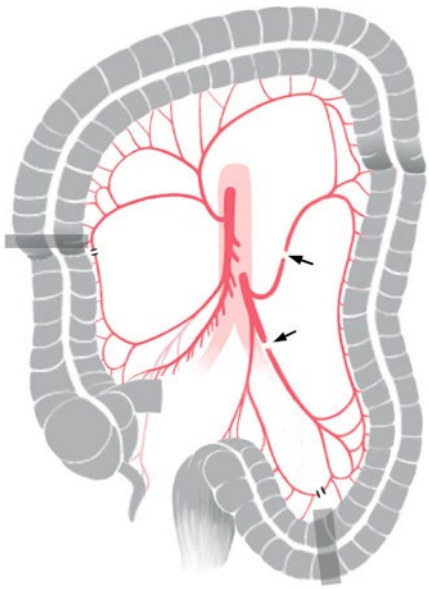


Fig. 23.2

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Step 10

Standard procedure: isoperistaltic reconstruction

In case of an insufficient vascular supply through the middle colic artery, the vascular supply can be based on the left colic artery, if a sufficient Riolan arcade exists.

This approach allows an isoperistaltic reconstruction (standard procedure). Care has to be taken not to injure the left colic vessels. Therefore, preparation has to be done carefully and close to the wall of the colon, and transection of the descending colon is always done without extensive dissection of the colon using a linear stapler device. The right and middle colic vessels are dissected close to their origin. A prophylactic appendectomy after total mobilization of the colon is recommended.

An antiperistaltic colon interposition supplied by the left colonic artery can be performed, if the Riolan anastomosis is either not present or insufficient due to previous surgical procedures (Fig. 23.3).

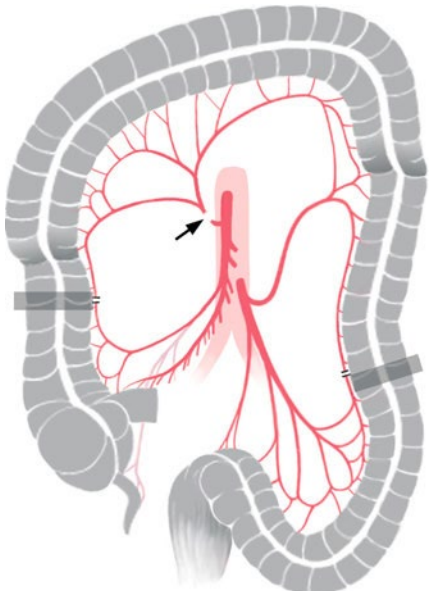


Fig. 23.3

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Step 11

Antiperistaltic reconstruction (not standard)

It is a very exceptional use of the transverse colon as substitute. Preparation of an antiperistaltic (not standard) colonic segment begins with incision of the peritoneum far from the colon and stepwise preparation of the mesocolon maintaining the paracolic arcades and the middle and left colic vessels. A vascular clamp is applied temporarily across the left colic artery and the sigmoid artery across the provisional colonic transection plane to ensure a sufficient arcade of Riolan. If no ischemia occurs after 3 min, the colon interposition can be performed (Fig. 23.4).

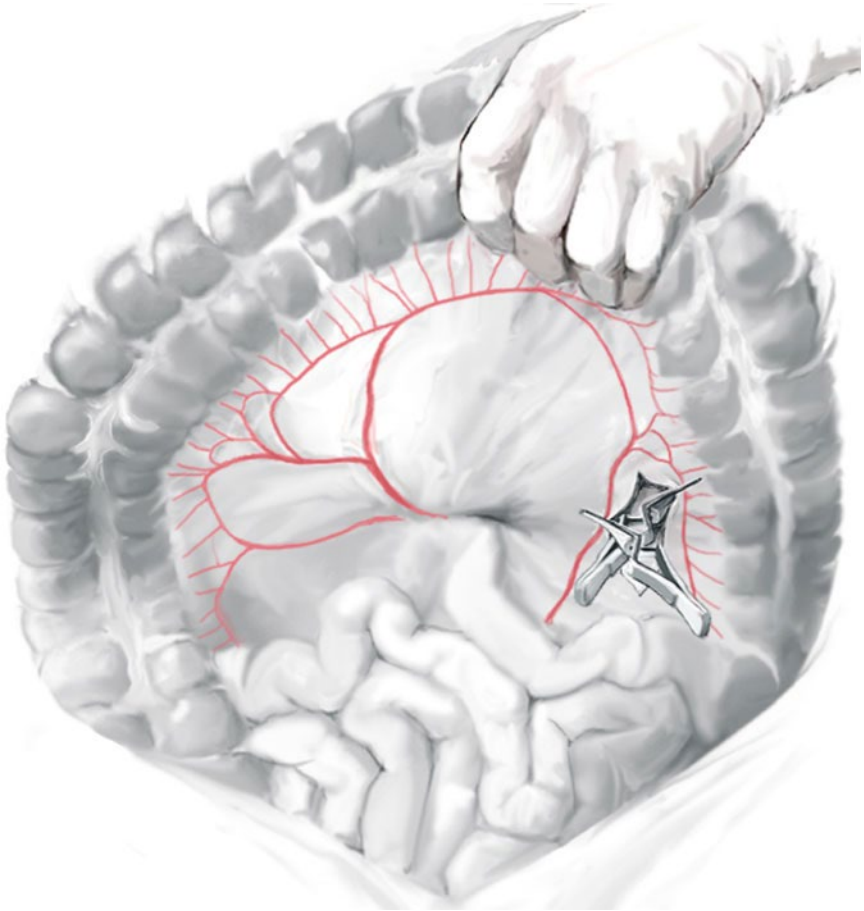


Fig. 23.4

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Step 12

Inadequate vascular supply

In case of an inadequate vascular supply by the left and middle colic artery, reconstruction of an isoperistaltic colon interposition supplied by the sigmoid artery is possible (Fig. 23.5).

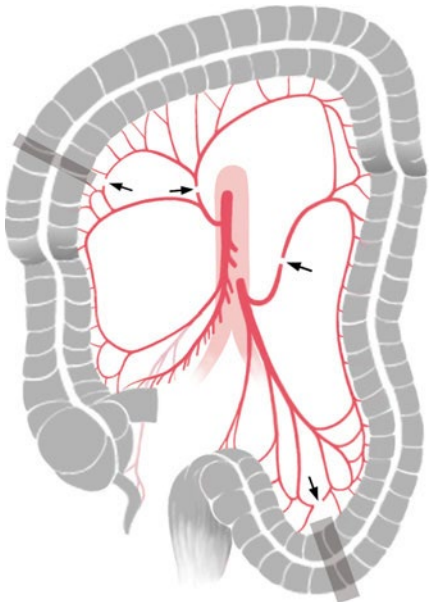


Fig. 23.5

Step 13

Inadequate vascular supply

In very rare cases, no effective vascular continuity is found between the left colonic artery and the first sigmoid artery. In those cases, the main branch of the inferior mesenteric artery can be used as the collaterial conduit between the two areas of blood supply. This can only be accomplished when the distal parts of the sigmoid colon are perfused adequately by the medial and inferior rectal artery. This situation must be assured by temporary clamping (Fig. 23.6).

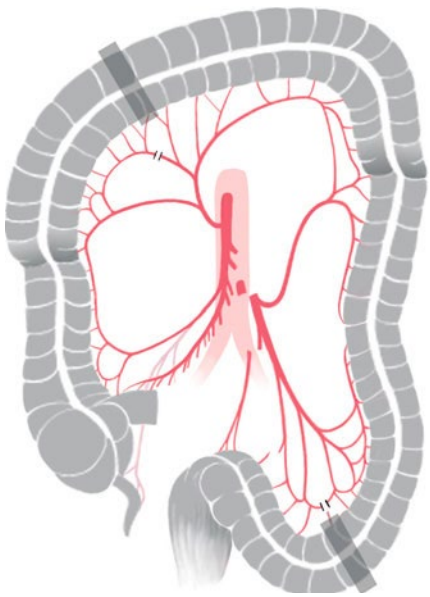


Fig. 23.6

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Step 14

A rare situation

Even after right hemicolectomy (e. g., following complicated right colonic interposition), construction of an antiperistaltic interposition is possible, if the middle colic artery has been spared during the first operation. The left colic artery and the first sigmoid artery are dissected (Fig. 23.7a). Vascular supply of the interposition comes from the middle colic artery. Reconstruction is performed with an ileosigmoidostomy.

Alternatively, an interposition after right hemicolectomy and after former transection of the middle colic artery can be performed using the left colon. The blood supply comes from the left colic artery. The entire sigmoid colon is needed for the purpose of achieving sufficient length for the interposition, and all sigmoid arteries have to be dissected (Fig. 23.7b). The proximal colon segment with poor vascular supply is resected.

If it is impossible to use the left hemicolon for interposition, the right hemicolon can be used to perform the transposition graft.

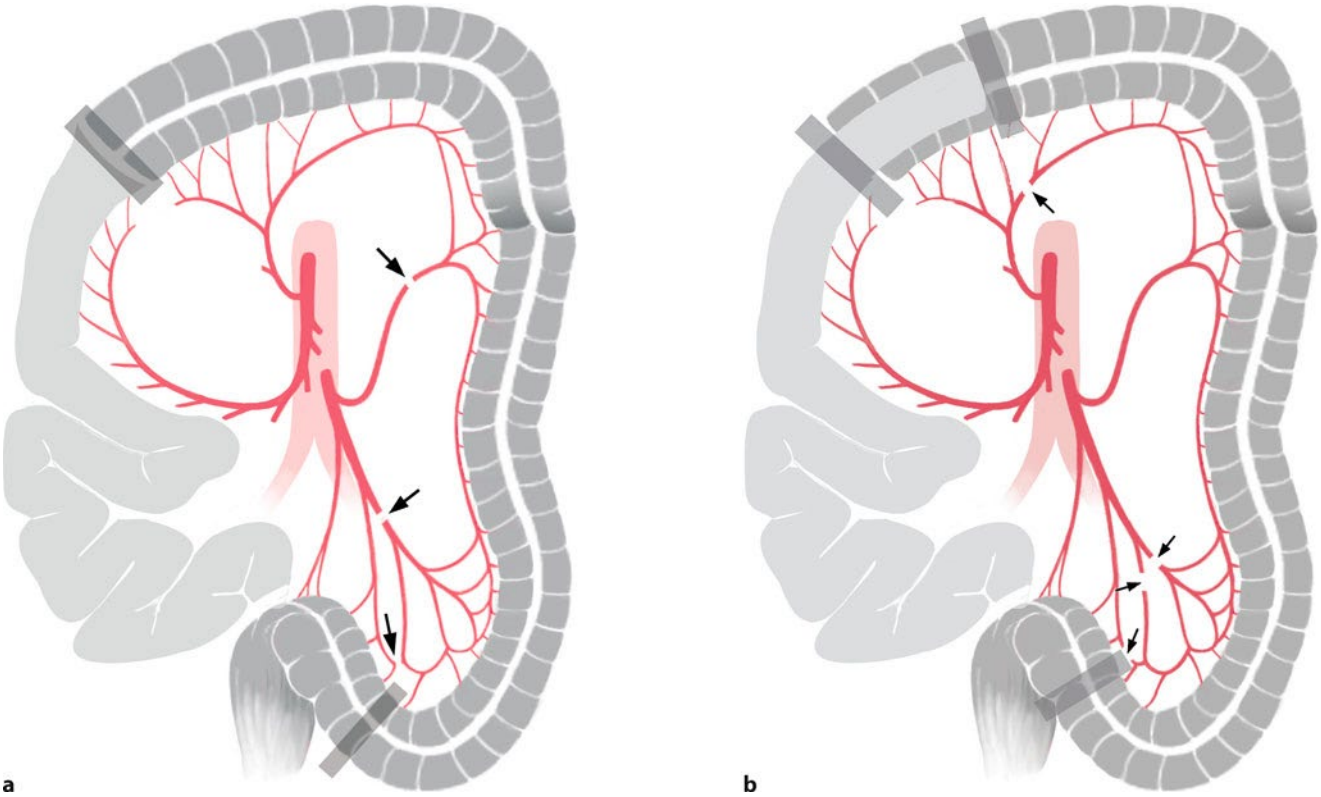


Fig. 23.7

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Step 14 ***(continued)***

Scheme of construction of an isoperistaltic colonic interposition using the right hemicolon and the terminal part of the ileum is illustrated here (Fig. 23.8). The vascular supply comes from the middle colic artery.

Using the right hemicolon for interposition is less ideal because of frequent complications leading to poorer postoperative functional results.

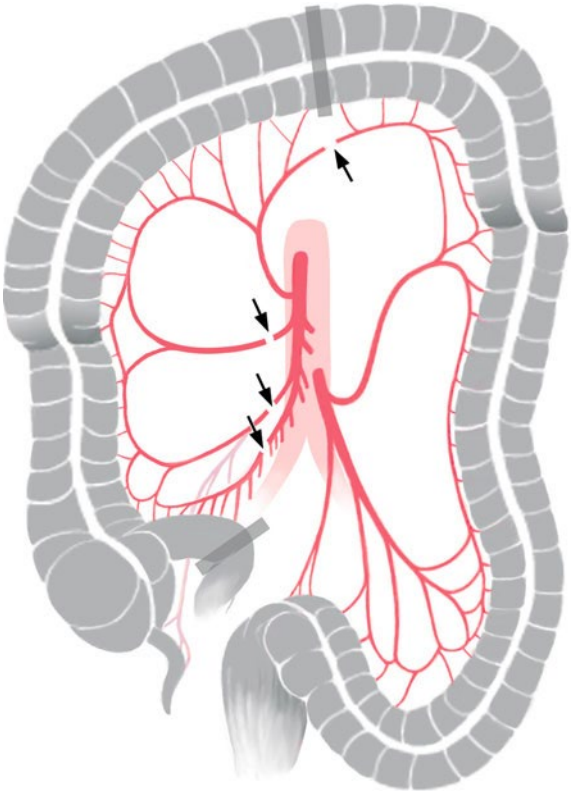


Fig. 23.8

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Step 15

Vascular supply of the colic interposition from the ileocolic artery

Also shown is the preparation of an antiperistaltic colonic interposition using the right hemicolon, with vascular supply from the ileocolic artery (Fig. 23.9a).

Adequate length of the right hemicolon enables construction of an isoperistaltic interposition without using the ileocolic portion of the intestine (Fig. 23.9b). This technique offers several advantages:

- Omission of the terminal ileum, which is prone to necrosis.
- Omission of the ileocecal region, which is prone to poor functional results; however if the ascending colon is not long enough to reach the supraclavicular fossa, the ileum should be included to enlarge the substitute length.

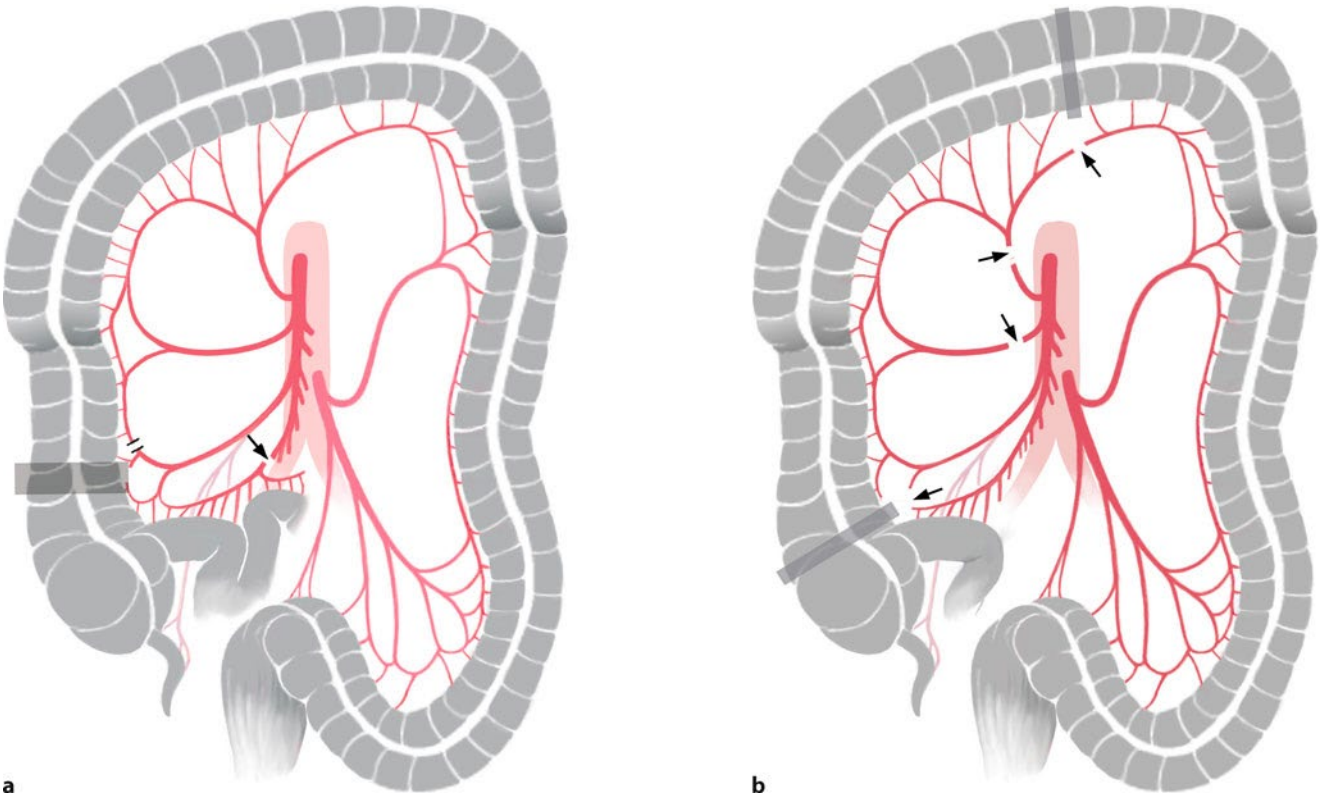


Fig. 23.9

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Step 16

Preparation of a substernal tunnel

A blunt opening is made in the substernal cavity by spreading the scissors, while retracting the xiphoid ventrally with a sharp retractor.

After opening the substernal space, a substernal tunnel is constructed with an atraumatic clamp.

The sternum has to be retracted anteriorly, and the endothoracic membrane is to be separated from the sternum. A longitudinal incision along the anterior border of the left sternocleidomastoid muscle is made to expose the cervical esophagus. Blunt preparation with the hand through the substernal tunnel usually leads to rupture of the mediastinal pleura (Fig. 23.10).

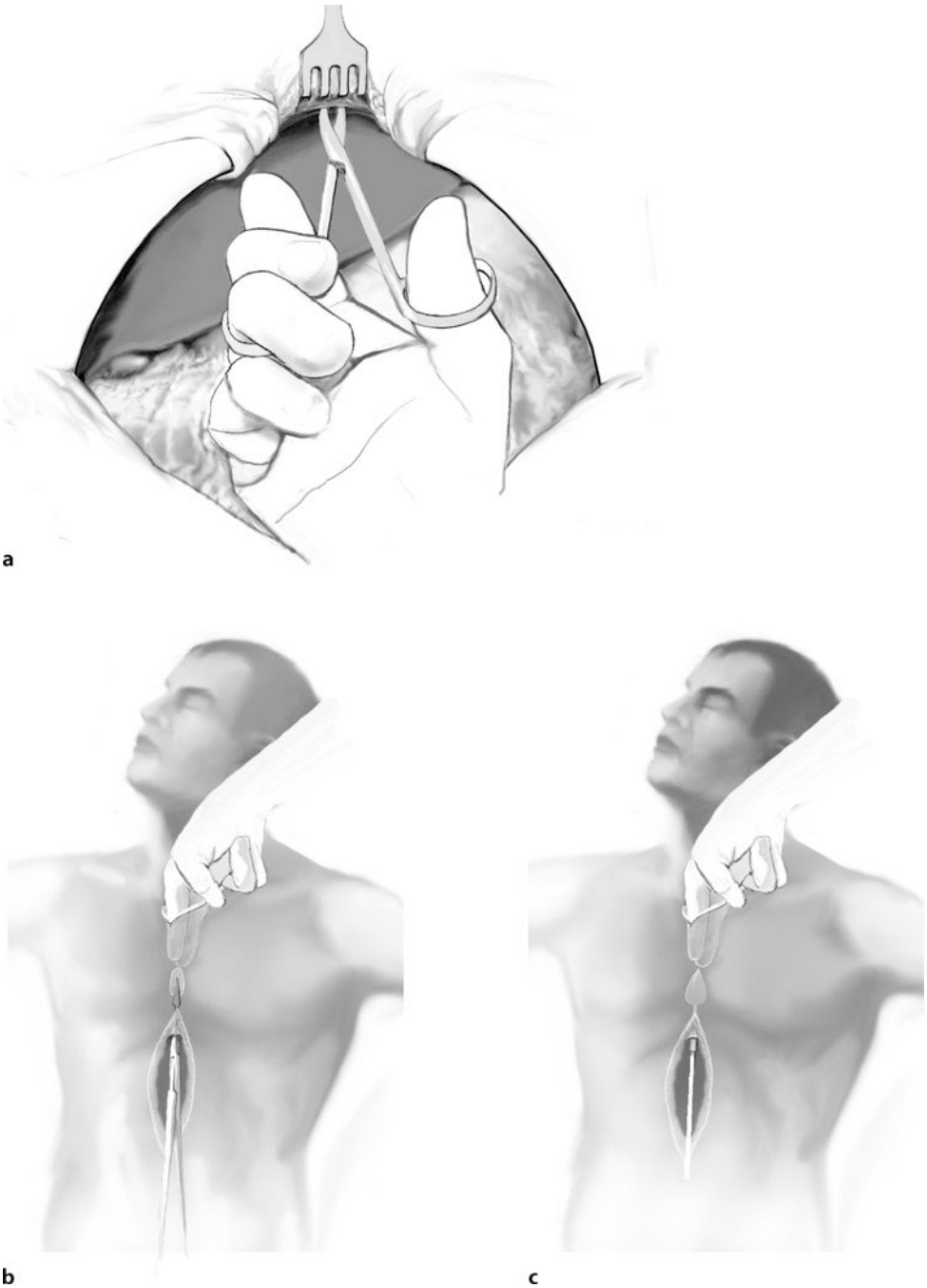


Fig. 23.10

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Step 17

Completed preparation of the retrosternal tunnel

In case of dense or tenacious adhesions to the sternum, these adhesions are dissected sharply with scissors (Fig. 23.11).

Between the corpus and the manubrium sterni, the substernal fascia is very tightly connected to the sternum. Furthermore, the visceral and parietal pleura are tightly connected in this region. For this reason, very careful, stepwise preparation with a long atraumatic clamp should be performed, and the preparation should be manually controlled by the substernally introduced finger of the surgeon.

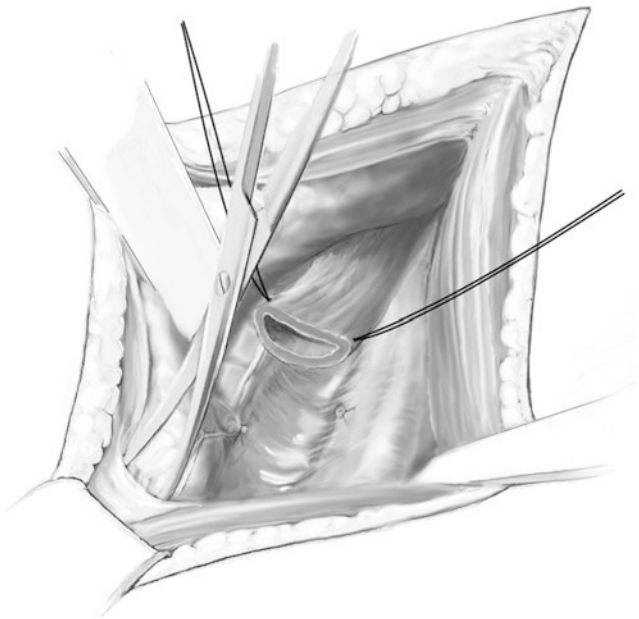


Fig. 23.11

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Step 18

Pull-through procedure

For the substernal reconstruction, a long strong suture is passed from the cervical incision through the mediastinal tunnel into the abdomen to facilitate the pull-through procedure. The suture is tied to the oral end of the colonic interposition. The colon is transposed through the substernal tunnel to the cervical incision under a continuous and gentle pull, and the sternum should be retracted upward with a sharp retractor during the procedure (Fig. 23.12).

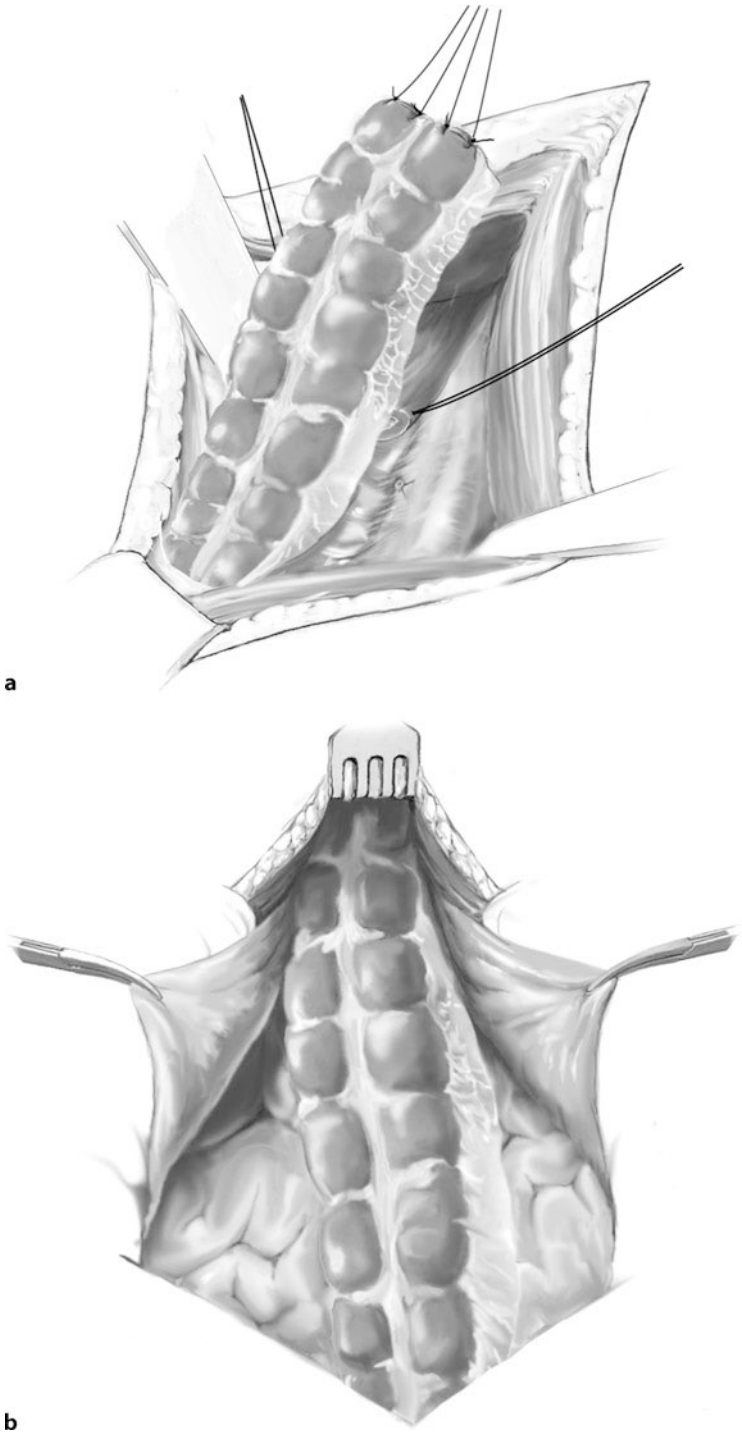


Fig. 23.12

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Step 19

Posterior mediastinum

Interposition of the colon through the posterior mediastinum is performed in the bed of the removed esophagus. The posterior mediastinal route of the interposed colon is favorable to the substernal or presternal position because of the shorter distance to the neck. In addition, the posterior mediastinal route prevents kinking of the colon and leads to better functional results. The interposed colon causes hemostasis in the operation field (Fig. 23.13).

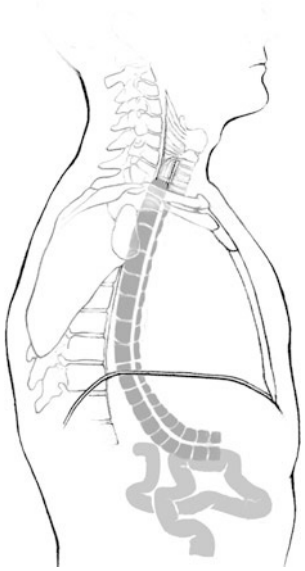


Fig. 23.13

Step 20

End-to-side anastomosis (esophago-colostomy or pharyngo-colostonomy)

If possible, the end-to-side anastomosis should be performed with a double-row suture technique.

In case of a different lumen diameter, interrupted sutures and a end-to-side anastomosis can be performed close to the tenia coli (Fig. 23.14).



Fig. 23.14

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Step 21

Side-to-side anastomosis (esophagotomy-colostomy or pharyngo-colostomy)

The alternative technique for anastomosis after colonic interposition is a side-to-side coloesophageal anastomosis performed by a linear stapler (Fig. 23.15).

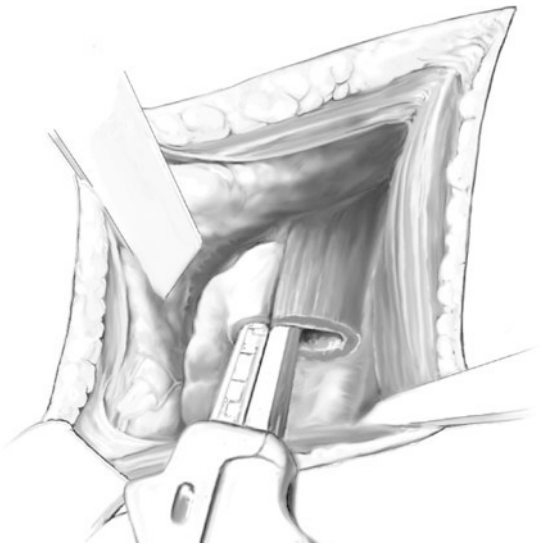


Fig. 23.15

Step 22

Reconstruction of the intestine (colo-jejunostomy)

Gastrointestinal continuity is achieved by distal colo-jejunostomy and jejunojejunostomy.

A colo-sigmoidostomy completes the reconstruction. The mesenteric defects have been closed. The operative site after transposition of the colon and reconstruction is shown (Fig. 23.16).



Fig. 23.16

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Combined Transhiatal Transthoracic Esophagectomy

We reported this technique for the first time in 1980. It uses the concepts acquired in transhiatal dissection in tumors located more superiorly in the cervicothoracic esophagus or in the middle third of the thoracic esophagus and avoids a "blunt" dissection performed without visual control, which increases the possibility of iatrogenic injury to mediastinal structures. However, at present more and more surgeons favor transhiatal esophagectomy for its technical simplicity and favorable outcome.

Indications and Contraindications

Indication

- Esophageal carcinoma in the mid or upper third after subtotal gastrectomy

Contraindication

- Extensive local invasion (trachea, vessels)

Preoperative Investigations/Preparation for the Procedure

- Bronchoscopy

Procedure

- **Access**

See ▶ Chap. 12, "Subtotal Esophagectomy: Abdominothoracic Approach."

Step 1

Abdominal exposure

The operation begins with a upper midline laparotomy, and the abdominal viscera and diaphragmatic section are examined (see earlier), which permits access to the posterior mediastinal space. The mediastinal dissection is done as above, allowing visual control as far as the tracheal branching.

Step 2

Right anterior thoracotomy

A right anterior thoracotomy is then performed, if possible without transection of the costal margin. If the rigidity of the thorax so requires, the anterior arch of the costal margin is removed, and should this prove insufficient, the remaining posterior arch of the costal margin is resected via the anterior thoracic incision.

Step 3

Esophageal dissection and mediastinal lymphadenectomy

The ipsilateral mediastinal pleura, which remains in contact with the esophagus, is incised through the anterior thoracic incision. The arch of the azygos vein is incised, enabling the dissection of the cervicothoracic esophagus. To expand the mediastinal lymphadenectomy, this incision is used to dissect the intercostal veins. The trunk of the azygos vein is ligated at the supradiaphragmatic level and resection of the associated thoracic duct is required by the lymphatic involvement.

During esophageal dissection at the high level of the cervical region, tracheobronchial intubation with a Carlens tube can be used to facilitate access to the esophagus, occluding the right bronchial tube (see ▶ Chap. 24, "Abdominothoracic Esophagohemigastrectomy," Steps 1–3).

Step 4

Technique of cervical anastomosis

See ◘ Fig. 23.14 and ◘ Fig. 23.15

Step 5

Technique of high intrathoracic esophagocolostomy

See ◘ Fig. 23.14 and ◘ Fig. 23.15

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Standard Postoperative Investigations

See ▶ Chap. 11 "Subtotal Esophagectomy: Transhiatal Approach."

Postoperative Complications

- **Early Postoperative Course**
  - Pulmonary infections
  - Septic complications: subphrenic or intra-abdominal abscess; cervical wound infection
  - Anastomotic leak
  - Necrosis of the interposition
  - hydro or pneumothorax
  - herniation of bowel into the right pleural cavity

- **Late Postoperative Course**
  - Cicatricial strictures of the cervical esophago- or pharyngeocolostomy, mostly due to anastomotic leak
  - Kinking of the interposition
  - Mechanical trauma to a subcutaneous graft, which often needs surgical intervention
  - Propulsive disorder
  - motor disorder of swallowing and passage of food through colonic segment

Tricks of the Senior Surgeon

- Treatment of anastomotic stenosis is performed by bougienage or balloon dilation. Very rarely is surgical intervention indicated.
- Reasons for necrosis of the interposition are: decrease of circulation due to kinking or compression of the main vessels, hypovolemia, and hypercoagulability. Avoidance is by interposition of a long colonic segment without tension. Optimization of the postoperative hemodynamic and rheologic parameters is necessary.
- Kinking of the interposition is a rare but dangerous complication, which often requires reoperative intervention, due to clinical symptomatic disturbance of the gastrointestinal passage by elongation of the interposition. Surgical intervention is performed by shortening of the graft.
- To avoid diaphragmatic paralysis, the phrenic nerves must be preserved.
- To avoid herniation of bowel into the right pleural cavity, the diaphragmatic defect must be closed.

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Abdominothoracic Esophagohemigastrectomy

Michael F. Nentwich, Dean Bogoevski

The surgical approach toward adenocarcinomas of the esophagogastric junction (AEG) is still under debate. Siewert and Stein provided a system for classifying the tumors into three types based on topographical-anatomical criteria; this has been widely accepted in Europe and has had a direct impact on therapeutic strategies. Type I AEGs involve the distal esophagus and arise mostly in the intestinal metaplasia of Barrett's esophagus, Type II originate at the anatomical cardia, and Type III are subcardial gastric carcinomas infiltrating the esophagogastric junction and distal esophagus from below.

In Europe patients with an AEG Type I carcinoma are treated with radical en-bloc esophagectomy and gastric tube reconstruction. In patients with AEG Type II, an extended gastrectomy or esophagogastrectomy is indicated. In the United States the standard surgical therapy in patients with AEG Types I and II is esophagectomy with hemigastrectomy, whereas the therapy for Type III carcinomas is similar to that in Europe. In some patients a tumor is operated on as an esophageal cancer, but definitive histology shows a gastric cancer, and vice versa.

In case of a tumor extension involving more than one quarter of the stomach and a 5-cm distal margin cannot be achieved, a total esophagogastrectomy with colonic interposition is advised.

Indications and Contraindications

Indications

- Carcinoma of the distal esophagus (AEG Type I) with involvement of the proximal stomach
- Locally advanced carcinoma of the cardia (AEG Type II)
- Adenocarcinoma of the proximal stomach (AEG Type III) with infiltration of the distal esophagus

Contraindications

- Active duodenal ulcer
- Severe or irreversible cardiopulmonary insufficiency

Preoperative Investigations/Preparation for the Procedure

- Esophagogastroduodenoscopy with histological diagnosis
- Total colonoscopy to exclude second malignancy or diverticula in the transposed colonic segment
- CT scanning of the thorax and abdomen; some surgeons also suggest a PET-CT scan
- Abdominal sonography
- Esophageal endosonography (if indicated)
- Pulmonary function tests and blood gas analysis
- Echocardiography (if indicated)
- Ergometry and other cardiac investigations (if indicated)
- Entire orthograde bowel preparation

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24

Procedure

Positioning

- Patient in the left lateral position for the thoracic part of the operation
- Right anterolateral thoracotomy through the fifth intercostal space (ICS)
- Repositioning to the supine position
- Upper transverse incision with median extension

Alternatively, a modified helical patient position without the need of intraoperative repositioning can be used

- Patient placed on a vacuum-positioning device and positioned in a right thoracoabdominal position (Fig. 24.1)



Fig. 24.1

- Shoulders are rotated approximately 45°, hips remain less rotated, right arm is elevated across the body exposing the axilla
- Table rotation for exposure of either abdominal or thoracic parts

Approach

- Upper transverse laparotomy incision with median T-shaped extension
- Insertion of Rochard retractor to elevate costal margin
- Anterolateral thoracotomy through the fifth ICS

Step 1

Laparotomy

The abdomen is entered by a supraumbilical transverse laparotomy with median reverse T-shaped extension. After ligation and transection of the ligamentum Teres and after abdominal wall adhesions are cleared, a Rochard retractor is inserted to elevate the costal margins on both sides.

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Step 2

Exposure

The peritoneum, omentum and the liver are palpated to exclude metastatic disease. Mobilization of the left lateral liver lobe is done by ligation of the left falciform ligament and by the dissection of the lesser sac close to the liver. The greater omentum is then detached from the transverse colon.

Step 3

Lymphadenectomy

Lymphadenectomy begins at the hepatoduodenal ligament and includes the lymph nodes surrounding the proper and the main hepatic artery and the hepatodoudenal ligament as well as the lymph nodes at the celiac trunk. Attention has to be paid to preserve the right gastroepiploic vessels. Lymphadenectomy is continued along the splenic artery until the splenic hilum is reached.

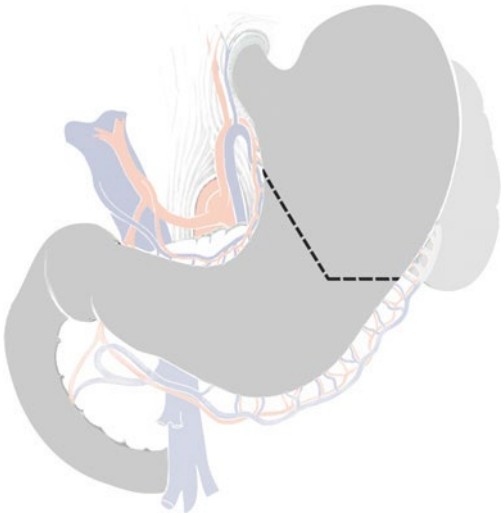
Step 4

Mobilization and resection of the proximal stomach

Traction is applied to the stomach toward the right upper abdomen to expose the origin of the left gastroepiploic artery and the short gastric vessels. These vessels are transected and ligated between clamps. Mobilization of the greater curvature of the stomach is performed up to the gastroesophageal junction. During this step the phrenicogastric ligament has to be transected with electrocautery.

Mobilization of the lesser curvature of the stomach is performed up to the gastroesophageal junction, paying special attention to the left gastric artery and the vein. These are transected and ligated between clamps.

The resection margins are set in the distal stomach region about 5–7 cm distal to the esophagogastric junction in the mid third of the stomach (◘ Fig. 24.2). A distal tumor margin of at least 5 cm should be obtained. The stomach is preferably divided with a stapler device; otherwise it is recommended to make a single-layer closure of the gastric incision with a running suture or interrupted stitches. In case a stapler device is used, the serosa should be adapted with seromuscular stitches.



◘ Fig. 24.2

Step 5

Transthoracic esophagectomy

See ► Chap. 23 “Abdominothoracic Esophagogastrectomy.”

Step 6

Preparation of the colonic interposition

See ► Chap. 23 “Abdominothoracic Esophagogastrectomy.”

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Step 7

Reconstruction

The interposition of the colon can be done either by creating a substernal or presternal tunnel or by using the posterior mediastinum route in the bed of the removed esophagus. This is the preferred route because it reduces kinking of the colon and the oral colonic end is closer to the cervical esophagus.

See ▶ Chap. 23 "Abdominothoracic Esophagogastrectomy."

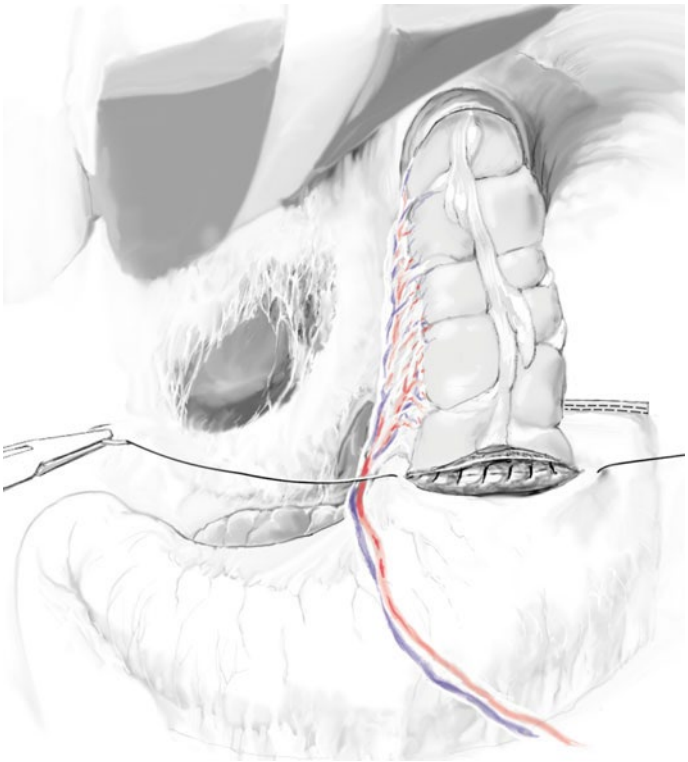
The anastomosis can be placed either intrathoracically or cervically. Usually the colonic interposition provides excessive length to reach the cervical area. An intrathoracic anastomosis is performed using a circular stapler, preferably with a large diameter (28 mm) to prevent future anastomotic strictures and a end-to-side anastomosis is applied. Alternatively, the anastomosis can be done as a hand-sewn one in a single-layer running suture technique. Attention has to be paid to the "corner" areas of the anastomosis and additional interrupted sutures may be placed to ensure a primary sufficient anastomosis.

If a cervical anastomosis is favored, it can be performed as described in the ▶ Chap. 23 "Abdominothoracic Esophagogastrectomy."

Step 8

Intestinal reconstruction

To reconstruct the intestinal continuity, a end-to-side or side-to-side cologastrostomy is performed by either a one- or two-layered anastomosis. The gastric remnant is incised for 3–4 cm close to the linear stapler line at the anterior gastric wall (◘ Fig. 24.3).



◘ Fig. 24.3

In addition, the colonic continuity is established by a side-to-side colonic anastomosis. Mesenteric incisions need to be closed to avoid internal herniation.

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Postoperative Complications

Early Postoperative Course

- Pulmonary infections
- Septic complications: subphrenic or intra-abdominal abscess; cervical wound infection
- Anastomotic leakage
- Necrosis of the colonic interposition
- Hydro or pneumothorax
- Herniation of bowel into the right pleural cavity

Late Postoperative Course

- Cicatricial strictures of the cervical esophagogastrostomy, mostly due to anastomotic leak
- Kinking of the interposition
- Mechanical trauma to a subcutaneous colonic interposition, which often needs surgical intervention
- Difficulty swallowing or motility disorder
- Anastomotic ulcers in the area of the colonogastrostomy

Tricks of the Senior Surgeon

- Treatment of the stenosis is performed by bougienage or balloon dilatation. Very rarely is surgical intervention indicated.
- Reasons for necrosis of the colonic interposition are decrease of circulation due to kinking or compression of the main vessels, hypovolemia, and hypercoagulability. It can be avoided by using a long colonic segment without tension. The postoperative hemodynamic and rheologic parameters need to be optimized.
- Kinking of the interposition followed by elongation often requires surgical intervention as it can lead to a disruption of the flow of injested food through the colonic conduit. The conduit has then to be shortened.
- To avoid herniation of bowel into the right pleural space, closure of the diaphragm has to be performed.

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Transhiatal Esophagohemigastrectomy

Dean Bogoevski, Jakob R. Izbicki

Introduction

Carcinomas of the cardia are still not classified as a separate entity and were staged like gastric carcinomas until January 2010. There is a discordance concerning the classification of carcinomas within this area owing to the topographical borderland between the esophagus and the stomach. Siewert and Stein provided a system for classifying the tumors into three types based on topographical-anatomical criteria. Type I adenocarcinomas of the esophagogastric junction (AEGs) involve the distal esophagus and arise mostly in the intestinal metaplasia of Barrett's esophagus, Type II originate at the anatomical cardia and Type III are subcardial gastric carcinomas infiltrating the esophagogastric junction and distal esophagus from below.

Different tumor entities at the esophagogastric junction (EGJ) should be treated by different surgical approaches. In patients with potentially resectable carcinoma of the cardia (AEG Types I and II), this can be achieved by a total or a hemigastrectomy with transhiatal resection of the distal esophagus and en-bloc removal of the lymphatic drainage in the lower posterior mediastinum and upper abdomen.

Indications and Contraindications

Indications

- Carcinoma of the distal esophagus where preoperatively infiltration of the gastric cardia cannot be excluded
- Adenocarcinoma of the EGJ Types I and II
- Distal esophageal carcinoma after subtotal gastrectomy
- Esophageal carcinoma of the mid or upper third after subtotal gastrectomy (abdominothoracic esophagogastrectomy with cervical or high intrathoracic anastomosis)
- Caustic ingestions

Contraindications

- Active duodenal ulcer

Preoperative Investigations/Preparation for the Procedure

- Esophagogastroduodenoscopy with histological diagnosis
- Total colonoscopy to exclude second neoplasm or diverticula in the transposed colon segment
- CT scanning of the thorax and abdomen; some surgeons also suggest a CR-PET scan
- Abdominal sonography
- Esophageal endosonography
- Pulmonary function tests and blood gas analysis
- Echocardiography
- Ergometry and other cardiac investigations if necessary
- Entire orthograde bowel preparation

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery*,
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Procedure

- **Positioning**
  - Supine position with hyperlordosis

- **Approach**
  - Upper transverse incision with median reversed T-shaped laparotomy
  - Insertion of Rochard retractor to elevate costal margin

Step 1 Laparotomy

See ► Chap. 11 "Subtotal Esophagectomy: Transhiatal Approach."

Step 2 Exposure

After mobilization of the left lateral liver lobe and dissection of the lesser sac close to the liver, the greater omentum is detached from the transverse colon. Lymphadenectomy begins at the base of the right gastroepiploic vessels. The peritoneal sheath is incised above the right gastroepiploic vessels. The lymph nodes around the origin of the right gastroepiploic artery are dissected, and special attention is paid not to injure the vessels, since the blood supply for the gastric remnant will be granted through these vessels.

Step 3 Lymphadenectomy

Dissection of the lymph nodes surrounding the stomach. For better exposure of these nodes, the stomach is held upward by ventral traction. The lymph nodes at the upper margin of the pancreas are dissected. Injury of the serosa of the duodenum and of the pancreatic capsule has to be avoided.

The lymphadenectomy in the hepatoduodenal ligament is performed. In addition, the lymph nodes around the origin of the right gastric artery are dissected and special attention is paid not to injure the vessels, since the blood supply for the gastric remnant will be granted through these vessels.

Step 4 Completion of the lymphadenectomy

The upper margin of the pancreas is now exposed by applying upward traction to the distal stomach. Lymphadenectomy continues from the hepatoduodenal ligament along the common hepatic artery down to the celiac trunk. Lymphadenectomy at the splenic artery, the celiac trunk and the para-aortal space is performed (see ► Chap. 21, "Total Gastrectomy with Conventional Lymphadenectomy," STEP 6).

Step 5 Total gastrectomy (see ► Chap. 21, "Total Gastrectomy")

Mobilization and resection of the proximal stomach

Traction is applied to the stomach toward the right upper abdomen to expose the origin of the left gastroepiploic artery and the short gastric vessels. These vessels are transected and ligated between clamps; some surgeons prefer to use an energy device for much of this procedure. Mobilization of the greater curvature of the stomach is performed up to the gastroesophageal junction. During this step the phrenicogastric ligament has to be transected with electrocautery.

Mobilization of the lesser curvature of the stomach is performed up to the gastroesophageal junction, paying special attention to the left gastric artery and the vein. These are transected and ligated between clamps.

The resection margins are set at the EGJ and then about 7 cm distal to the EGJ in the mid third of the stomach. The stomach is divided with the stapler device. It is also recommended to make a single-layer closure of the gastric incision with a running suture or interrupted stitches. In case a stapler device is used, the serosa should be approximated with seromuscular stitches.

Step 6 Transhiatal esophageal resection

See ► Chap. 11, "Subtotal Esophagectomy: Transhiatal Approach."

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Step 7

Mobilization of the left colonic flexure

The left lateral peritoneal reflection is finally mobilized by dissection of the peritoneum in the cranial direction. The splenocolic ligament and the phrenicocolic ligament are ligated and divided using cautery or scissors or an energy device. Thus the whole splenic flexure of the colon is mobilized (Fig. 25.1).

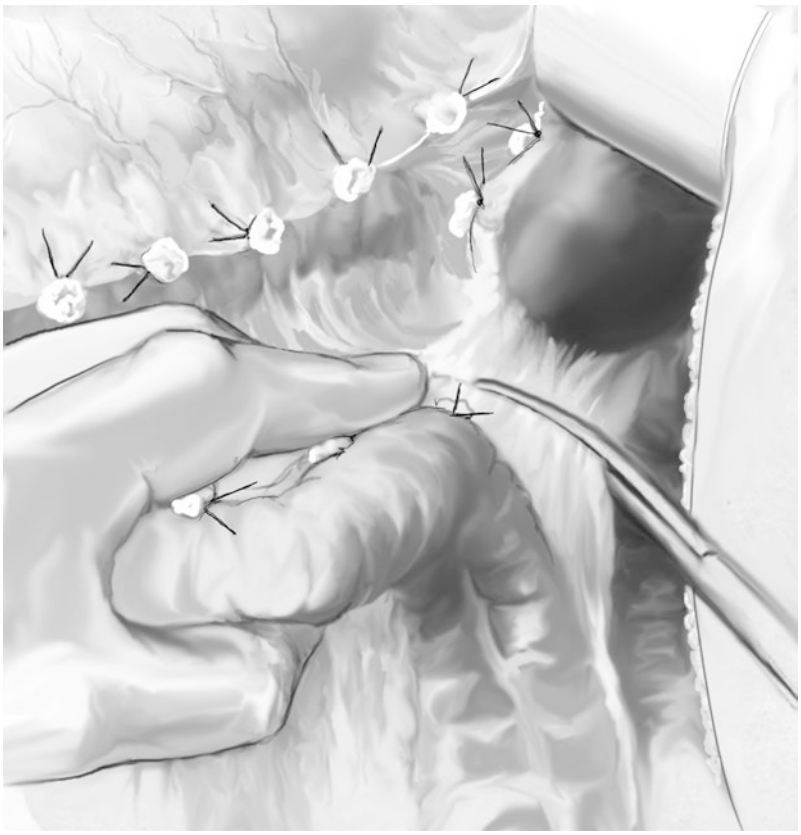


Fig. 25.1

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Step 8

Mobilization of the sigmoid colon

Mobilization of the sigmoid colon is facilitated by performing mediocranial traction to expose the embryonic adhesions between the colon and the retroperitoneum. Further dissection is done between the mesosigmoid and the retroperitoneal fat, taking care of the left ureter and gonadal vessels (Fig. 25.2).

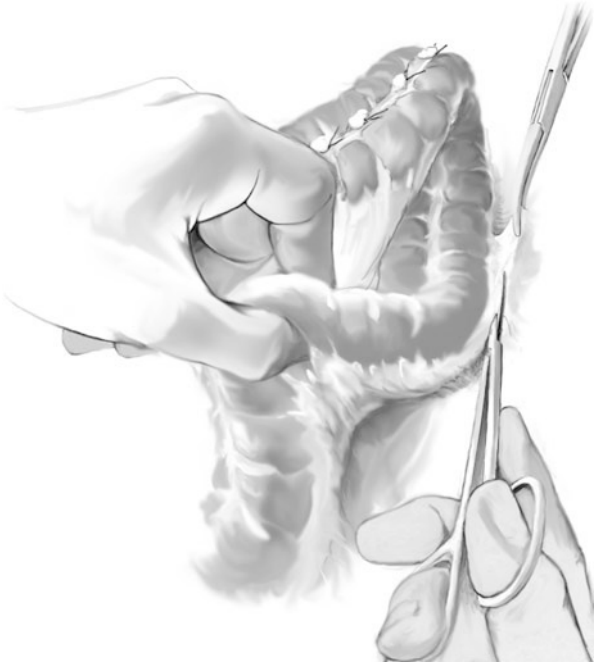
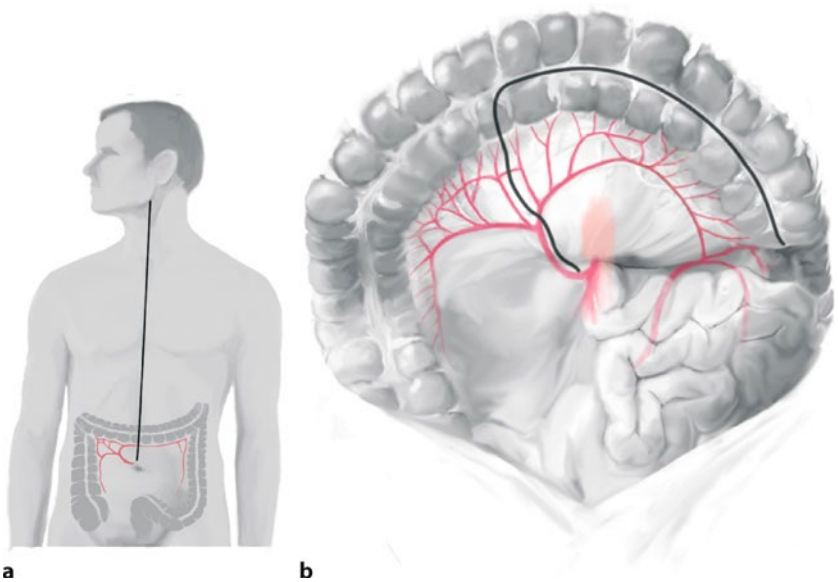


Fig. 25.2

Step 9

Determination of the essential length

A colonic segment is selected suitable for interposition. The essential length is determined by the following procedure: elevation of the colon in front of the abdominal wall, and measurement of the distance between the abdomen and the angle of the mandible by a suture, fixed at the root of the vessel of the colonic mesentery on which the vascular supply to the colonic interposition will be based (Fig. 25.3). The length of the suture is finally transferred to the colon and the resection margin is marked.



a b

Fig. 25.3

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The black bars show alternative lines for transection of the colon. Resection of bluish margins on the right flexure of the transverse colon between the middle and the right colic artery should be performed after preservation of the paracolic arcades. Following this procedure, a better mobilization of the colonic segment can be obtained. To perform the pharyngocolostomy in carcinomas of the upper third of the esophagus, a long colonic segment is required. Therefore parts of the sigmoid colon have to be used and the first (and probably the second) sigmoid artery has to be ligated close to the inferior mesenteric artery. Prior to dissection of the vessels, an atraumatic clamp is provisionally applied to prove the sufficiency of the vascular supply to the proposed colonic segment to be used. Dark arrows point to the vascular resection margins. The arcade between the right and the middle colic artery should be preserved for a better vascular supply of the colonic segment chosen for interposition (Fig. 25.4).

Advantages of using the left colonic segment are the following:

- The more predictably longer length and the smaller diameter of the left colon
- Adequacy of the vascular pattern due to arteries with larger diameter, instead of vascular supply via several arcades as in the right colon
- Using an antiperistaltic colonic segment has no clinical relevance because the injested food is transported through the colonic interposition by gravity

The essential advantage of the left colon is the opportunity to obtain a longer colonic segment.

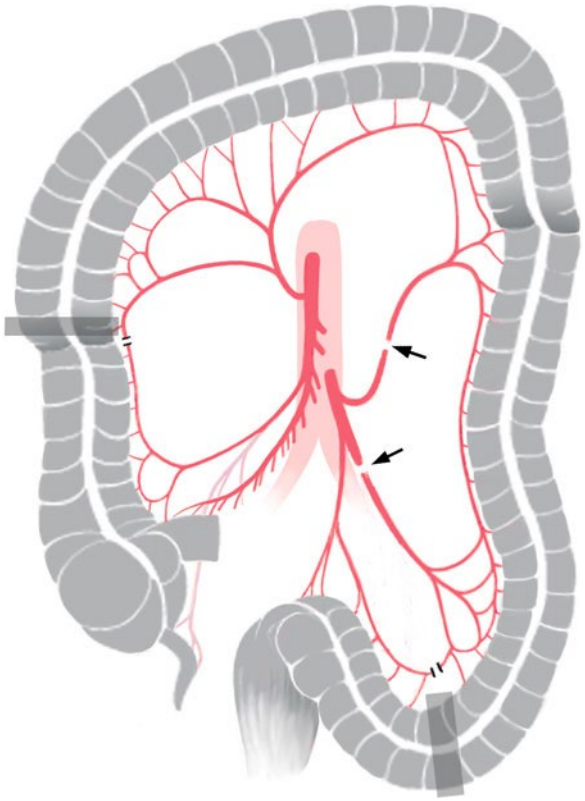


Fig. 25.4

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Step 10

Standard procedure: isoperistaltic reconstruction

The middle colic artery is divided and the vascular supply is through the left colic artery, if a sufficient Riolan arcade exists.

This approach ensures an isoperistaltic reconstruction (standard procedure). Care has to be taken not to injure the left colic vessels. Therefore preparation has to be done carefully and close to the wall of the colon, and transection of the descending colon is always done without extensive dissection of the colon using a linear stapler device. The right and middle colic vessels are dissected close to their origin. A prophylactic appendectomy after total mobilization of the colon is recommended.

An antiperistaltic colon interposition supplied by the left colic artery can be performed, if the Riolan anastomosis is either not present or insufficient due to previous surgical procedures (Fig. 25.5).

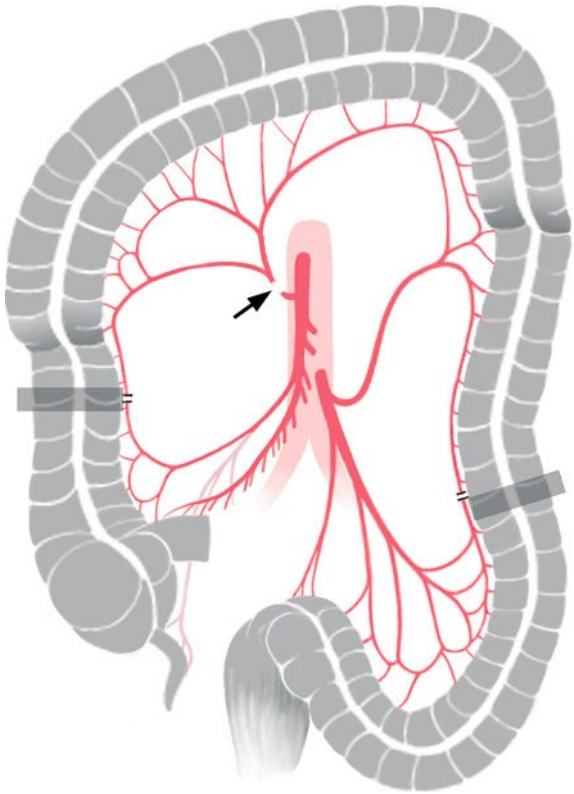


Fig. 25.5

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Step 11

Antiperistaltic reconstruction (not standard)

Preparation of an antiperistaltic (not standard) colonic segment begins with incision of the peritoneum of the left mesocolon far from the colon and stepwise preparation of the mesocolon maintaining the paracolic arcades and the middle and left colic vessels. An atraumatic vascular clamp is provisionally applied across the left colic artery and the sigmoid artery to assure adequate blood supply to the colonic segment to be used for the conduit based on a sufficient arcade of Riolan. If no ischemia occurs after 3 min, the colon interposition can be performed (Fig. 25.6).

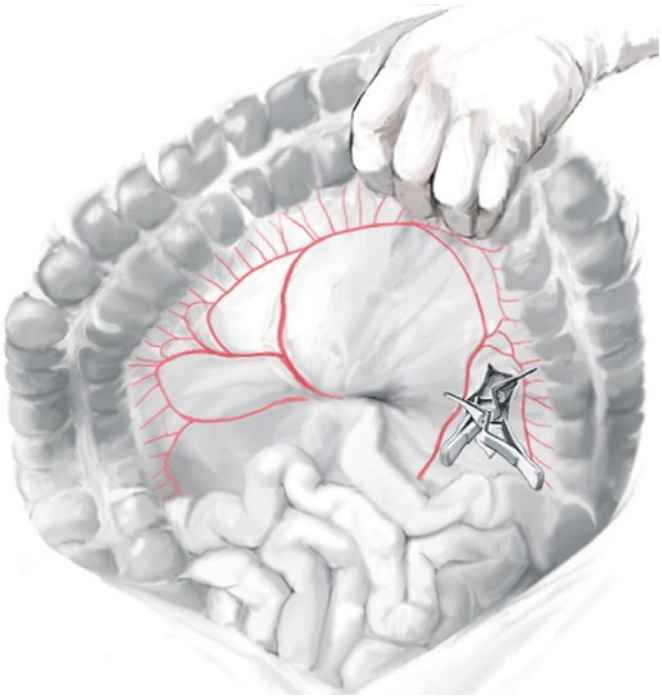


Fig. 25.6

Step 12

Inadequate vascular supply

In case of an inadequate vascular supply by the left and middle colic artery, reconstruction of an isoperistaltic colon interposition supplied by the sigmoid artery is possible (Fig. 25.7).

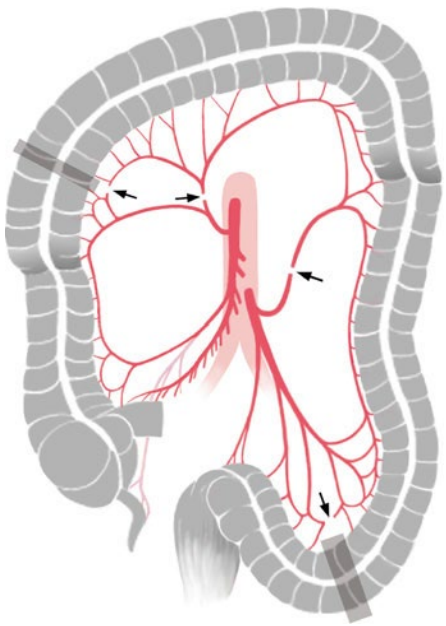


Fig. 25.7

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Step 13

Inadequate vascular supply

In very rare cases no anastomosis is found between the left colic artery and the first sigmoid artery. In those cases the main branch of the inferior mesenteric artery can be used as an anastomosis between the two areas of blood supply. This can only be accomplished when the distal parts of the sigmoid colon are adequately perfused by the medial and inferior rectal artery. This has to be checked by temporary vascular clamping (Fig. 25.8).

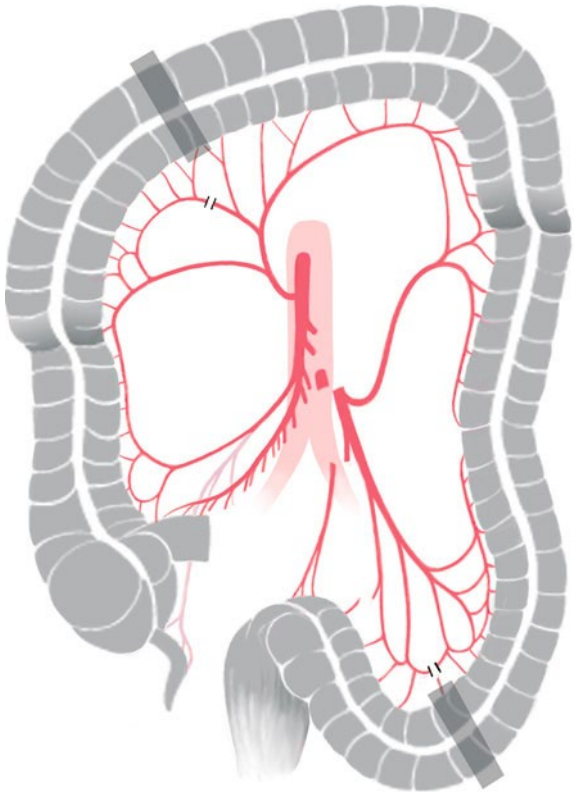


Fig. 25.8

Step 14

Rare situations

Even after right hemicolectomy (e. g., following unsuccessful right colonic interposition), construction of an antiperistaltic interposition is possible if the middle colic artery has been spared during the first operation. The left colic artery and the first sigmoid artery are dissected (Fig. 25.9a). Vascular supply of the colonic interposition comes from the middle colic artery. Reconstruction is performed with an ileosigmoidostomy.

Alternatively, a colonic interposition after right hemicolectomy and after former transection of the middle colic artery can be performed using the left colon. The blood supply comes from the left colic artery. The entire sigmoid colon is needed for the purpose of achieving sufficient length for the interposition and all sigmoid arteries have to be dissected (Fig. 25.9b). The proximal colon segment with poor vascular supply is resected.

If impossible to use the left hemicolon for interposition, the right hemicolon can be used to perform the colonic interposition.

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Step 14 *(continued)*

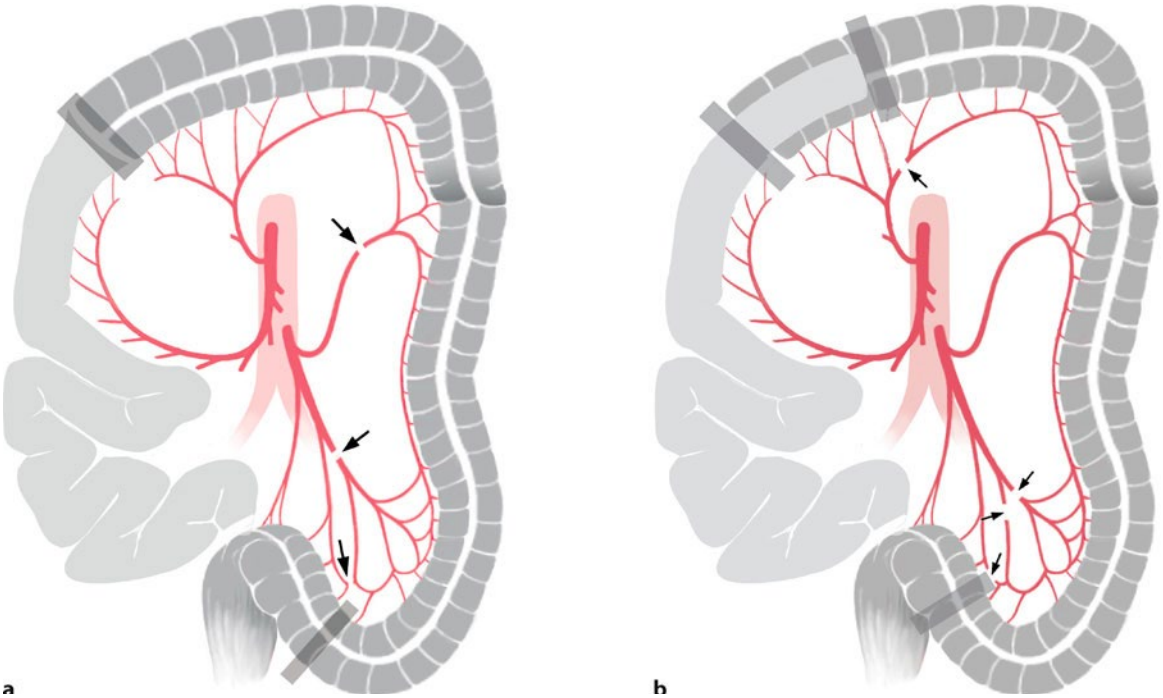


Fig. 25.9

Scheme of construction of an isoperistaltic colonic interposition using the right hemicolon and the terminal part of the ileum is illustrated here (Fig. 25.10). The vascular supply comes from the middle colic artery.

Using the right hemicolon for interposition is burdened by frequent complications leading to poorer postoperative functional results.

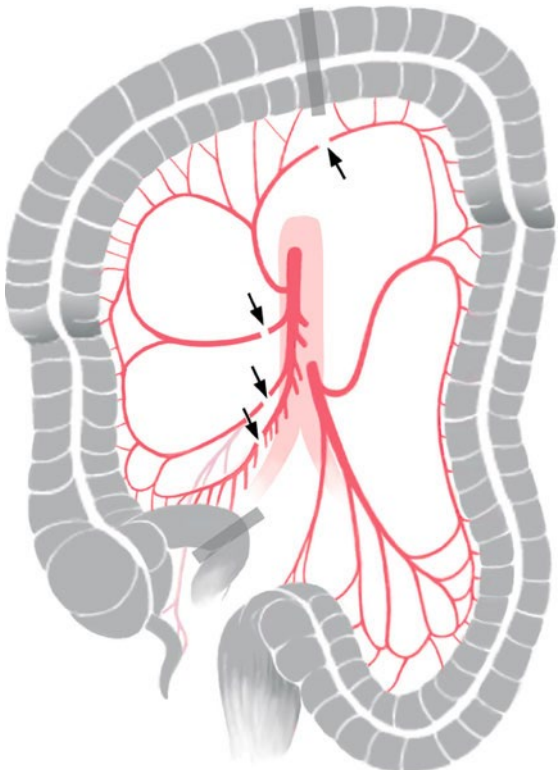


Fig. 25.10

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Step 15

Vascular supply of the colonic interposition from the ileocolic artery

Also shown is the preparation of an antiperistaltic colonic interposition using the right hemicolon, with vascular supply from the ileocolic artery (Fig. 25.11a).

Adequate length of the right hemicolon enables construction of an isoperistaltic interposition without using the ileocolic portion of the intestine (Fig. 25.11b). This technique offers several advantages:

- Omission of the terminal ileum, which is prone to necrosis
- Omission of the ileocecal region, which is prone to poor functional results

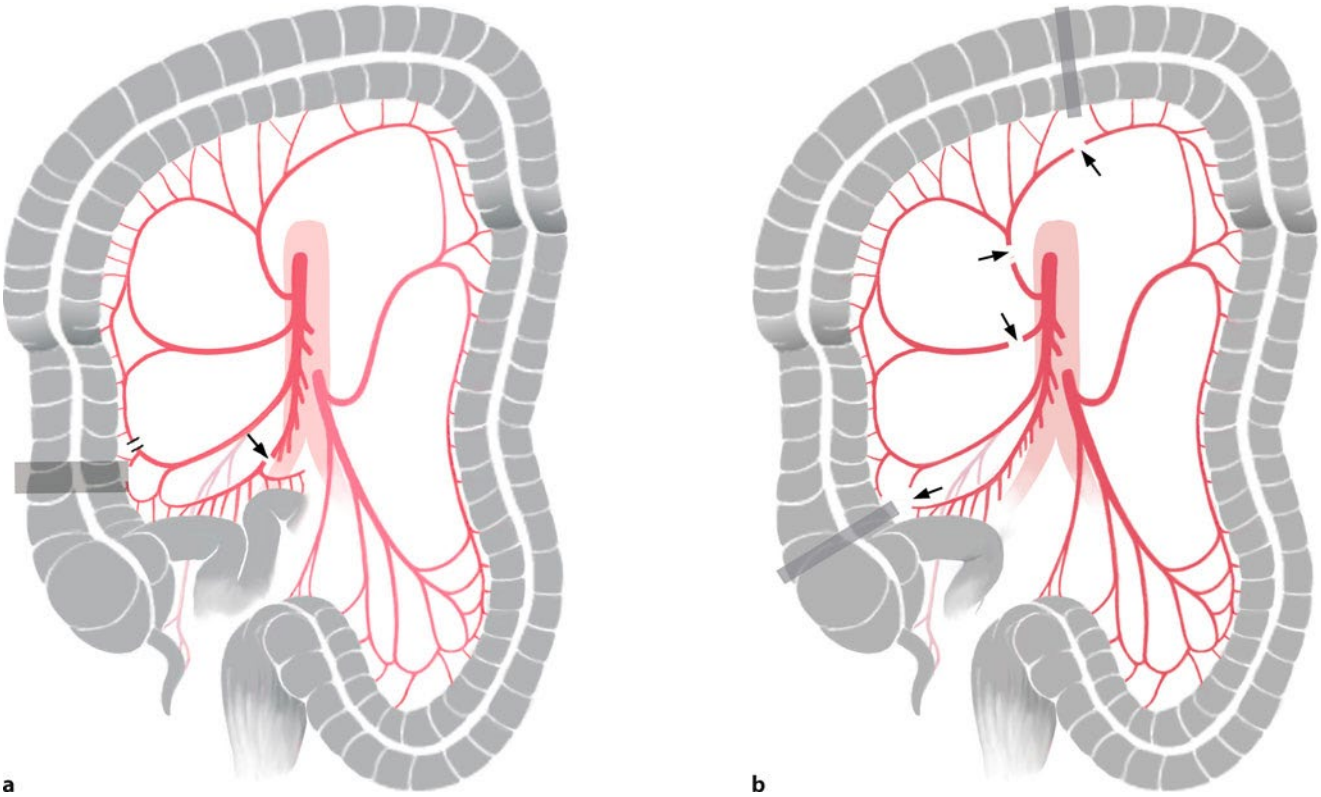


Fig. 25.11

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Step 16

Preparation of a substernal tunnel

A blunt opening is made in the substernal cavity by spreading the scissors, while retracting the xiphoid ventrally with a sharp retractor (Fig. 25.12a).

After opening the substernal cavity, a substernal tunnel is constructed with an atraumatic clamp.

The sternum has to be retracted anteriorly, and the endothoracic membrane is to be separated from the sternum. A longitudinal incision along the anterior border of the left sternocleidomastoid muscle is made to expose the cervical esophagus. Blunt preparation with the hand through the substernal tunnel usually leads to rupture of the mediastinal pleura (Fig. 25.12b,c).

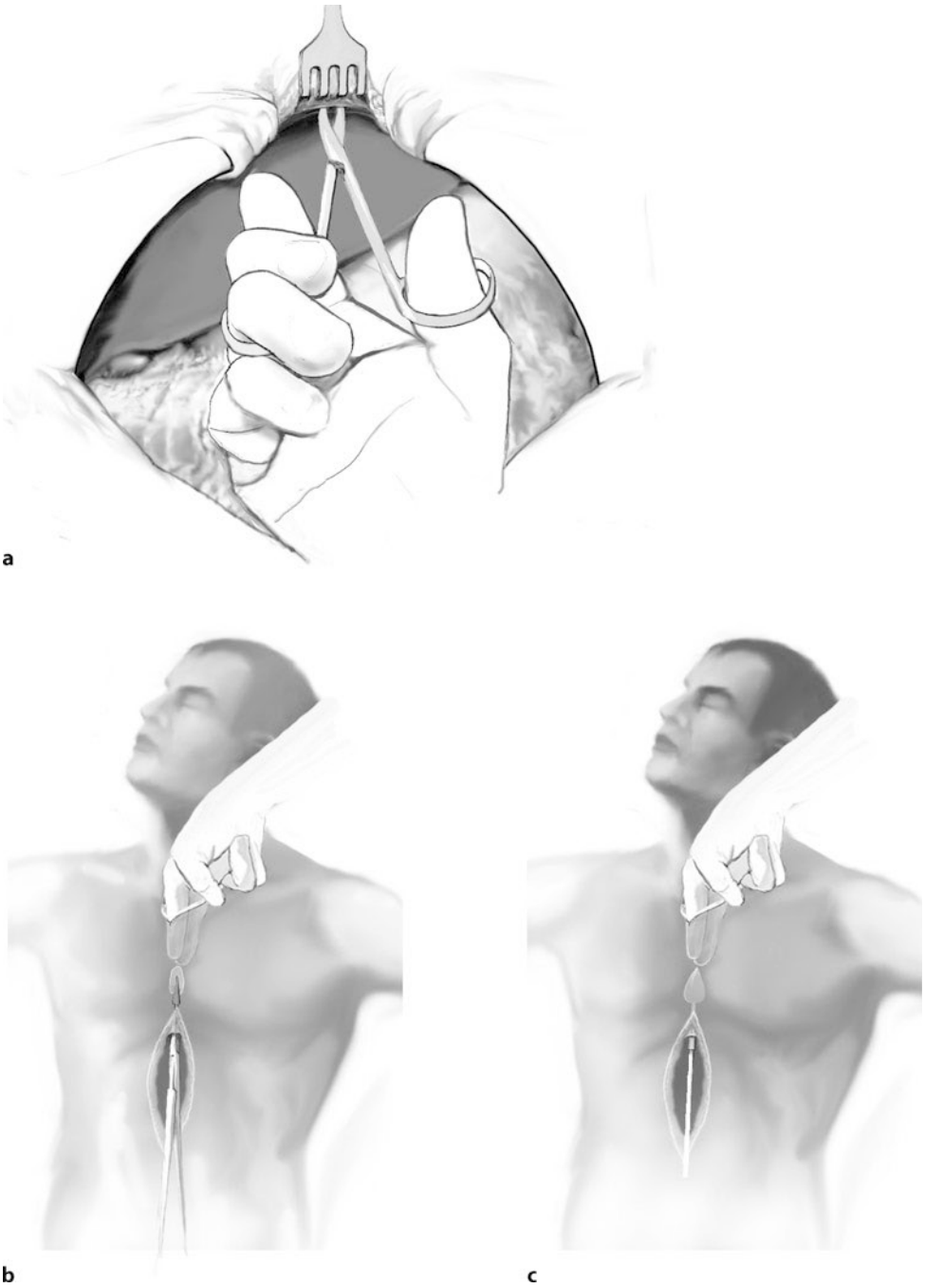


Fig. 25.12

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Step 17

Completed preparation of the retrosternal tunnel

In case of tight adhesions to the sternum, these adhesions are dissected sharply with scissors.

Between the corpus and the manubrium sterni the substernal fascia is very tightly connected to the sternum. Furthermore, the visceral and parietal pleura are tightly connected in this region. For this reason, very careful, stepwise preparation with a long atraumatic clamp has to be performed, and the preparation should be manually controlled by the substernally introduced finger of the surgeon (Fig. 25.13).

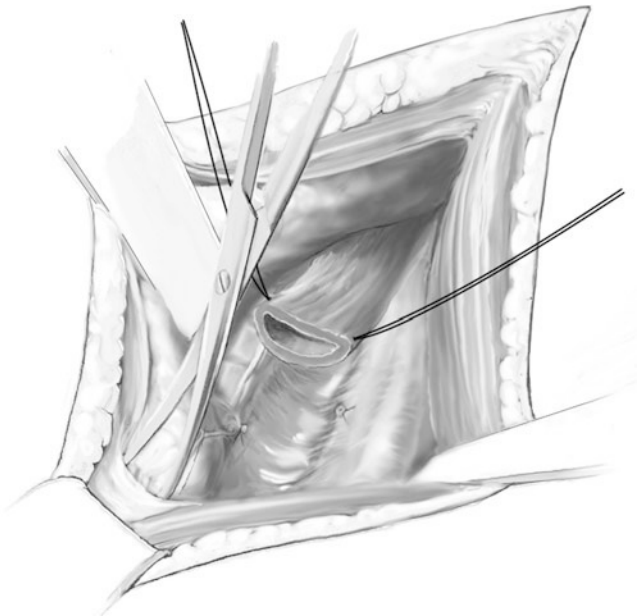


Fig. 25.13

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Step 18

Pull-through procedure

For the substernal reconstruction, a long strong suture is passed from the cervical incision through the mediastinal tunnel and into the abdomen to facilitate the pull-through procedure. The suture is tied to the oral end of the colonic interposition. The colon is transposed in the substernal tunnel to the cervical incision under a continuous and gentle pull, and the sternum should be pulled upward with a sharp retractor during the procedure (Fig. 25.14).

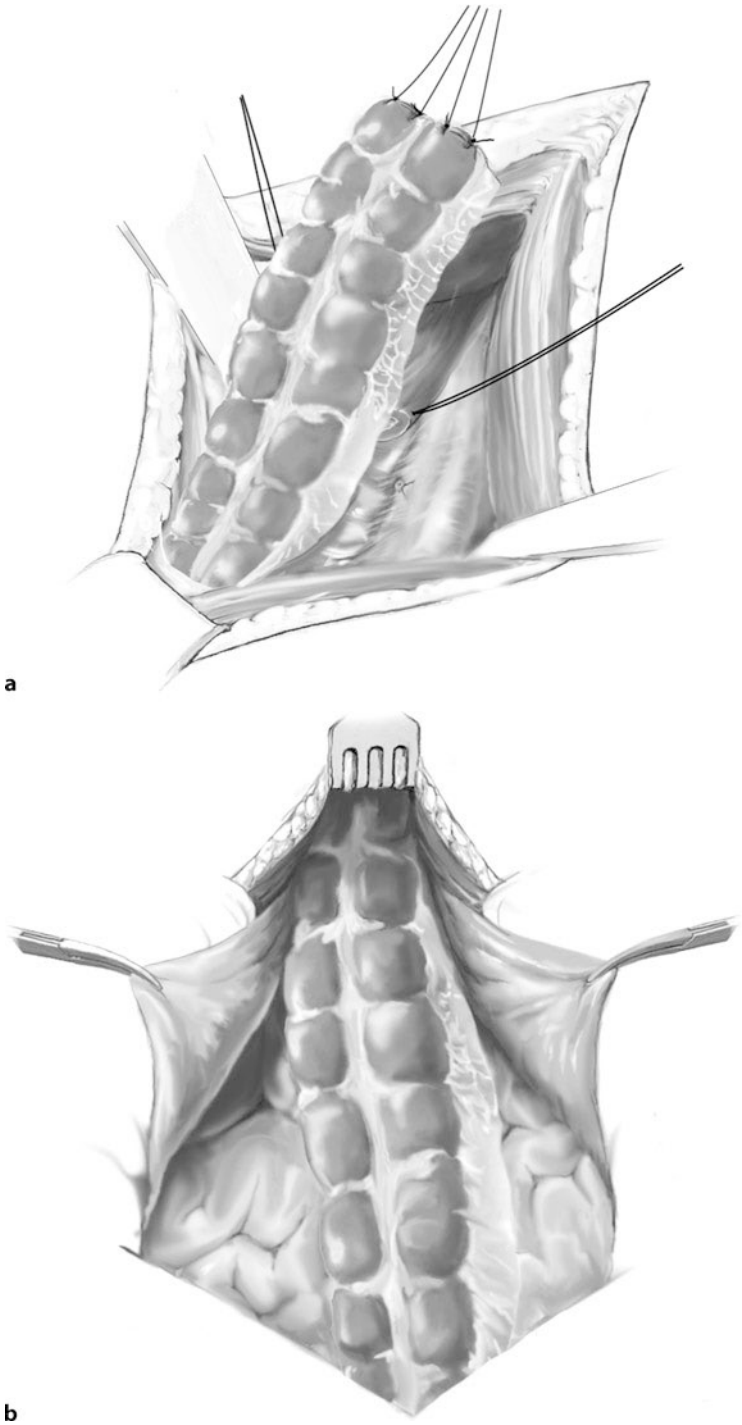


Fig. 25.14

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Step 19

Posterior mediastinum

Interposition of the colon through the posterior mediastinum is performed in the bed of the removed esophagus. The posterior mediastinal route of the colonic interposition is favorable to the substernal or presternal position because of the shorter distance to the neck. In addition, the posterior mediastinal route prevents kinking of the colon and leads to better functional results. The interposed colon causes hemostasis in the operative field (Fig. 25.15).

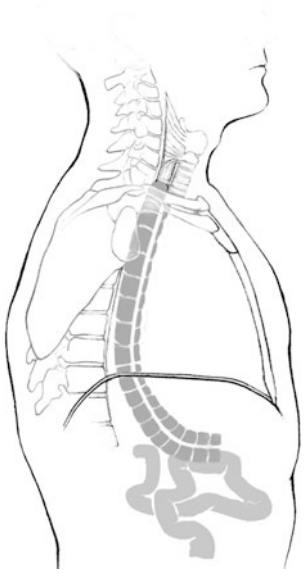


Fig. 25.15

Step 20

End-to-side anastomosis

If possible, the esophago-colonic or pharyngo-colonic end-to-side anastomosis should be performed in a double-row suture technique.

In case of a different lumen diameter, interrupted stitches and a end-to-side anastomosis can be performed close to the tenia coli (Fig. 25.16).



Fig. 25.16

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Step 21

Side-to-side anastomosis

The alternative technique for anastomosis after colonic interposition is a side-to-side coloesophageal anastomosis performed by a linear stapler (Fig. 25.17).

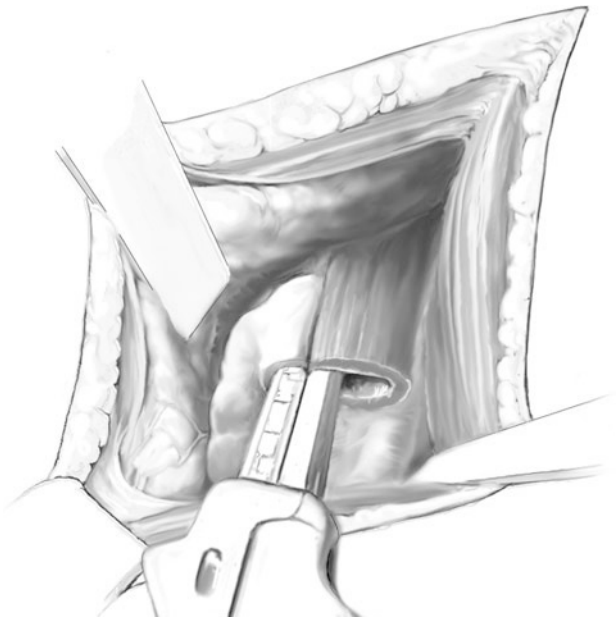


Fig. 25.17

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Step 22

Reconstruction of the intestine

Gastrointestinal continuity is achieved by cologastrostomy.

A colosigmoidoscopy completes the reconstruction. The mesenteric incisions have to be closed. The operative site after transposition of the colon and reconstruction is shown (Fig. 25.18).

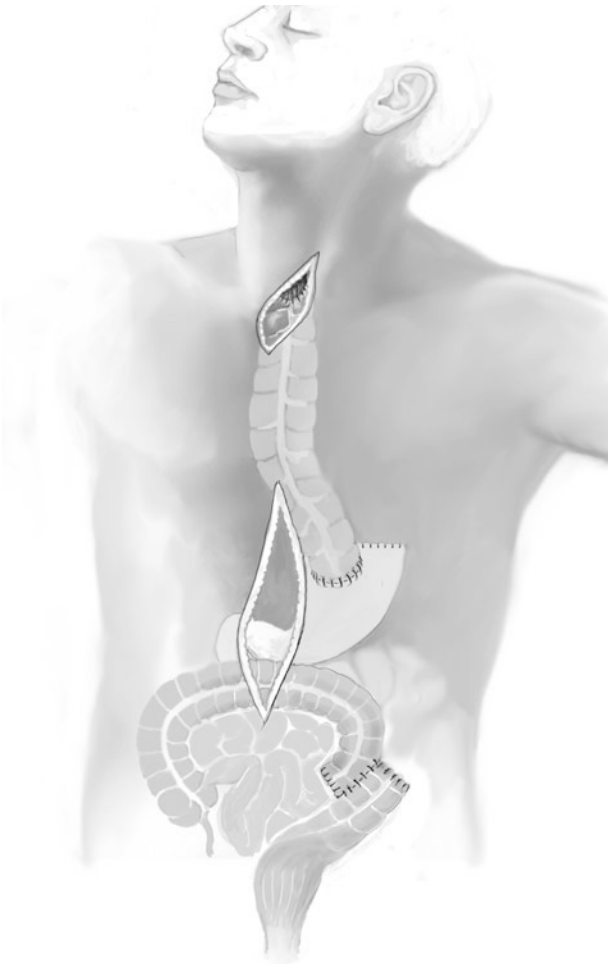


Fig. 25.18

Standard Postoperative Investigations

See ▶ Chap. 24 "Abdominothoracic Esophagohemigastrectomy" and also ▶ Chap. 11 "Subtotal Esophagectomy: Transhiatal Approach".

Postoperative Complications

Early Postoperative Course

- Pulmonary infections
- Septic complications: subphrenic or intra-abdominal abscess; cervical wound infection
- Anastomotic leak
- Necrosis of the colonic interposition
- Hydro or pneumothorax
- Herniation of bowel into the right pleural cavity

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Late Postoperative Course

- Cicatricial strictures of the cervical esophago- or pharyngeocolostomy, mostly due to anastomotic leak
- Kinking of the interposition
- Mechanical trauma to a subcutaneous graft, which often needs surgical intervention
- Difficulty swallowing or a motility disorder

Tricks of the Senior Surgeon

- Treatment of the stenosis is performed by bougienage or balloon dilatation. Very rarely is surgical intervention indicated.
- Reasons for necrosis of the interposition are decrease of circulation due to kinking or compression of the main vessels, hypovolemia, and hypercoagulability. Avoidance is by interposition of a long colonic segment without tension. Optimization of the postoperative hemodynamic and rheologic parameters is necessary.
- Kinking of the interposition is a rare but dangerous complication, which often requires surgical intervention, due to clinical symptomatic difficulty with emptying of the colonic conduit by elongation of the interposition. Surgical intervention is performed by shortening of the graft.
- To avoid herniation of bowel into the pleural cavity, the diaphragmatic hiatus has to be closed.

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Extended Gastrectomy

Asad Kutup, Jakob R. Izbicki

Clinical TNM staging and an evaluation according to the adenocarcinoma of the esophagogastric junction (AEG) classification in Type I (esophagus), Type II (cardia), and Type III (subcardia) form the basis for an individualized surgical treatment of AEG. Endoscopic resection is only appropriate for the infrequent mucosal carcinomas whereas the majority of the junctional carcinomas are treated by surgical resection. A Type I carcinoma is removed by radical transthoracic en-bloc esophagectomy with high intrathoracic esophagogastrostomy or by the transhiatal esophagectomy. In case of Type II or III carcinomas, a transhiatal extended gastrectomy including distal esophageal resection is performed with reconstruction by Roux-en-Y esophagojejunostomy in the lower mediastinum. However, some advanced Type II carcinomas, which cannot be resected R0 at the esophagus, need a total esophago-(hemi-)gastrectomy with colon interposition. This surgical strategy is justified by the topography of the lesion and the corresponding lymphatic drainage. Neoadjuvant treatment should be considered in cT3 and cT4 tumors.

Indications and contraindications

Indications

- AEG Types II and III tumors (cT1sm1–cT3; cT4 if resectable)
- After incomplete endoscopic resection of cT1 tumors

Contraindications

- Peritoneal carcinomatosis
- Child-Pugh C cirrhosis with severe portal hypertension

Preoperative Investigation/Preparation for the Procedure

- See ▶ Chaps. 21 and 23 "Total Gastrectomy" and "Transhiatal Esophagectomy."
- Consider bowel preparation in case of colonic interposition.

Procedure

- **Access**

Upper transverse incision with median extension or, alternatively, midline incision

Step 1 to Step 7

See "Total Gastrectomy ▶ Chaps. 21 and 22.

Step 8

Exposure of the esophagogastric junction

After lymphadenectomy of the celiac trunk, the lymphatic dissection is continued along the celiac trunk to the upper para-aortic region. Lymphatic tissue thus remains adherent en bloc with the lesser curvature and is later resected en bloc with the specimen. The abdominal esophagus is mobilized and caudal traction is applied with a soft rubber tubing like a Penrose drain. For better exposure of the esophageal hiatus and the para-aortic region, the diaphragmatic crura are incised and the stumps are ligated. During this maneuver connective tissue between esophagus, the diaphragmatic crura, and the abdominal aorta must be removed carefully. Thus the diaphrag-

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Step 8 ***(continued)***

matic crura become exposed to the left and right side of the esophagus and both are resected en bloc with the specimen. A wide and sharp transection of the phrenoesophageal ligament and the gastrophrenic ligament at the esophagogastric angle of His is undertaken (Fig. 26.1).

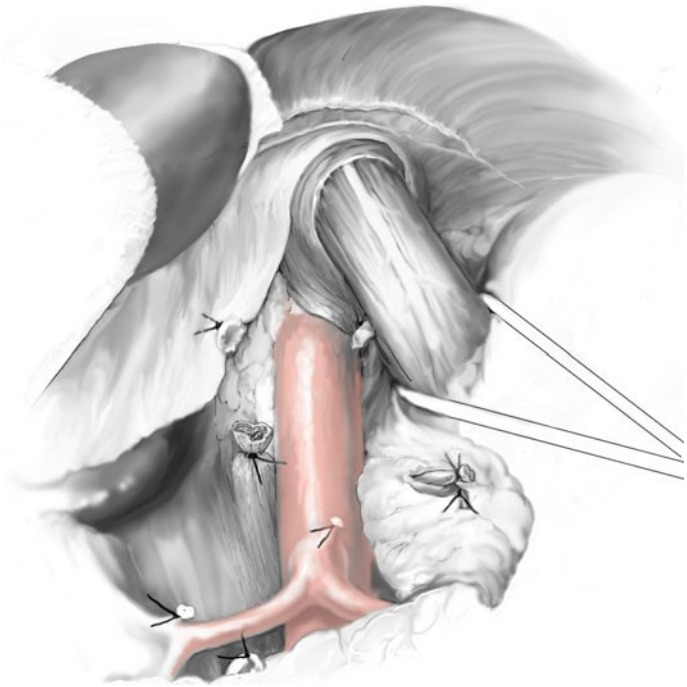


Fig. 26.1

Step 9

Exposure of the distal esophagus

For a better exposure of the distal esophagus, the diaphragm is incised up to the inferior left phrenic vein. Transection and suture ligation of the left phrenic inferior vein are performed. Incision of the diaphragm up to the central portion is done (Fig. 26.2)

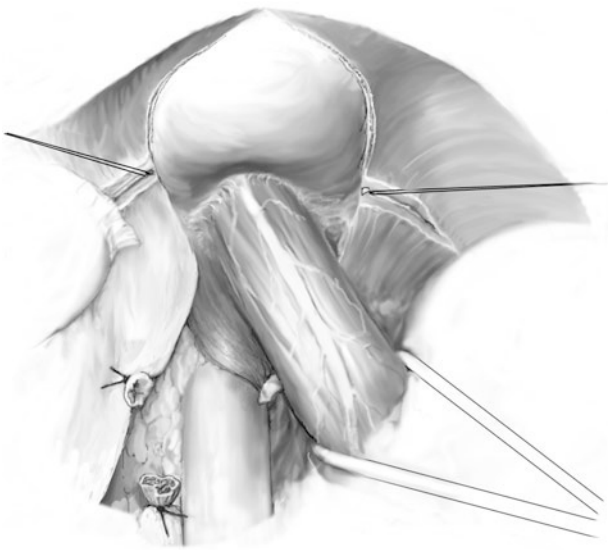


Fig. 26.2

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Step 10

Mobilization of the distal esophagus

Insert Mikulicz retractors, which are pulled upward to the left and right. Dissection starts with sharp dissection at the anterior esophageal surface to separate the diaphragm and pericardium from the esophagus (Fig. 26.3a).

To the right and left, the pleural cavity is incised and the parietal pleura are removed en bloc with the specimen. The esophagus is pulled caudally and the lateral esophageal ligaments consisting of branches of the vagal nerves, pulmonary ligaments, and esophageal branches are transected carefully between clamps or clips. Some surgeons prefer to use an energy device to ligate these connections. (Fig. 26.3b).

Mobilization of the region posterior to the esophagus including paraesophageal lymphatic tissue from the aorta and paravertebral fascia up to the tracheal bifurcation is done sharply and under vision (Fig. 26.3c).

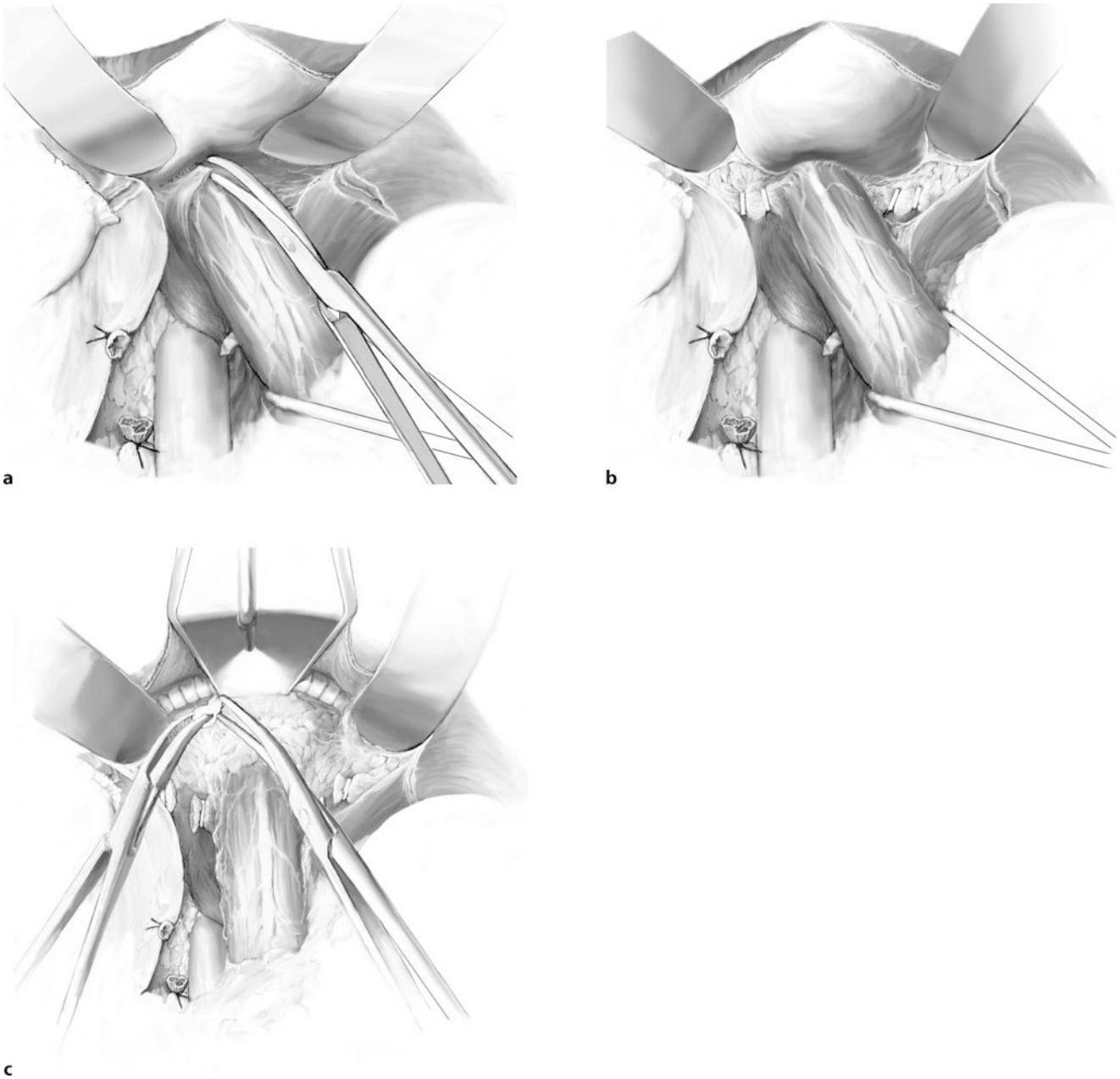


Fig. 26.3

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Step 11

Transection of the esophagus

After complete mobilization, the esophagus is divided by a purse-string clamp with an adequate distance to the tumor after fixation and therefore control of the esophagus with strong sutures above the transection line (Fig. 26.4). The specimen – which consists of stomach, greater omentum, regional lymph nodes, and the distal esophagus of up to 10 cm with en-bloc resected lymph nodes of the posterior mediastinum and both parietal pleura membranes is sent to pathology to confirm adequate resection margins before reconstruction.

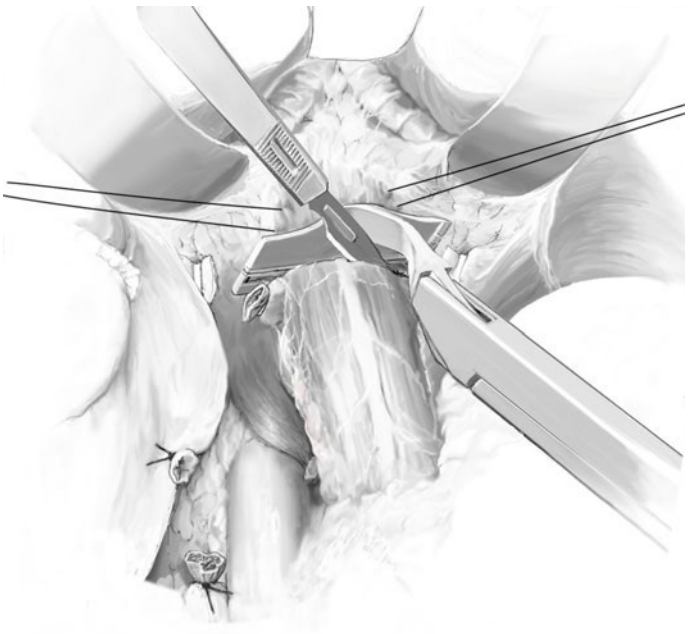


Fig. 26.4

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Step 12

Roux-en-Y Reconstruction

A standard Roux-en-Y limb is fashioned with enough length to allow tension-free anastomosis. A long segment of the proximal jejunum is isolated and transposed with its mesenteric root to the diaphragmatic region through the transverse mesocolon. Care has to be taken to dissect the vascular pedicle of this jejunal interposition to provide adequate length. The proximal anastomosis is then performed by a circular stapling device as a end-to-side esophagojejunostomy (Fig. 26.5a). The stapler is introduced into the end of the jejunal Roux limb. After firing of the anastomosis the blind end of the limb is then resected and closed with a linear stapler (Fig. 26.5b).

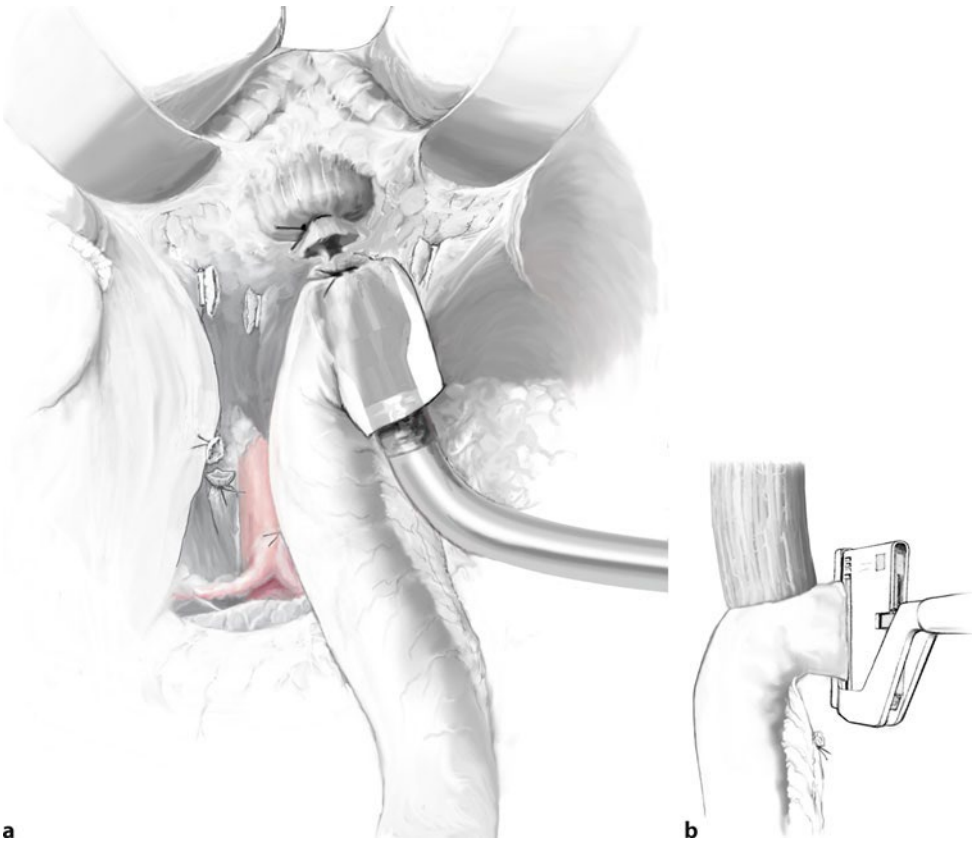


Fig. 26.5

Standard Postoperative Investigations

Daily check the drains for anastomotic leakage of the intrathoracic anastomosis.

Postoperative Complications

- Slipped ligatures or retracted vessel stumps are the main causes of mediastinal hemorrhage from esophageal branches
- Anastomotic leakage of the esophagojejeunostomy
- Mediastinitis
- Pleural empyema
- Chylothorax

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Tricks of the Senior Surgeon

- In advanced AEG Type II tumors, exposure of the esophagogastric junction and distal esophagus is recommended in case of change of surgical strategy.
- Care has to be taken to avoid any injury to the thoracic duct to avoid chylothorax. If the thoracic duct has been injured then ligation should be performed both above and below the injured area. To avoid this complication, preparation and ligation of the lateral esophageal ligaments should be performed under direct vision.

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Laparoscopic Gastrectomy

Geert Kazemier

Laparoscopic resection of the stomach should mimic an open operation as closely as possible. This is applicable to the technique, as well as to the indications for the operation. Palliative resection for gastric malignancy can be indicated to prevent hemorrhage or obstruction.

Indications and Contraindications

Indications

- Malignant tumors (carcinoma, gastrointestinal stromal tumor [GIST])
- Benign tumors (e. g., Leiomyoma)
- Arteriovenous malformations
- Recurrent peptic ulcer disease

Contraindications

- Severe cardiac failure (unable to withstand pneumoperitoneum)
- Sepsis
- Severe coagulopathy
- Previous upper abdominal surgery (relative)
- T4 or bulky tumors (relative)

Preoperative Investigation/Preparation for the Procedure

See ▶ Chap. 21 "Total Gastrectomy with Conventional Lymphadenectomy."

Instrumentation

- Two monitors
- Three 10- to 12-mm trocars, two 5-mm trocars
- One 15-mm trocar (optional) to pass the 60-mm stapler and retrieval bag
- 30° laparoscope
- Unipolar or bipolar coagulation
- Hemostatic device (LigaSure, Ultracision)
- Standard laparoscopic instruments for advanced laparoscopic surgery, including fenestrated clamps and endo-Babcock clamp
- Vascular clip applier
- Endostapler (45–60 mm, with white, blue, and green cartridges)
- Liver retractor
- Vessel loops
- Gastroscope (optional, to identify small lesions)
- Retrieval bag or wound protector

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Procedure

Step 1

Positioning and installations

Positioning

The patient is placed in the supine position. The surgeon stands between the legs of the patient, the first assistant on the left, the second assistant on the right side of the patient. The scrub nurse is positioned on the right or left hand side of the surgeon (Fig. 27.1a).

Installation of pneumoperitoneum and inspection of abdominal cavity

Pneumoperitoneum is established cranial to the umbilicus, in the midline. In obese patients the umbilicus is located more caudally; in these patients the first trocar may be just caudal to the left costal margin in the muscle ocular line – a safe area in obese individuals. In case of malignancy the abdominal cavity is inspected for signs of dissemination to the peritoneum or other organs. To allow for optimal inspection and to create the opportunity to take biopsies, one or more additional trocars are inserted. Inspection of the caudal side of the mesentery of the transverse colon and the region of Treitz ligament can be facilitated by bringing the patient into a Trendelenburg position.

Introduction of trocars (Fig. 27.1b)

The total number and position of trocars is dependent on the level of resection. The subxiphoidal trocar is only necessary for high resections of the stomach. Introduction of this trocar should be on the left side of the falciform ligament, especially when exploration of the cardia and gastroesophageal junction is necessary.

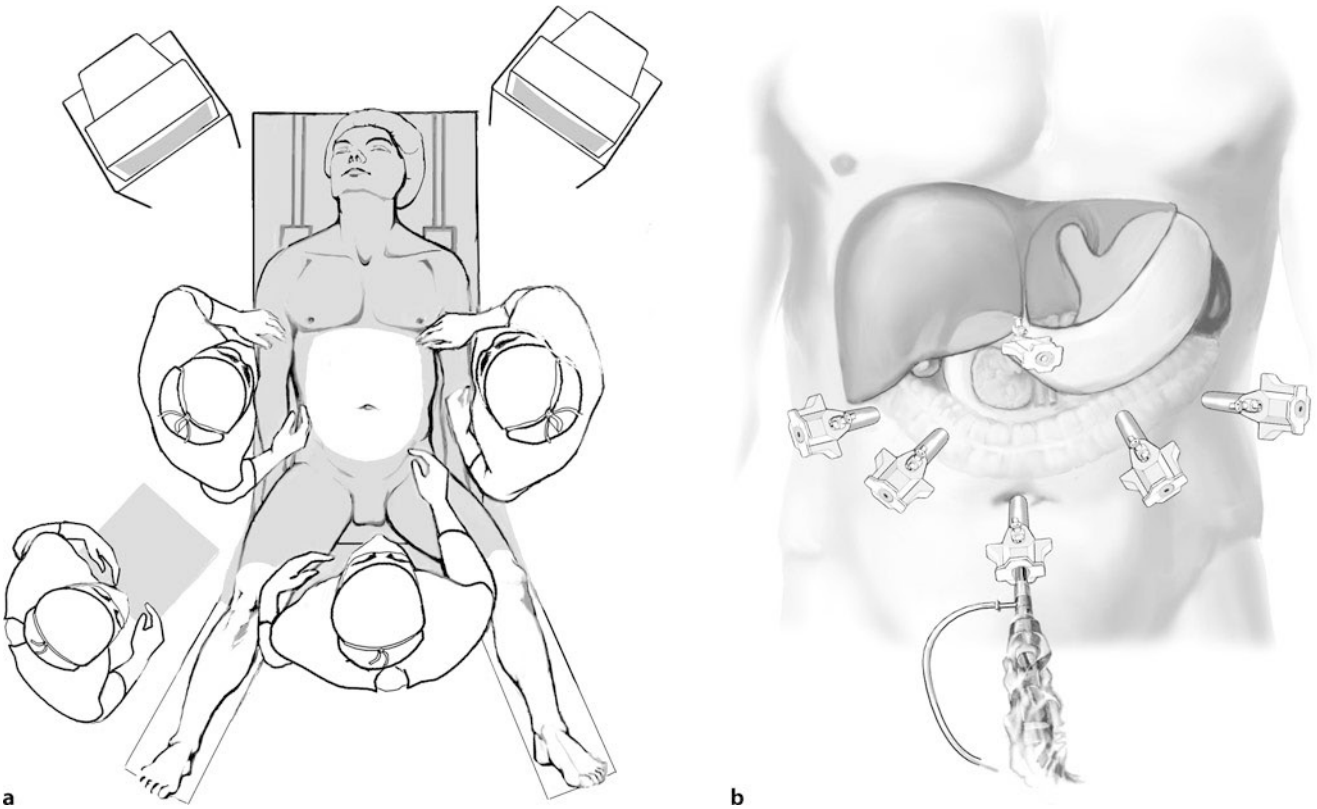


Fig. 27.1

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Step 2

Opening of the lesser sac

To determine (laparoscopic) resectability of the tumor, opening of the lesser sac is achieved by detaching the greater omentum from the transverse colon by sharp dissection. In case of a benign indication, opening of the lesser sac can be performed more easily by creating a window in the greater omentum, for instance by using Ultracision. Involvement of the pancreas in malignant tumors requires conversion to open resection in most cases. In case of malignancy, once resectability has been established, the lesser sac is opened until the gastrocolic ligament is completely dissected from the hepatic to the splenic flexure (Fig. 27.2).

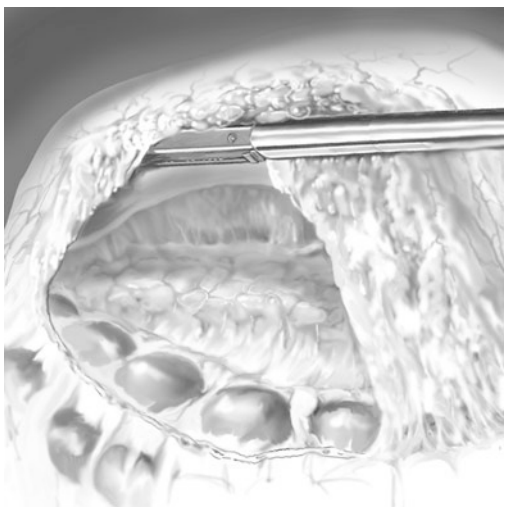


Fig. 27.2

Step 3

Resection of benign lesions

In benign lesions a stapled wedge resection is performed. Resection is performed under gastroscopic surveillance in case the lesion is not visible on the serosal side of the stomach especially if the lesion is located near either the gastroesophageal junction or in the antrum to assure that there is no stenosis of the gastric lumen. The gastrohepatic ligament must be opened if the tumor is located on the lesser curvature of the stomach (Fig. 27.3).

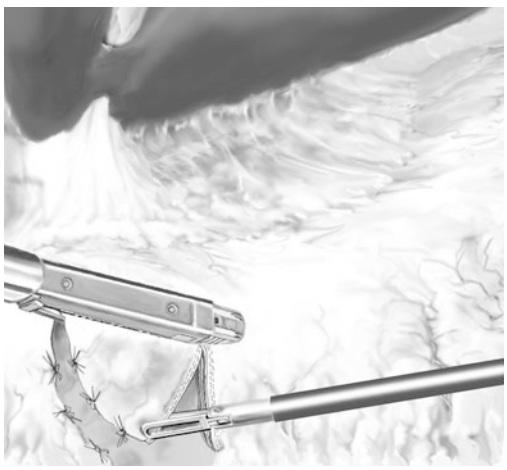


Fig. 27.3

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Step 4

Transection of duodenum and resection of gastrohepatic ligament

After detachment of the greater omentum, the right gastroepiploic vessels are identified and secured with clips at the level of the duodenum. Mayo's vein will locate the exact position of the pylorus. Identification of the pylorus can be facilitated by gentle palpation with a clamp in the postpyloric area. Care should be taken not to damage the pancreatic parenchyma as this may result in a pancreatic fistula. Sharp dissection at the posterior side of the postpyloric part of the duodenum creates space to introduce a 45-mm stapling device. A vessel loop can be used to facilitate safe insertion of the stapler. Prior to the closure of the stapler, care should be taken that the vessel loop and vascular clips are not included in the line of stapling (Fig. 27.4a).

The assistant retracts the liver to allow exposure of the lesser omentum. The gastrohepatic ligament is opened at the level of the hepatoduodenal ligament. The right gastric artery is transected using Ultracision (Fig. 27.4b). The assistant retracts the liver to allow exposure of the liver hilum. Following the common, proper, and left hepatic artery, the lesser omentum is freed, securing lymph nodes of the pyloric group up to the right pericardial group. This en bloc lymphadenectomy is part of a level D2 resection and is optional. A replaced or aberrant left hepatic artery, originating from the left gastric artery, can be safely dealt with, using clips if necessary. Alternatively this lymphadenectomy can be done after transection of the stomach.

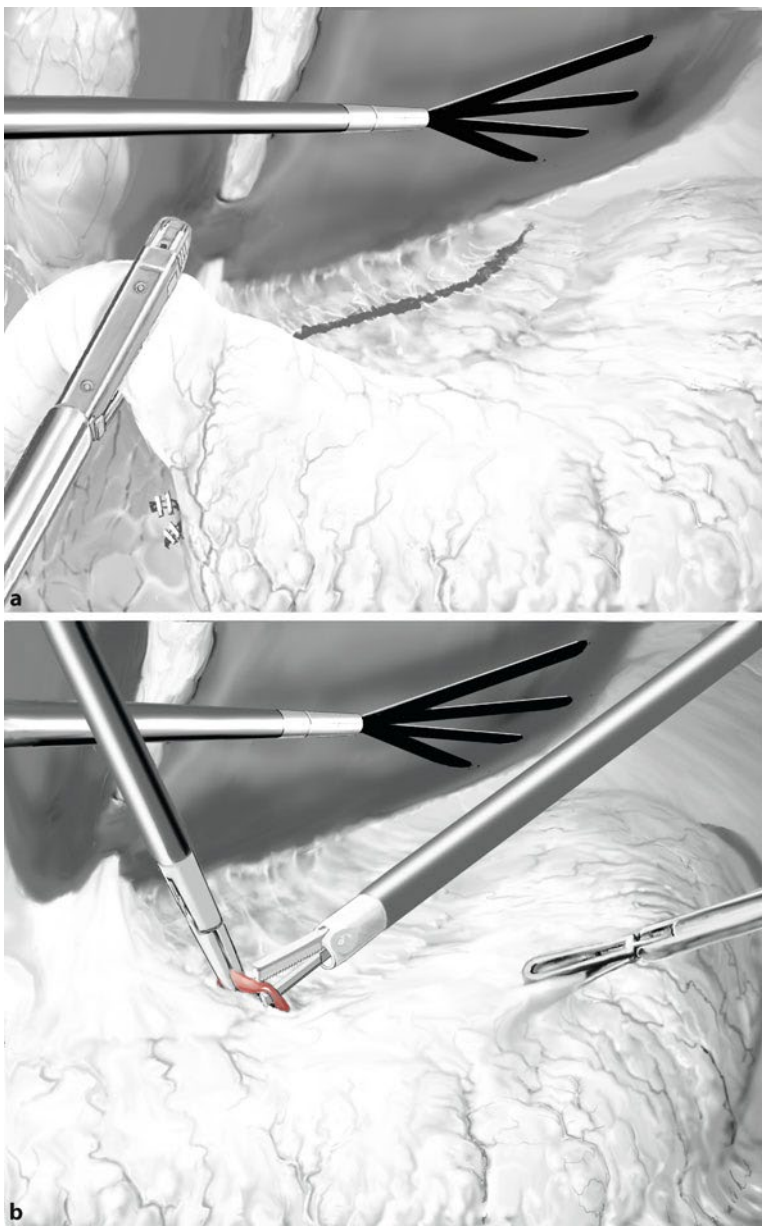


Fig. 27.4

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Step 5

Securing of left gastric vessels

The posterior aspect of the stomach is freed from the anterior surface of the pancreas by sharp dissection of adhesions. At this stage a vessel loop can be used to allow easier manipulation of the stomach. In most patients, the splenic artery is identified cranial to the pancreas. More cranially, the left gastric vessels are identified and transected with clips or a vascular stapler. Optional D2 lymphadenectomy of the stomach implies formal lymphadenectomy at this stage (Fig. 27.5).



Fig. 27.5

Step 6

Transection of the stomach

The transection line of the stomach is performed 5 cm orally to the tumor (Fig. 27.6a). If the tumor cannot be identified adequately on the serosal side of the stomach, intraoperative gastroscopy is mandatory to determine the exact line of transection. Location of the tumor high in the body of the stomach may require opening of the gastrosplenic ligament and securing of short gastric vessels with Ultracision (Fig. 27.6b).

D2 lymphadenectomy requires resection of lymph nodes of the gastrohepatic ligament and along the hepatic artery. If the nodal clearance has not been performed en bloc, it is feasible to do it at this stage (Fig. 27.6c).

After transection of the stomach, the specimen is placed in a retrieval bag for safe extraction. Extraction is done through a mini-laparotomy. This laparotomy can be conducted at a cosmetically preferred site (e.g., Pfannenstiehl). Alternatively a midline mini-laparotomy is performed in the upper abdominal region. In the latter option the anastomosis can be done in an open fashion.

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Step 6 *(continued)*



Fig. 27.6

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Step 7

Anastomosis

Open anastomosis

Through a small midline laparotomy a standard Billroth II or Roux-en-Y reconstruction can be performed (Fig. 27.7a).

Laparoscopic anastomosis (Billroth II)

To perform a laparoscopic side-to-side gastrojejunostomy, the ligament of Treitz and the proximal jejunum are identified by lifting the transverse colon and tilting the table into a Trendelenburg position (head down). A loop of proximal jejunum is brought up in an antecolic or retrocolic fashion. This loop of jejunum is sutured to the anterior aspect of the stomach remnant with two resorbable, seromuscular stay sutures, approximately 2 cm apart. A stab incision in both the stomach and the jejunum is made with diathermia. Care should be taken that the incision in the stomach is made through all gastric wall layers. The stab incisions are enlarged, and the endostapler is introduced with one blade in the stomach and the other in the jejunum. Subsequently the stapler is fired one or two times, dependent on the size of the cartridges (60 or 45 mm). In case a 60-mm stapler is used, a 15-mm trocar should be introduced (Fig. 27.7b).

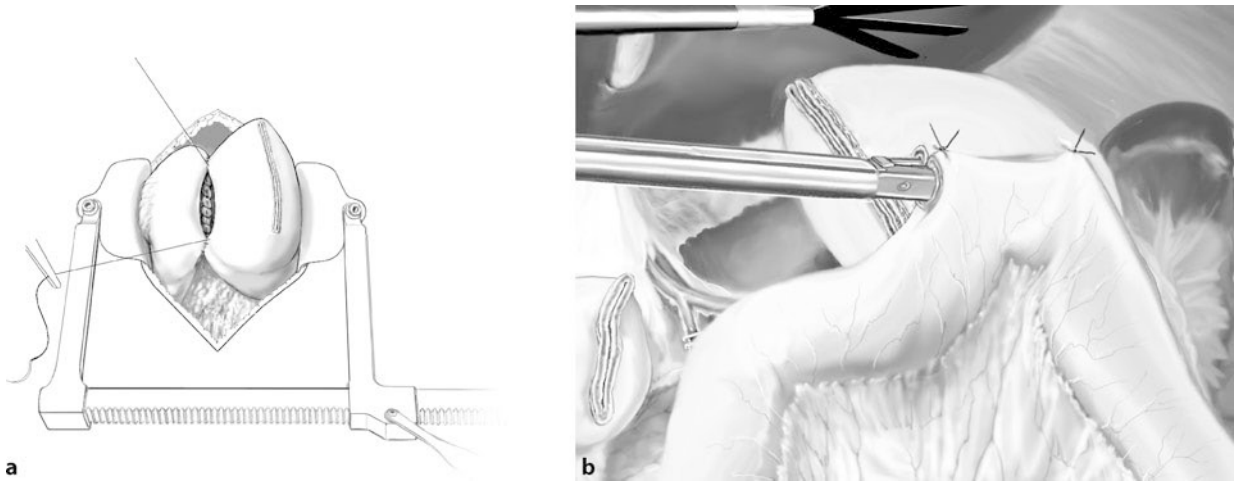


Fig. 27.7

Step 8

Closure of stab incisions in stomach and jejunum

The incision that remains in the stomach and the jejunum after firing the endostapler is closed using a single-layer resorbable, polyfilament suture. Closure with an endostapler should not be attempted as the anastomosis is easily compromised because it is difficult to ensure inclusion of all tissue of the stomach and jejunum on both sides of the stab incisions in the staple line without narrowing the anastomosis (Fig. 27.8).

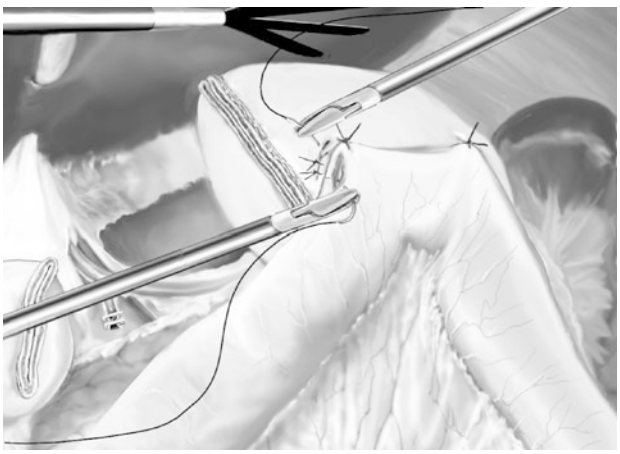


Fig. 27.8

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Postoperative Investigations

See ► Chap. 21 "Total Gastrectomy with Conventional Lymphadenectomy."

Postoperative Complications

- **Short term**
  - Anastomotic leakage (including duodenal stump leakage)
  - Pancreatic fistula
  - Chylous ascites (particularly after R2 resection)

- **Long term (all indications)**
  - Bile gastritis (particularly after Billroth II reconstruction)
  - Anastomotic ulcer disease

- **Long term (in case of malignancy)**
  - Local recurrence (duodenal stump or resection line of stomach)
  - Distant metastases

Tricks of the Senior Surgeon

- Instead of a vessel loop, a heavy resorbable suture can be used to pull the stomach or duodenum into the endostapler. Even if this suture is included in the staple line, this will not compromise the anastomosis.
- In lean patients it is often possible to remove one of the 10- to 12-mm trocars and directly introduce the 60-mm stapler or the retrieval bag, instead of using a 15-mm trocar.
- Suturing is best done with the laparoscope in the middle and two needle holders on either side of the scope with a 60° to 90° angle between the two needle holders.

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Laparoscopic and Conventional Gastroenterostomy

John Tsiaoussis; Gregory G. Tsiotos

Indications and Contraindications

Indications

- Palliation of gastric outlet obstruction caused by advanced gastric, duodenal, or periampullary tumor.
- Gastric drainage following vagotomy when pyloroplasty is not feasible.
- *Note:* Gastroenterostomies for reconstruction after all sorts of gastrectomies are described in separate chapters of this Atlas.

(Relative) Contraindications

- Severe hypoalbuminemia
- Evidence of diffuse metastatic spread, indicating extremely short life expectancy
- Prohibitive comorbidity

Preoperative Investigation/Preparation for the Procedure

History	Persistent vomiting
Laboratory tests	Electrolytes, albumin, coagulation parameters (all to be corrected preoperatively)
Radiology	Upper GI contrast study (to document gastric outlet obstruction)
CT scan	Assessment of primary disease/condition
Endoscopy	Assessment of gastric outlet obstruction, periampullary biopsy for tissue diagnosis

A large-bore nasogastric tube is placed the day prior to the operation for gastric decompression and irrigation.

The patient's water and electrolyte balance are corrected preoperatively.

Procedures

Open, Hand-Sewing Technique

Access

Midline incision from the xiphoid process to the umbilicus

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
DOI 10.1007/978-3-662-46546-2_28, © Springer-Verlag Berlin Heidelberg 2016

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Step 1

Creation of gastrojejunostomy (interrupted sutures)

The gastroepiploic vessels are dissected, clamped, divided, and ligated starting about 5 cm proximal to the pylorus and moving for 6 to 7 cm proximal along the greater curvature of the stomach, so this portion of the stomach is completely dissected free from the omentum.

The jejunal loop can be brought either anterior to the transverse colon (antecolic) or through a window in the transverse mesocolon (retrocolic). Although a retrocolic gastrojejunostomy has been considered more prone to obstruction because of its closer proximity to an ever-enlarging unresectable periampullary tumor, this has never proved true, especially because patients' survival in this context rarely exceeds 6 months. Conversely the retrocolic route allows more proximal placement of the gastrojejunostomy and smoother angles between afferent, efferent loops and stomach both in the coronal as well as in the sagittal plane. The retrocolic route is thus described.

The mesocolic window (wide enough to allow comfortable sliding of both afferent and efferent jejunal loops) is made in an avascular plane of the mesocolon to the left of the middle colic vessels. The ligament of Treitz is identified by lifting up the transverse colon and the jejunal loop is brought up through the mesocolic window in apposition to the greater curvature (now free from omental vessels). The length of the afferent jejunal limb should not exceed 20 cm.

The gastrojejunostomy can be placed on either the anterior (easier and thus preferable) or the posterior gastric wall; the latter has not proved superior in terms of gastric emptying. Place 3-0 silk traction seromuscular sutures, taking into account that the incision in the jejunum will not be made exactly at the antimesenteric border, but at a level closer to its mesentery on the stomal side. This provides for more comfortable lining of the completed anastomosis without any undue angles in the transverse plane. Place 3-0 silk interrupted seromuscular Lembert sutures and tie at 5-mm intervals to create the posterior outer suture line. Two incisions along the gastric and the jejunal apposite segments are then made. Although the gastric incision should be about 4 cm, the jejunal incision should be a bit shorter, because it always tends to dilate and ends up being realistically longer than initially planned or thought to be (Fig. 28.1).

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Step 1 *(continued)*

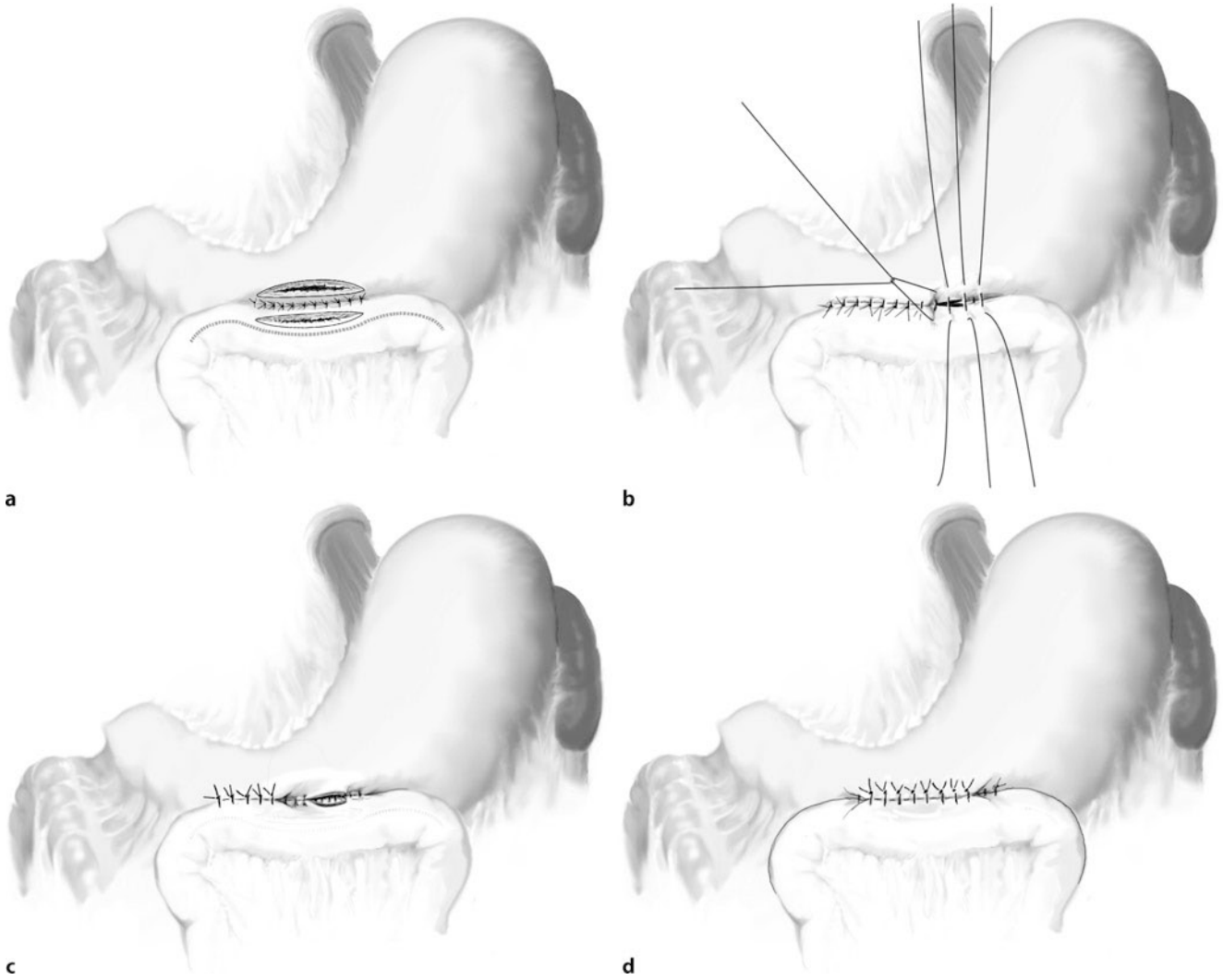


Fig. 28.1

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Step 2

Creation of gastrojejunostomy (running sutures)

The posterior *full-thickness* inner anastomotic layer is made by two 3-0 PDS running sutures in an over-and-over fashion starting at the middle of the posterior layer and moving in opposite directions toward each corner of the anastomosis, where the two corner traction seromuscular stitches are still present. Then, the two 3-0 PDS running suture lines continue into the anterior wall of the gastrojejunostomy (again *full-thickness*) using the Connell technique in order to invert all gastric and jejunal mucosa, which might otherwise protrude out through the anastomosis. Moving from the two corners toward the middle, the sutures meet and are tied together (Fig. 28.2). The anastomosis is completed by placing the anterior seromuscular layer with interrupted 3-0 silk Lembert sutures starting at the corner away from the surgeon and moving toward the surgeon, so that there are no sutures tangling in the middle of the operative field. These outer sutures should be first *all* placed and then tied; "tying as we go" will lead to puckering of the serosa toward the inner suture line and thus placement of each successive suture at an ever-increasing distance away from the inner suture line, which may then lead to entrapment of a lot of seromuscular tissue within the suture lines and protrusion of this soft tissue mass toward the anastomosis itself with its potential obliteration.

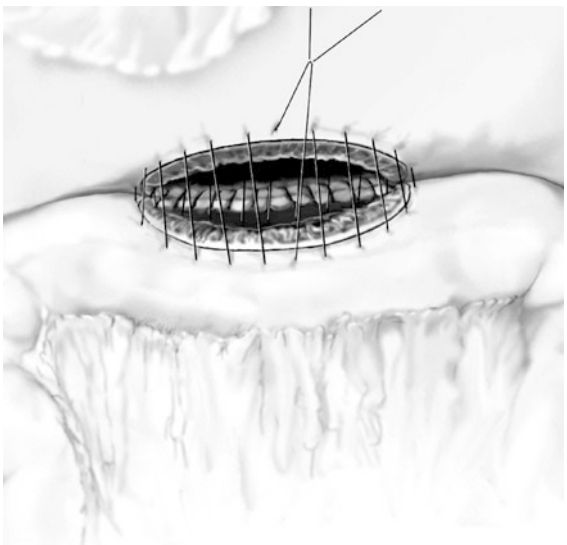


Fig. 28.2

Step 3

Restoration of infracolic anastomosis

After completion the anastomosis is brought below the mesocolic window and the *gastric* wall (not the jejunal) is tacked circumferentially on the mesocolon with interrupted 3-0 Vicryl sutures. A drain tube does not need to be placed.

Open Stapling Technique

Step 1

Stapled gastrojejunostomy

The greater curvature is freed from the omentum, the mesocolic window is made, and the jejunum and greater curvature are brought to apposition as previously described. Two stab wounds are made with the electrocautery in the greater curvature (12 cm from the pylorus) and at the antimesenteric aspect of the jejunum (20 cm from the ligament of Treitz). Two Allis clamps, incorporating full-thickness gastric and jejunal wall, are placed one each in the gastric and the jejunal stab wounds. The cartridge fork of the GIA-60 stapler is inserted in the gastric lumen and the anvil fork into the jejunal lumen (the move is to *push the GIA's jaws* into the lumens, *not to pull* the stomach and jejunum up toward the stapler). With the help and maneuvering of the two Allis clamps, align equal lengths of gastric and jejunal walls on the forks, keep the jejunal mesentery away from the anastomosis, close the instrument, and fire. Open the handle of the stapler slowly and slide it out. Inspect the luminal side of the staple line for possible bleeding.

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Step 2

Closure of gastro/entertomy

The two Allis clamps are now repositioned to grab the two corners of the GIA staple line and the inner (luminal) anastomotic line is inspected for bleeding (Fig. 28.3). Approximate the gastric and jejunal walls with two additional Allis clamps. Slip the jaws of the TA-55 beneath the Allis clamps incorporating all tissue layers as well as the corner end staples of the GIA staple line within the jaws. The corner ends of the two GIA staple lines should be the two corners of the TA-55 staple line, so that these three staple lines (two from the GIA, one from the TA-55) form a triangle and the wide patency of the anastomosis is assured. Close the instrument and fire. Use a scalpel to excise the protruding tissue along a special groove on the surface of the stapler. Open the instrument to release the tissue and inspect for bleeding. Three single full-thickness 3-0 silk reinforcing sutures are placed at the three corners of the stapled anastomosis, as these represent the theoretically more "vulnerable" points of the anastomosis, because this is where two staple lines meet and overlap. A drain tube does not need to be placed.

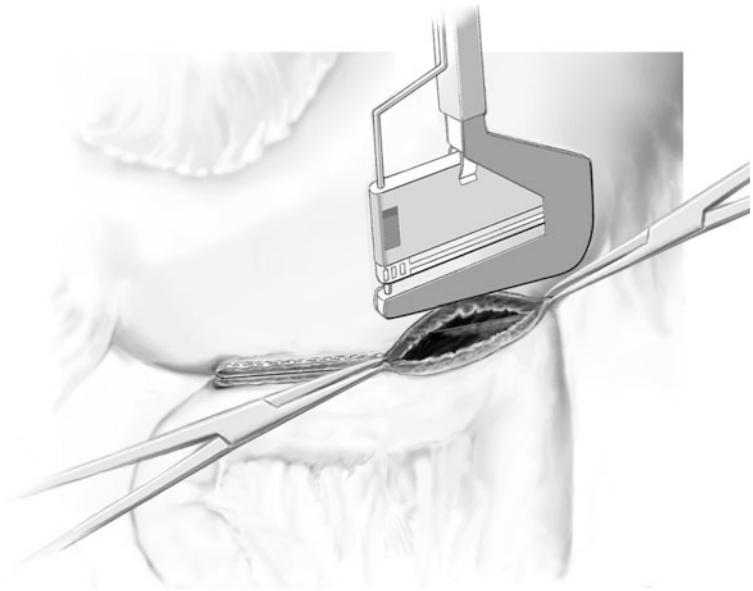


Fig. 28.3

Laparoscopic Technique

Step 1

Mobilization of jejunal loop

The patient is placed supine. The senior surgeon stands on the patient's right side and the first assistant on the left. Pneumoperitoneum is established with the Veres needle (by insufflating at a preset pressure of 12–15 mmHg), the 0° or 30° laparoscope is introduced through a supraumbilical 10-mm port, but it can be moved to other ports as needed intraoperatively. Then, two 10-mm trocars and one 12-mm trocar are inserted in the anterior abdominal wall. The table is tilted at a 30° Trendelenburg position and a Babcock forceps (more atraumatic) is used to bring the omentum and transverse colon cephalad to identify the ligament of Treitz.

Step 2

Preparation for stapler insertion

The first jejunal loop is identified and approximated to the proximal antrum in an antecolic route. If the retrocolic route is chosen, a window in the transverse mesocolon is made using the harmonic scalpel and the jejunal loop is brought up through it. Two 3-0 silk traction sutures are placed (5–6 cm from each other) to apposite the jejunum (at a distance of 20 cm from the ligament of Treitz) along the greater curvature (at a distance of 5 cm from the pylorus). Two stab incisions are made at the approximated gastric and jejunal walls using the Hook device, one opposite to the other.

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Step 3

Insertion of laparoscopic stapler

As two graspers are holding the traction sutures on the approximated stomach and jejunum, a 45-mm Endo-GIA stapler is inserted through the 12-mm port. The jaws of the instrument are introduced in the gastric and jejunal lumens (Fig. 28.4). Maneuvering of the suture-holding graspers accommodates stapler insertion. The stapler is closed, fired, and eventually removed. The staple line is inspected internally for patency and bleeding.

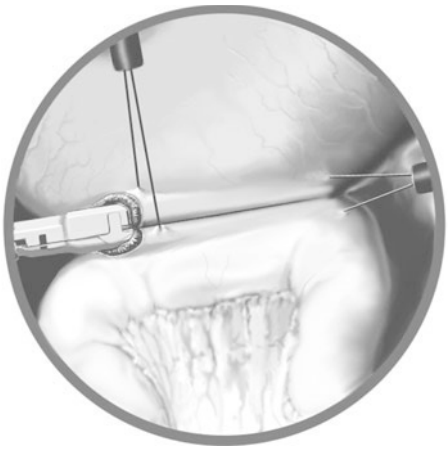


Fig. 28.4

Step 4

Closure of gastrotomy/enterotomy

The common gastric and jejunal opening is closed with full-thickness, running 2-0 Vicryl suture tied intracorporeally. Alternatively, an endo-GIA device can be used for closure of the common gastric and jejunal opening. A drain tube does not need to be placed.

Robotic Technique

Utilization of robotic instrumentation has been increasing. Robots are now available in more hospitals and operative experience is steadily increasing. Although robotic technology is not cost effective for a gastroenterostomy, nor does it provide realistic benefits compared with the laparoscopic technique, it should nevertheless be described for completeness' sake. As with all robotic procedures, the technique is essentially a combination of the laparoscopic technique (in terms of operative access and minimal invasiveness) and the open technique (in terms of the actual performance of the procedure inside the peritoneal cavity).

The incisions are the same as with the laparoscopic technique, only placed about 2 cm inferior to each of those, in order to facilitate maneuvering of the bulky "arms" of the robot. Then the procedure continues by reproducing the hand-sewn open technique, with the additional advantage of the visual magnification and the higher precision because of this. Placing of and tying sutures is far easier using robotic "wrist" flexibility than laparoscopic instruments. Utilization of staplers during the robotic technique, although possible, may not be as expeditious as the hand-sewn technique.

Postoperative Tests

- Gastrografin upper GI radiograph (when significant nasogastric tube output persists for longer than a week postoperatively)

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Local Postoperative Complications

- **Short term**
  - Anastomotic bleeding
  - Anastomotic leak
  - Obstruction (anastomotic or functional)

- **Long term**
  - Anastomotic stenosis

Tricks of the Senior Surgeon

- When an antecolic gastrojejunostomy is chosen, the afferent jejunal loop can be kept short by placing the transverse colon as much to the right of the gastrojejunostomy as possible.
- Excessive length of the afferent limb may predispose to "afferent loop syndrome."
- Inadvertent gastroileostomy is not that uncommon! Make sure, especially when a laparoscopic gastroenterostomy is performed, that the appropriate site of the *jejunum* is used.
- Gastric emptying is based on inherent gastric motor function, not on hydraulic pressure gradients. Thus, placing the anastomosis at the "most dependent" portion of the stomach does not have any scientific merit.
- Place the anastomosis *where it lies more comfortably*. Provided that there is *no kinking, or acute angles, or pressure* on the efferent and afferent loops, the choice of retrocolic versus antecolic, or distal gastric versus proximal gastric, placement of the anastomosis is not so important.

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Percutaneous Endoscopic Gastrostomy

Eleazer Yousefzadeh, Capecomorin S. Pitchumoni

Indications and Contraindications

Indications

Requirement of enteral feeding for more than 30 days owing to

- Poor oral intake
- Failure to thrive
- Dysphagia (common examples follow)
  - Mechanical dysphagia: esophageal cancer, head and neck cancer
  - Neurological dysphagia: stroke, multiple sclerosis, amyotrophic lateral sclerosis, cerebral palsy, myotonic dystrophy

Alternatively, PEG tube placement is indicated for gastric decompression ("venting") due to bowel obstruction or gastroparesis

Contraindications

- Anatomical factors causing poor apposition of anterior stomach and abdominal wall
- Peritonitis
- Abdominal wall infection
- Severe coagulopathy
- Rapidly reaccumulating ascites
- Expected survival less than 6 weeks (palliative "venting" PEG excluded)

Preoperative Investigations/Preparation for the Procedure

- Consent or advanced directives
- Cardiorespiratory status assessment
- Baseline laboratory parameters

Procedure

Step 1

Preparation

The patient's medical condition is reevaluated prior to PEG placement; the expected survival may have changed.

A single dose of intravenous antibiotics is administered. Commonly, cefazolin is used (vancomycin if penicillin allergic).

The patient is placed in the supine position.

The abdomen is examined for surgical scars, cellulitis, and ascites. The skin over the abdomen is prepared then draped.

Step 2

Esophagogastroduodenoscopy

The endoscope is passed from the mouth to the stomach. Examination is performed to rule out local contraindications, such as tumor, ulceration, gastric varices, and outlet obstruction.

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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Step 3

Air inflation

The gastric lumen is inflated with air so that the anterior wall of the stomach abuts the abdominal wall, pushing away any interpositioned bowel loops.

Step 4

Transillumination

Transillumination is attained through the anterior abdominal wall after darkening the room. Failure to transilluminate suggests poor apposition of the anterior stomach to the abdominal wall, making the procedure unsafe.

The assistant makes a finger impression over the point of transillumination. Endoscopically, this impression must be clearly visible as a focal depression of the gastric wall (Fig. 29.1).

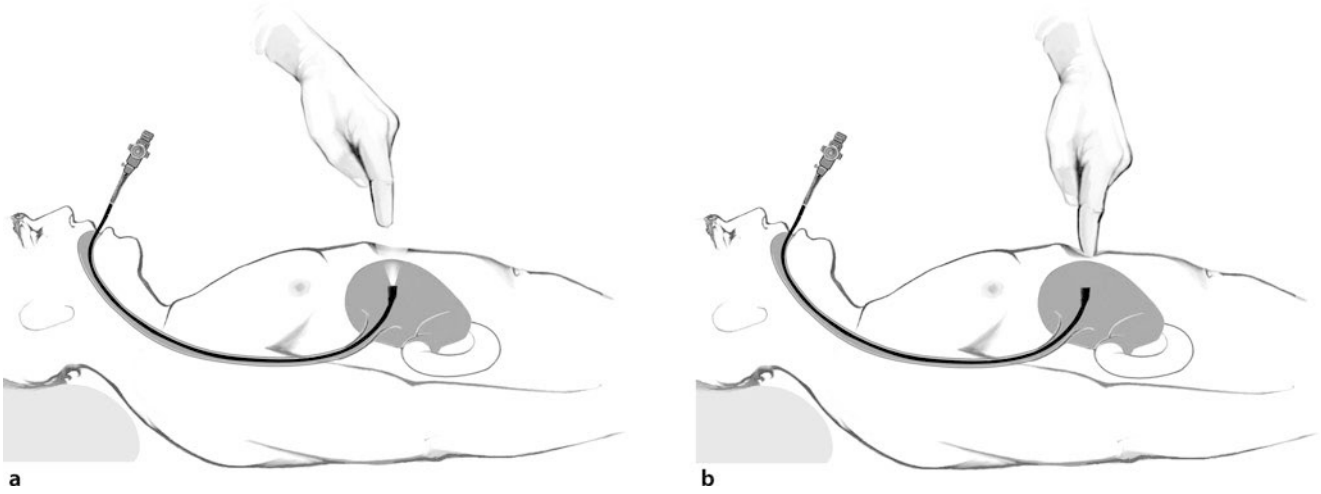


Fig. 29.1

Step 5

Local anesthesia

After marking the site of optimal finger impression on the skin, the assistant injects the skin with a local anesthetic and makes a shallow 1 cm incision.

Step 6

Safe track maneuver

To ensure that no loops of bowel are interposed between the stomach and the abdominal wall, the needle used to inject local anesthetic is advanced into the gastric lumen. While the plunger is aspirated, the needle is slowly withdrawn through the peritoneum, fascia, and abdominal wall. Air should not enter the syringe.

Following the same trajectory of the previous puncture, an 18-gauge hollow trocar is advanced through the incision, piercing the gastric wall.

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Step 7

Introduction of guidewire

The assistant passes a guidewire through the trocar. The guidewire is grasped by a snare that is passed through the endoscope. The endoscope and guidewire are pulled out through the mouth as one unit, as the assistant feeds more wire into the stomach (Fig. 29.2).

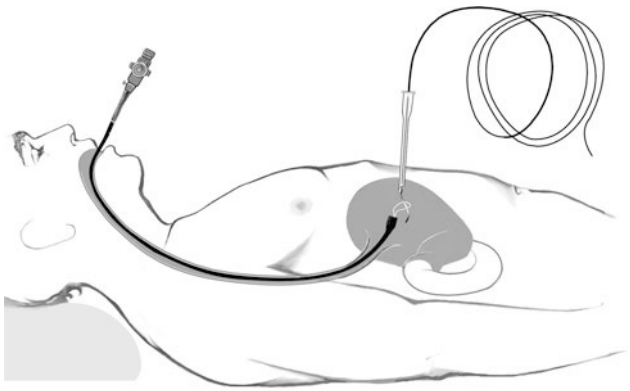


Fig. 29.2

Step 8

Pull through

The tapered end of the lubricated PEG tube is secured to the guidewire then pulled through the mouth into the esophagus and stomach by the assistant. This is called a "pull" PEG because the assistant pulls the guidewire and PEG tube out through the abdominal wall. As the guidewire is pulled, the tapered end of the PEG tube emerges from the incisional site. The PEG tube is pulled until the bumper within the gastric lumen is snugly apposed to the gastric wall (Fig. 29.3).

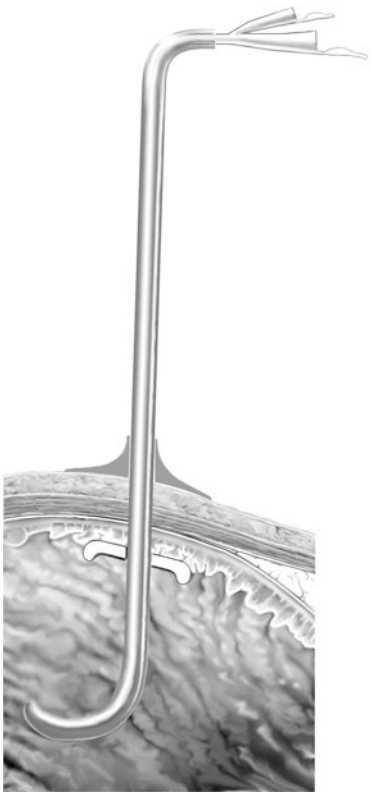


Fig. 29.3

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Step 9

Trimming and securing

The PEG tube is trimmed in length, and a feeding port is attached to the end after anchoring the tube to the anterior abdominal wall using an external stopper. The exact position of the stopper will depend on the patient's body habitus and other anatomical considerations, but generally ranges from 2 to 5 cm.

Procedure: "Push" PEG

Although equally effective, this technique is less commonly performed.

Alternatively, Step 7 is replaced with the following: The PEG tube assembly is advanced, dilator end first, over the portion of the guidewire exiting the mouth. Firm tension is maintained on both ends of the guidewire as the PEG tube assembly is pushed through the mouth into the esophagus and stomach. This is called a "push" PEG, because it involves pushing the PEG tube into the stomach and through the abdominal wall. As the assembly is pushed, the tapered end of the PEG tube emerges from the incisional site. The PEG tube is pushed until several centimeters remain beneath the skin.

Post-PEG Tube Placement Feeding

Feeding is generally commenced on the following day, after the patient is examined.

PEG Tube Removal

This is advisable only for cases in which a well-defined tract has formed.

Indications

- The PEG tube is no longer needed (reversal of original indication).
- The PEG tube is damaged/worn out.
- The PEG tube is clogged and cannot be flushed.

Percutaneous Removal

Steps

Identify the type of PEG tube. The "mushroom" type has only one lumen whereas the balloon type has two lumens on sectioning the tube.

Mushroom type

Clean the stoma and apply a topical anesthetic.

A sustained pull at 90° to the anterior abdominal wall will cause collapse of the bumper as it "pops" out of the stoma.

Clinically significant bleeding is uncommon and the stoma closes in 1 to 2 days.

Balloon type

Deflate the balloon using a syringe or by cutting the tube, allowing the water to leak out of the balloon.

Once the balloon is deflated, the tube can be pulled out with no resistance.

Endoscopic Removal

Indications

When percutaneous removal is not possible; for example, when the mushroom PEG cannot be pulled out or the balloon PEG cannot be deflated.

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Steps

Upper endoscopy is performed. The bumper is snared inside the stomach. Alternatively, a balloon can be deflated using a sclerotherapy needle.

The tube is cut from the outside using a pair of scissors or a scalpel.

The snared end is pulled out through the mouth along with the endoscope.

Reinsertion

Steps

A balloon-type PEG tube is inserted through the existing stoma and inflated with water. The balloon end is pulled up toward the stomach wall and an external stopper is applied to position it against the abdominal wall.

Standard Postoperative Investigations

- Check for adequate approximation of the stomach to the abdominal wall, ensuring that a proper tract will form.

Postoperative Complications

- Perforation of esophagus, stomach, or transverse colon
- Hemorrhage
- Cellulitis or abscess
- Peritonitis
- Gastric ulcer
- "Buried bumper syndrome" when the bumper is embedded within the stomach wall
- Gastric outlet obstruction due to distal migration of the bumper
- PEG tube clogging
- PEG tube being pulled out

Tricks of the Senior Surgeon

A too firmly approximated stomach and anterior abdominal wall may lead to tissue necrosis or "buried bumper syndrome." Care should be taken to ensure that the PEG tube is snug but rotates freely.

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Conventional and Laparoscopic-Assisted Gastrostomy

Nathaniel Melling, Oliver Mann

Conventional Gastrostomy

Nowadays, surgical gastrostomy has been replaced in most instances by less invasive procedures such as percutaneous endoscopic gastrostomy (PEG) or percutaneous endoscopic jejunostomy (PEJ). However, surgical gastrostomy still plays an important role in well-selected instances, such as when transillumination of the stomach cannot be seen on attempted endoscopic percutaneous gastrostomy, after prior gastrectomy, when percutaneous access to the stomach is otherwise not possible, or when there is ascites.

Indications and Contraindications

Indications

- Locally non-resectable and/or metastatic obstructing tumor of the esophagus, gastroesophageal junction, and proximal stomach
- Tumor totally obstructing the esophagus preventing passage of the endoscope or even a guide wire for transtumoral endoluminal intubation
- Contraindications for endoscopic treatment ("percutaneous endoscopic gastrostomy"), such as severe ascites
- Severe unfit for major surgery
- Neurological disorders (cerebral dysphagia)

Contraindications

- Resectable carcinoma
- Previous major gastric resection or gastrectomy (in this case, feeding tube jejunostomy is the treatment of choice)

Preoperative Investigation/Preparation for the Procedure

History:	Previous upper abdominal surgery (i. e., gastric resection; contraindication for [PEG])
Clinical investigation:	Exclusion of further obstruction distal to the stomach such as antral and pyloric strictures in cases of caustic burns.

Procedures

Temporary Tube Gastrostomy

(Synonyms: Witzel Procedure, Balloon Catheter Gastrostomy, Kader Procedure)

Step 1

Exposure

Opening of the peritoneal cavity is performed through the upper third of the left rectus muscle by a vertical or horizontal incision or by a midline incision. Sharp transection of the skin and fasciae should be followed by blunt division of the muscle.

The anterior wall of the body of the stomach can them be pulled anteriorly by clamps or retention sutures.

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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Step 2

Preparation and incision of the gastric wall

A purse-string suture with a diameter of about 3 cm is usually placed at the anterior aspect of the gastric body midway between the lesser and greater curvatures.

A gastrostomy is made in the center of the purse-string suture, and a tube is inserted with its tip directed to the cardia. After the purse-string suture has been tested for leakage, the suture is tied with some form of memory, either a Foley catheter, another form of balloon catheter, or a Malecot catheter.

In cases of caustic burns, antral and pyloric stenoses should be excluded by intragastric digital palpation of the distal stomach (Fig. 30.1).

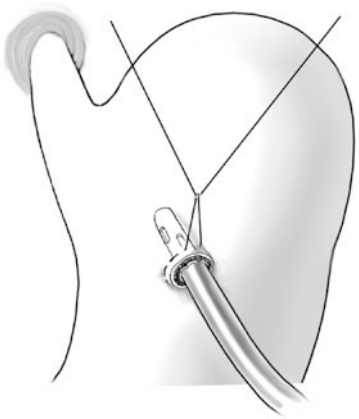


Fig. 30.1

Step 3

Positioning of the catheter

When inserting a feeding catheter with a diameter of about 1 cm, the tip should be directed toward the cardia.

After proper positioning of the catheter with a minimum distance between insertion site and tip of the tube of 5 cm, the purse-string suture is tied.

Check for leaks at the site of the purse-string suture by filling the stomach with liquid.

Step 4

Witzel Fashion

A Witzel-type gastro-gastric plication with single stitches aborally to the insertion site of the tube and for a length of 8 cm distal to the insertion of the tube in the gastric wall is recommended (Fig. 30.2).

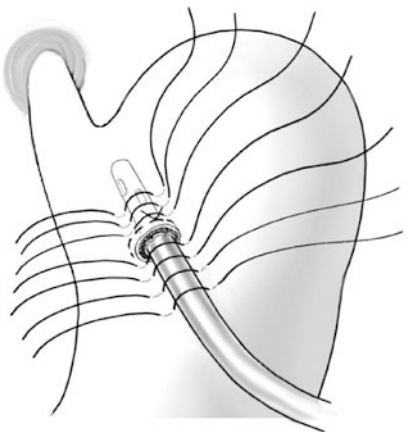


Fig. 30.2

The gastric serosa is fixed to the abdominal wall by drawing the stomach upward and sewing the stomach to the abdominal wall in Stamm-like fashion where the tube exits the abdominal wall.

The tube is then fixed to the skin.

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Balloon Catheter Gastrostomy (Stamm fashion)

Step 1

Access to the peritoneal cavity, exposure, and preparation of the anterior aspect of the stomach as described previously.

Step 2

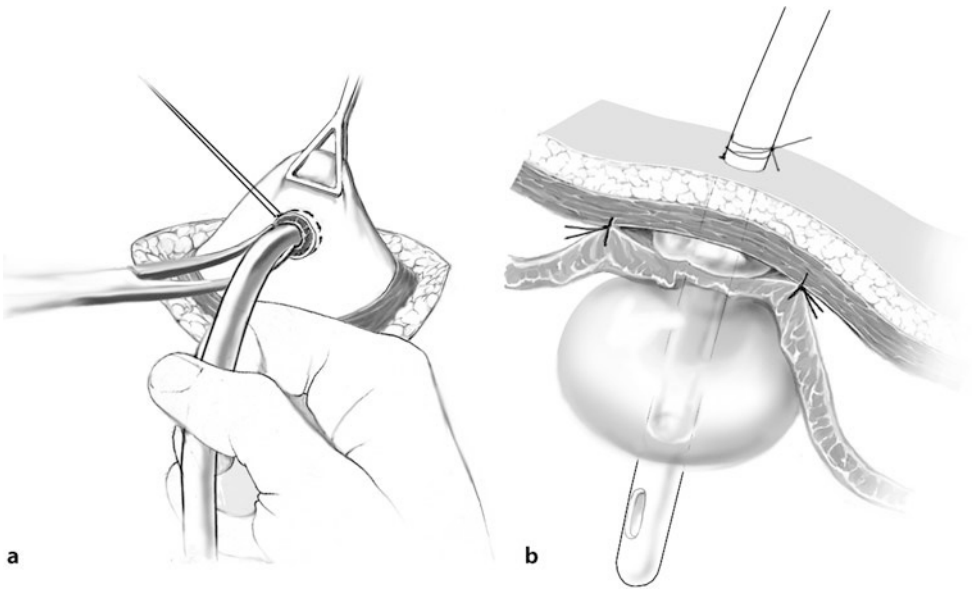
Positioning of the balloon catheter and fixation

After exposure of the anterior wall of the stomach by clamps, a purse-string suture is prepared. In the center of this suture, a small gastrotomy is made. If necessary, the incision is dilated gently and the tube is introduced into the gastric lumen (◘ Fig. 30.3a).

In cases of caustic burns, antral and pyloric stenoses should be excluded by intragastric digital palpation of the distal stomach. After proper positioning of the catheter, the purse-string is tied. Sufficiency of the suture line is tested by filling with liquid. Pulling the catheter to the abdominal wall should not result in tension.

At least four seromuscular interrupted stitches then fix the stomach to the abdominal wall in Stamm-like Fashion.

Then the balloon is inflated and the tube pulled through an incision in the abdominal wall. Note, if ascites is present, the tube can be Z-tracked through the abdominal wall via a long intramural track in attempt to hamper an ascitic leak at the insertion site (◘ Fig. 30.3b)



◘ Fig. 30.3

Permanent Stapled Continent Gastrostomy (Janeway Gastrostomy)

Step 1

Access

Access to the peritoneal cavity and exposure of the stomach as described previously.

Step 2

Creation of the gastric tube

For creation of a permanent reverse gastrostomy, the greater curvature is used. The left gastroepiploic vessels represent the vascular pedicle of the tube. After ligation of the right gastroepiploic vessels at the site of the beginning of the tube, the gastrocolic and, if necessary, gastrosplenic ligaments are transected at a safe distance from the left vascular pedicle without compromising the integrity of the gastroepiploic arcade.

The apex of the gastric tube is situated at the middle third of the greater curvature. The left gastroepiploic vessels are the vascular pedicle of the gastrostomy.

A sufficient length of the tube is achieved by two to three applications of a linear stapler, depending on the thickness of the abdominal wall. Inversion of the GIA suture lines is performed by interrupted or running sutures (◘ Fig. 30.4).

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Step 2 *(continued)*



Fig. 30.4

Step 3

Attention should be paid not to compromise the tube's blood supply at its superior aspect.

The gastric tube is pulled through a narrow incision in the abdominal wall in the left upper abdominal quadrant as one would for an ileostomy. Opening of the gastric tube and sewing of the mucosa to the skin as a permanent stoma are performed flush with the skin so as to minimize the effects of gastric secretions that may induce peristomal dermatitis. Stomaplast around the stoma is applied to protect the skin from peristomal problems (Fig. 30.5).

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Step 3 ***(continued)***



Fig. 30.5

Postoperative Instructions

- Liquid diet feeding 6 to 12 hours following surgery.
- Feeding with pureed foods as soon as evidence for postoperative abnormalities of gastroduodenal clearance has been excluded.

Postoperative Complications

- Postoperative obstruction due to stomal edema
- Leakage of the gastrotomy or suture line disruption
- Peritonitis
- Intragastric and intraperitoneal bleeding
- Gastric wall or stomal necrosis

Tricks of the Senior Surgeon

- The continence of the gastrostomy can be enhanced by drawing the tube upward and bringing it to the surface near the costal margin.
- Avoid linking and narrowing of the stomal tube due to oversewing of the staple lines and/or anchor sutures of the tube to the posterior abdominal wall. Both may compromise the blood supply of the gastrostomy from the left gastroepiploic vessels.

Acknowledgments

The authors acknowledge the contribution of Asad Kutup and Emre F. Yekebas in the previous edition.

Laparoscopic-assisted Gastronomy

Nathaniel Melling, Oliver Mann

Laparoscopic-assisted gastrostomy is an excellent minimally invasive procedure for patients who are unable to swallow and unable to undergo a PEG. The original conventional method was devised as a feeding tube by Bronislaw Kader in 1896 and modified for the minimally invasive approach in the 1990s.

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Indications and Contraindications

Indications

- See above section on conventional gastrostomy

Contraindications

- Severe Ascites
- Previous gastric or major upper abdominal surgery (in this case laparoscopic exploration can be tried)

Preoperative Investigation/Preparation for the Procedure

See above section on conventional gastrostomy

Procedure

- **Access via**
- 3-trocar technique (2 × 10 mm and 1 × 5 mm)
- Pneumoperitoneum (12 mm Hg)
- 10 mm subumbilical trocar
- 10 mm trocar in left lower quadrant
- 5 mm trocar in right upper quadrant

Step 1

Exposure

Exposure and exploration, adhesiolysis if necessary (Fig. 30.6).



Fig. 30.6

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Step 2

Three full-thickness stitches

Using a straight needle, which is brought into the abdomen through the skin of the left upper quadrant, a triangle is created by three full-thickness stitches which allow the catheter system to be introduced under laparoscopic control (stitches: skin-abdominal wall-stomach-abdominal wall-skin) (Fig. 30.7).

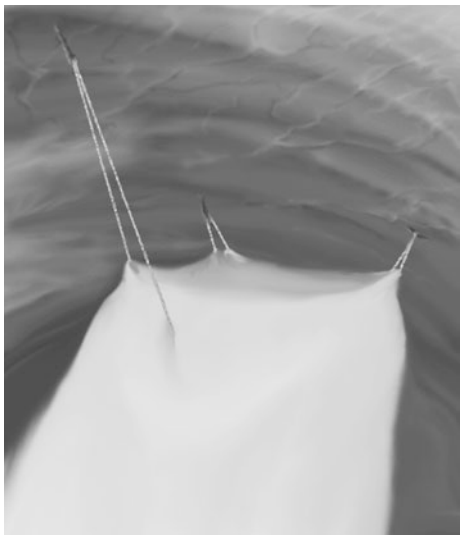


Fig. 30.7

Step 3

Insertion of the guidewire

A 1 cm incision is made in the center of the triangle created by the three sutures which are held under tension. Under laparoscopic vision the anterior stomach wall is punctured by an 18-gauge needle exactly in the center of the triangle. Through the needle a guidewire is inserted into the stomach and a 26 Fr dilator with a peel-away sheath is pushed over the guidewire into the stomach percutaneously (Fig. 30.8).

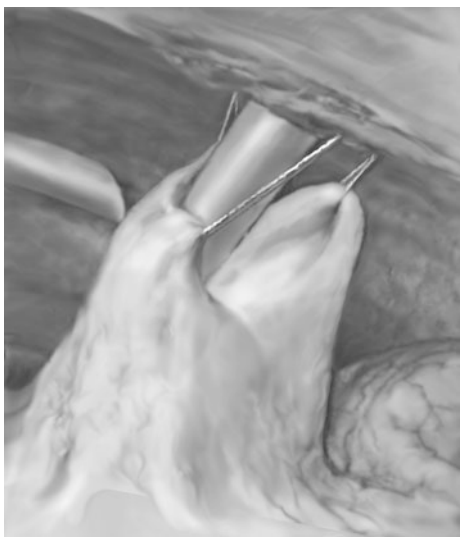


Fig. 30.8

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Step 4

Introducing the catheter system

The inner dilator is removed and a regular 24 Fr urinary balloon catheter is placed through the remaining peel-away sheath into the stomach. The peel-away sheath is removed. After the balloon of the catheter is inflated, the stomach is pulled against the abdominal wall and the sutures are subcutaneously tied under traction and progressive reduction of the pneumoperitoneum. The catheter is then put under gentle traction for 24 hours (Fig. 30.9). Alternatively, a purse string suture can be placed laparoscopically and a Stamm gastrostomy performed laparoscopically as done with an open Stamm gastrostomy.

See above conventional gastrostomy section for postoperative investigations and complications.

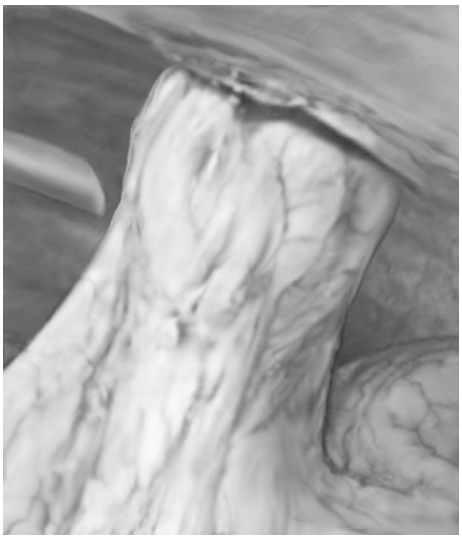


Fig. 30.9

Tricks of the Senior Surgeon

- Exchange the 24 Fr urinary catheter for a special gastrostomy button device 14 days postoperatively (Fig. 30.10).
- To avoid dietary deficiencies, patients should be under the supervision of a nutritional specialist.
- In case of contraindications for general anesthesia, the procedure can also be performed under local or regional anesthesia.

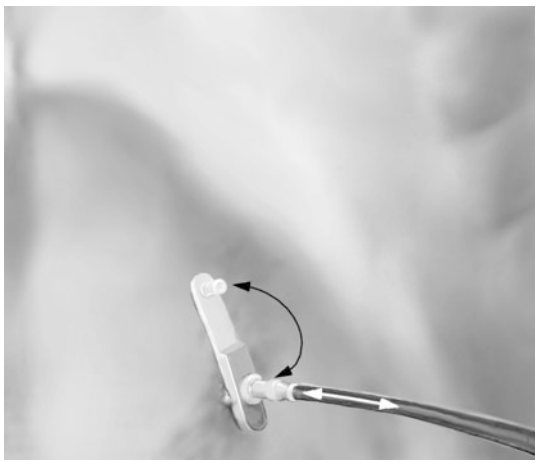


Fig. 30.10

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Fundoplication for GERD: Laparoscopic Approach

Nathaniel J. Soper

Laparoscopic antireflux surgery (LARS) has assumed a major role in the treatment of gastroesophageal reflux disease (GERD). The advancement in laparoscopic techniques and instrumentation over the past two decades has led to an increase in the number of antireflux operations. Although the operation is fundamentally similar to open antireflux procedures, clear benefits to the laparoscopic approach have been described.

In 1955, Rudolf Nissen reported the efficacy of a 360° gastric wrap through an upper abdominal incision to control reflux symptoms. It was not until 1991 that the first laparoscopic Nissen fundoplication was reported. From that point, acceptance on the part of patients and physicians to proceed with surgical treatment began to grow. Although the minimally invasive approach follows the same surgical principles as the open operation, LARS reduces postoperative pain, shortens the hospital stay and recovery period, and achieves a functional outcome that is similar to, or better than, that of the open operation.

Indications and Contraindications

Indications

- GERD symptoms (heartburn, regurgitation, dysphagia, chest pain) not controlled by medical therapy
- Volume reflux (regurgitation)
- Paraesophageal hernia (PEH) with GERD
- Inability to take acid reduction medication (allergic reaction, poor compliance, cost)
- Preference for surgery (young age, lifestyle choice)

Absolute Contraindications

- Inability to tolerate general anesthesia or laparoscopy

Relative Contraindications

- Previous upper abdominal surgery
- Morbid obesity
- Short esophagus

Preoperative Investigations/Preparation for the Procedure

History: Presence or absence of typical/atypical GERD symptoms, and acid reduction medication use; warning symptoms of gastrointestinal bleeding or dysphagia

Upper endoscopy with biopsies: Evaluation for esophagitis, gastritis, Barrett's metaplasia/dysplasia, hiatal hernia, and strictures

Esophageal manometry for evaluation of esophageal motility disorder: Measurement of esophageal body peristalsis and lower esophageal sphincter (LES) position/length/pressure, separation of LES from diaphragm

24-h pH testing: Following the cessation of proton-pump inhibitors for longer than 7 days

Laparoscopic Nissen Fundoplication

Used in greater than 90 % of patients with GERD. It can be argued that total (360°) fundoplication is generally not performed in patients with severe esophageal dysmotility.

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery*,
DOI 10.1007/978-3-662-46546-2_31, © Springer-Verlag Berlin Heidelberg 2016

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Procedure

Step 1

Operating room and patient setup

The patient is placed supine with the legs abducted on straight leg boards (no flexion of the hips or knees). An orogastric tube is placed.

The operating room personnel and equipment are arranged with the surgeon between the patient's legs, the assistant surgeon on the patient's right, and the camera holder to the left.

Video monitors are placed at either side of the head of the table and should be viewed easily by all members of the operating team.

Irrigation, suction, and electrocautery connections come at the head of the table on the patient's right side. Special instruments include endoscopic Babcock graspers, cautery scissors, curved dissectors, clip applier, atraumatic liver retractor, 5-mm needle holders, and ultrasonic coagulating shears (Fig. 31.1).



Fig. 31.1

Step 2

Port placement

Port arrangement should allow easy access to the hiatus and permit comfortable suturing by placing the optics between the surgeon's hands. Access to the abdominal cavity is achieved by either a closed or an open technique cranial to the umbilicus.

The initial port is placed in the left midrectus muscle approximately 12 to 15 cm below the xiphoid process. Four additional ports are placed under direct vision of the laparoscope. Ports are typically placed in the following locations to optimize visualization and tissue manipulation and to facilitate suturing: right subcostal, 15 cm from the xiphoid process; a point midway between the first two ports in the right midrectus region; in the left subcostal region 10 cm from the xiphoid; and in the right paramedian location at the same horizontal level as the left subcostal trocar (usually 5 cm caudal to the xiphoid process).

The gastroesophageal junction is usually deep to the xiphoid, and from a point 15 cm distant, only half of the laparoscopic instrument must be introduced to reach the hiatus. This distance establishes the fulcrum at the midpoint of the instrument and maximizes its range of motion during tissue manipulation.

With current 5-mm equipment and optics, we generally use only one 10- to 12-cm port, for the surgeon's right hand, to allow insertion of an SH needle through the valve mechanism (Fig. 31.2).

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Step 2 *(continued)*

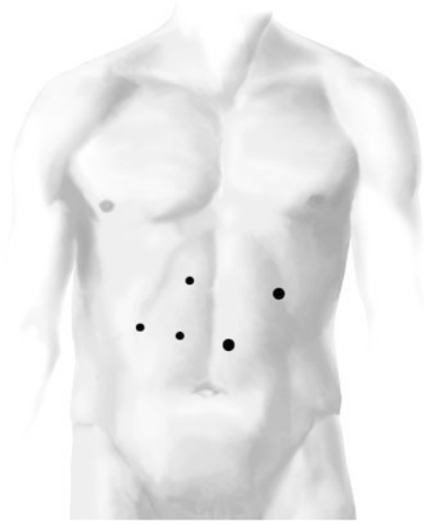


Fig. 31.2

Step 3

Exposure

Exposure of the esophageal hiatus is facilitated by gravity and maintained by an assistant. Positioning the patient in the reverse Trendelenburg position displaces the bowel and stomach from the diaphragm and brings the patient's torso closer to the surgeon.

A skilled camera holder and the use of an angled laparoscope (30° or 45°) are important.

The assistant introduces a self-retaining liver retractor through the right lateral subcostal port, and a Babcock grasper is introduced through the right midrectus port to pull the stomach and epiphrenic fat pad inferiorly and allow division of the gastrohepatic ligament using the ultrasonic shears. Division of the gastrohepatic ligament is done with preservation of the anterior vagus nerve and its hepatic branch. Note, the anterior vagus nerve is left on the anterior surface of the esophagus.

The left triangular ligament is not divided but is left to aid in retracting the liver anteriorly. Next, both the crura and the anterior vagus nerve are identified after opening the phrenoesophageal membrane (Fig. 31.3).

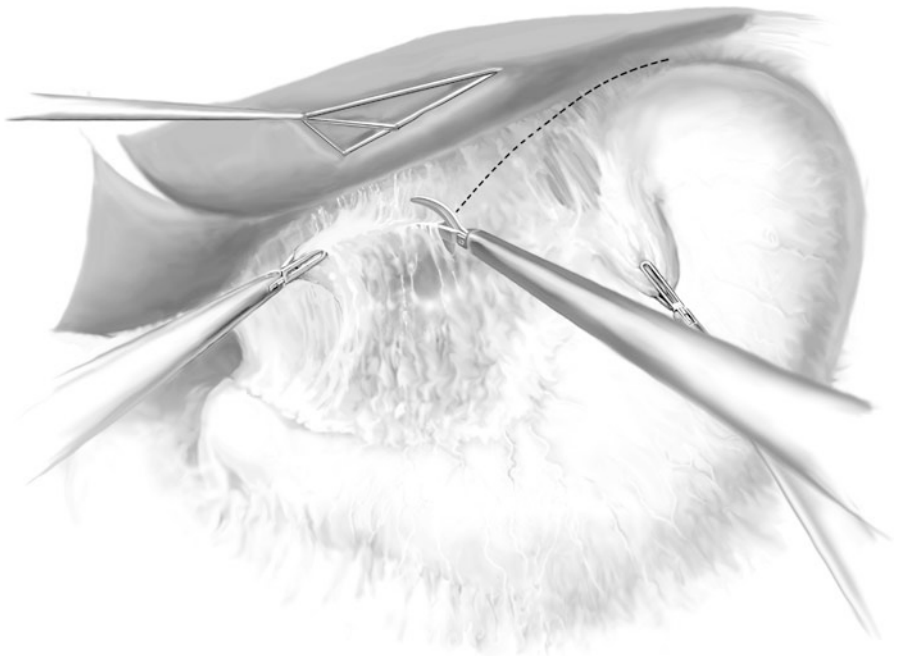


Fig. 31.3

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Step 4

Dissection

If a hiatal hernia is present, the stomach is repositioned into the abdominal cavity with gentle traction after cutting all adhesions to the hernia sac.

The right crus is retracted laterally, and the right side of the esophagus is carefully dissected to visualize the aortoesophageal groove and posterior vagus nerve.

The left crus is similarly dissected from the esophagus and fundus to its point of origin from the right crural leaflet. A "window" is created between the crura and the posterior esophageal wall under direct vision from the angled laparoscope (Fig. 31.4a).

The fundus and proximal stomach is then fully mobilized by dividing the proximal gastrosplenic ligament. The short gastric vessels are placed on traction and a window is created into the lesser sac. The short gastric vessels are then divided by serial application of the ultrasonic shears or by clipping and dividing them (Fig. 31.4b). To fully mobilize the distal esophagus, esophagogastric junction, and proximal stomach, all posterior retroperitoneal adhesions are divided being careful to preserve the posterior vagus nerve.

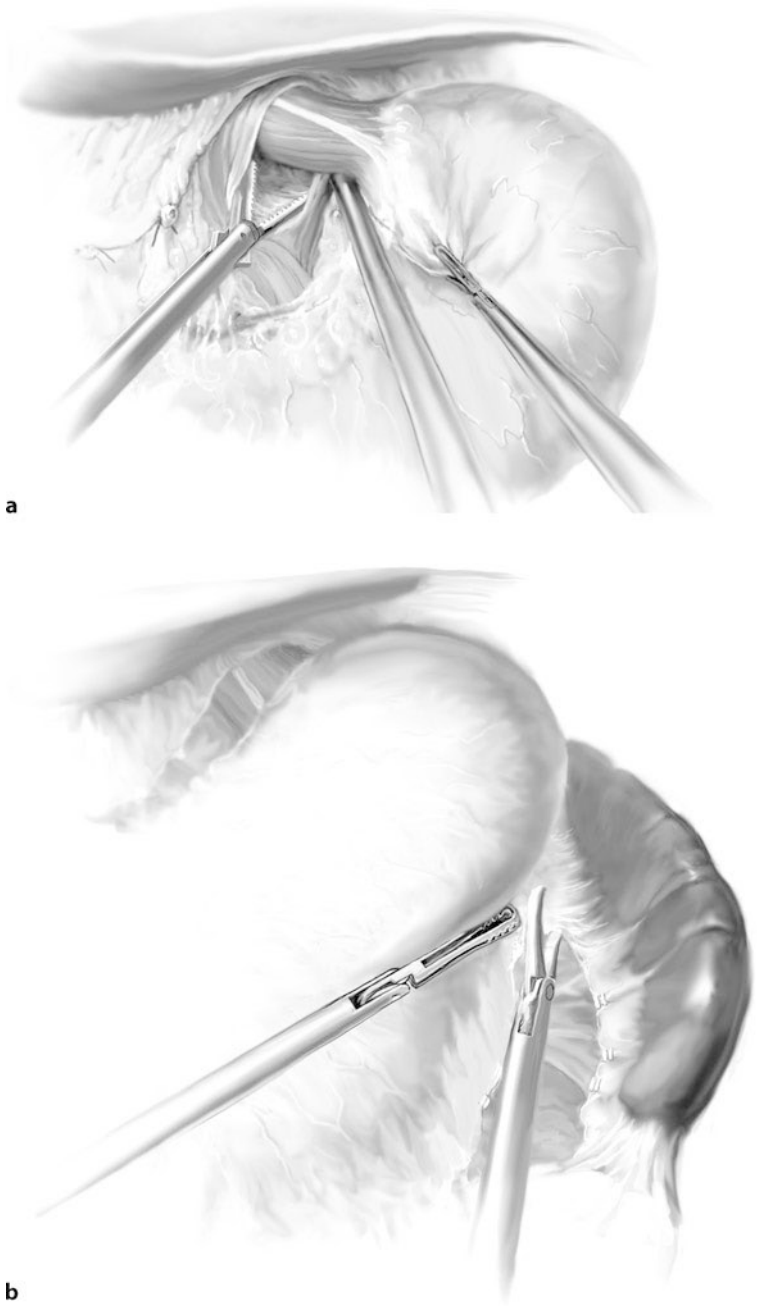


Fig. 31.4

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Step 5

Closure of the hiatal defect

After the mobilization of esophagus and proximal stomach, a Babcock clamp is passed right to left in front of both crura and behind the esophagus. The Babcock clamp grasps the fundus near the insertion of the short gastric vessels and pulls the fundus left to right around the esophagus. Following the "shoe-shine" maneuver, the fundus should lie in place (Fig. 31.5a). If the fundus springs back around the esophagus, the wrap will be under tension.

The hiatal defect is closed with several interrupted 0-Ethibond sutures (Fig. 31.5b). Retroesophageal exposure of the crura is gained either by using the mobilized fundus to retract the esophagus anteriorly and to the left or by placing a Penrose drain around the distal esophagus for retraction. This allows visualization of the retroesophageal space. Approximation of the right and left crura is usually performed posterior to the esophagus, although anterior closure may be appropriate in select cases. The crura are reapporoximated until they just touch the surface of the empty esophagus. A dilator is not in place during crural closure, as this limits exposure of the tissue posterior to the esophagus.

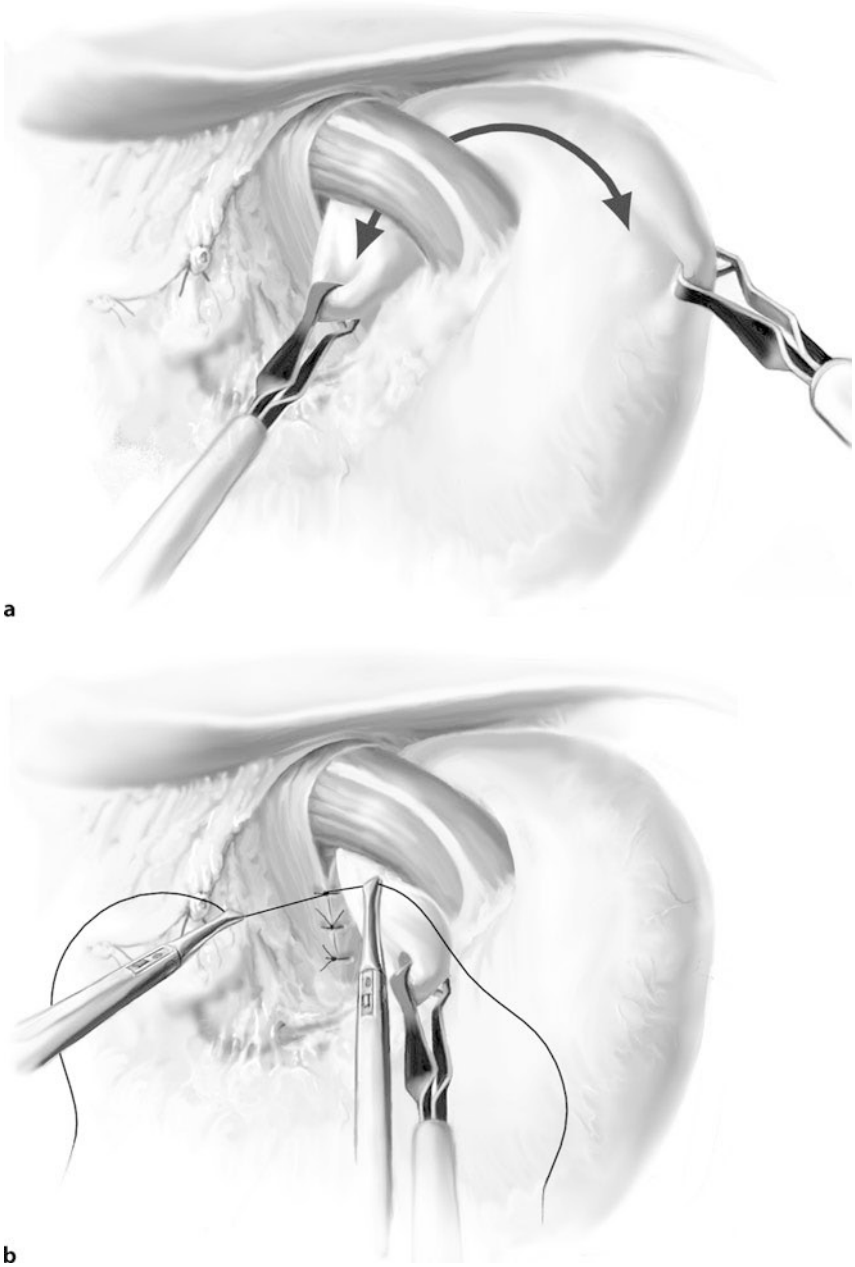


Fig. 31.5

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Step 6

Fundoplication

The esophagus is serially dilated, and a 50- to 60-French Maloney dilator is left in place during the creation of the wrap. The dilator calibrates the wrap and prevents excessive narrowing of the esophagus during the actual fundoplication. Dilation must be performed cautiously if the patient has esophageal stricture or severe inflammation.

The surgeon should watch the bougie pass smoothly through the gastroesophageal junction. If the bougie appears to be hung up at the gastroesophageal junction, the surgeon can sometimes improve the angulation by retracting the stomach anteriorly or caudally.

With the dilator in the esophagus, the fundus is positioned, and a "short, floppy" Nissen fundoplication is constructed using three interrupted, braided 0- or 2-0 polyester sutures. Usually 3 seromuscular bites of fundus to the left of the esophagus, the anterior esophageal wall away from the anterior vagus nerve, and the fundus to the right are all incorporated in the 360° fundoplication. The esophageal wall should be incorporated in at least one of the sutures to inhibit slippage of the wrap inferiorly onto the body of the stomach or into the thoracic cavity. The surgeon should take generous tissue bites and appose the gastric wall without strangulating tissue. Ideally, the wrap should be 2 cm or less in length. Note, the anterior vagus nerve is included in the wrap, but usually not the posterior vagus nerve whenever possible.

After three sutures to secure the fundoplication, additional sutures may be placed from the wrap to the crura for stabilization, although we currently do not perform this step. The esophageal dilator is withdrawn by the anesthesiologist. At this point the Nissen fundoplication is complete (Fig. 31.6).

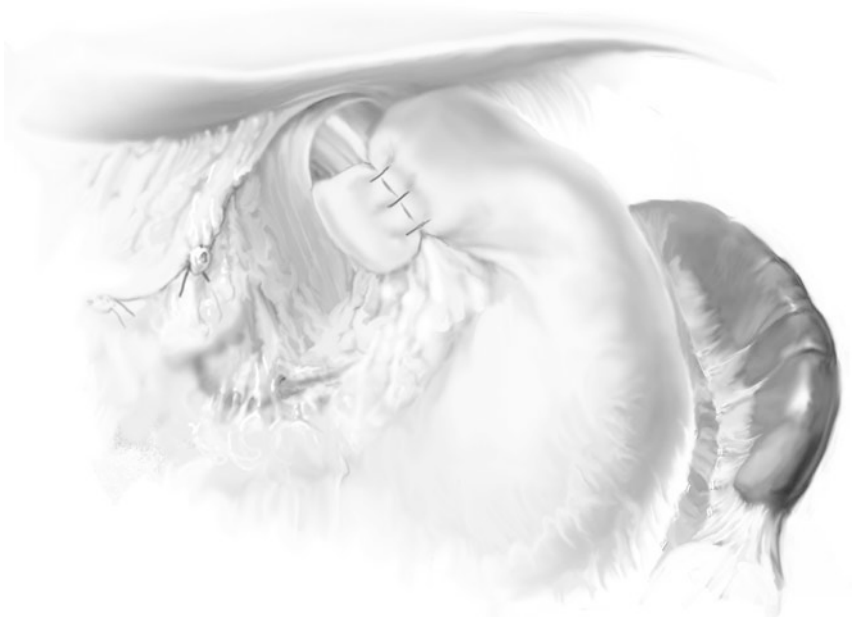


Fig. 31.6

Laparoscopic Partial Fundoplication

- Procedure of choice for GERD patients with preoperative dysphagia and markedly abnormal proximal esophageal motility in order to prevent excessive postoperative dysphagia or gas bloating symptoms (Table 31.1).

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Table 31.1 Partial Fundoplication Techniques	
Thal	90° anterior wrap
Watson	120° anterolateral wrap
Dor	150–200° anterior wrap
Toupet	270° posterior wrap
Belsey Mark IV	270° transthoracic anterolateral wrap

Indications and Contraindications

- *Primary esophageal motility disorders*
- Achalasia (after myotomy)
- Scleroderma
- *Secondary esophageal motility disorders*
- Severely disordered motility secondary to chronic reflux/Barrett's esophagus
- *Inability to tolerate complete fundoplication*
- Dysphagia
- Gas bloating
- Chronic nausea
- Aerophagia
- Revision of obstructing 360° wrap

Laparoscopic Toupet Fundoplication

Procedure

Initial operating room/patient setup, port placement, exposure, dissection, and closure of hiatal defect identical to the procedure outlined in "Laparoscopic Nissen Fundoplication."

Fundoplication

Step 1

Fixation of the fundus to the right crus

After the leading edge of the fundus is pulled posterior and to the right of the esophagus, the fundus is sutured to the right crus and to the right side of the esophagus over a length of 2 to 3 cm being careful to avoid both vagus nerves in the fundoplication (Fig. 31.7a and 31.7b).

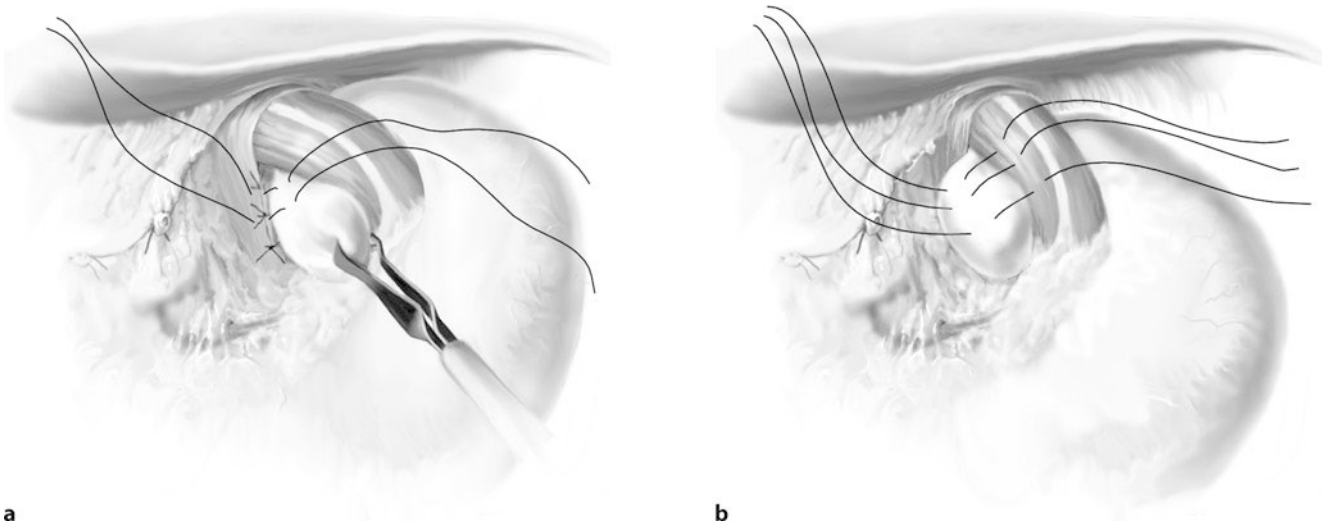


Fig. 31.7

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Step 2

Fixation of the fundus to the esophagus and the right crus

The anterior fundus is sutured to the right side of the esophagus over a length of 2 cm (Fig. 31.8a).

The 270° fundoplication is secured to the right crus with separate gastrocrural sutures (Fig. 31.8b).

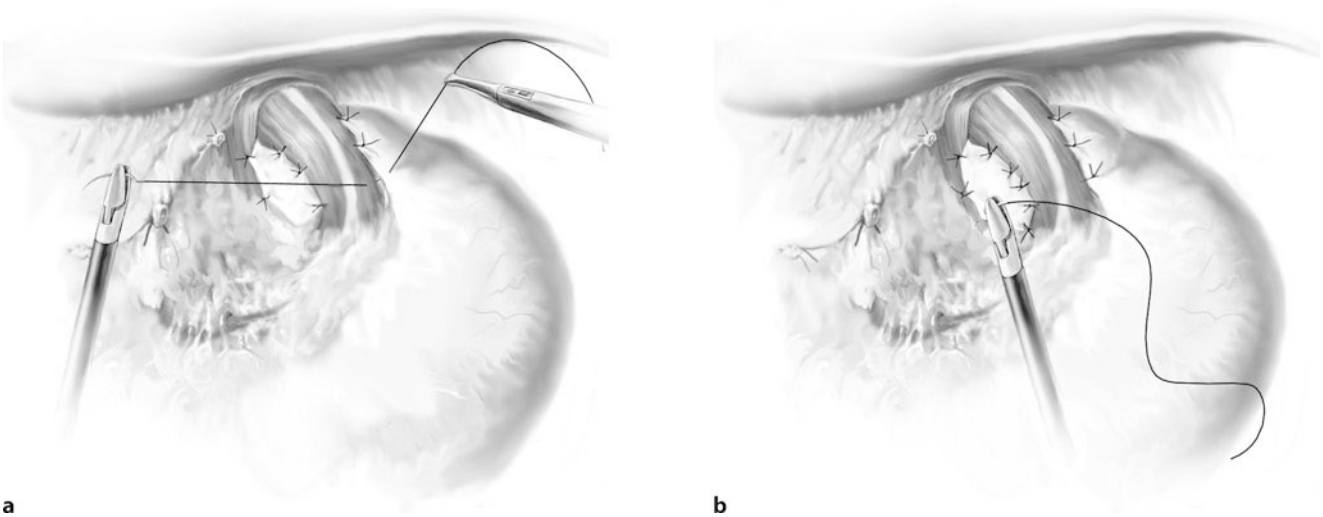


Fig. 31.8

Standard Postoperative Investigations

Patients who report unusual abdominal or chest discomfort, GERD-related symptoms, or dysphagia should undergo testing (endoscopic, radiological, and/or physiological evaluation).

Postoperative Complications

- Dysphagia
- Recurrent GERD symptoms and/or esophagitis
- Wrap disruption/migration or acute paraesophageal hernia
- Gas bloat syndrome

Tricks of the Senior Surgeon

Securing the patient to the table using a beanbag will allow steep reverse Trendelenburg positioning for gravity displacement of the bowel and maximum exposure of the gastroesophageal junction.

Dividing the short gastric vessels will freely mobilize the fundus.

Adequacy of fundic mobilization is checked before suturing the fundoplication by releasing the fundus and watching whether the fundus rests in place or recoils under tension.

Care should be taken not to excessively angulate the esophagus when performing posterior hiatoplasty.

A short, "floppy" wrap 2 cm or less in length is ideal.

A 360° wrap is too tight if a 5-mm Babcock clamp does not easily pass under the wrap.

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Operation for GERD: Conventional Approach

Karim A. Gawad, Alexandra M. König

In 1956, Rudolph Nissen introduced the antireflux effect of wrapping the gastric fundus around the distal esophagus. The "open Nissen fundoplication" and its modifications have since been used to treat moderate-to-severe gastroesophageal reflux disease (GERD) in situations in which medical therapy has failed. Laparoscopic antireflux procedures have, since the first reports in 1991, become the method of choice in dealing with surgical options for symptoms of GERD. As has been the case for several other laparoscopic procedures, questions have arisen about the limitations of these procedures in comparison with the traditional open techniques. An open approach may be preferable in patients who have undergone previous open upper abdominal surgery or in cases of recurrent or re-recurrent GERD when revisional laparoscopy may not seem sufficient to definitely treat the disease.

Indications and Contraindications

Indications

- Significant gastroesophageal reflux
- "When a laparoscopic approach is not indicated"
- Recurrent disease following previous open or laparoscopic surgery; a laparoscopic revision of a prior fundoplication should only be done by experienced laparoscopic surgeons
- Status postconventional upper abdominal surgery with massive adhesions
- Failure of conservative treatment
- Anatomical reasons such as difficulties in retracting the left lobe of the liver or an excess of intraperitoneal fat
- Physiological derangements secondary to a pneumoperitoneum

Contraindications

- General contraindications for surgery under general anesthesia

Preoperative Investigations/Preparation for the Procedure

See ▶ Chap. 31 "Operation for GERD: Laparoscopic Approach."

Procedures

Access

Transverse upper abdominal incision, if required, with additional upper midline incision; *alternatively,* left subcostal *or* upper midline incision

Division of the triangular ligament to expose the esophagogastric junction

Choice of Procedure

- Simple reflux disease (esophagitis up to III):
  - Fundoplication

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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- Ligamentum teres (round ligament) plasty
- Complicated reflux disease (esophagitis IV)
  - Fundoplication + dilation (of florid esophagitis)
  - Fundoplication + parietal cell vagotomy (in gastric hyperacidity) + if necessary dilation (of florid esophagitis)
  - Fundoplication + parietal cell vagotomy + stricturoplasty (of scarred strictures)
  - Limited resection of the gastroesophageal junction

Step 1

Mobilization of the distal esophagus and fundus

The distal esophagus is completely dissected and encircled with a vessel loop being careful to avoid injury to the vagus nerves. The gastric fundus is completely mobilized by division of the short gastric vessels in order to form a loose, "floppy" fundoplication.

If ligamentum teres plasty is planned, there is no need for fundic mobilization. Special attention has to be paid to thoroughly preserving the ligament at laparotomy.

In the presence of a hiatal hernia, a posterior hiatoplasty is performed using nonabsorbable suture material (Fig. 32.1).

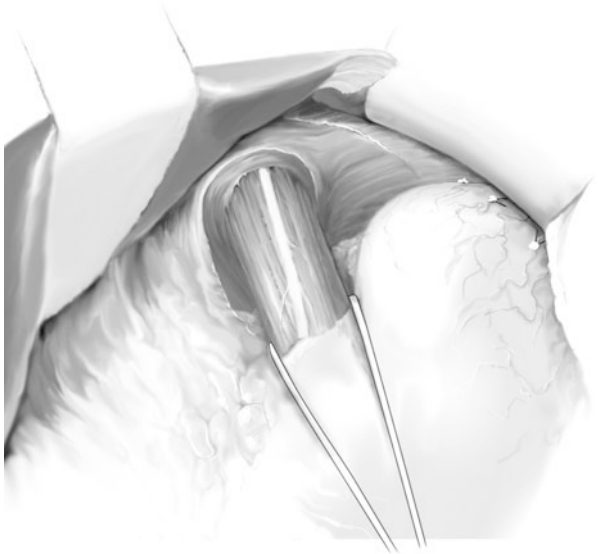


Fig. 32.1

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Total ("Nissen") Fundoplication

Step 2

Passage of the fundus

The mobilized fundus is passed behind the esophagus to the right side so far that it can be easily sewn to the remaining front wall of the wrapped fund is in front of the esophagus (Fig. 32.2).

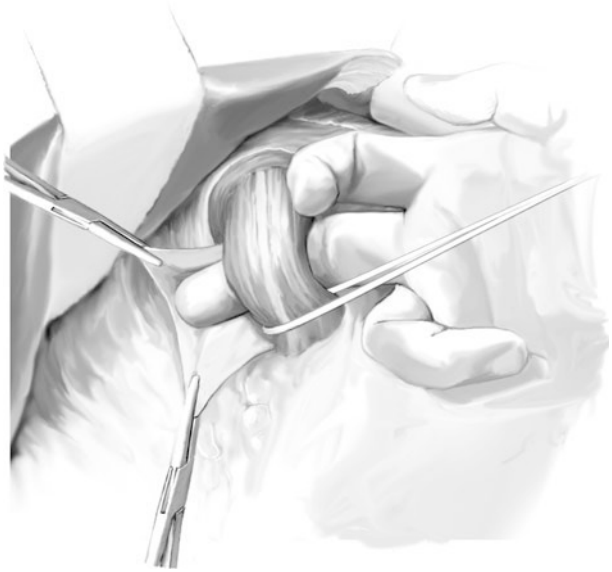


Fig. 32.2

Step 3

Formation of the wrap

The two cuff folds are fixed with three, maximally four, nonabsorbable sutures. At least, one or more sutures should include the esophageal wall to prevent proximal or distal "slippage" of the fundoplication wrap (Fig. 32.3).

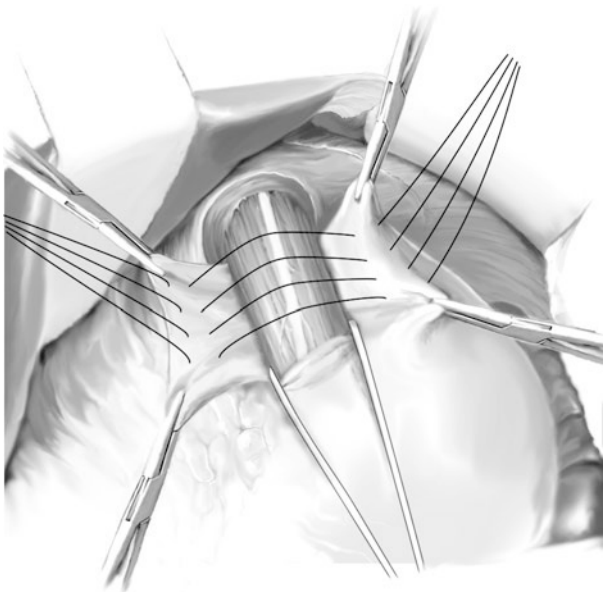


Fig. 32.3

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Step 4

Anchoring of the wrap

Finally the fundic cuff is again tested. Two fingers should easily pass under the loose wrap around the distal esophagus ("floppy Nissen").

One or two additional sutures can fix the left cuff of the anterior gastric wall to the right crus in order to prevent slippage (Fig. 32.4).



Fig. 32.4

Ligamentum Teres (Round Ligament) Plasty

Step 1

See above.

Step 2

Dissection of the round ligament

The round ligament is carefully dissected from the abdominal wall and from the liver, respectively. The free end of the ligament is transposed posteriorly around the esophagus coming from the right side (Fig. 32.5).

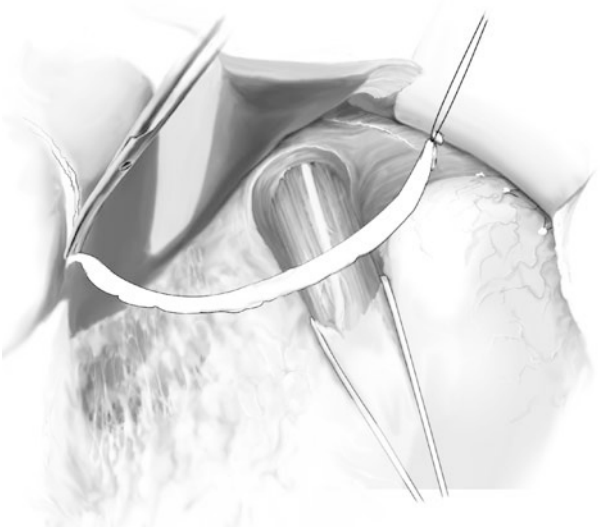


Fig. 32.5

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Step 3

Fixation to the anterior gastric wall

The round ligament is then attached to the anterior gastric wall under relative tension using three or four nonabsorbable sutures. Fixation to the anterior aspect of the gastric corpus is performed (Fig. 32.6).

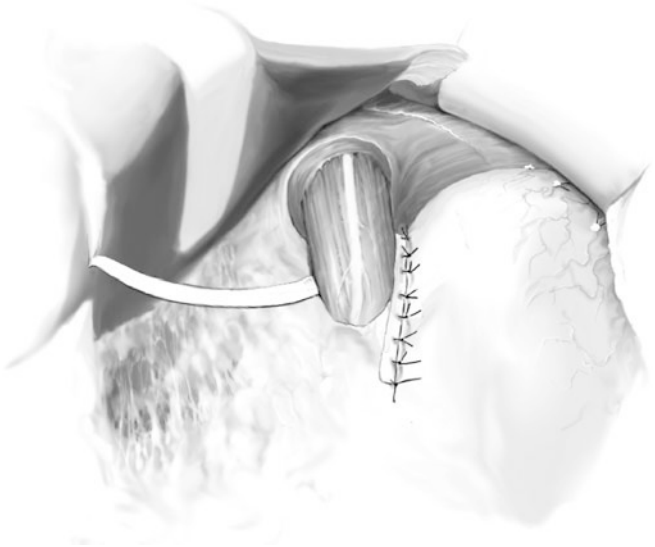


Fig. 32.6

Standard Postoperative Investigations

See ▶ Chap. 31 "Operation for GERD: Laparoscopic Approach."

Postoperative Complications

- **Short term**
  - Esophageal perforation
  - Dysphagia
- **Long term**
  - Dysphagia
  - Gas bloat
  - Recurrent disease

Tricks of the Senior Surgeon

- Perform Nissen fundoplication around a large 45 to 60 Fr bougie to facilitate formation of a loose "floppy," fundic wrap.
- Use of a self-retaining retractor system will facilitate exposure of the esophagogastric junction.
- Dissection of the short gastrics is not mandatory but will ensure a loose fundoplication, thus preventing postoperative dysphagia.
- Do not dissect the round ligament at laparotomy.
- Consider partial posterior fundoplication (Toupét technique) especially in patients with poor esophageal motility – the only difference is that in step 4 (as described above) suture both fundus cuff folds to the right and left esophageal aspect respectively, thus forming a posterior 270° cuff instead of a 360° cuff. Anchor the posterior wall of the cuff to the right and left crus with two sutures each.

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Operation for Paraesophageal Hernia

Jean-Marie Michel, Lucas Krähenbühl

In 1889, Postempski first reported the repair of a wound of the diaphragm. Ackerlund described different types of paraesophageal hernia in 1926, and the first hiatal hernia repair (fundoplication) was reported by Nissen in 1955. Since then, Nissen fundoplication has gained wide acceptance and is now recognized as the operation of choice for antireflux surgery and, although technically challenging, the laparoscopic approach has become the "gold standard" of paraesophageal hernia repair.

The goal of a paraesophageal hernia repair is to bring the stomach (with other organs such as colon, omentum, spleen) and the lower esophagus back into the abdominal cavity, to excise the hernia sac, to approximate crura, to perform a fundoplication in order to prevent gastroesophageal reflux, and finally to perform a gastropexy in order to prevent gastric volvulus.

Indications and Contraindications for Laparoscopy

Indications

Symptomatic or asymptomatic type II, type III, and type IV hiatal hernia

- Type II: Pure paraesophageal hernias; the gastroesophageal junction remains in its normal anatomical position but a portion of the fundus and proximal stomach herniates through the diaphragmatic hiatus adjacent to the esophagus.
- Type III: The gastroesophageal junction and the fundus herniating through the hiatus. The fundus lies above the gastroesophageal junction.
- Type IV: These hernias are characterized by the presence of a structure other than the stomach, like the omentum, colon, small bowel, or spleen, within the hernia sac.

Contraindications

- **Absolute**
  - Intrathoracic gastric perforation with type II, type III, or type IV hiatal hernia
- **Relative**
  - Gastric incarceration
  - Partially fixed paraesophageal hernia
  - Short esophagus

Indications and Contraindications for Laparotomy

Contraindications

- Intrathoracic gastric perforation with type II, type III, or type IV hiatal hernia due to the peritonitis/mediastinatis no plastic reparation in the acute phase.

- **Relative**
  - None

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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Preoperative Investigations/Preparation for the Procedure

History: Long-term history of gastroesophageal reflux disease (GERD), symptoms of upper gastrointestinal occlusion

Upright radiograph of the thorax: Search for a retrocardiac air-fluid level

Contrast radiographic studies (barium swallow): Preoperative localization of the gastroesophageal junction, assessment of the type of hernia

Esophageal manometry: To exclude a motility disorder of the esophagus

Upper endoscopy: To confirm findings of GERD and/or exclusion of gastric ulcer disease

24-h pH monitoring and stationary manometry: To document GERD and esophageal dysmotility. In type II hernias, 70 % of patients have pathologic pH-metry, with up to 100 % of patients with type III hernias.

Actively treat dehydration

Empty the stomach: Nasogastric tube or immediate preoperative endoscopy

One-shot prophylactic antibiotic with second-generation cephalosporine

Procedure

The patient is placed in a modified lithotomy position. The table is placed in a steep reverse Trendelenburg position (French position), with the surgeon standing between the patient's legs, the first assistant on the patient's left, and the camera assistant on the patient's right.

33

Port Placement

A 10-mm port is placed 5 to 8 cm cranial to the umbilicus in the midline (open Hasson technique). A carbon dioxide pneumoperitoneum is established (12 mmHg). A 30° laparoscope is mandatory. After exploratory laparoscopy, the next four trocar sleeves are placed under direct vision. A subxiphoid 5-mm port for liver retraction; two working ports: one 5-mm one in the right upper quadrant (UQ), another 10-mm one in the left UQ; and a 5-mm left subcostal port (Fig. 33.1).

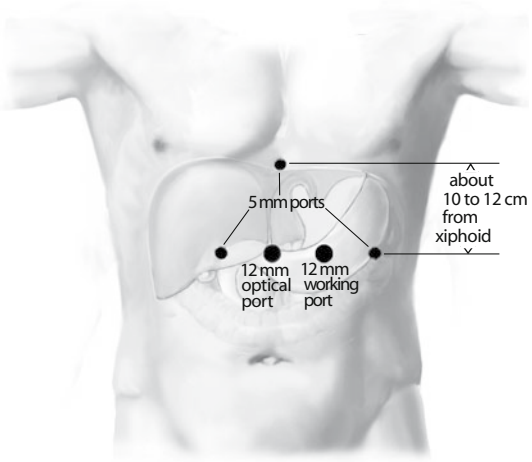


Fig. 33.1

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Exposure

To allow free access to the enlarged esophageal hiatus, the left lobe of the liver has to be elevated with a liver retractor to expose the esophago-gastric junction (Fig. 33.2).

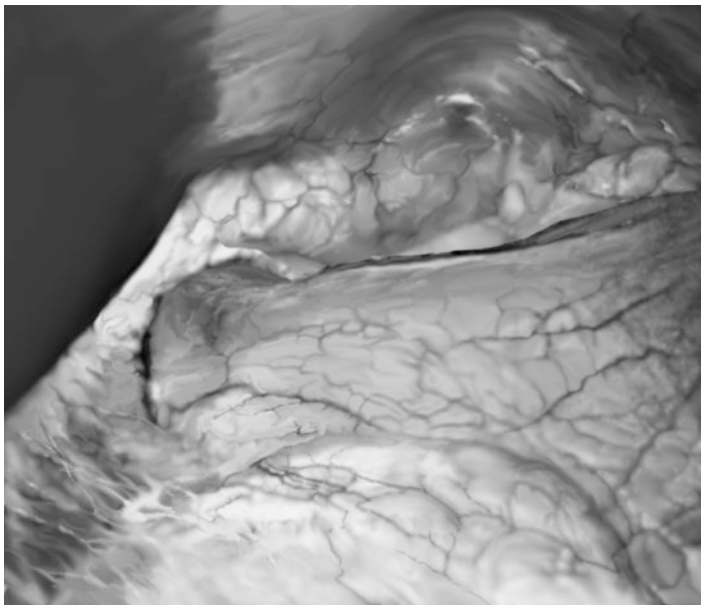


Fig. 33.2

Step 1

Reduction of herniated stomach

The herniated stomach and the greater omentum are reduced into the abdominal cavity with two Babcock graspers. A nasogastric tube is then introduced to decompress the stomach.

This maneuver is a dangerous step of the procedure with risks of stomach perforation, particularly in case of mechanical obstruction of the stomach (volvulus) with incarceration and gastric wall ischemia.

The spleen, colon, and omentum should also be reduced if they have herniated into the thorax (Fig. 33.3).

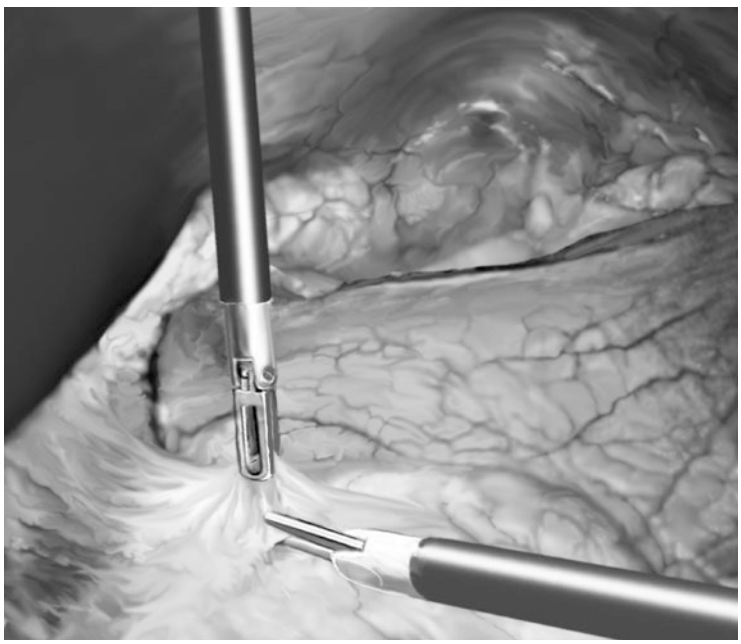


Fig. 33.3

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Step 2

Exposure of the hiatal hernia

Open the gastrohepatic ligament after reduction of the hernia content and expose the right crus of the diaphragm. The hepatic trunk of the vagus nerve and aberrant left hepatic artery should be preserved if possible. The hiatus and the hernia sac are now visible (Fig. 33.4).

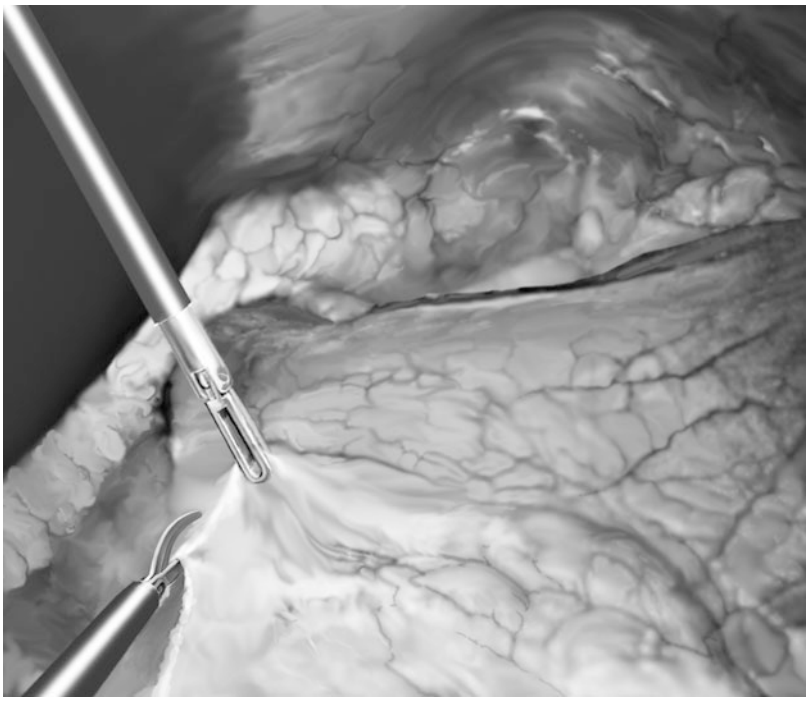


Fig. 33.4

Step 3

Circular incision of the hernia sac

Start the procedure on the right side and dissect the hernia sac off the right crural edge using the harmonic scalpel (Ethicon Endo-Surgery, Cincinnati, OH). Complete the dissection inferiorly and obtain a good exposure of the junction between the right and the left crura, then cranially with the incision of the phrenoesophageal membrane, finally to the left over the left crus. The dissection over the inferoposterior edge of the left crus is difficult at this moment and is best achieved when the hernia sac is completely reduced from the mediastinum.

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Step 4

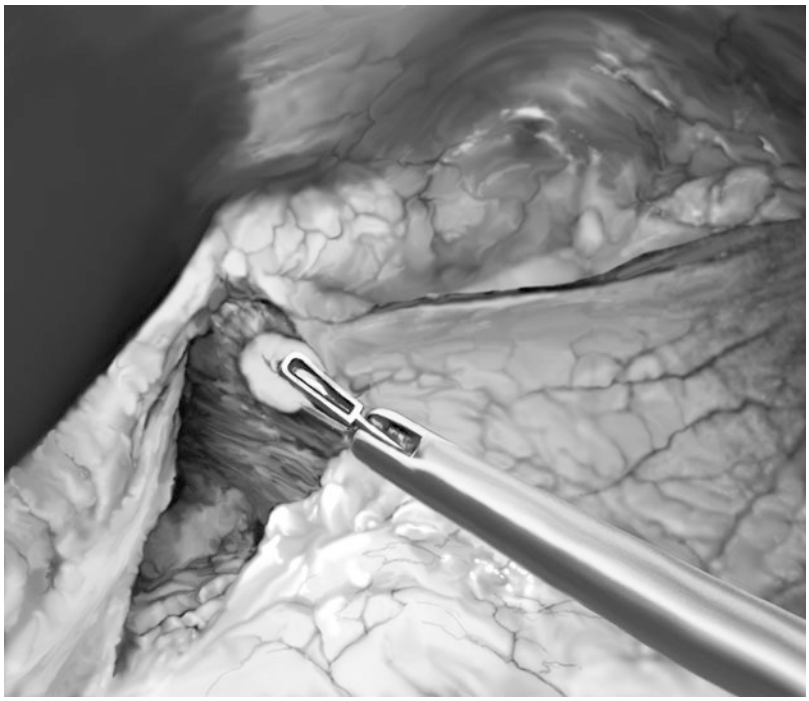
Blunt dissection of the hernia sac

The hernia sac now should be bluntly removed from the mediastinum with complete exposure of the right and left crura (*see* STEP 3) (◘ Fig. 33.5).

During this step anterior and posterior vagal nerves have to be identified and protected; this can be difficult to perform if there is associated inflammation.

It is not unusual for the left and/or right pleura to be opened within the mediastinum during blunt dissection, but most of the time pleural drainage is not mandatory.

Complete the dissection of the inferoposterior edge of the left crus. Pay particular attention to finding the plane between the esophagus and the body of the left crus, which may sometimes be extraordinarily difficult. It is not necessary to excise the hernia sac.



◘ Fig. 33.5

Step 5

Intra-abdominal reduction of the gastroesophageal junction

The distal esophagus is now completely freed and a Penrose drain is placed around the gastroesophageal junction to permit a better retraction in the abdominal cavity.

It is reported that as many as 15 % of giant type III paraesophageal hernias will present with a shortened esophagus and have an irreducible gastroesophageal junction. Adequate mobilization of the esophagus then should be performed as high as possible into the mediastinum. If the reduction remains impossible after this maneuver, the patient will most benefit from a Collis-Nissen gastroplasty, which can be done via a laparoscopic and/or a thoracoscopic approach.

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Step 6

Closure of the hiatal defect (posterior cruroplasty)

The hiatal defect is closed with five to six nonabsorbable 2-0 Ethibond mattress sutures placed posteriorly and anteriorly from the esophagus to return the gastroesophageal junction into the abdomen (Fig. 33.6a). The sutures are placed from caudad to cephalad so the hiatus is snug around the esophagus.

The axis of the hiatal hernia has an inferosuperior direction with an angle of about 10° clockwise in the perpendicular plane, and an inferosuperior direction with an angle of about 70° clockwise in the sagittal plane. Thus closure of the hiatal defect must follow the schema represented in Fig. 33.6b.

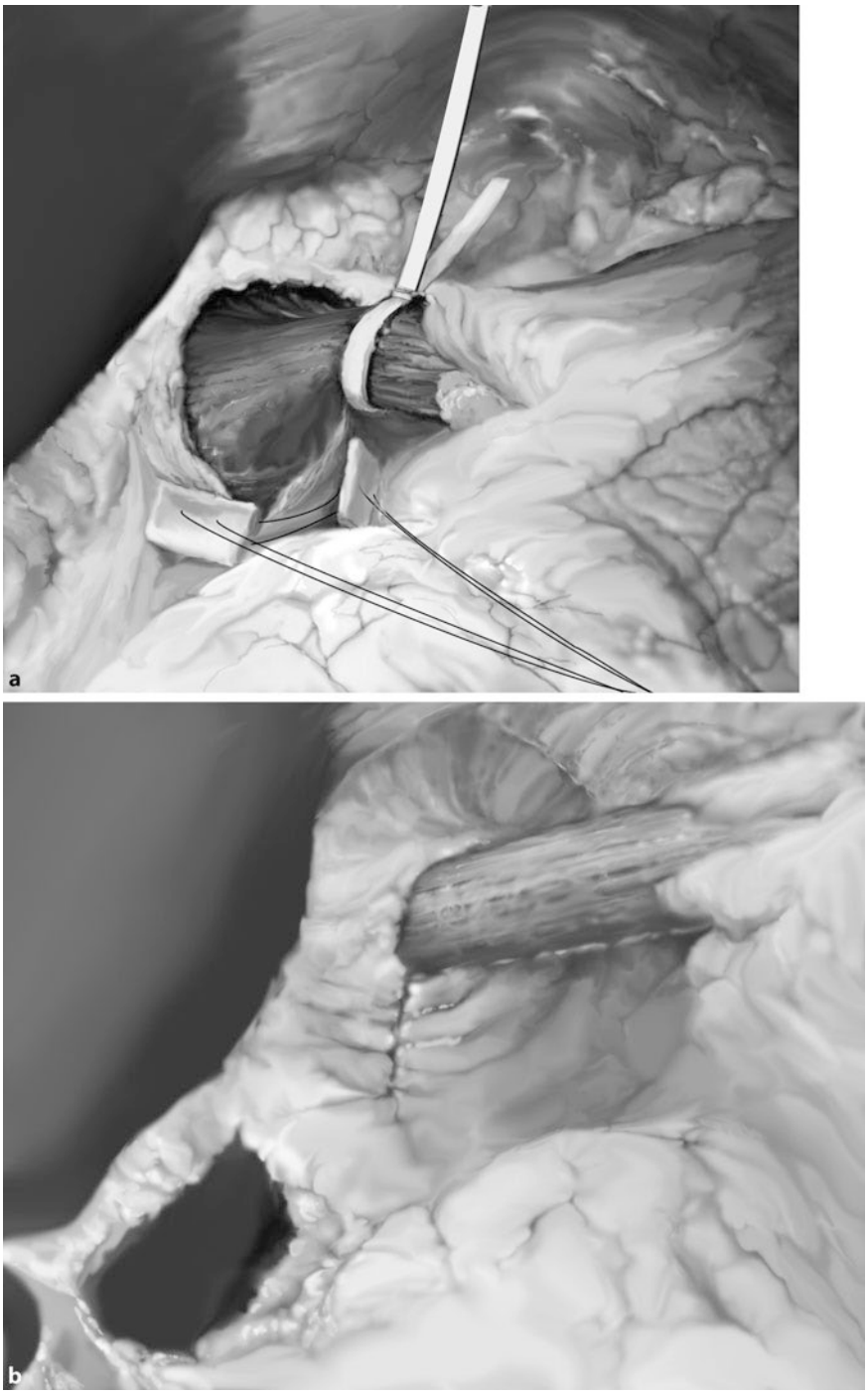


Fig. 33.6

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Step 6 ***(continued)***

Sometimes one or two anterior sutures are mandatory to avoid an "S-shape" of the distal esophagus. The inferior edge of the newly created hiatus may produce external compression leading to dysphagia (Fig. 33.7).

Some groups use a prosthetic reinforcement with polytetrafluoroethylene (PTFE) or with a bioprosthesis to create a posterior cruroplasty to reduce the rate of postoperative wrap herniation into the mediastinum.



Fig. 33.7

Step 7

Nissen fundoplication

Perform a floppy 2-cm three-stitch Nissen fundoplication over a 56-French bougie after mobilization of the great curvature (we divide the short gastric vessels). One or more of the most cephalad stitches of the fundoplication incorporates the esophagus wall to prevent slippage (Fig. 33.8). Be careful not to include the vagus nerves in the sutures of the fundoplication.

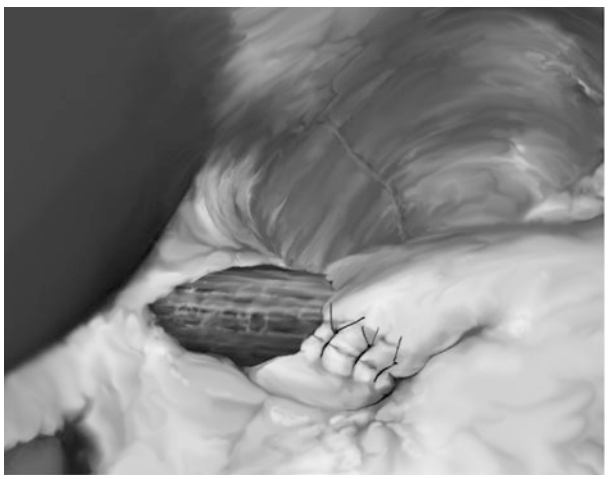


Fig. 33.8

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Step 8

Gastropexy

Wide suturing of the anterior wall of the proximal stomach to the anterior abdominal wall as a gastropexy helps to prevent re-herniation.

Postoperative Tests

- Resume alimentation the day after surgery
- Obtain a barium esophagogram within 1 month (for follow-up purposes)

Postoperative Complications

- Pneumothorax
- Pleural effusion
- Vagus nerve injury (anterior and posterior bundles)
- Cardiac dysrhythmia
- Pericarditis
- Pneumonia
- Pulmonary embolism
- Gastric volvulus
- Dysphagia

Tricks of the Senior Surgeon

- Use nonabsorbable mattress sutures to perform the posterior cruroplasty
- At the end of the procedure, perform an anterior gastropexy to avoid postoperative gastric volvulus

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Management of the Duodenal Stump

Yogesh K. Vashist, Florian Gebauer, Jakob R. Izbicki

One of the most serious complications after gastrectomy is leakage from the duodenal stump. Historically duodenal leak has been a potentially devastating complication after Billroth II resections following emergency surgery for duodenal ulcer perforation.

Causes of duodenal stump suture dehiscence are:

- Technical failure
- Postoperative pancreatitis
- Attempt to close a severely diseased and scarred, edematous duodenal stump
- Blood clots in the duodenal bed leading to super infection
- Excessive use of sutures at the stump leading to necrosis

Indications and Contraindications

Indications

- Peritonitis
- Sepsis

Contraindications

- None

Preoperative Investigations/Preparation for the Procedure

- Analysis of abdominal secretion in the drain tube (bilirubin, amylase, lipase)
- Physical examination
- Abdominal ultrasound
- Computed tomography (CT)

Procedure

Access

The abdominal cavity is opened through the previous incision.

If the dehiscence is small or barely visible, an omental flap is performed and the area well drained (Fig. 34.1). For some patients primary suture of the duodenum might be performed. This is usually hand-sewn, although some surgeons prefer the stapler technique.

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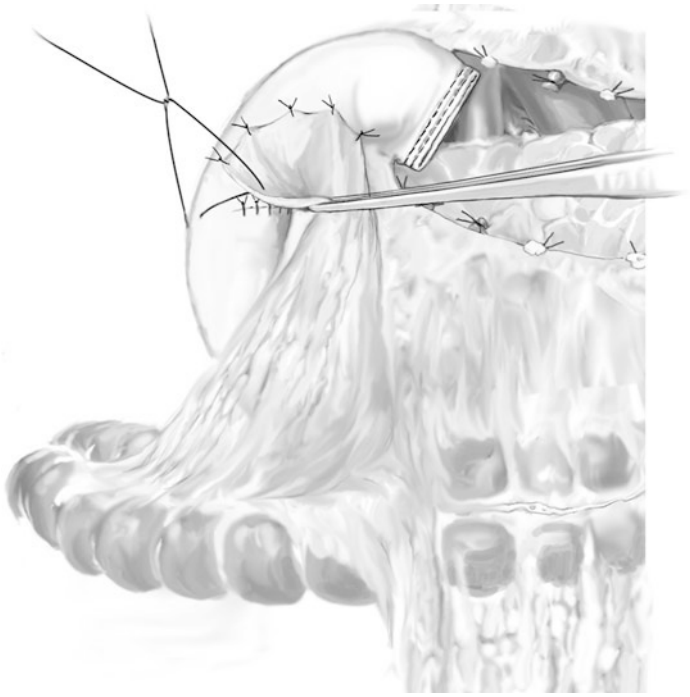


Fig. 34.1

If technically feasible, an end-to-side duodenojejunostomy may be performed using single-layered sutures.

If the duodenum is opened widely and the wall is edematous, a primary closure is usually unsuccessful because the sutures will not last. Here it is suggested to insert a Malecot catheter into the leak, which may be fixed using a purse-string suture.

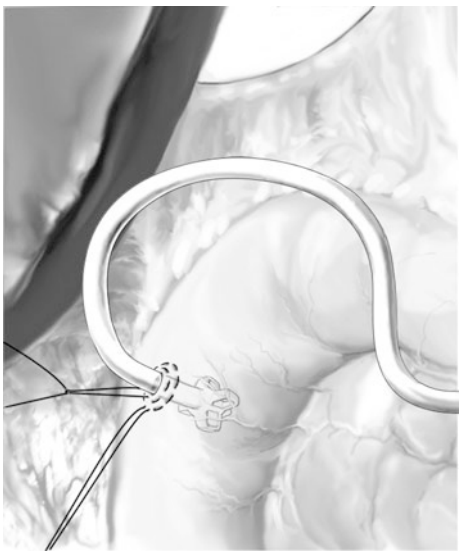


Fig. 34.2

The catheter shall be completely covered by the greater omentum and externalized using a separate incision. Most fistulas will close spontaneously after 3 to 4 weeks. An alternative is to cover the leak by a jejunal loop using the Roux-en-Y technique either as a serosal patch or a formal duodeno-jejunostomy.

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Most protection from the catastrophic sequelae associated with the occurrence of duodenal leakage is provided by temporary biliary diversion (large-bore T-tube into the common bile duct) and covering the leak by a jejunal loop using the Roux-en-Y technique. The duodenojejunostomy can be done in an end-to-side or side-to-side manner.

Wide intraperitoneal peri-duodenal drainage is necessary because all of these different forms of repair of a duodenal stump leak are at risk for leading to a recurrent leak.

Late suture dehiscences will present usually 2 weeks after (distal) gastrectomy. This course is less dramatic, because postsurgical adhesions lead to a contained leak. The presentation can be either by fever, pain, or drainage out of the wound. By using total parenteral nutrition as well as antibiotics, the fistula will close spontaneously. If a collection is visible on CT and the patient is symptomatic, the interventional placement of a drain, such as a Sonnenberg catheter, for optimized drainage of the duodenal fluid is necessary (Fig. 34.3).

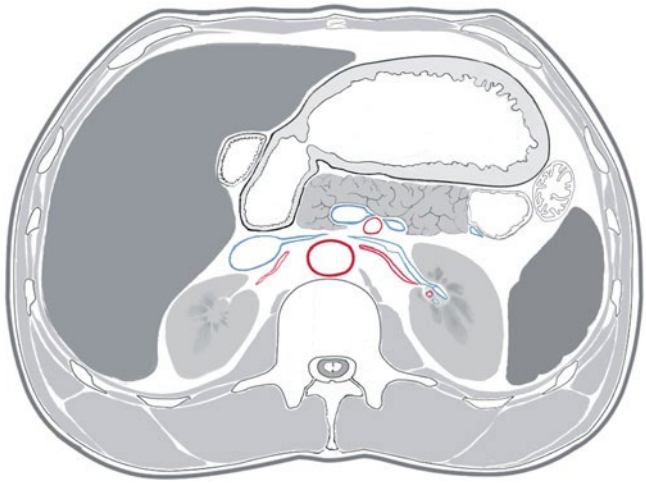


Fig. 34.3

Standard Postoperative Investigations

- Daily check of the abdominal drainage

Postoperative Complications

- Recurrent duodenal stump leak or leak at the site of diodenojejunostomy
- Peritonitis
- Sepsis
- Pancreatitis
- Fistula formation
- Wound infection

Tricks of the Senior Surgeon

- Tissue should not be too edematous. Therefore the indication for some form of intervention, such as re-laparotomy or percutaneous drainage, should be immediately undertaken once duodenal stump leak has been diagnosed.
- All surgeons know that these patients can be very ill and aggressive intervention is necessary without delay. In extremely rare situations, a partial pancreatiduodenectomy might even be necessary but only in life savings circumstances.

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Operations for Morbid Obesity

Stefan Wolter, Jakob R. Izbicki, Oliver Mann, Markus Weber, Markus K. Müller, Michael G. Sarr

The prevalence of obesity has increased dramatically over the past several decades worldwide and is currently reaching epidemic proportions. In the United States, two thirds of individuals are considered overweight. One in five Americans is currently obese. Morbid obesity, defined as body mass index (BMI) > 40 kg/m² or BMI > 35 kg/m² with weight-related morbidity, is associated with many diseases responsible for a high prevalence of morbidity and mortality, such as insulin-resistant diabetes mellitus, hypertension, coronary artery disease, hyperlipidemia, and sleep apnea. These direct weight-related complications eventuate in enormous health care costs.

The only evidence-based approach to substantial and sustainable weight loss in patients with severe obesity is bariatric surgery.

Current bariatric surgical procedures are divided into restrictive, malabsorptive, and combined procedures.

- *Restrictive procedures* aim to decrease the volume of oral intake. These include laparoscopic adjustable gastric banding (LAGB), sleeve gastrectomy (SG), and vertical banded gastroplasty (VBG).
- *Malabsorptive procedures* are designed to decrease protein and caloric absorption by decreasing the effective absorptive surface for digestion and/or absorption. The most common procedures currently are biliopancreatic diversion (BPD) and duodenal switch with a biliopancreatic diversion (BPD/DS).
- *Combined procedures* utilize both a restrictive and a selective malabsorptive anatomy and involve primarily the Roux-en-Y gastric bypass (RYGB) (the malabsorptive effect correlates with length of Roux limb).

Most of these procedures lead to a change in secretion of several gut hormones which influence eating behavior and insulin secretion. The metabolic effect of these procedures appears to play a major role in the remission of co-morbidities.

The advantages of laparoscopic surgery, especially in these obese patients, which involve shorter recovery time and fewer abdominal wound complications have led to widespread use of minimal access approaches in bariatric surgery.

This chapter addresses the most commonly performed bariatric procedures, focusing on the most important ones: Roux-en-Y gastric bypass (Fig. 35.1a), sleeve gastrectomy (Fig. 35.1b), and adjustable gastric banding (Fig. 35.1c). RYGB has been best documented to produce and maintain long-term weight loss in severely obese patients. Sleeve gastrectomy gained popularity more recently in the field of bariatric surgery, because this procedure is technically less demanding than RYGB. Use of adjustable gastric banding in the United States and in Europe has declined tremendously.

Biliopancreatic diversion (Scopinaro procedure) (Fig. 35.1d) and biliopancreatic diversion with duodenal switch (BPD/DS) (Fig. 35.1e) provide excellent weight loss and high rates of remission of co-morbidities, but because they are malabsorptive procedures close follow-up regarding malnutrition is mandatory.

Vertical banded gastroplasty (VBG) is described because more and more patients require revisional surgery after VBG (Fig. 35.1 f). Because use of an artificial band in this anatomic region leads to complications, it has become less attractive as a primary procedure over the past decade; indeed, few centers still perform this form of operative gastroplasty.

Although several other procedures have been described in bariatric surgery, the above mentioned are considered the standard procedure in bariatric surgery. Gastric electrical stimulation or "mini" gastric bypass, ileojejunal transposition, as well as endoscopic procedures like the duodeno-jejunal

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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bypass liner (Endobarrier; GI Dynamics; Lexington, MA, USA), need to prove their long-term efficiency and safety in larger studies at high-volume bariatric centers before they can be adopted widely.

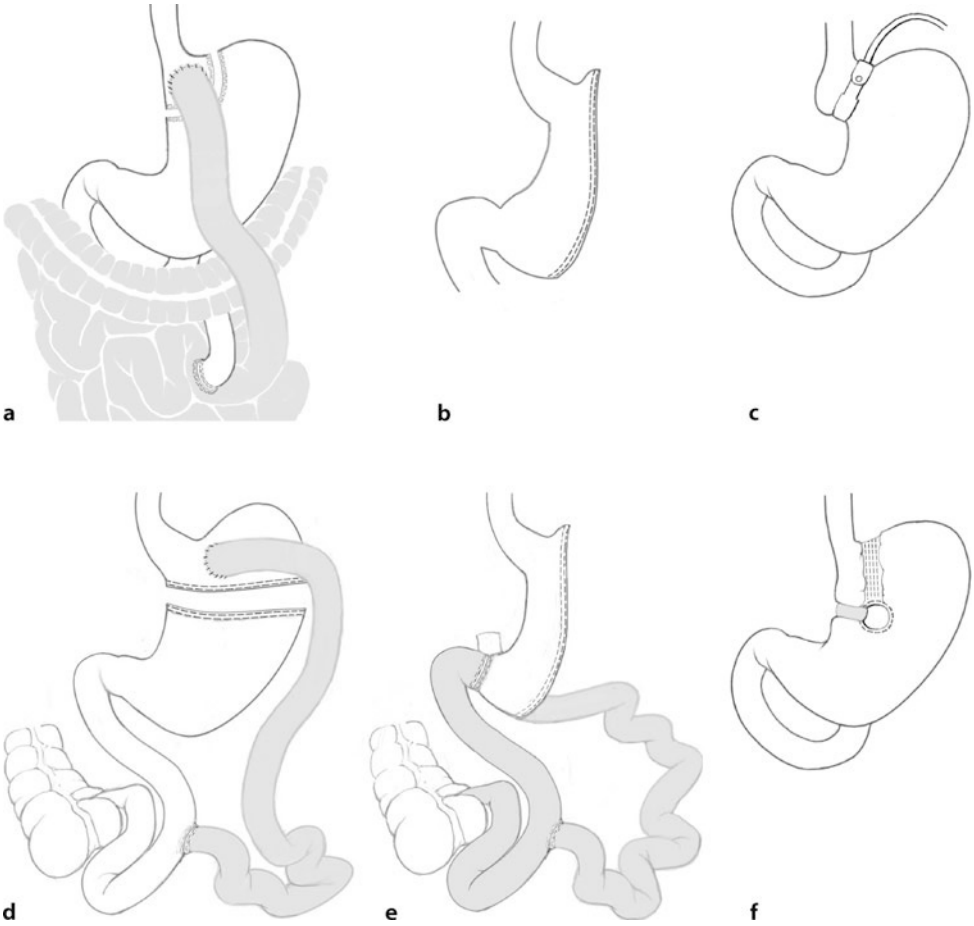


Fig. 35.1

Indications and Contraindications

Indications

- Patients with ineffective dietary attempts for weight control and
- BMI > 40 kg/m² or
- BMI > 35 kg/m² with weight-related comorbidity

Contraindications

- Age < 16 and > 60 years (these are relative contraindications)
- Obesity history < 3 years
- Unacceptable operative risk
- Active gastric or duodenal ulcer
- Active inflammatory bowel disease
- Moderate/severe portal hypertension
- Pregnancy
- Untreated endocrine disorders
- Unstable severe psychiatric disorders (psychosis, uncontrolled depression, active substance abuse)

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Relative contraindications

- Lack of family/social support
- Borderline personality disorder

Preoperative Investigations/Preparation for the Procedure

Clinical

- Physical examination (abdominal hernia, former abdominal surgery)
- Phenotype of obesity: androgenic (central obesity) versus gynecoid (peripheral obesity) (note: male/androgene phenotype and BMI > 50 are associated with increased pre- and perioperative morbidity)
- Electrocardiography (ECG), pulmonary function tests (if necessary), sleep study if symptoms suggest sleep apnea, and detailed cardiac evaluation if necessary (echocardiography, functional cardiac scintigraphy)

Laboratory

- Nutritional and metabolic parameters
- Hormonal parameters

Upper GI examinations

- Gastroscopy in selected patients, esophageal manometry in patients with gastroesophageal reflux disease if a restrictive procedure is to be performed (gastric banding, sleeve gastrectomy)
- Radiology: upper GI studies for reoperative surgery and especially after failed gastric banding (reflux, esophageal dysmotility, pouch dilation, band erosion?)

Anthropometry/body composition (optional)

- Bioimpedance analysis
- Calorimetry

Psychologic evaluation

- Exclude psychosis (rare), severe uncontrolled depression, active substance abuse, or borderline personality disorder
- Establish psychiatric care if necessary

Procedures

Roux-en-Y gastric bypass

RYGB is the most commonly performed bariatric procedure worldwide. The effect of the RYGB consists of restriction, selective malabsorption, and hormonal changes. Most commonly, an antecolic, antegastric route is used. The anastomosis technique can be circular or linear stapled construction. We describe the circular stapled (21/25) technique for the gastro-jejunal anastomosis, but a linear stapler or a hand-sewn technique can be used as well.

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Step 1

Positioning of the patient and access

The patient is placed in the lithotomy position in steep reverse Trendelenburg tilt with arms positioned upwards. The operating surgeon stands between the legs, first assistant on the left, and second on the right side of the patient. Two monitors are placed at the head of the bed. Afterwards, seven trocars are inserted (Fig. 35.2):

1. One 5 mm in the midline distal to the xiphoid for the liver retractor
2. One 10/12 mm on the right in the mid-clavicular line 10 cm caudal to the costal arch for the linear cutter, grasper, and Ultracision shears (Ethicon; Cincinnati, OH, USA)
3. One 10/12 mm in the midline 15 cm caudal to the xiphoid for the optic port
4. One 10/12 mm on the left in the mid-clavicular line just distal to the costal arch for the linear cutter, grasper, needle holder, and Ultracision
5. One 10/12 mm on the left in the mid-clavicular line 15 cm caudal to the costal arch for the linear cutter, grasper, needle holder, and Ultracision
6. One 5 mm on the right in the mid-clavicular line 15 cm caudal to the costal arch for the grasper and Ultracision
7. One 5 mm on the left in the extended anterior axillary line for the grasper

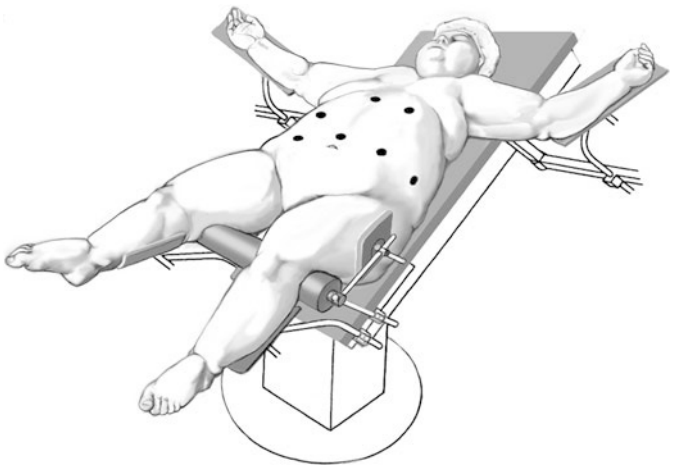


Fig. 35.2

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Step 2

Division of stomach and creation of proximal gastric pouch

The left lobe of the liver is retracted with a liver retractor inserted in the upper 5 mm midline port. On occasion, a paddle liver retractor may be necessary, requiring insertion via a right upper abdominal 12 mm port. Using the Ultracision shears, a window is created 3–4 cm distal to the esophagogastric junction along the lesser curvature close to the gastric wall to avoid injury to the vagus nerves.

The stomach is then transected using a linear stapler device (blue/purple cartridge, 3.5-mm staples). The stapler device is first applied transversely and then vertically heading up to the angle of His until the stomach is completely divided. The dissection of the fat pad at the angle of His before transection is not always necessary, but it may help in difficult exposures and is necessary when there is a large fat pad. To ensure a small proximal gastric pouch of 20 mL, a calibration tube/balloon filled with 20-mL saline can help define the site of the transection line (Fig. 35.3). Be certain, however, to remove any nasogastric tube.

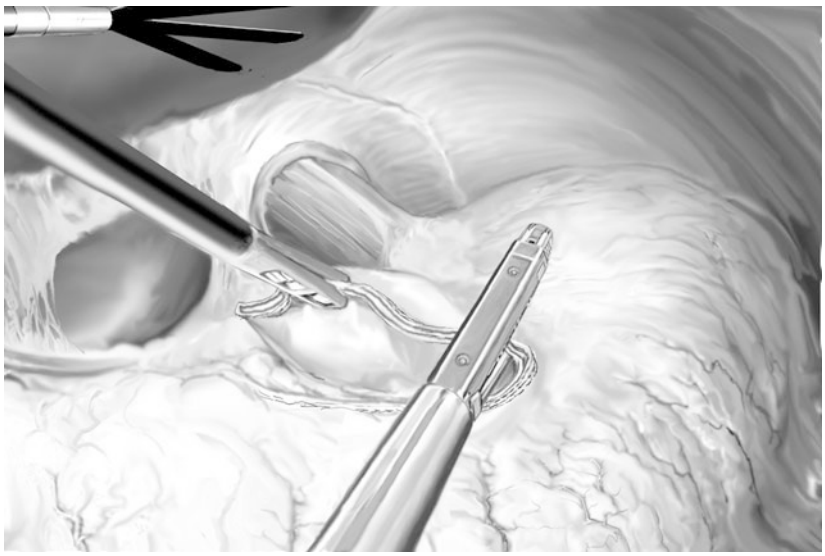


Fig. 35.3

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Step 3

Placement of 25-mm EEA anvil into the proximal gastric pouch

The distal end of the Orvil tube (Covidien; Dublin, Ireland) (Fig. 35.4a) is passed into the oropharynx, down the esophagus, into the gastric pouch, and out of a small gastrotomy made with laparoscopic scissors (Fig. 35.4b). The tube is then pulled into the abdomen with a grasper until the post of the anvil appears through the gastrotomy. The orogastric tube is removed after cutting the suture and tube at the proximal end with shears (Fig. 35.4c).

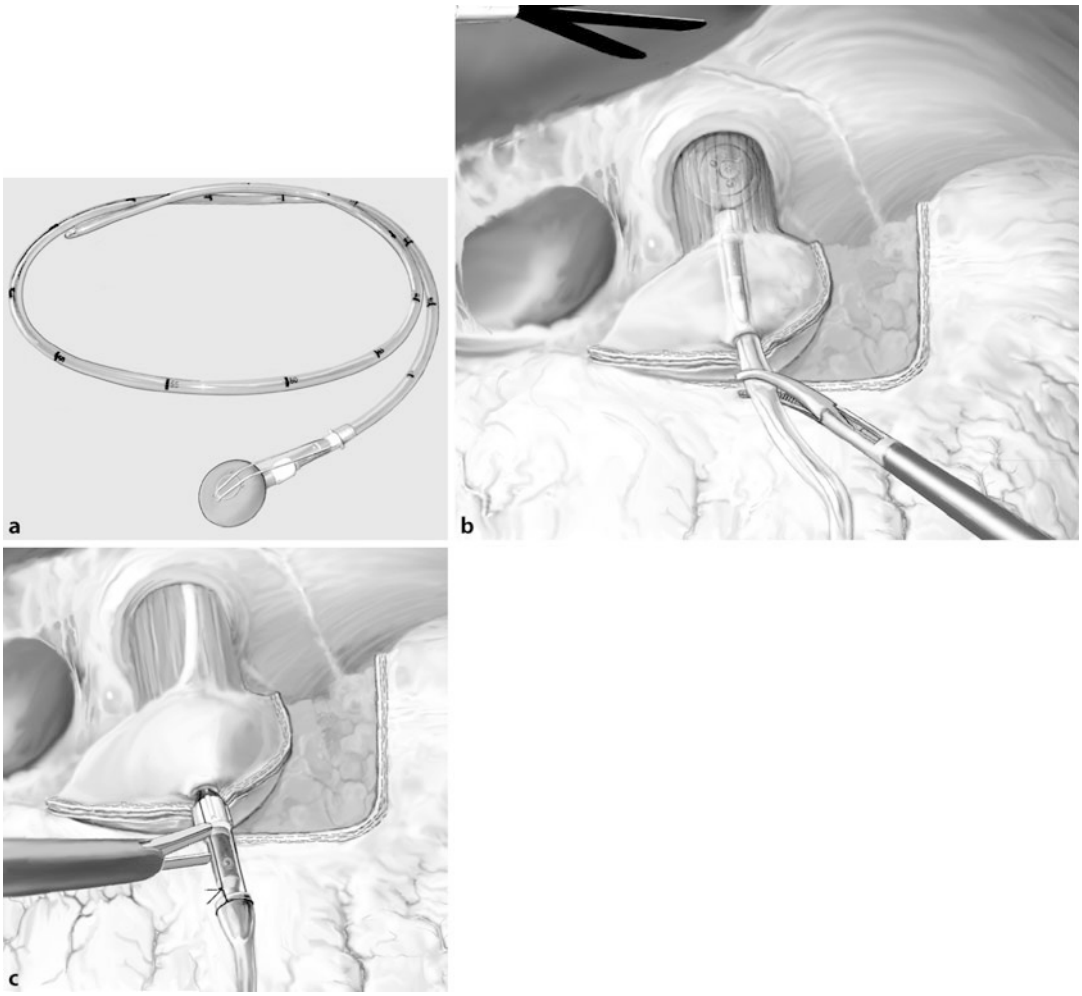


Fig. 35.4

Step 4

Creation of Roux-en-Y limb

The patient is brought into the supine position. The transverse colon is lifted up by two graspers inserted through the left-sided cannulas, and the ligament of Treitz is identified. Transection of the jejunum is performed 50 cm distally with 60-mm Endo GIA (white cartridge 2.5-mm staples minimize staple line bleeding). Afterwards, the mesentery is transected perpendicular to the bowel wall with Ultracision shears.

The Roux-en-Y limb is measured (80–150 cm). Fixation of the pancreatobiliary limb is done with a one stay suture to the Roux-en-Y limb (the anti-obstruction stitch) and a jejunojejunostomy is created with a 60-mm Endo GIA stapler using a white cartridge (Fig. 35.5a). The site of stapler insertion is closed with a running 4-0 polydioxanone suture. The mesenteric defect should be closed fully with interrupted stitches of non-reabsorbable suture (Fig. 35.5b) to prevent internal herniation here or via Petersen's defect (potential infracolic space posterior to the Roux mesentery and anterior to the retroperitoneum) and transverse mesocolon.

The alimentary Roux-en-Y limb is brought antecolic to the proximal gastric pouch, being careful to avoid a twist in the mesentery; if necessary (bulky omentum), the omentum can be transected vertically to allow a path for the Roux limb to be brought antecolic.

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Step 4 *(continued)*

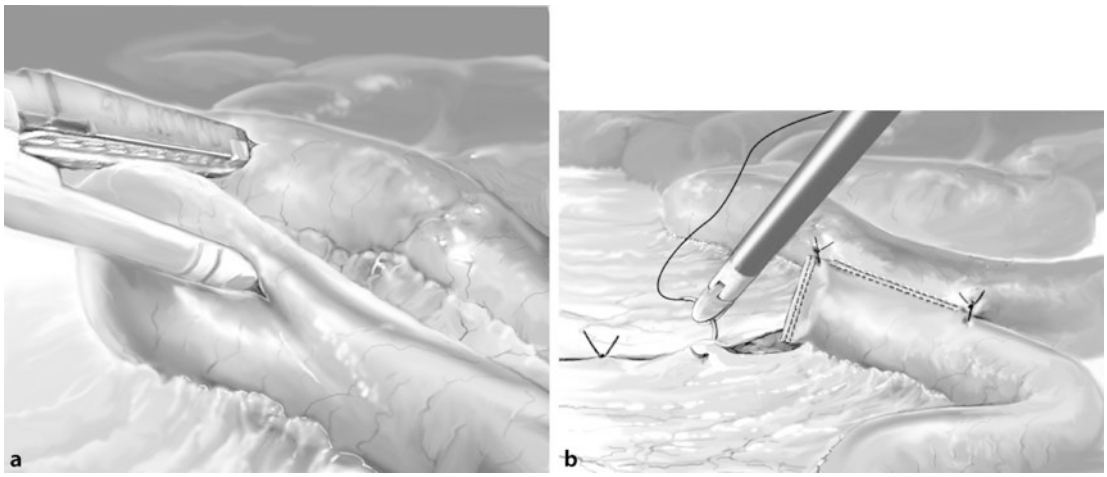


Fig. 35.5

Step 5

Creation of gastrojejunostomy

The end of the Roux limb is opened with Ultracision shears. A 3-cm incision between the two trocars in the left mid-clavicular line allows intraperitoneal introduction of the cartridge of the 25-mm circular EEA stapler. The cartridge head of the EEA stapler is passed into the lumen through the end of the Roux limb (Fig. 35.6a) and docked with the post of the anvil (Fig. 35.6b).

After firing the stapler, the "donuts" are checked carefully; if incomplete, the anastomosis must be evaluated; we prefer a methylene blue test (150 mL of dilute methylene blue injected through the nasogastric tube into the proximal gastric pouch) after the end of the Roux limb is closed with an Endo GIA stapler using a white cartridge. Closure of any leak is done by suture.

Even if there is no leak, the gastrojejunal anastomosis should be oversewn with single stitches along the anterior circumference; these sutures decrease any tension on the stapled anastomosis. A perianastomotic drain is left routinely by some but not all surgeons and removed postoperatively after a radiographic contrast study confirms integrity of the anastomosis.

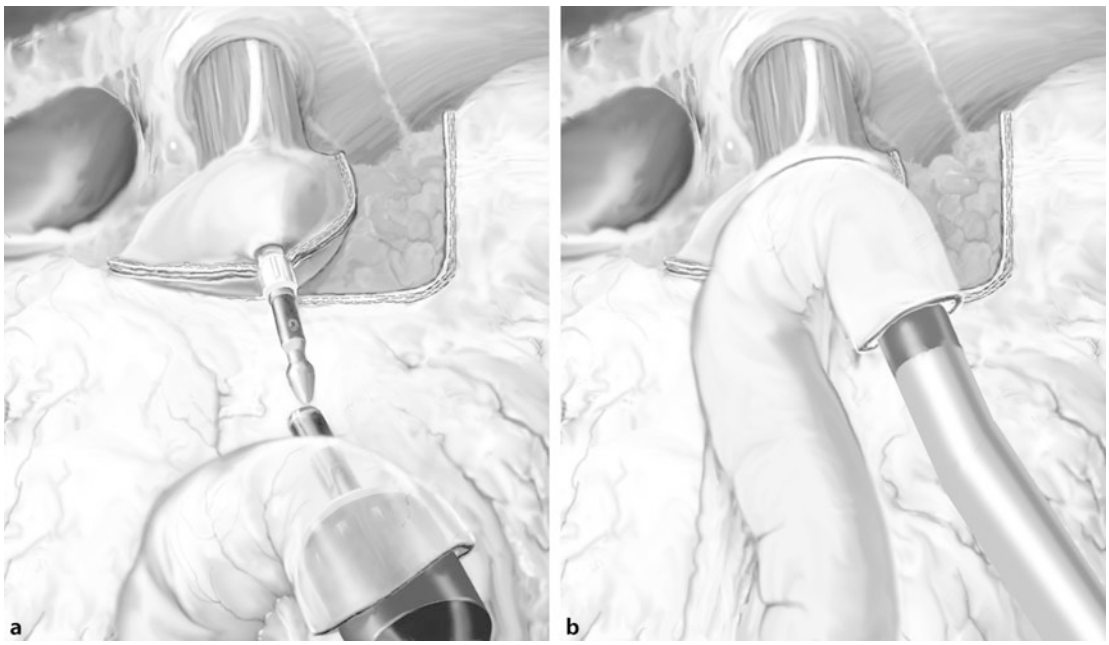


Fig. 35.6

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Sleeve gastrectomy (SG)

Sleeve gastrectomy works by a restriction of the oral intake and by a decrease in the serum concentration of the pro-appetite hormone ghrelin through resection of the greater curvature and fundus of the stomach.

Step 1

Positioning of the patient and access

The patient is placed as described for laparoscopic RYGB. Afterwards, six trocars are placed:

1. One 5 mm in the midline distal to the xiphoid for the liver retractor
2. One 15 mm on the right in the mid-clavicular line 10 cm caudal to the costal arch for the for the linear cutter, grasper, and Ultracision
3. One 10/12 mm in the midline 15 cm caudal to the xiphoid as the optic port
4. One 10/12 mm on the left in the mid-clavicular line just distal to the costal arch for the linear cutter, grasper, needle holder, and Ultracision
5. One 10/12 mm on the left in the mid-clavicular line 15 cm caudal to the costal arch for the linear cutter, grasper, needle holder, and Ultracision
6. One 5 mm on the left in the extended anterior axillary line for the grasper

Step 2

Dissection of the greater omentum from the greater curvature

After the identification of the gastric antrum (4–6 cm proximal to the pylorus on the greater curvature), ultrasonic scissors are used to divide the gastrocolic ligament from the greater curvature of the stomach up to the esophagogastric junction (Fig. 35.7).



Fig. 35.7

After placing a 32/34 Fr bougie into the stomach transorally, the first two 45–4.5 mm applications of the linear stapler are placed at the point of the initial dissection on the greater curvature, creating a vertical cut on the gastric wall (Fig. 35.8a). Then sequential firings of the linear stapling device with 60–3.5 mm linear staplers are applied along but not tight against the bougie up to the gastroesophageal junction (Fig. 35.8b). When placing the last staple line near the esophagogastric junction, remain about 1 cm lateral to the esophagogastric junction to avoid having the staple line include the much less secure intraabdominal esophagus. The staple line is oversewn; some surgeons use a bioabsorbable "peri-strip" when applying the linear stapler to "reinforce" the staple line.

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Step 2 ***(continued)***

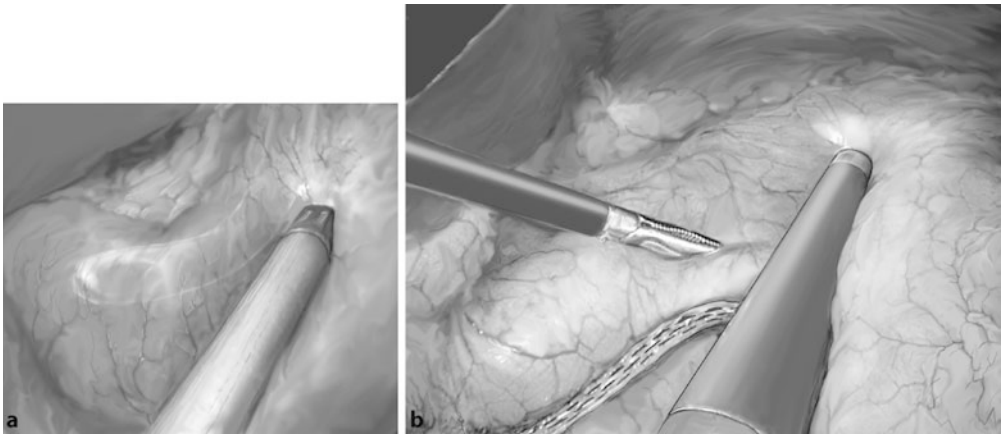


Fig. 35.8

Laparoscopic Adjustable Gastric Banding (LAGB)

Adjustable gastric banding works by restriction of the oral intake. High patient compliance is required for efficacy, because strict dietary implementations are needed for an adequate weight loss. Band- and port-related complications and inadequate weight loss are common, which makes patient selection difficult.

Step 1

Positioning of patient and access

The patient and trocars are placed as described for laparoscopic RYGB; the right lower 5-mm trocar is not necessary for LAGB.

Step 2

Determination and creation of pouch size

A specially designed orogastric balloon calibration tube is inserted; the balloon is filled with 25 mL saline and pulled back to wedge itself at the esophagogastric junction (Fig. 35.9).

The dissection begins at the lesser curvature at the largest circumference of the balloon. The "pars flaccida technique" has been shown to have less band slippage.

The lesser omentum is entered in the avascular window, and the right crus of the diaphragm identified.



Fig. 35.9

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Step 3

Retrogastric preparation and band placement

The retrogastric passage from right to left crus is created by blunt dissection using an articulating "finger" dissector which exits at the angle of His. However, the lesser sac should not be entered during this maneuver. If the lesser sac is entered, retrogastric passage is too far distal along the lesser curvature of the stomach and will predispose to band slippage.

The Silastic band is then pulled through the retrogastric tunnel from the left to right side of the stomach, encircling the most proximal stomach, anterior vagus nerve, and upper part of the lesser omentum (35.10).

The Silastic band is locked around the inflating calibrating catheter, which is inflated with 15 mL saline and positioned proximal to the band, thereby determining the size of the proximal pouch. The calibration catheter is deflated but left in place.



Fig. 35.10

Step 4

Band fixation

The band is fixed in position along the anterior stomach by placing 3–5 interrupted, seromuscular sutures of nonabsorbable material, approximating the gastric wall proximal and distal to the band. The left gastric wall distal to the band is fixed to the left crus of the diaphragm (Fig. 35.11).

The procedure is finished by implantation of the reservoir subcutaneously just below the xiphoid, allowing easy access to the port.

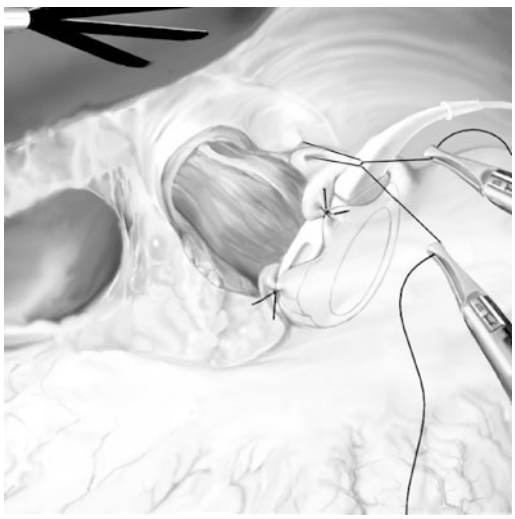


Fig. 35.11

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Biliopancreatic diversion with duodenal switch (BPD/DS)

Biliopancreatic diversion with duodenal switch works similar to the gastric bypass but with a much more pronounced malabsorptive component. It is technically more demanding than other the procedures and has a higher complication rate than RYGB and SG. The division of the duodenum can lead to the feared duodenal stump leak. The procedure can be done as a two-step procedure with a sleeve gastrectomy initially for weight loss, with completion of the duodenal switch after one to two years.

Step 1 Positioning of the patient and access

The patient and trocars are placed as described for laparoscopic sleeve gastrectomy.

Step 2 Creation of the sleeve gastrectomy

The sleeve gastrectomy is performed as described before.

Step 3 Division of the duodenum

The duodenum is divided 3 cm distal to the pylorus (◘ Fig. 35.12) by carefully dissecting the duodenal mesentery just distal to the duodenal bulb using the Ultrasonic shears and then mobilizing bluntly behind the duodenum. The duodenum is then divided using a 60-mm Endo GIA stapler using a white cartridge.



◘ Fig. 35.12

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Step 4

Creation of the jejunoileostomy

The small bowel is divided 250 cm proximal the ileocecal valve (junction of distal jejunum and proximal ileum) with a 60-mm Endo GIA stapler using a white cartridge. The biliopancreatic limb is formed by anastomosing the distal jejunum just proximal to the transection to a point 50–150 cm proximal to the ileocecal valve. The jejunoileostomy is created with a 60-mm Endo GIA stapler using a white cartridge (Fig. 35.13). The site of stapler insertion is closed with a running 4-0 polydioxanone suture. The ileum distal to the transaction is brought up as an alimentary limb to the upper abdomen for the duodenoileostomy.

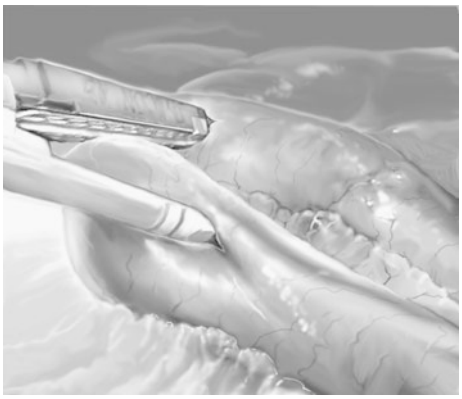


Fig. 35.13

Step 5

Creation of the duodenoileostomy

Similar to the gastrojejunostomy for a RYGB, the anvil of a 25-mm EEA stapler can be used to create the duodenoileostomy using the Orvil tube. After a small duodenotomy is made in the proximal duodenum, the distal end of the Orvil® tube is passed into the oropharynx, down the esophagus, and into the gastric remnant. The tube is then pulled into the peritoneum with a grasper until the post of the anvil appears through the duodenotomy.

The end of the ileal alimentary limb is opened with Ultracision shears. A 3-cm incision in the right mid-clavicular line allows intraperitoneal introduction of the cartridge of the 25-mm circular EEA stapler. The cartridge head of the EEA stapler is passed into the lumen through the end of the alimentary limb and docked with the post of the anvil (Fig. 35.14). The anastomosis is oversewn with three single transmural stitches to reduce tension.

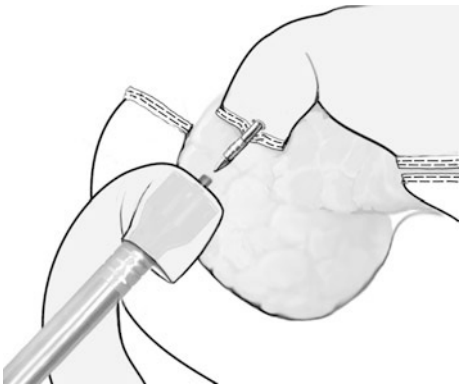


Fig. 35.14

Biliopancreatic diversion Scopinaro

The original biliopancreatic diversion developed by Scopinaro is performed by a hemigastrectomy gastrectomy to create a 250-mL proximal gastric pouch, which is then anastomosed to a 200-cm

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alimentary limb of mid to distal ileum, joining a 50-cm common channel of the terminal ileum. Because of the high rate of malnutrition and side effects like diarrhea, most surgeons prefer a longer common channel.

Step 1

Positioning of the patient and access

The patient and trocars are placed as described for laparoscopic Sleeve Gastrectomy.

Step 2

Hemigastrectomy

The omentum is freed from the distal stomach using harmonic scalpel in the direction to the duodenum, beginning approximately 15 cm distal to the angle of His along the greater curvature. The dissection ends at the pylorus. The duodenum just distal to the pylorus is divided by a 45-mm linear stapling device. After this step, the gastric lesser curvature is mobilized up to the level of the left gastric artery.

Gastric division is performed with a 60-mm linear stapling device starting from the lesser curvature (Fig. 35.15). The gastric remnant should have a capacity of approximately 200–400 mL. The resected stomach is removed through the right subcostal incision.

Some surgeons prefer a nonresectional biliopancreatic diversion in which the distal stomach is neither mobilized nor removed.

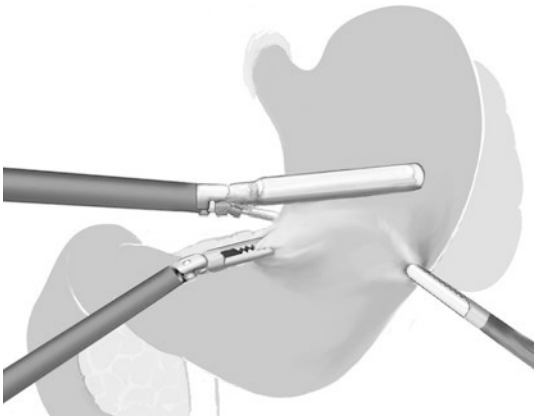


Fig. 35.15

Step 3

Jejunoileostomy

The next step is the measurement for the common channel (marked at 50–100 cm proximal to the ileocecal valve; we prefer 100 cm) and division of the small bowel (250 cm proximal to the ileocecal valve creating the alimentary limb of ileum). The alimentary limb is temporarily sutured to the stomach for better orientation.

The biliopancreatic limb is then brought to the marked point, and an jejunoileostomy is created with a 60-mm Endo GIA stapler using a white cartridge (Fig. 35.16).

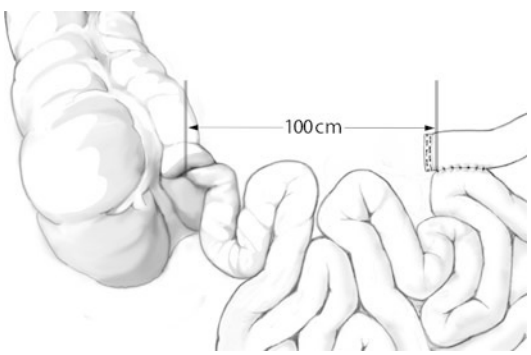


Fig. 35.16

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Step 4

Gastroenterostomy

The gastroileostomy anastomosis is created to the posterior wall of the stomach. Parallel openings are made in the small intestinal limb and the gastric pouch (Fig. 35.17). A 45 mm linear stapling device is positioned toward the greater curvature. The defect is closed with a hand-sewn, running seromuscular suture.

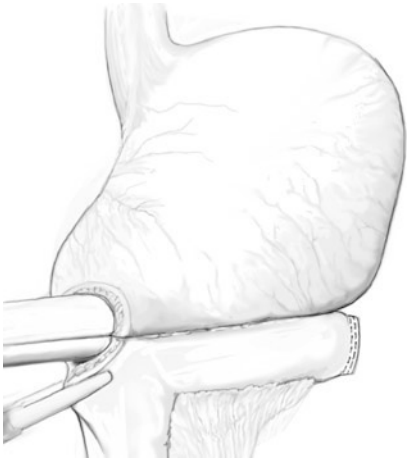


Fig. 35.17

Vertical banded gastroplasty (VBG)

35

The vertical banded gastroplasty is a procedure with one of the highest long-term complication rates. It is important for its historic background (performed between 1980 and 2000) and because it is encountered frequently in revisional bariatric surgery. Therefore, some of the key steps should be mentioned here, although its use as a primary bariatric procedure today is low.

Step 1

Placement of anvil of circular stapler

The gastrohepatic ligament is opened in the avascular window with Ultracision shears to expose the posterior aspect of the stomach. The optimal position of the anvil is 6–7 cm distal to the esophagogastric junction close to the lesser curvature. It should allow a 32-Fr tube to pass alongside the lesser curvature; once the optimal site is determined, a straight needle is passed from anterior to posterior through the stomach and a suture tied to the tip of the anvil (Fig. 35.18a). This suture will guide the spike of the anvil through the posterior and then the anterior gastric walls. A tight hold of the anvil by a strong grasper is essential (Fig. 35.18b). A short incision with electrocautery where the tip of the anvil will pass helps it to perforate the gastric wall. The circular stapler cartridge is passed through the abdominal wall, docked with the anvil, and fired, creating the transgastric circular "donut hole" defect in the gastric wall (Fig. 35.18c).

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Step 1 ***(continued)***

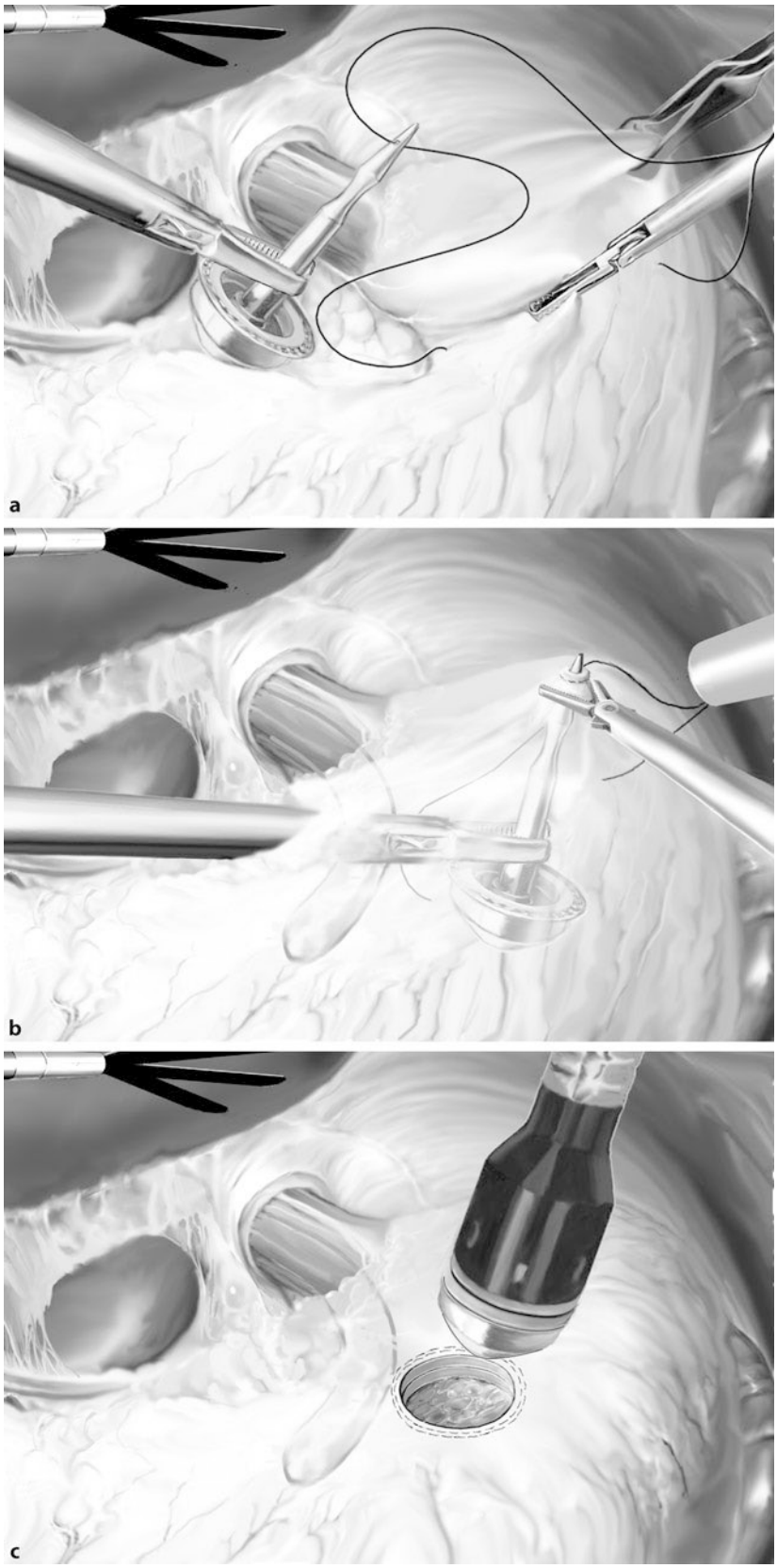


Fig. 35.18

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Step 2

Vertical transection of stomach and placement of band

Beginning in this circular defect, the proximal stomach is divided with a 60-mm Endo GIA stapler (blue cartridge) up to the angle of His, staying close to the left side of the 32-Fr calibration tube. A 7 × 1.5-cm strip of polypropylene or ePTFE is introduced and wrapped around the outflow (stoma) of the proximal gastric pouch along the lesser curvature (Fig. 35.19a).

A circular "band" is created by sewing together the ends of the strip with three or four interrupted, non-absorbable sutures with a 32-Fr. calibration tube in place; the circumference should be 5 cm (Fig. 35.19b). A very similar procedure, called a vertical ring gastroplasty, uses a circular ring of Silastic tubing instead of a band.

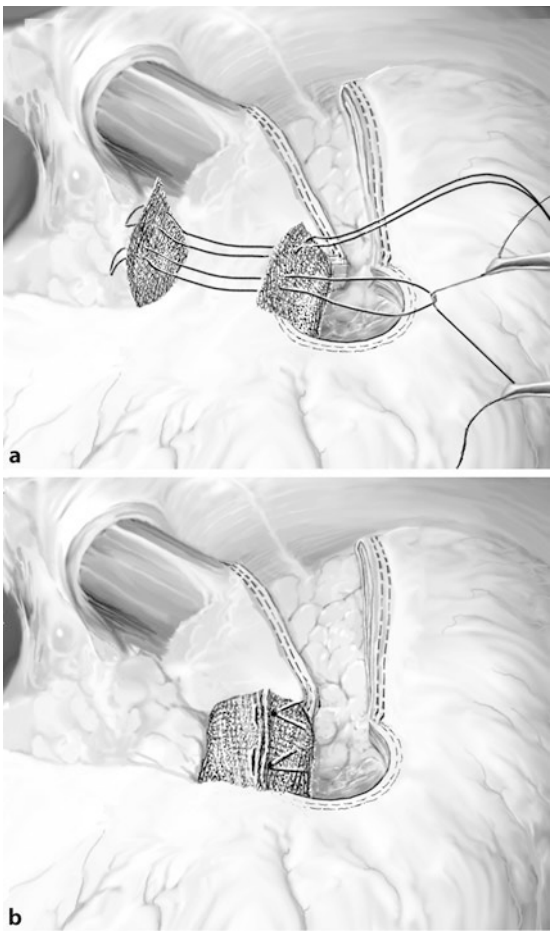


Fig. 35.19

Robotic Bariatric Surgery

In some specialized centers, surgeons prefer robotic-assisted bariatric surgery, although its percentage comparing to the overall bariatric procedures is quite low. The advantages of robotic surgery over conventional laparoscopic surgery include 3D visualization of the operative field, increased degrees of freedom of movement of the tips of the instruments, ergonomic positioning, and elimination of any surgeon tremor. As robotic surgery gains popularity in bariatric surgery and becomes less expensive, robotic-assisted laparoscopic RYGB may become more common.

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Step 1

Positioning of the patient and access

The patient and trocars are placed as described for the laparoscopic RYGB. The robotic cart is placed above the patient on the patient's left side in a 30° angle. The surgeon's console stands distant from the patient (Fig. 35.20).

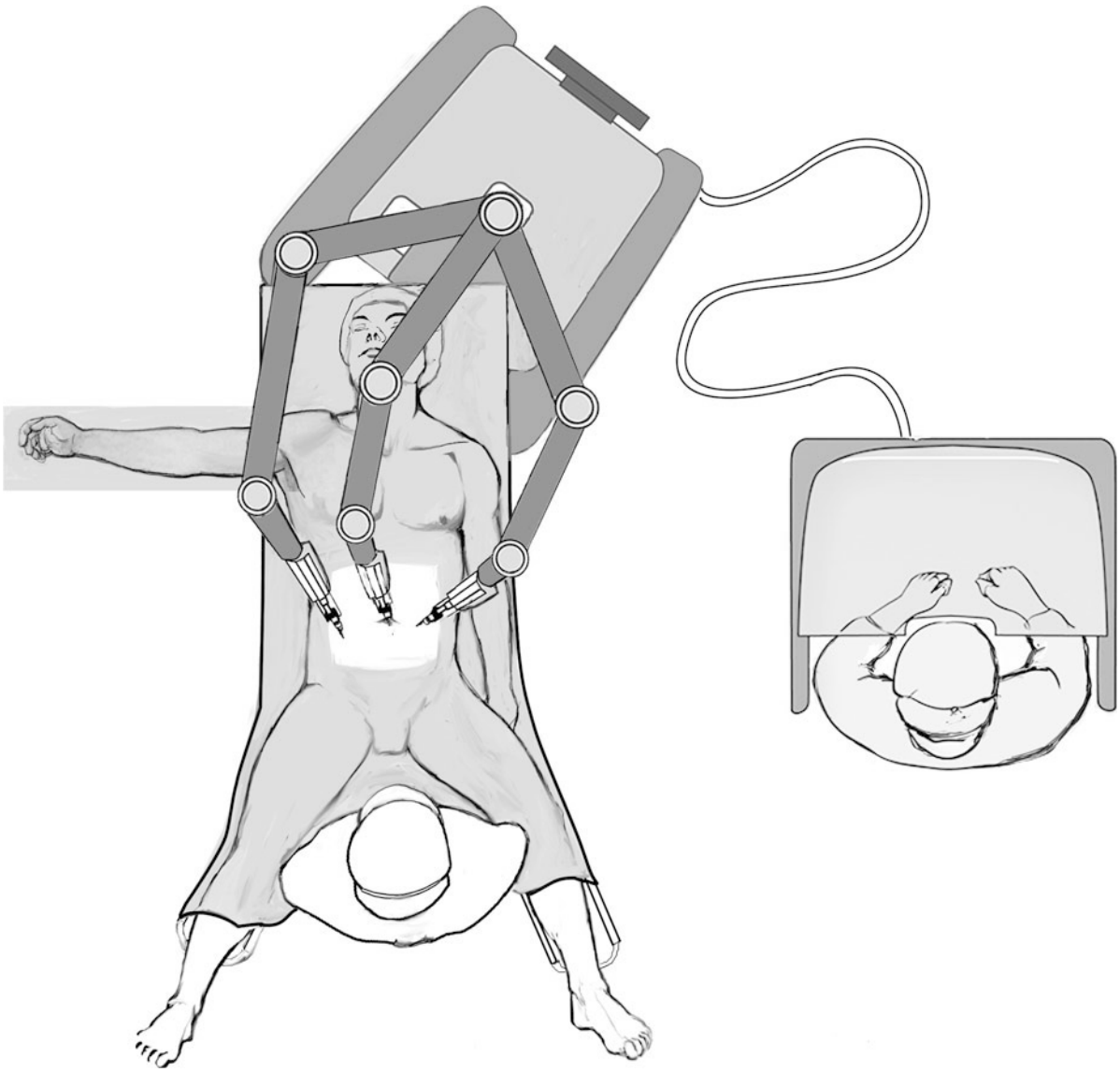


Fig. 35.20

Step 2

Creation of Roux-en-Y limb

Similar to the conventional laparoscopic RYGB, the ligament of Treitz is identified. The jejunum is transected 50 cm distally with 60-mm Endo GIA.

Afterwards, the mesentery is transected perpendicular to the bowel wall with Ultracision shears. The Roux-en-Y limb is measured (150 cm).

As with the laparoscopic RYGB, the jejunojejunostomy is created with a 60-mm Endo GIA stapler using a white cartridge or hand sewn. The site of stapler insertion is closed with a running 4-0 polydioxanone suture. The mesenteric defect should be closed with interrupted stitches of non-reabsorbable suture. The alimentary Roux-en-Y limb is brought antecolic to the proximal gastric pouch. The omentum should be transected vertically to allow a path for the Roux limb to be brought antecolic.

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Step 3

Construction of the Gastric Pouch and Gastrojejunostomy

The gastric pouch is created with three linear stapler firings, similar to conventional laparoscopic gastric bypass surgery. Parallel openings are made in the small intestinal limb and the gastric pouch. The anastomosis is sewn back and forth with a running suture (Fig. 35.21). It is here where the robot has its greatest advantage.

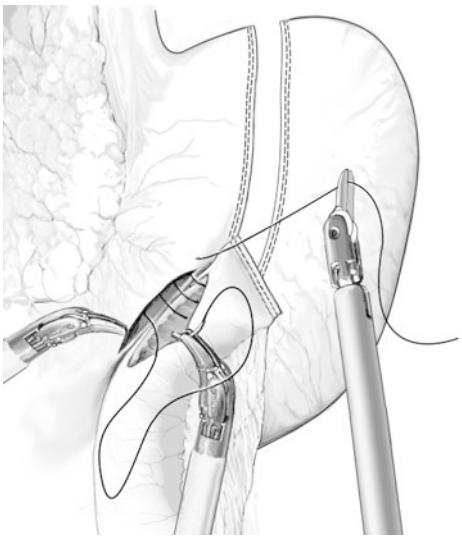


Fig. 35.21

Standard Postoperative Investigations

- Postoperative surveillance in an intermediate care unit if the patient has sleep apnea or a history of severe cardiac disease.
- Oral liquid diet after routine Gastrografin swallow radiography on the first or second postoperative day; this radiograph becomes less often obtained with increasing experience of the surgeon.
- Clinical and metabolic follow-up at 2 and 6 weeks and at 3, 6, 9, and 12 months and once yearly thereafter are absolutely mandatory to ensure outcome.
- Multivitamin administration routinely, parenteral vitamin B_{12} after RYGB, BPD/DS, and BPD, and iron supplementation according to the blood tests.

Postoperative Complications

General

- Intra-abdominal bleeding
- Wound infection
- Port site hernia
- Deep vein thrombosis/pulmonary embolism
- Adhesive small bowel obstruction
- Protein/calorie malnutrition (depending on the procedure)

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Procedure-specific

- **RYGB, BPD/DS, BPD**
  - Anastomotic leakage from gastrojejunostomy or duodenoileostomy (BPD/DS), remnant gastric pouch, or enteroenterostomy
  - Internal hernia
  - Stenosis at gastrojejunostomy
  - Stomal ulcer/stomal bleeding
  - Afferent (pancreatobiliary) limb obstruction

- **SG**
  - Staple line leakage
  - Gastroesophageal reflux
  - Stenosis within the sleeve (usually at the incisura of the lesser curvature)

- **LAGB**
  - Pouch dilation or band slippage
  - Reservoir infection
  - Band erosion into the stomach (late)
  - Band leakage (late)
  - Reservoir/band (balloon) dysfunction

- **VBG**
  - Stricture at the stoma
  - Gastroesophageal reflux
  - Staple line rupture causing gastrogastric fistula
  - Band erosion into stoma
  - Maladaptive eating disorder

Tricks of the Senior Surgeon

- The Opti-View trocar (FIOS; Ethicon) allows the easiest and fastest access to the abdominal cavity. The incision should be placed just below (< 1 cm) the left costal margin.
- Generally a high placement of trocars is recommended, especially the upper two 10/12-mm trocars below the xiphoid and left costal arch.
- The circular EEA staplers for the laparoscopic approach are wrapped with a plastic cover to protect the abdominal wall incision from contact with the contaminated outside of the cartridge of the stapler after intraluminal insertion and firing.
- Conservative weight reduction with dietary measures of 5–10 kg before surgery is believed by some to facilitate technical performance by "shrinking liver size," especially in super-obese (male) patients.
- Placement of the Brolin "anti-obstruction" stitch between the efferent limb of the common channel and the biliopancreatic limb can prevent obstruction at the jejunojejunostomy (RYGB) or jejunoileostomy (BPD, BPD/DS).

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Pancreas-Sparing Duodenectomy

Maximilian Bockhorn, Michael G. Sarr

Pancreas-sparing duodenectomy (PSD) is reserved for premalignant lesions of the duodenal mucosa and the papilla of Vater, when local excision is not appropriate owing to the size or multiplicity of the lesions. PSD involves complete or near-complete resection of the duodenum with preservation of the entire pancreas. Although the duodenum and the pancreas share the same blood supply, the duodenum may be resected without compromising viability of the pancreas, but reinsertion of the bile and pancreatic duct into a "neoduodenum" is necessary.

Indications and Contraindications

Indications

- Multiple premalignant lesions of the duodenal mucosa (e.g., familial adenomatous polyposis syndrome) and of the papilla of Vater (villous and tubulovillous adenomas)
- Localized benign or premalignant neoplasms of the duodenum

Contraindications

- Malignant disease
- Previous surgical procedures of the duodenum, the stomach, or the pancreatic head

Preoperative Investigations/Preparation for the Procedure

- Gastroduodenoscopy with biopsy
- Endoscopic ultrasonography to determine depth of wall involvement
- Endoscopic retrograde cholangiopancreatography (ERCP) (alternatively magnetic resonance cholangiopancreatography [MRCP]) for duct anatomy and morphology

Procedure

Step 1

Exposure of the duodenum

The abdomen is explored via a transverse or midline upper celiotomy. The gallbladder is resected to allow later passage of a probe or biliary Fogarty catheter to localize the ampulla. The hepatic flexure of the colon is mobilized inferiorly and the lesser sac is opened widely. An extensive Kocher maneuver well to the left of the midline is performed to expose the first through the third portions of the duodenum.

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Step 2

Preparation and resection of the duodenum

The ligament of Treitz is transected. The proximal jejunum is then transected with a GIA stapler, after which the mesenteries to the proximal jejunum and fourth portion of the duodenum are transected and ligated close to the bowel wall. The now-freed proximal jejunum is transposed either in the bed of the duodenum behind the mesenteric root to the right upper abdomen or through the right transverse mesocolon.

The third and fourth portions of the duodenum are detached from the pancreas by meticulous dissection with ligation of these small and fragile mesenteric vessels. This dissection is performed proximally up to the level of the papilla.

Precise localization of the papilla is important to facilitate dissection of the periampullary region. This localization is accomplished by passing a bile duct probe into the duodenum via the cystic duct remnant (after cholecystectomy) or via a choledochotomy. Retrograde cannulation of the bile duct with a probe via a lateral duodenotomy will also help the periampullary dissection. In this region, the duodenum is dissected carefully from its attachments to the pancreas, thus exposing the confluens of the common bile duct and the main pancreatic duct (Fig. 36.1a).

Next, the extraduodenal bile and pancreatic ducts are transected close to the duodenum. This step is shown in Fig. 36.1b. If a long common channel (pancreatic and bile ducts) is present and the duodenal disease does not extend past the ampullary region, this common channel can be transected, leaving only one "ductal structure" for reimplantation into the neoduodenum. The pancreatic and bile ducts are intubated separately with two catheters (Fig. 36.1c).

In the duodenum proximal to the papilla, the pancreas is densely adherent to the duodenum. One can dissect and develop a narrow subserosal plane outside the muscularis propria of the medial wall of the duodenum up to the distal part of the first part of the duodenum where a "duodenal mesentery" becomes present. Alternatively, dissection can also be initiated at the proximal duodenum and continued distally to the papilla. Small vessels are ligated. A careful search for the separate minor pancreatic duct should be made; if found and identified, we recommend suture ligation of this duct. Often, the duct is not identified, and thus all vessels and "fibrous" connections to the second portion of the duodenum should be ligated.

The duodenum is transected either 1 to 2 cm distal to the pylorus if this area is disease-free or directly distal to pylorus. The resected specimen should be sent for pathologic examination with intraoperative frozen section to exclude the presence of invasive malignancy.

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Step 2 *(continued)*



Fig. 36.1

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Step 3

Reconstruction

The proximal jejunum, which will now become the "neoduodenum," is passed either behind the superior mesenteric vessels or retrocolically through the right transverse mesocolon.

The bile and pancreatic duct anastomoses are performed at an equivalent distance from the pylorus as the native papilla. Some groups perform an intraluminal anastomosis via an enterostomy in the neoduodenum; others perform the anastomosis from a serosal approach. The ducts are implanted into the neoduodenum via a 2-cm enterotomy opposite to the proposed site of reimplantation. The anastomoses are done with interrupted, transmural, fine (6-0 or 7-0) monofilament resorbable sutures (Fig. 36.2). Several techniques for ductal reimplantation should be available in the surgeon's armamentarium. If a common channel can be preserved, one anastomosis will suffice. In contrast, if the disease involves the distal ducts and/or ampulla, usually the ductal transection leaves two ducts connected only by the interductal septum. In this situation a single anastomosis can be fashioned by carefully including both ducts into the anastomosis (Fig. 36.3a). If the ductal transection leaves two individual ducts without preservation of the interductal septum (an unusual situation), the best approach is to sew together the adjoining walls of the ducts using 6-0 or 7-0 absorbable suture material and then reimplant the joined ductal structures as one anastomosis (Fig. 36.3b).

A pancreatic stent is inserted into the neoduodenum using a hollow needle via a long submucosal tunnel and then externalized percutaneously through the abdominal wall. The access enterotomy used to position the stent into the pancreatic duct is closed transversely, and the pancreatic stent is left in situ, to be removed 4 to 6 weeks after surgery.

Gastrointestinal continuity is reestablished by end-to-end anastomosis of the neoduodenum with either the proximal duodenum or the pylorus with a single layer of interrupted sutures. A T-tube may be inserted in the common bile duct or a small tube positioned via the cystic duct remnant. Soft drains are placed behind the neoduodenum. The complete reconstruction is shown in Fig. 36.4.

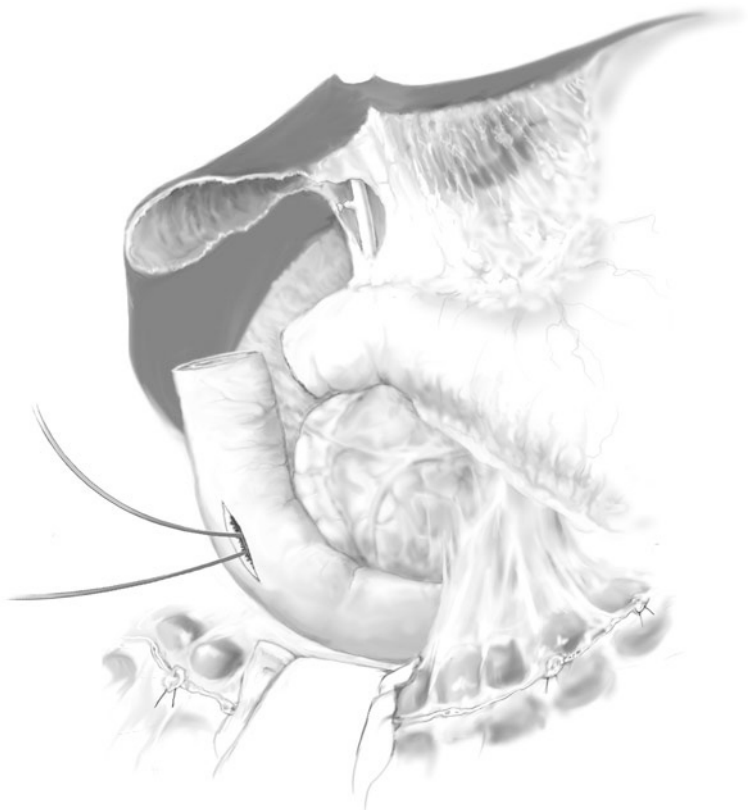


Fig. 36.2

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Step 3 ***(continued)***

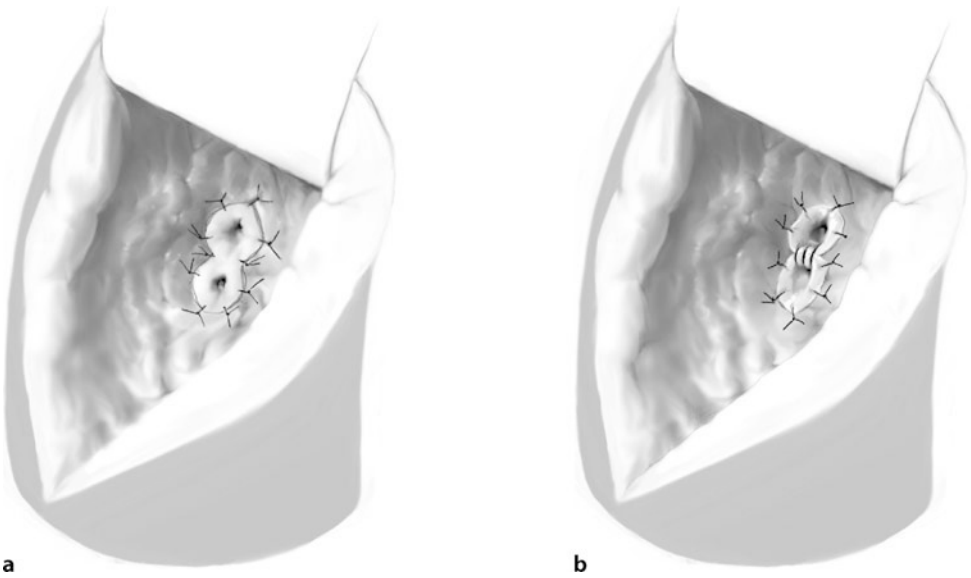


Fig. 36.3

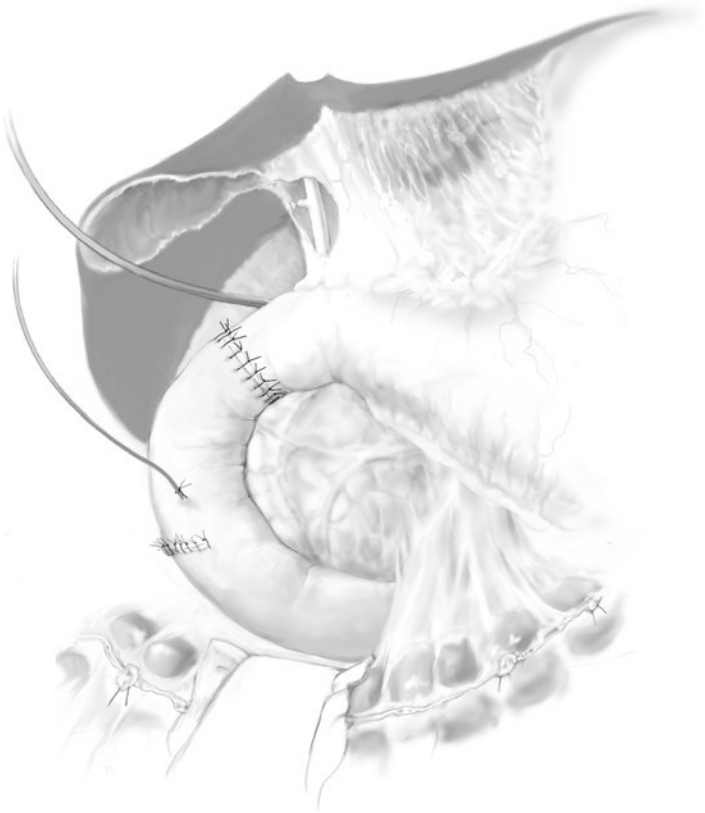


Fig. 36.4

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Standard Postoperative Investigations

- Choledochostomy tube and pancreatic duct drain are left in situ for 6 weeks postoperatively
- Cholangiography is performed prior to removal of these tubes/stents

Postoperative Complications

- Dislocation of pancreatic duct drain or tube choledochostomy
- Pancreatic and/or biliary fistula
- Anastomotic dehiscence
- Pancreatitis
- Cholangitis
- Anastomotic strictures

Tricks of the Senior Surgeon

- Fixation of the pancreatic duct drain by a resorbable stay suture at the "neopapilla."
- Tension-free anastomoses are mandatory.
- Do not compromise safety (tenuous high-risk pancreatic and bile duct anastomoses) in an attempt to perform PSD.

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Robotic Gastrectomy and D2 Lymphadenectomy

Woo Jin Hyung, Yanghee Woo

Robotic surgery is a successful approach to the management of curable patients with gastric cancer. Since the first laparoscopic radical gastrectomy was reported by Kitano et al. in 1994, the minimally invasive approach for gastric cancer surgery has gained favor as the procedure of choice for many experts. Minimally invasive radical gastrectomy offers the benefit of shorter hospital stay, decreased postoperative pain, earlier return of bowel function, and less blood loss than open gastric cancer operations. The widespread application of the laparoscopy in gastric cancer surgery, however, has been limited owing to the technical complexity of a radical gastrectomy with extended lymphadenectomy (LND) and the concerns about maintaining oncological principles during the laparoscopic procedures.

Gastric cancer surgeons are adopting the robotic technology of the da Vinci Surgical Systems to assist in the technically challenging procedure of radical gastrectomy with extended LND. The technical advantages of the improved three-dimensional magnified operative view, the precision of the tremor filter and articulating instruments, along with the ability of the surgeon to control four arms provide the surgeon with superior control over the entire procedure. Robotic surgery for gastric cancer has been demonstrated to be safe and feasible with an expected shorter learning curve. The data from retrospective studies and limited prospective comparisons support the short-term benefits of robotic gastrectomy (RG) to be comparable with those of laparoscopy and, when compared with open surgery, to offer the advantages of the minimally invasive approach. Moreover, adherence to the oncological principles of gastric cancer treatment, such as the no-touch technique, negative margins, and adequate lymph node (LN) dissection is being practiced using da Vinci Surgical Systems (Intuitive Surgical, Sunnyvale, California, USA).

Debate continues on the efficiency of robotic radical gastrectomies, however, because the disadvantages such as longer operative time, limited training opportunities, and increased cost of the robotic system fuel the controversies. In the absence of randomized trials evaluating the operative morbidity, mortality, long-term outcome, quality of life, and cost-effectiveness of RG, the decision to perform RG is based largely on the perceived advantages for the surgeon conferred by the new technology and the known improved postoperative patient outcomes of minimally invasive surgery.

Robotic radical gastrectomy is a sound minimally invasive option for the surgical treatment of gastric cancer patients with the potential for great benefit for both the surgeon and the patient. As surgeons become increasingly sophisticated in the use of emerging robotic technology, robotic surgical treatment of gastric cancer patients will evolve in the years to come.

Since the robotic approach to gastric cancer treatment was initially reported in 2003, surgeons at experienced centers have adopted robotic radical gastrectomy as a minimally invasive alternative to laparoscopy. As with all gastric cancer operations, robotic radical gastrectomy must adhere to the oncological principles governing the treatment of gastric cancer requiring a multidisciplinary treatment strategy, complete preoperative evaluation, and intensive operative planning. RG and LND requires thorough knowledge of the vascular anatomy of the stomach and the accompanying nodal stations as defined by the Japanese Gastric Cancer Association (JGCA). The steps of the operative procedure are explained relative to the dissection of the LN stations in D2 LND.

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Indications

Indications for robotic radical gastrectomy are the same as for laparoscopic gastric cancer operations. Currently, minimally invasive radical gastrectomy is recommended for early gastric cancer based on the Japanese gastric cancer treatment guidelines.[18] In practice, the indications have been expanded to locally advanced gastric cancer according to surgeon's experience and expertise.

- Indications for RG with limited LND: pT1a, pT1b, pN0. Mucosal and submucosal tumors that do not meet criteria for endoscopic resection or have failed treatment with endoscopic mucosal resection or endoscopic submucosal dissection
- Indications for RG requiring D2 LND: pT1N1M0, pT2N0/N1M0, pT3N0/N1/N2M0
- Expanded indication for RG requiring D2: pT4a

Relative contraindications to RG

- Extensive lymphadenopathy
- cT4a (serosa-positive tumors)

Absolute contraindications to robotic gastric cancer operations are the same as those of the laparoscopic approach.

- Preoperative staging of T4b or distant metastasis
- Inability to tolerate general anesthesia
- Refractory coagulopathy
- Hemodynamic instability

Preoperative Evaluation

The preoperative evaluation of patients includes comprehensive work-up of the patient's clinical status, pathological confirmation of the diagnosis, the localization of the tumor, and determination of the extent of disease. For thorough preoperative surgical planning, the following tests are required:

- Upper endoscopy with biopsy
- Endoscopic marking of the proximal edge of tumor
- Endoscopic ultrasound
- CT scan of the abdomen

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Patient Positioning, Port Placement, Robot Docking

Under general anesthesia, the patient is placed in the supine position with both arms tucked to the patient sides and the table in 15° reverse Trendelenburg position (Fig. 37.1a). The abdomen is prepared from the nipple line to the suprapubic region as widely as possible. The operation is performed with five ports (two 12 mm and three 8 mm) placed in a V-shaped position (Fig. 37.1b). The port placements are adjusted to account for the patient's body habitus; especially, the No. 2 arm robot trocar on the patient's right midclavicular line should be placed just caudal to the level of the duodenum. The robot surgical cart is brought directly over the head of the patient parallel to the operating table and the robot arms are docked (Fig. 37.1c).

- Infraumbilical port (Fig. 37.1b) is the camera arm.
- No. 1 arm holds the Maryland curved bipolar graspers.
- Nos. 2 and 3 arms hold the ultrasonic shears or a monopolar device and the Cadiere forceps, interchangeably.

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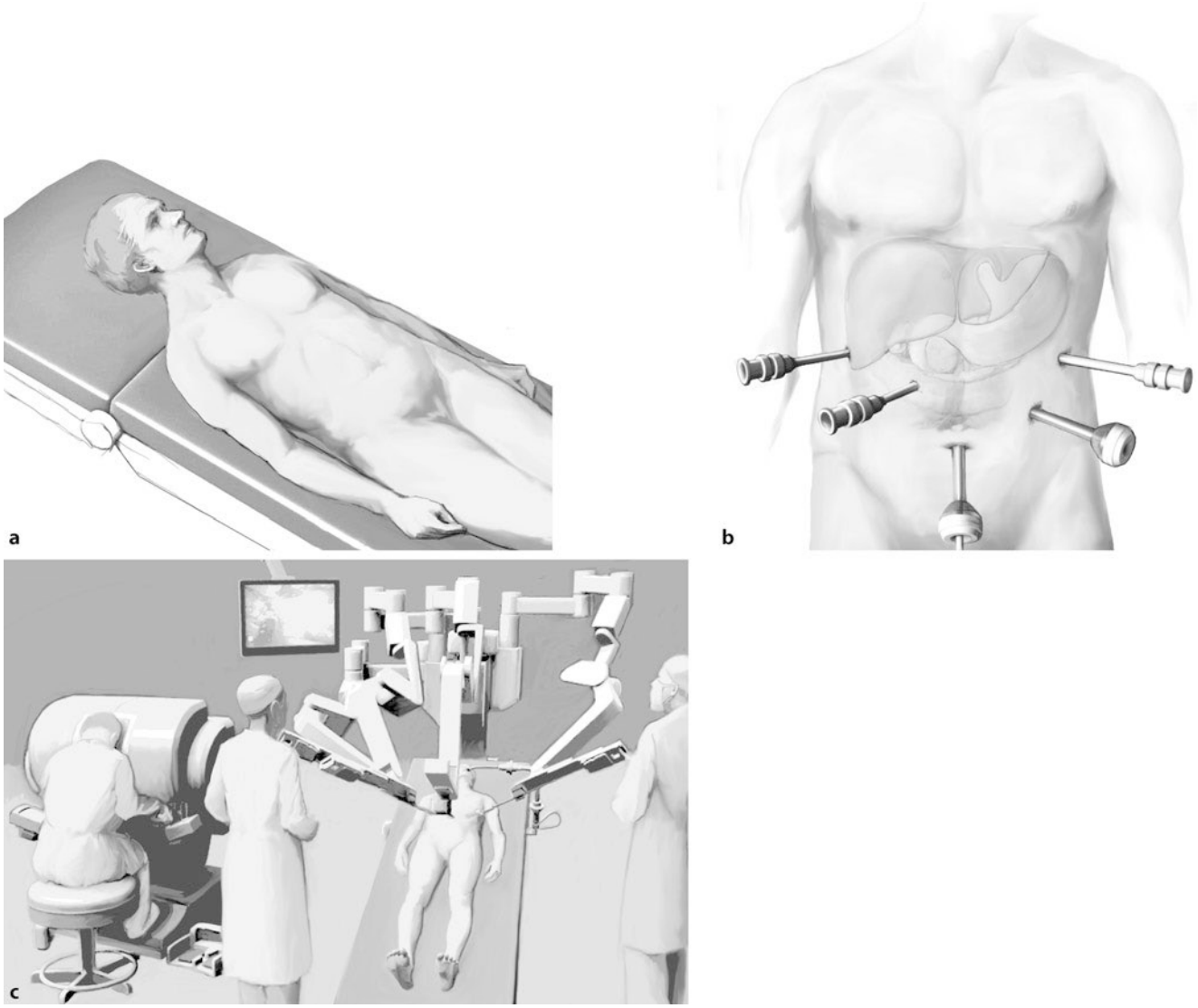


Fig. 37.1

Liver retraction

The liver is retracted to facilitate exposure of the hepatoduodenal ligament, the lesser curvature of the stomach, the suprapancreatic area, and the gastroesophageal junction. Whereas several self-sustaining liver retraction methods have been described, we prefer the gauze-suspension method.

Procedure of D2 LN Dissection During Distal Subtotal Gastrectomy

Five essential steps and associated anatomical landmarks

1. **Left side dissection**

The Cadiere forceps in the third robot arm is used to retract the stomach cephalad and toward the anterior abdominal wall to create a draping of the greater omentum. This lifts the omentum away from the colon and exposes the gastrocolic ligament for safe division and retrieval of LN stations No. 4sb and 4d.

- Using an energy device like the harmonic ultrasonic shears, enter the lesser sac in the area of the midtransverse colon and the divide greater omentum toward the lower pole of the

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spleen (Fig. 37.2a). The dissection is facilitated with repositioning of the Cadiere forceps and the use of the Maryland bipolar grasper to gain greater exposure between the stomach and pancreas. Take down the adhesions between the posterior stomach and the anterior surface of the pancreas.

- Carefully identify and isolate the left gastroepiploic vessels at its root during the proximal dissection and ligate using clips or an energy device (Fig. 37.2b). Then clear the soft tissue along greater curvature of the stomach from the proximal resection margin to the short gastric vessels because it contains part of the No. 4sb nodal station.

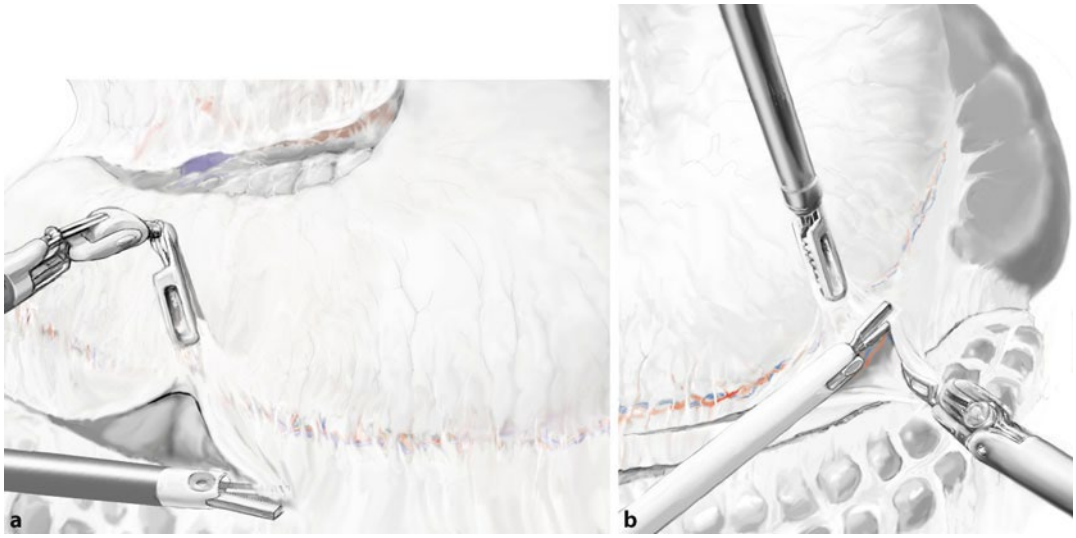


Fig. 37.2

2. **Right side dissection**

The dissection of the right side of the patient is performed by mobilizing the distal stomach and 2 cm of the proximal duodenum from the head of the pancreas. At this time care is taken to dissect the soft tissues containing LN station No. 6, which is bordered by right gastroepiploic vein (RGEV) and anterior superior pancreaticoduodenal vein (ASPDV). Exposure is gained in this area using the third arm to lift the stomach in the area of the pylorus along the greater curvature away from the head of the pancreas.

- Again using the Maryland bipolar grasper to dissect out the layers and harmonic ultrasonic shears to divide with hemostasis, dissect the soft tissues leading to the head of the pancreas in layers until the RGEV is identified. Isolate the RGEV, ligate, and divide it as it joins the ASPDV (Fig. 37.3a).
- Continue clearing of the soft tissue in the area to identify, ligate, and divide the right gastroepiploic artery (RGEA) as it branches from the gastroduodenal artery (GDA). The infrapyloric artery may be encountered during this portion of the dissection and should also be ligated using clips or an energy device.
- Next, release the attachments between the posterior duodenum and the pancreas along the GDA until the common hepatic artery (CHA) is reached.
- Insert a 4"×4" gauze anterior to the head of pancreas to protect the GDA from injury during the suprapancreatic dissection (Fig. 37.3b).
- Clear the supraduodenal region approximately 2 cm distal to the pylorus and divide the proximal duodenum using an Endo-linear stapler (Fig. 37.3c).

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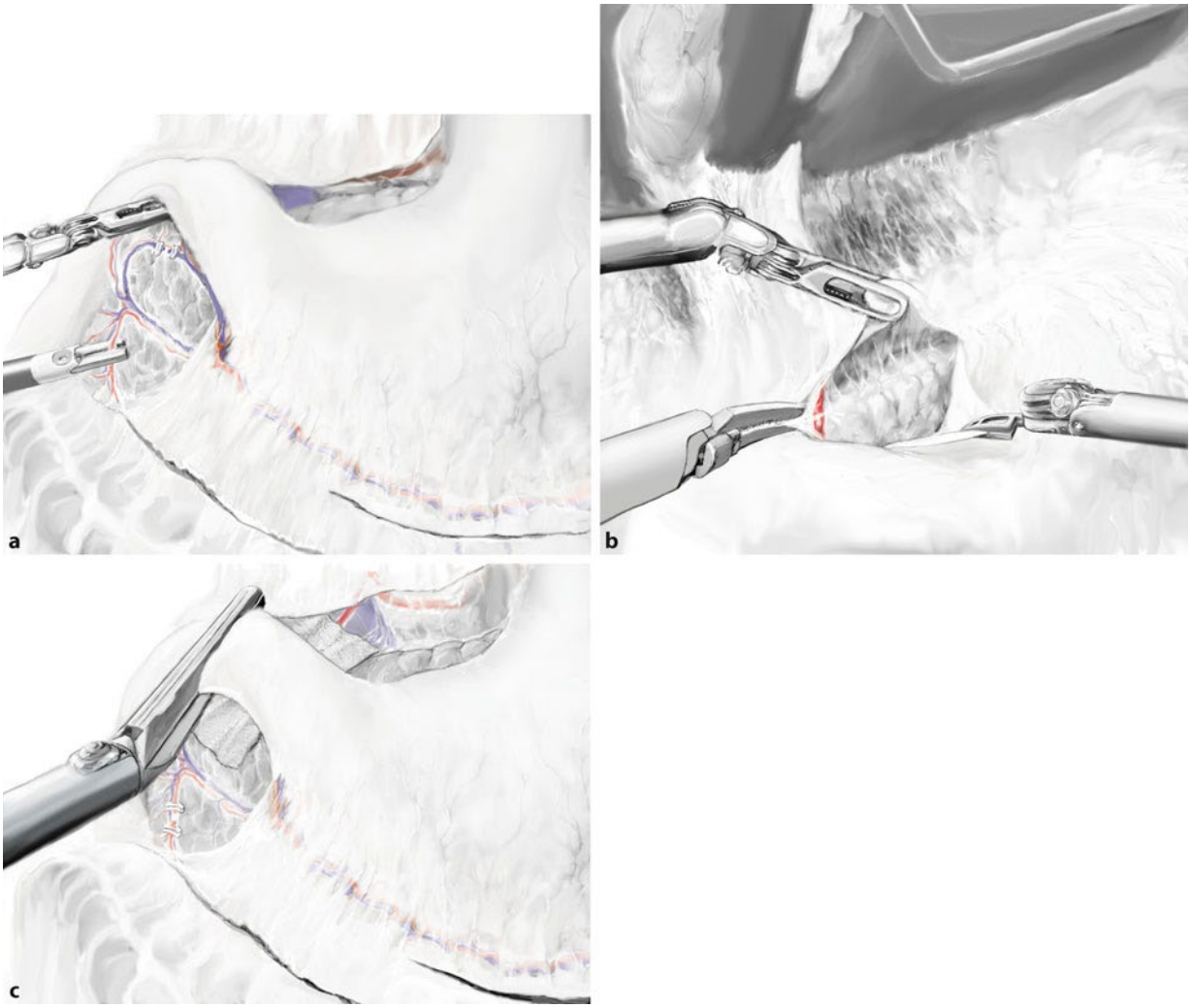


Fig. 37.3

3. **Suprapancreatic dissection**

At this time, LN dissection is performed in the hepatoduodenal region and the suprapancreatic area en bloc by meticulous dissection along the vessels using a combination of harmonic shears and the Maryland bipolar grasper. The Cadiere forceps is again used for retraction and exposure as needed. Retracting the stomach to the patient's left and slightly toward the anterior abdominal wall, and identify the right gastric vessels on tension.

- Dissect along the anterior surface of the proper hepatic artery (PHA) to identify and divide the right gastric artery (RGA) at its origin and retrieve LN station No. 5.
- Clear the soft tissues containing LN station No. 12a by dissecting anteriorly and medially to the PHA until the portal vein (PV) is exposed medially (Fig. 37.4a). The exposure in this area can be facilitated by the bedside assistant who gently retracts the PHA to the patient's right for the CHA inferiorly.
- Continue to clear the soft tissues around CHA that contain LN station No. 8a (Fig. 37.4b).
- Retract the stomach to expose the lesser curvature and note the left gastric vein as soft tissue is cleared from this area. Divide the left gastric vein as it drains into the portal vein. (In some patients the left gastric vein can be found draining anteriorly into the splenic vein.)

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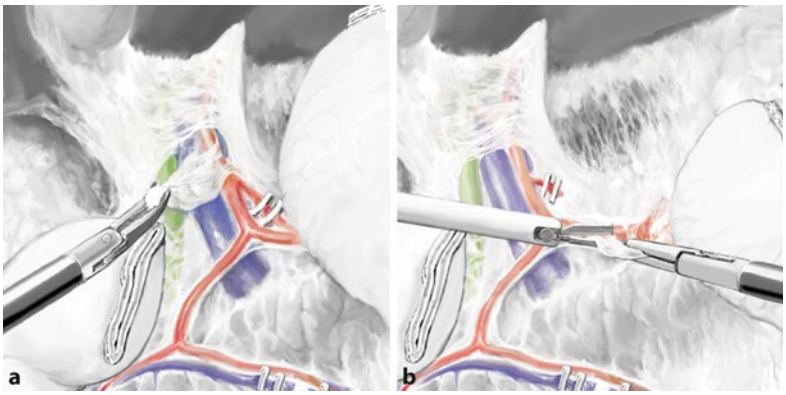


Fig. 37.4

4. **Dissection around the left gastric artery and skeletonization of the splenic vessels**

The retroperitoneal dissection of the soft tissues along the left gastric artery (LGA), celiac trunk, and splenic vessels permits retrieval of LN station Nos. 7 and 11p, respectively (Fig. 37.5a,b).

- Improve exposure to access the root of the LGA by dividing the retroperitoneal attachments to the lesser curvature of the stomach.
- Expose and place clips on the root of the LGA before diving the LGA leaving two clips on the patient side (Fig. 37.5a).
- Continue the dissection with skeletonization of the CHA toward the celiac axis and retrieve the soft tissues containing LN station No. 9 around the celiac artery (Fig. 37.5b).
- After moving the stomach to the left upper quadrant, skeletonize the anterior and superior surfaces of the splenic artery. As the soft tissue is lifted away from the artery, superior dissection helps expose the anterior surface of the splenic vein. (Once the midpoint of the splenic vessels or the posterior gastric is reached, the dissection of LN station No. 11p is complete.) (Fig. 37.5c).

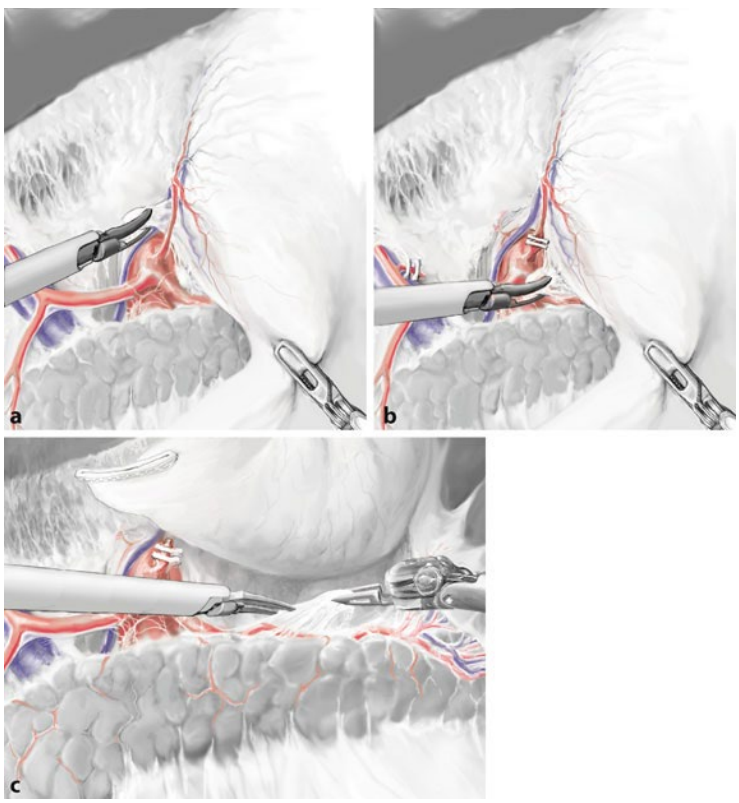


Fig. 37.5

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5. Lesser curvature dissection and proximal resection

The lesser curvature of the stomach is released from the retroperitoneum up to the esophageal crus (Fig. 37.6).

- To expose this area, have the assistant retract the mobile stomach to the patient's left and clear the soft tissues along the right side of the intra-abdominal esophagus, the right cardia, and the lesser curvature of the stomach.
- Perform the truncal vagotomy at this time by dividing the anterior and posterior vagus nerves. This completes the dissection of LN stations Nos. 1 and 3.
- After the stomach is fully mobilized, transect the stomach using a 60-mm blue load Endo-linear stapler ensuring sufficient proximal margin. (Additional load for the stapler may be required.)

This completes the procedure of robotic D2 LND for distal subtotal gastrectomy.

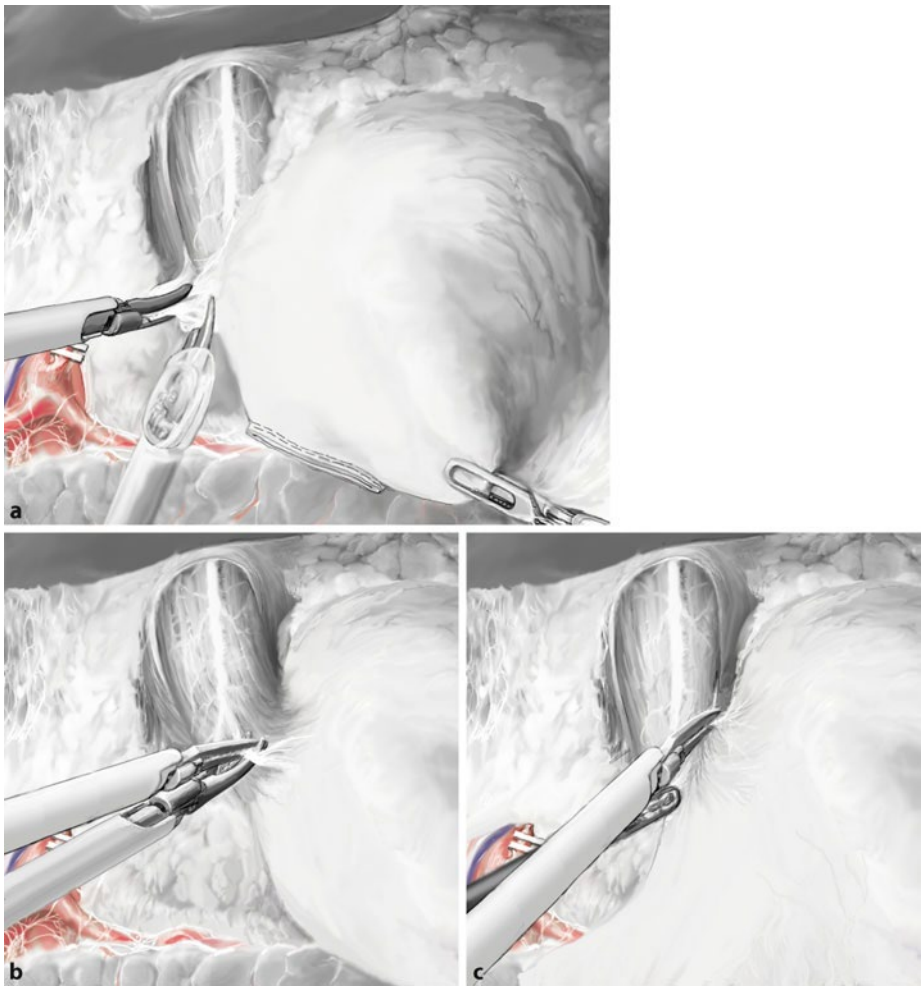


Fig. 37.6

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Reconstruction

The extent of gastric resection and the surgeon's preference guide the appropriate selection of gastrointestinal reconstruction method. Depending on the size of the remnant stomach, we perform a gastroduodenostomy, loop gastrojejunostomy, or Roux-en-Y gastrojejunostomy to restore gastrointestinal integrity after robotic gastric resections. Most distal gastrectomies involve the removal of two thirds of the stomach and usually require a gastrojejunostomy.

Loop gastrojejunostomy

Once the specimen is completely resected and margins of resection are satisfactory, the reconstruction begins by inspecting the size of the remnant stomach and the mobility of the jejunal loop to be used for reconstruction.

- Prepare the greater curvature of the stomach by clearing at least 6 cm of the serosal surface proximally from the staple line. At times, the first set of short gastric artery may need to be ligated and divided. If so, the gastric remnant may be too small for a loop gastrojejunostomy
- Bring up a loop of jejunum 15 to 20 cm from the ligament of Treitz with the proximal jejunal end aligned with the proximal remnant stomach greater curvature (Fig. 37.7a). The loop can be passed either antecolically or retrocolically through the transverse mesocolon.
- Create a gastrotomy and jejunotomy to accommodate the insertion of the Endo-linear stapler load to enter through the left-sided assist port in the proximal to distal bowel orientation (Fig. 37.7b).
- Close the common enterotomy with the stapler coming in from the right side of the patient. In order to perform this part of the procedure, the No. 2 arm of the robot needs to be undocked and the 8-mm robot port switched out for a 12-mm trocar, which will accommodate the Endo-linear stapler (Fig. 37.7c).
- Alternative option is to suture closed the common enterotomy using robotic assistance. Switch out the harmonic ultrasonic shears and the Maryland bipolar with needle drivers. Use the third arm to position the common enterotomy and close the enterotomy using running 2-0 Vicryl and 3-0 silk sutures.

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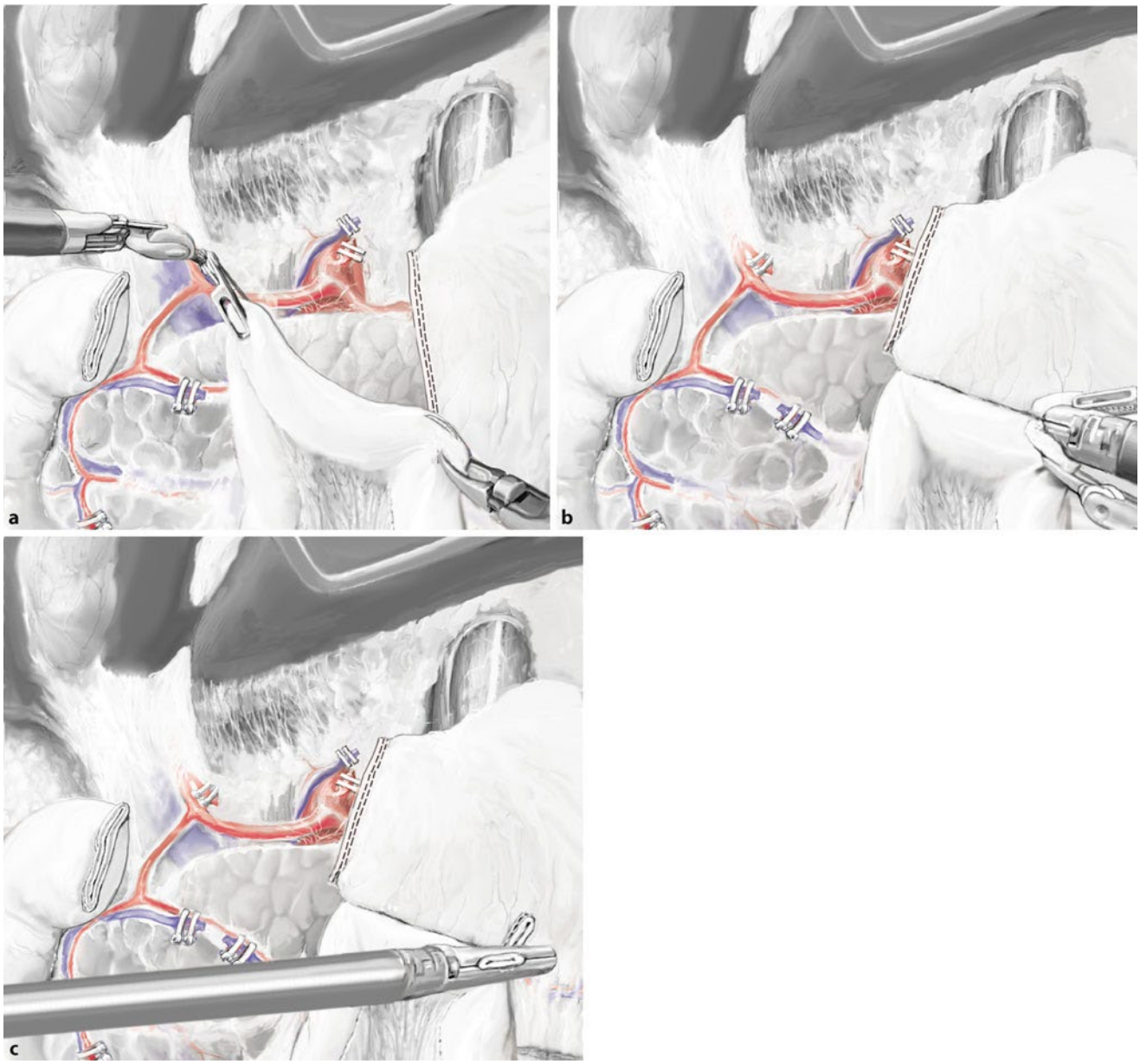


Fig. 37.7

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Roux-en-Y Gastrojejunostomy

To limit bile esophagitis and gastritis after vagotomy and distal gastrectomy, some surgeons prefer Roux-en-Y gastrojejunostomy as the method of choice for reconstruction.

- Transect the jejunum 15 to 20 cm from the ligament of Trietz using the Endo-linear stapler and bring up the distal jejunum either antecolically or retrocolically and position the antimesenteric side of the jejunum side by side with the greater curvature of the stomach with the stapled end of the jejunum proximally placed.
- Create a gastrotomy in the proximal edge of the cleared greater curvature and an enterotomy on the antimesenteric edge of the jejunum near the staple line.
- Carefully pass the Endo-linear stapler through the enterotomies, approximate the two edges, and fire the stapler. Close the common enterotomy in two layers using robotic needle holders.
- Measure 50 to 60 cm from the gastrojejunal anastomosis and line up the biliary jejunal limb and the enteric limb using the robotic grasper and Maryland bipolar grasper. Make enterostomies and create a stapled side-to-side anastomosis using the assist port to introduce the stapler. Close the common enterotomy with two-layer running sutures.
- Verify the orientation of the reconstructed small bowel.

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Robotic-Assisted Minimally Invasive Esophagectomy (RAMIE): Ivor Lewis

Inderpal S. Sarkaria, Nabil P. Rizk

It has become increasingly recognized that minimally invasive esophagectomy (MIE) approaches have comparable oncologic and functional outcomes as open approaches. Additionally, a growing body of literature – including one prospective, randomized, controlled study – suggests that MIE provides improvements in pulmonary and wound complications and short-term pain indices, compared with open surgery.

Although the experience with robotic-assisted MIE (RAMIE) is relatively limited compared with standard MIE, experience with RAMIE is increasing. Published studies cite a wide range of surgical approaches featuring robotic assistance, most commonly with robotic assistance used for thoracoscopic esophageal mobilization. A smaller number of studies have described combined laparoscopic and thoracoscopic robotic esophagectomy with an anastomosis performed in either the neck or the chest. At our institution, we have developed and standardized one such RAMIE approach that uses a four-arm robotic platform for both the Ivor Lewis and McKeown (three-hole) approaches. The Ivor Lewis approach, which is most commonly performed in our service, is described here.

Indications and Contraindications

Indications

The malignant and benign indications for RAMIE are similar to those for open and standard MIE Ivor Lewis resections. Malignant indications are largely based on tumor location and size and represent the predominant indications for esophageal resection. In the North American population, these most commonly consist of distal and midesophageal adenocarcinomas. For patients with distal squamous cell carcinomas, Ivor Lewis resection may be considered; however, given the higher incidence of multifocal disease among these patients, we favor McKeown esophagectomy. For patients with midesophageal squamous cell tumors and those with proximal tumors of any histologic type, we perform a McKeown resection. Benign indications are less common and generally represent advanced esophageal disease with significant organ dysfunction. Patients with the following diagnoses are most suitable for a RAMIE approach:

- Distal esophageal adenocarcinomas and squamous cell carcinomas
- Midesophageal adenocarcinomas
- End-stage achalasia
- Recalcitrant benign strictures of the middle and distal esophagus

Contraindications

The contraindications for RAMIE (versus open surgery) are similar to those for standard MIE. Although these contraindications may be relative across institutions, we have not performed MIE for the following cases:

- Patients requiring colon interposition
- Patients with proximal esophageal tumors possibly requiring laryngectomy
- Patients with extensive adhesions not amenable to minimally invasive approaches

Our relative contraindications for the Ivor Lewis RAMIE approach are identical to those for standard MIE and open resections at our institution:

- Proximal and midesophageal squamous cell carcinomas
- Proximal esophageal adenocarcinomas

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
DOI 10.1007/978-3-662-46546-2_38, © Springer-Verlag Berlin Heidelberg 2016

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Preoperative Workup

Patients with biopsy-confirmed esophageal carcinoma undergo preoperative evaluation to assess their fitness for surgery. Staging assessment includes computed tomography scanning of the chest, abdomen, and pelvis; endoscopic ultrasound; and 18-fluorodeoxyglucose positron emission tomography (PET) scanning. In appropriate patients with limited disease, tumors confined to the mucosa (T1a or less) undergo endoscopic mucosal resection and ablation of remaining Barrett's mucosa or dysplasia. Patients not amenable to endoscopic therapy and those with clinically early-stage invasive lesions (T1b or T2, with no evidence of local lymph node metastases) are recommended for surgery. Patients with clinically advanced local-regional disease (T3 and/or N1, N2, or N3) are referred for induction chemotherapy and radiation, followed by surgical resection approximately 4 to 6 weeks after completion of neoadjuvant treatment.

Procedure

Room setup and patient positioning

For both the abdominal and the thoracic phases, the robotic instrumentation cart is set up on the patient's right side. We use a four-arm robotic platform with two operating consoles. Two attending surgeons are present for all cases – one at the bedside and one at the robotic console – with an advanced surgical trainee at the second operating console. Single-lung isolation with double-lumen tube intubation is performed during the thoracoscopic phase. To assess the position of the tumor, upper endoscopy is performed before the patient is positioned.

For the abdominal phase, the patient is placed supine on the table, with a footboard in place. The patient's arms are placed at 45°, and the patient is shifted to the right side of the bed to allow appropriate use of the liver retractor. The left arm may be tucked to minimize interaction with the robotic assistant arm. The table is turned 90° to allow placement of the robotic cart and arms (da Vinci Surgical Robot; Intuitive Surgical; Sunnyvale, CA, USA) directly over the midline of the patient (Fig. 38.1a). The patient is placed in reverse Trendelenburg position, and the robotic arms are docked to the ports. For the thoracic phase, the patient is placed in flexion, in the standard left lateral decubitus position, with the right side up and the upper arm in a neutral position. The bed is turned approximately 60°, and the robotic cart is brought in obliquely over the right shoulder (Fig. 38.1b).

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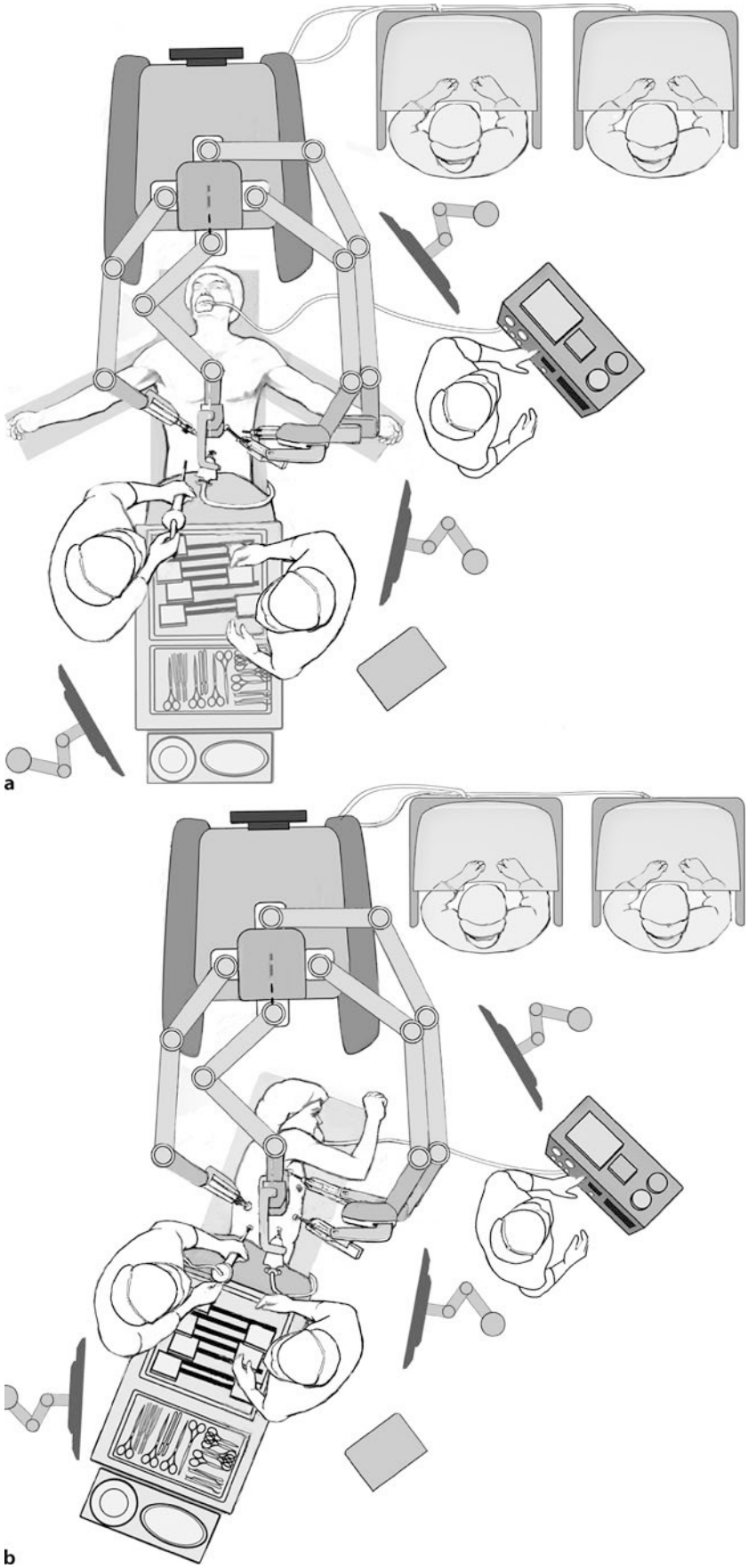


Fig. 38.1

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Port placement

For the abdominal phase, a supraumbilical 12-mm camera port is placed, and pneumoperitoneum is established with CO_2 at a pressure of 15 mm Hg. A 12-mm, 30° robotic camera is used. Additional ports are placed under direct vision, including a left lateral 5-mm subcostal port for use by the 5-mm robotic atraumatic grasper (Schertl Grasper; Intuitive Surgical); a left midclavicular 8-mm port, placed 13 to 15 cm from the xiphoid, for use by the robotic ultrasonic shears (Harmonic Scalpel; Ethicon; Somerville, NJ, USA); a right lateral 5-mm subcostal port for placement of the liver retractor (Diamond Flex; Snowden Pencer; San Diego, CA, USA); an 8-mm right midclavicular, midabdominal port for use by the bipolar atraumatic grasper (Fenestrated Bipolar Grasper; Intuitive Surgical); and a right paraumbilical 10-mm port for suction, retraction, stapling, and passage of sutures by the bedside assistant (Fig. 38.2a). To minimize robotic arm collisions, a distance of at least 9 to 10 cm is maintained between robotic ports.

For the thoracic phase, right lung isolation is performed, a Veress needle is placed within the chest, and pneumothorax is established with CO_2 at a pressure of 8 mm Hg. Establishing a pneumothorax is helpful in flattening the diaphragm and exposing the hiatus. A 12-mm camera port is placed in the eighth or ninth interspace, in the posterior axillary line. Additional ports are placed under direct vision, including a 5-mm port in the third intercostal space, in the mid- to posterior axillary line, for use by the 5-mm robotic atraumatic grasper; an 8-mm robotic port in the fifth intercostal space for use by the robotic ultrasonic shears; an additional 8-mm port laterally in approximately the ninth or tenth interspace (positioned over the hiatus) for use by the robotic bipolar grasper; and a 12-mm assistant port laterally at the diaphragmatic insertion for suction, retraction, stapling, and passage of sutures by the bedside assistant (Fig. 38.2b).

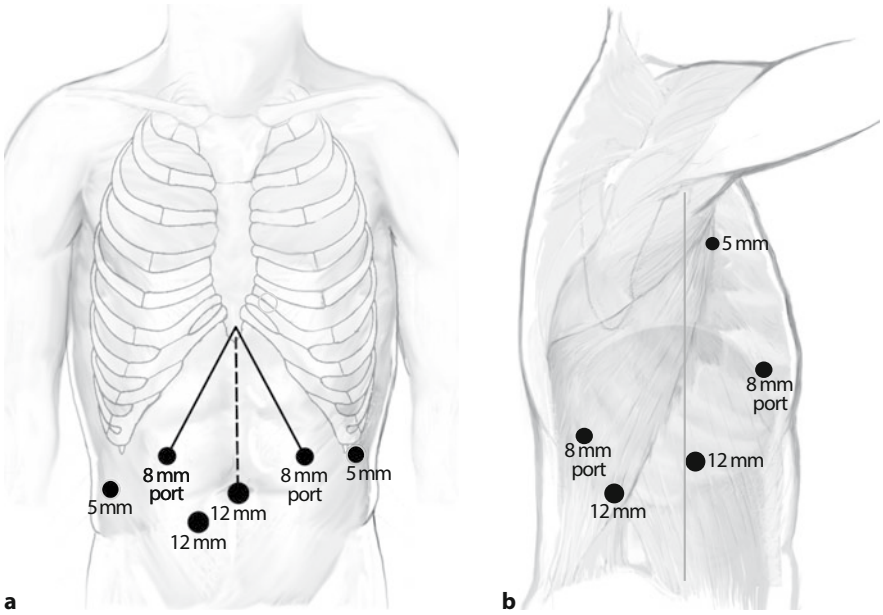


Fig. 38.2

Abdominal Phase

Step 1

Hiatal and retrogastric dissection

Initial dissection is begun by opening the lesser sac and dissecting the anterior right and left crura (Fig. 38.3). For lower esophageal tumors, portions of the right or left crus should be resected en bloc with the esophagus if tumor involvement is identified. To avoid entry into the pleural spaces, which may cause hemodynamic compromise and loss of intraperitoneal CO_2 insufflation, excessive early mediastinal dissection should be minimized at this time. If hemodynamic compromise

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Step 1 ***(continued)***

or loss of intraperitoneal CO_2 insufflation occurs, the surgeon should consider a low threshold for the initiation of tube thoracostomy.

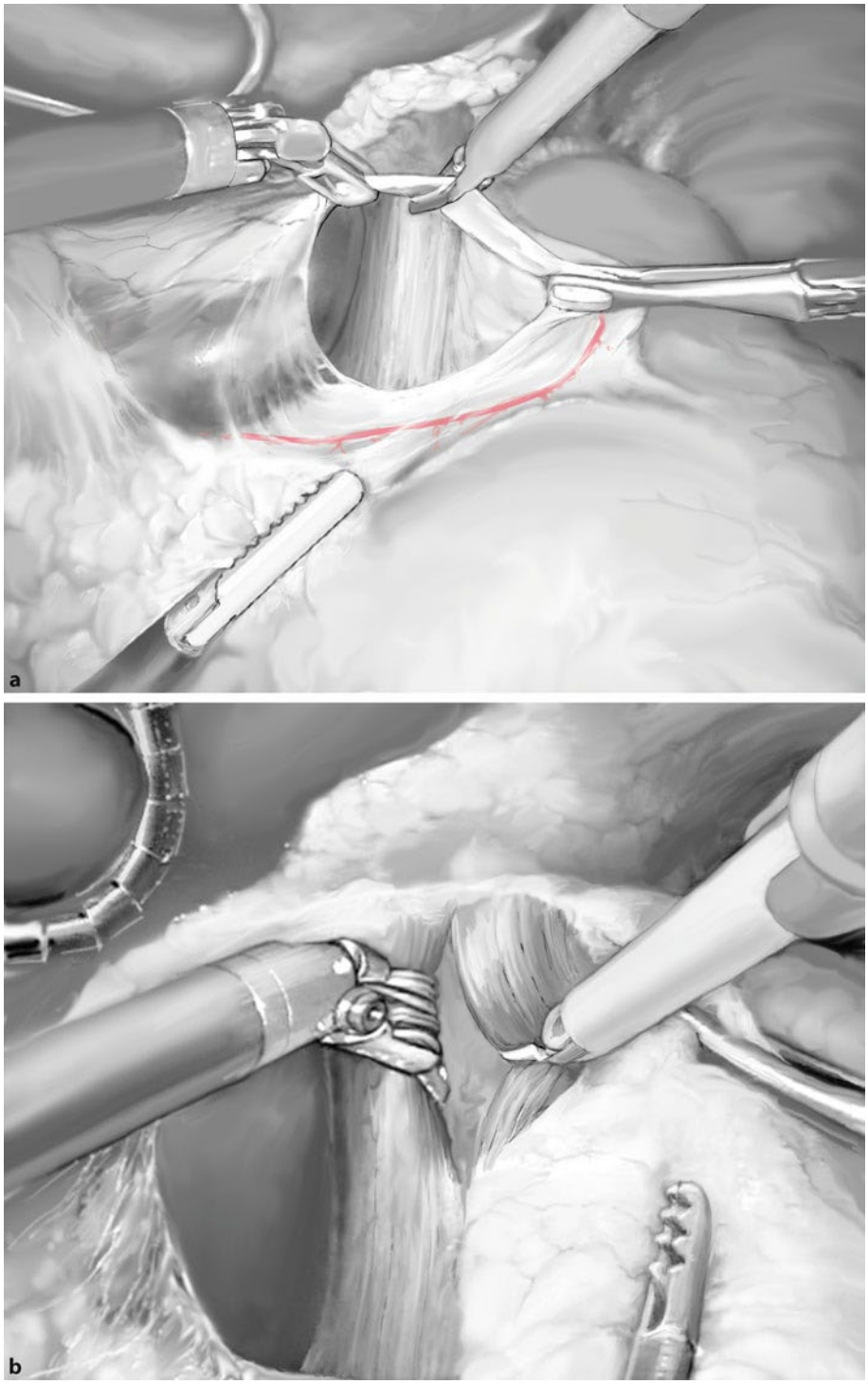


Fig. 38.3

Exposure to the left gastric vascular pedicle and the lesser sac is achieved through the lesser gastric curve, with anterior retraction using the robotic assistant arm and caudal retraction by the bedside assistant. The celiac axis is skeletonized and the surrounding lymph node–bearing tissues are cleared, with dissection along the superior border of the pancreas and splenic artery, posteriorly to the retroperitoneum, medially along the common hepatic artery, and cranially toward the hiatus. The presence of bulky celiac adenopathy with persistent disease may preclude

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Step 1 ***(continued)***

resection if the adenopathy is not surgically removable. The dissected lymph node packet is removed separately or is lifted anteriorly toward the specimen, along the left gastric vascular pedicle, which is divided using an endovascular stapler (Fig. 38.4). Gentle retraction of the stomach using the robotic assistant arm allows for exposure and additional dissection of the left crus from the lesser gastric curve.

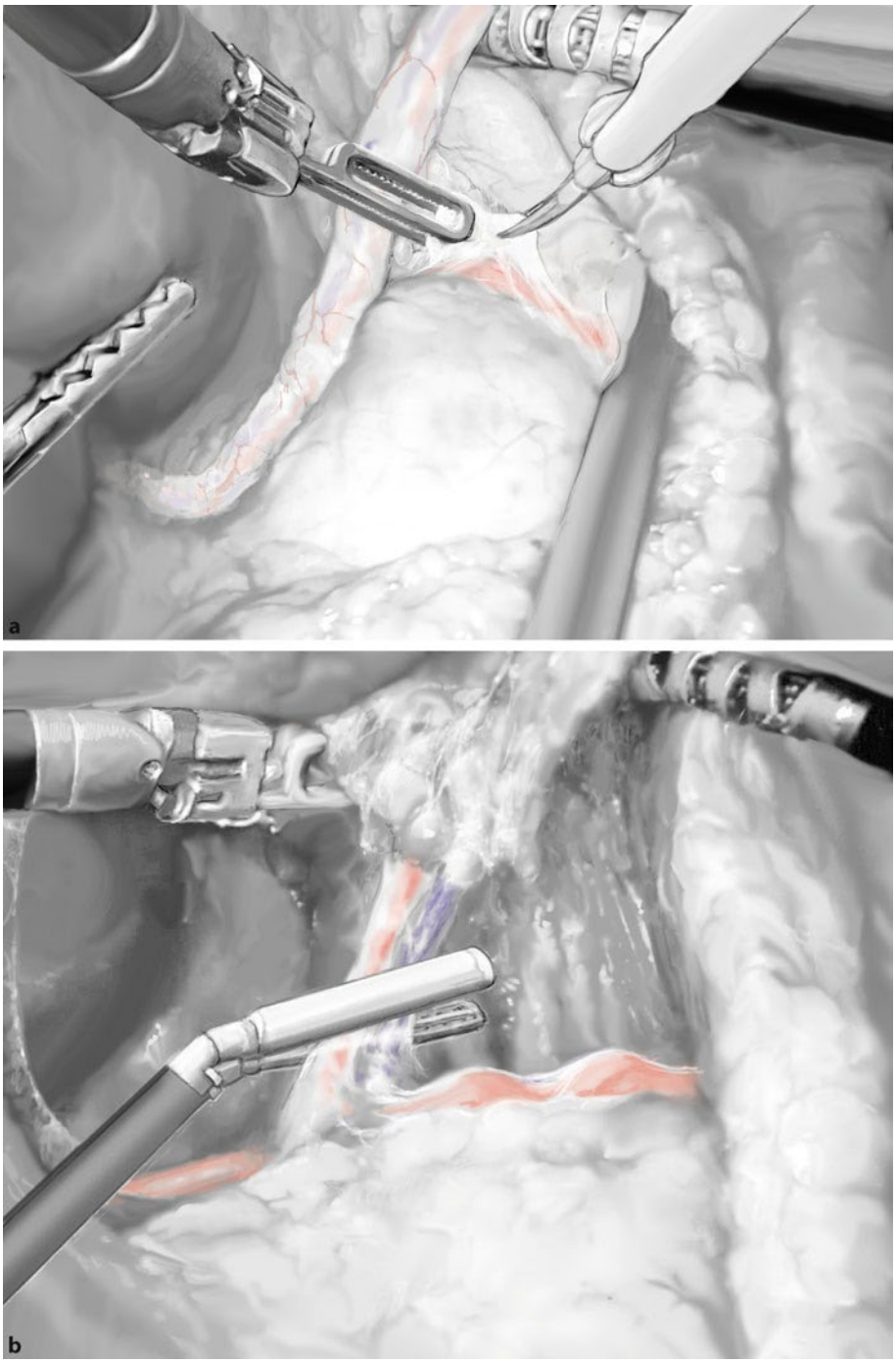


Fig. 38.4

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Step 2

Gastric mobilization

The termination of the gastroepiploic arcade is identified, and the short gastric arteries are divided using the ultrasonic shears. The lesser sac is entered through the greater omentum, and gastric mobilization is completed to the level of the pylorus, with great care to visualize and preserve the right gastroepiploic vascular arcade. The left lateral robotic assistant arm can be used to bluntly retract the greater curve of the stomach medially and superiorly, to better visualize the gastroepiploic vasculature (Fig. 38.5) and to expose and lyse retroperitoneal and gastropancreatic adhesions.

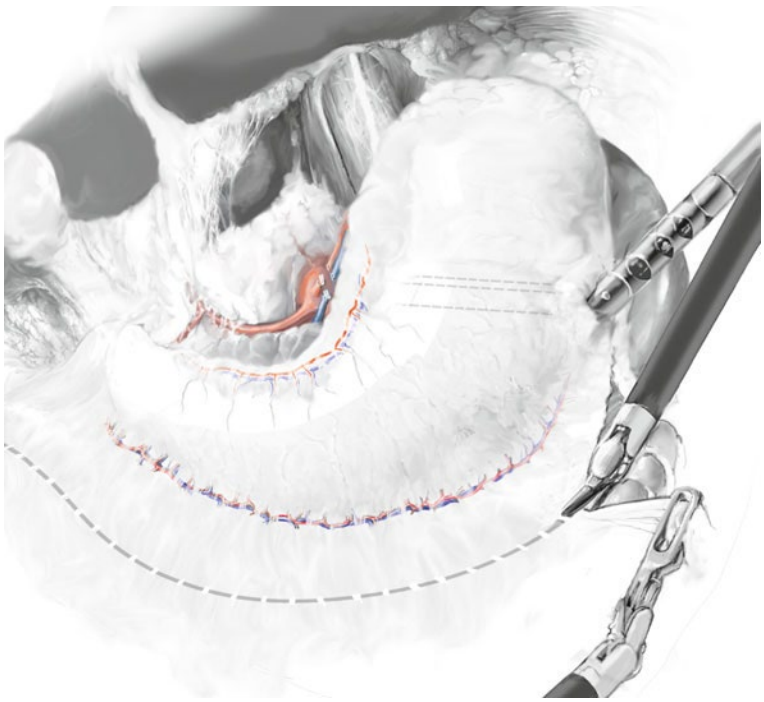


Fig. 38.5

Step 3

Pyloroplasty

The robotic assistant arm with the atraumatic grasper is used to gently retract the gastric antrum leftward to expose the pylorus. Retraction stitches are placed laterally across the pyloric muscle, pylorotomy is performed using the ultrasonic shears, and the defect is closed transversely with interrupted sutures (Fig. 38.6).

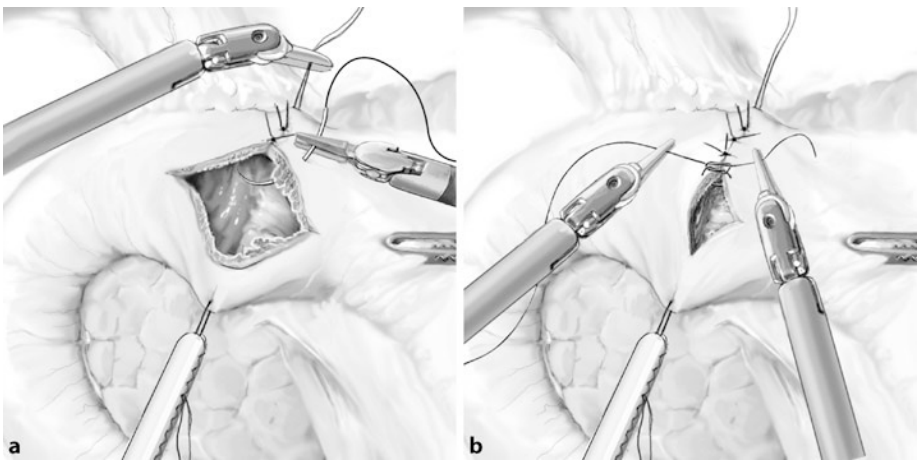


Fig. 38.6

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Step 4

Gastric conduit formation

The nasogastric tube is withdrawn into the esophagus. The robotic assistant arm is used to gently grasp the tip of the gastric fundus along the line of the divided short gastric arteries and toward the left upper quadrant. The right robotic arm with an additional atraumatic grasper (Cadierre Forceps; Intuitive Surgical) is used to provide gentle inferior traction on the antrum, thus straightening the greater gastric curve (Fig. 38.7). An endovascular stapler is used to divide the lesser curve vasculature at a point approximating the incisura. The gastric tube is constructed and is divided from the specimen by multiple fires of the endoGI stapler, with care to maintain proper orientation of the evolving gastric conduit at all times. The proximal gastric tube is reapproximated to the specimen with heavy suture to allow properly oriented entry through the hiatus into the chest during the thoracoscopic phase of the operation.

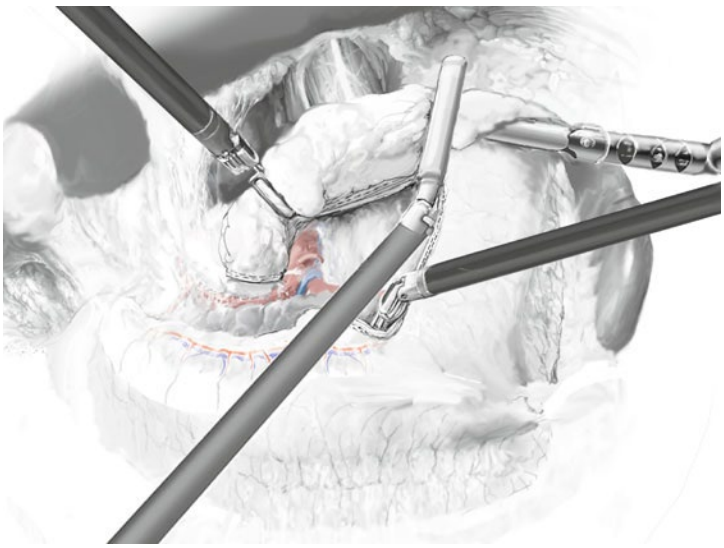


Fig. 38.7

38

Thoracic Phase

Step 5

En bloc esophageal mobilization

Complete en bloc mobilization of the esophagus is performed with clearance of all adjacent lymph node bearing tissue at the hiatus posteriorly along the aorta, anteriorly along the pericardium and airway, and posteriorly along the contralateral pleura.

After division of the inferior pulmonary ligament, dissection is initiated along the pericardium, adjacent to the inferior vena cava, and is continued medially to the contralateral pleura, with craniolateral lung retraction performed using the robotic assistant arm. The lung is retracted anteriorly using the robotic assistant arm, and dissection is continued cranially along the posterior hilum. The airway is identified, and subcarinal lymph node dissection is completed (Fig. 38.8). To minimize the risk of thermal injury to the airway from the rigid ultrasonic shears, the robotic bipolar Maryland dissector (Intuitive Surgical) in the right robotic arm is used during subcarinal dissection. Thoracoscopic suction by the bedside assistant maintains a clear surgical field and aids in retraction.

Posterior dissection along the aorta is aided by anterior retraction of the esophagus using the robotic assistant arm. Lymphatic perforators are liberally clipped and aortoesophageal perforating arteries are divided using the ultrasonic shears. The thoracic duct may be ligated near the hiatus.

The distal specimen is brought through the hiatus, with the lesser curve staple line of the attached gastric conduit oriented laterally. The specimen and conduit are separated, and the conduit is temporarily secured to the diaphragm, preventing retraction into the abdomen. The specimen is retracted craniolaterally, and medial dissection is completed along the contralateral pleura and left mainstem bronchus.

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Step 5 ***(continued)***

The dissection is continued cranially above the azygous vein, which is divided. The esophagus is divided sharply using the shears in the right robotic arm (Monopolar Scissor; Intuitive Surgical), 2 to 3 cm above the azygous vein, and the nasogastric tube is withdrawn proximally under direct vision into the remaining proximal esophagus. The robotic left-hand 8-mm port is temporarily removed, the incision is extended 3 to 4 cm in length, and a wound protector device is placed. The specimen is removed and evaluated by frozen section to assess proximal and distal margins.



Fig. 38.8

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Step 6

Creation of anastomosis

The 28-mm anvil of the circular anastomotic stapler (DST EEA Stapler; Covidien Surgical; Dublin, Ireland) is placed into the chest through the access incision. In rare cases, a 25-mm anvil may be required if the esophagus cannot accommodate the larger size. The orifice of the open esophagus is gently retracted and held open using the right robotic arm and assistant arm graspers, and the anvil is gently inserted using the left robotic arm grasper (Cadierre Forceps; Intuitive Surgical) (Fig. 38.9a). Needle drivers are situated in the right and left robotic arms, and a "baseball" purse-string stitch, with nonbraided permanent suture (0 Prolene SH Needle; Ethicon), is placed to secure the anvil (Fig. 38.9b). Alternatively, the suture may be placed before insertion of the anvil. Care is taken to place each suture bite full thickness through esophageal muscle and mucosa. An additional reinforcing purse-string suture is placed after the anvil is secured (Fig. 38.9c).

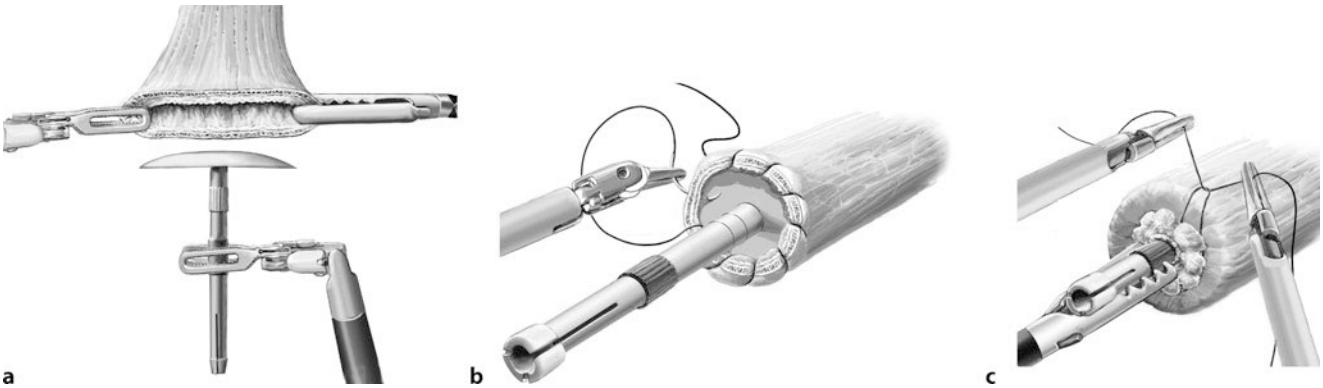


Fig. 38.9

The conduit is released from the diaphragm and brought into the chest. A proximal gastrotomy is made and is retracted open at three points using the right robotic arm and the assistant arm graspers, as well as by the bedside assistant. The cartridge of the stapler is introduced through the mini access incision and placed into the proximal conduit, and the spike is brought out through the greater curve, just above the vascular arcade (Fig. 38.10a). The spike and anvil are joined, the anastomosis is created, and the tissue rings of the esophageal and gastric staplers are inspected for completeness. The nasogastric tube is advanced into the gastric conduit under direct vision, and the redundant conduit and gastrotomy are resected using the endogastrointestinal stapler. The procedure is completed with the placement of an apical-posterior chest tube (10 French flat Jackson-Pratt drain) adjacent to the anastomosis posteriorly. The final position of the gastric conduit is shown with a high intrathoracic anastomosis (Fig. 38.10b).

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Step 6 ***(continued)***

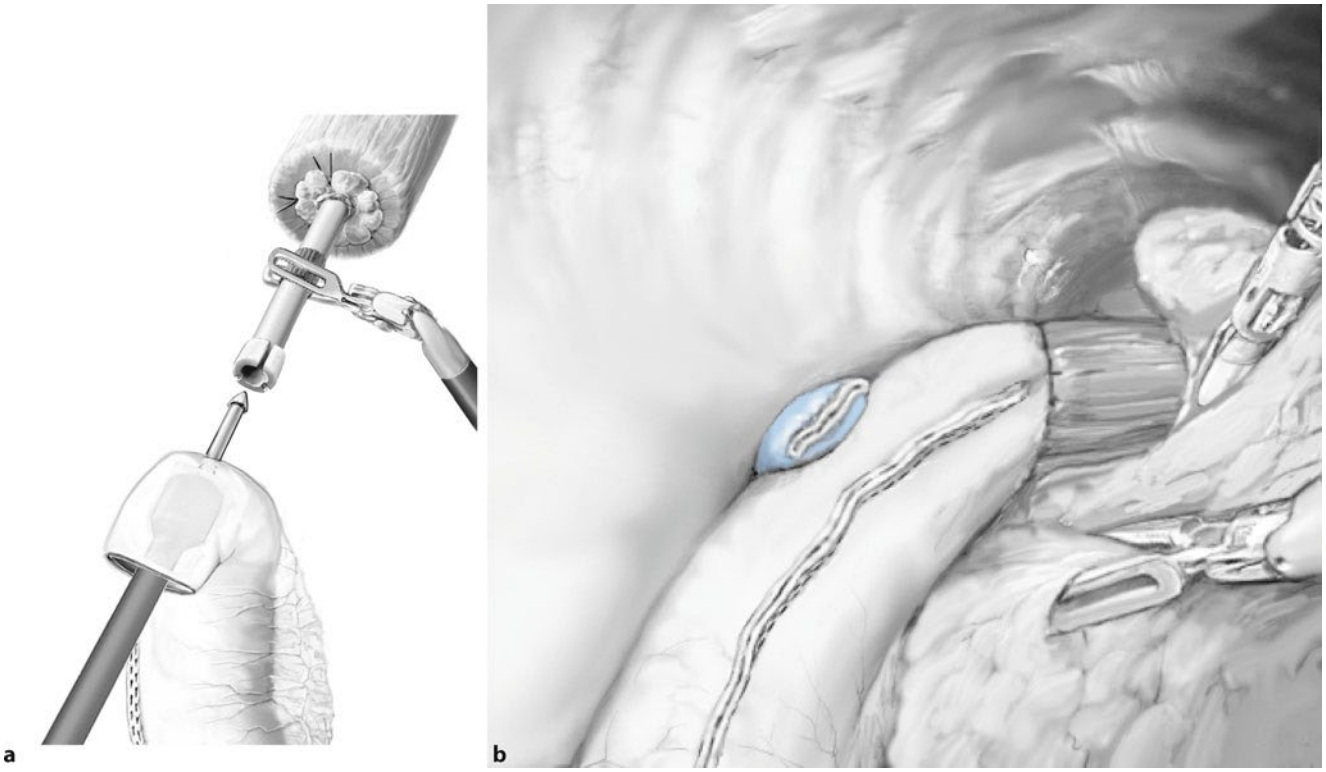


Fig. 38.10

Immediate Postoperative Care

Patients are extubated in the operating room and remain overnight in a step-down unit. Early ambulation on postoperative day 1 is routine. Tube feeding is begun on postoperative day 2 and is slowly advanced. Nasogastric tubes are left in place for 5 to 7 days. Upon removal of the nasogastric tubes, an esophagram is performed to assess for anastomotic leak, and a liquid diet is begun. Patients are typically discharged on day 7, with cycled tube feeding and a graded schedule of advancement to a mechanical soft diet without tube feeding. The perianastomotic Jackson-Pratt drain and the feeding jejunostomy are usually removed at the first postoperative clinic visit, which occurs 2 to 3 weeks after discharge.

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Introduction: Liver

Pierre-Alain Clavien, Yuman Fong

Liver surgery was considered until the early 1980s as a "heroic" field of medicine associated with much blood loss, and high patient morbidity and mortality. With such a reputation, only life-threatening conditions were usually referred for liver surgery.

As surgeons acquired a better understanding of surgical anatomy and physiology, a better understanding of peri- and intraoperative management, and importantly formal training periods in this field, hepatic surgery began to enjoy rapid expansion and high credibility among colleagues and patients. Today, liver surgery is one of the most complex and successful areas of medicine with the availability of a variety of highly sophisticated procedures for many indications including complex liver resection or transplantation of only one part of the liver from a living donor.

Compared to the first edition, we have separated non transplant (Chapters 40–58) from transplant (Chapters 59–65) procedures with significant changes in about a third of the chapters. Particularly, the part on laparoscopic liver resection was updated and new technology such as microwave ablation or the use of electroporation ablation (NanoKnife) was introduced. A new chapter is dedicated to the emerging and challenging two-stage hepatectomy described with the acronym "ALPPS." On the side of liver transplantation, the challenging use of double living donor graft, *in situ*/*ex situ* splitting of cadaveric liver graft, and graft after cardiac arrest are newly described.

The first chapter presents a comprehensive approach to the terminology of liver anatomy and resection (Brisbane 2000 terminology), according to an international effort including leaders from all continents. The next three chapters present available techniques for vascular exclusion, parenchyma dissection and the "hanging" maneuver, which may enable better exposure for anatomic resections. The hepatic surgeon must be familiar with all these techniques, which may be of great help in many difficult situations. Then, the focus turns to formal anatomic and non-anatomic liver resections, including laparoscopic approaches, which are gaining increasing popularity. As liver resection is often not possible due to local difficult situations (poor liver reserve or location of a tumor) or poor general condition of the patient, alternative techniques are presented including the new two-staged liver resection ALPPS, cryosurgery, radiofrequency ablation, the nanoknife technique and selective intra-arterial chemotherapy. Benign and infectious cysts require particular strategies, which are well covered in two separate chapters. A chapter also comprehensively covers the available strategies for liver trauma in the modern area of "damage control injury." Emerging robotic liver resection is introduced in a separate chapter. The last seven chapters cover various aspects of liver transplantation from organ procurement to partial living or cadaveric orthotopic liver transplantation, double transplant as well as auxiliary liver transplantation.

While there is no substitute for experience in performing complex surgical procedures, we hope that this section, prepared by worldwide experts, will clarify standards and limitations for surgeons in performing hepatic surgery.

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Terminology of Liver Anatomy and Resections: The Brisbane 2000 Terminology

Steven M. Strasberg

The Brisbane 2000 Terminology of Hepatic Anatomy and Liver Resections

In December 1998, at its meeting in Berne, Switzerland, the Scientific Committee of the International Hepato-Pancreato-Biliary Association (IHPBA) established a Terminology Committee to deal with the confusion in terminology of hepatic anatomy and liver resections. The impetus for doing so came from an article published in 1997, which challenged the existing terminology. After nearly 18 months of work, the recommendations of the committee were presented to the Scientific Committee at the biannual meeting of the IHPBA in Brisbane, Australia, in May, 2000. These recommendations, consisting of a new terminology, The Brisbane 2000 Terminology of Liver Anatomy and Resections, were unanimously accepted by the Scientific Committee of the IHPBA and were presented to the membership as the official terminology of the IHPBA. The recommendations were published in the official journal of the IHPBA in 2000, and it has recently been shown that they have been widely adopted throughout the world. The terminology shown is based on the universally accepted anatomy of the ramification of the hepatic artery and bile duct, which is coincident with the ramification of the portal vein as described by Goldsmith and Woodburne. Although a terminology based on the division of the portal vein according to Couinaud was added as an addendum in the original description, it is not presented here.

The terminology is presented as a set of five figures. The liver is divided into successive orders. The following notes serve as a guide to the figures.

Note 1. Couinaud segments are indicated in short form as Sg1–8 (e. g., Sg6). "Sg" was chosen rather than "S" to avoid confusing "segment" with "section." Arabic numerals are chosen rather than Roman numerals because many non-Western nations do not use Roman numerals.

Note 2. Wherever the word "**OR**" (uppercase, bold) appears, it indicates equally acceptable terminology: for example, "right hemiliver" **OR** "right liver." Wherever the word "**or**" (lowercase, bold) appears, it indicates that the first term is preferred but that the second is acceptable: for example, "right trisectionectomy" **or** "extended right hepatectomy." In this case, "extended" is less desirable because some surgeons use the adjective "extended" to indicate any degree of extension of a resection beyond the midplane, which in some cases is less than a whole section. Thus the terms containing the word "extended" are less precise.

Note 3. When segment 1 is resected as part of a procedure, it should be stated as in the following example: "left hemihepatectomy with resection of segment 1" or "left hemihepatectomy extended to segment 1." For clarity, the position of Sg1 is shown only in ◘ Fig. 40.1c.

Note 4. It is correct to refer to any resection by its segments. For instance, "right hepatectomy" and "resection Sgs 5–8" are equally acceptable. Similarly, "left lateral sectionectomy" and "resection Sgs 2,3" are equally acceptable.

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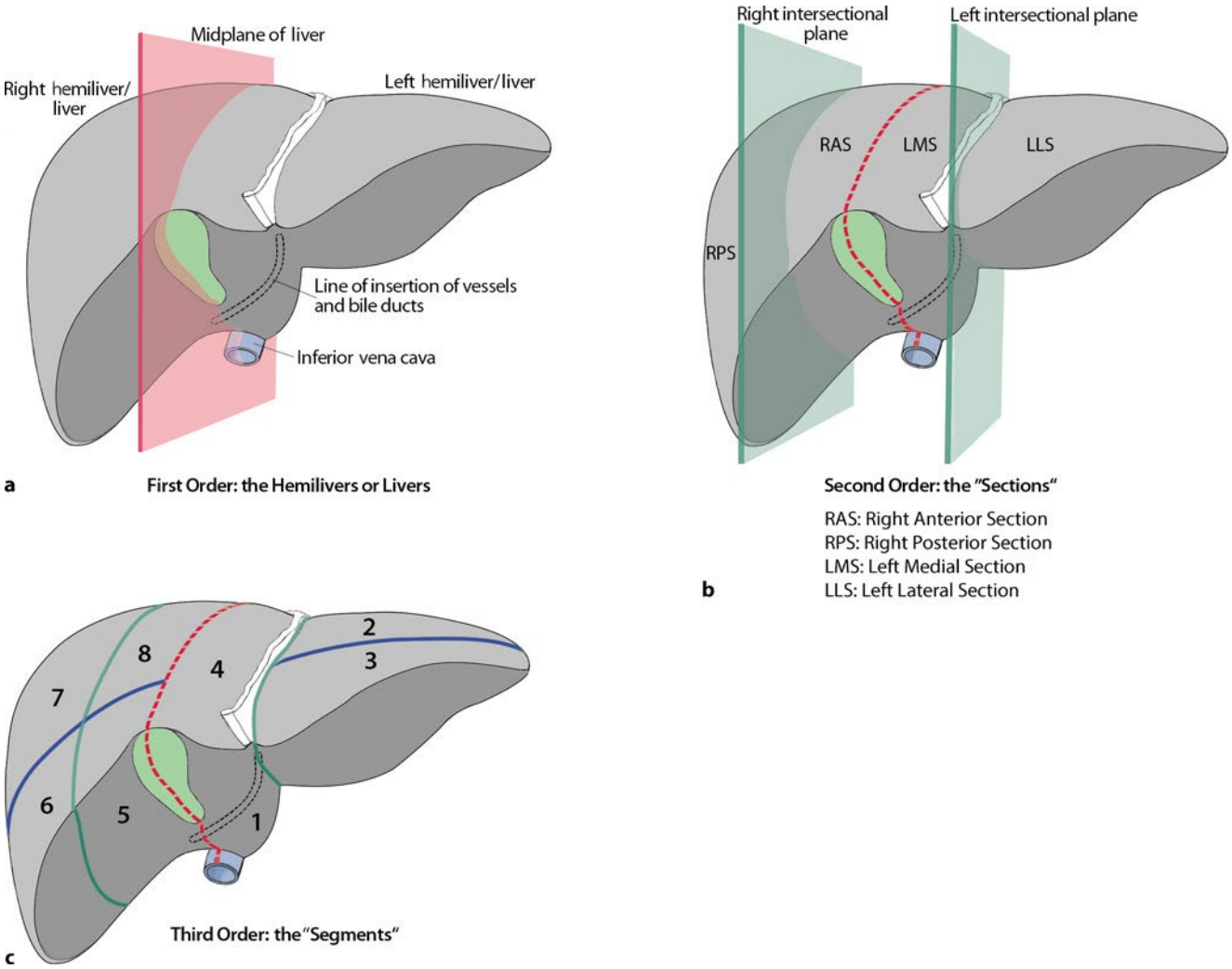
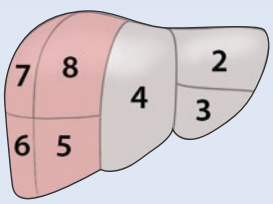
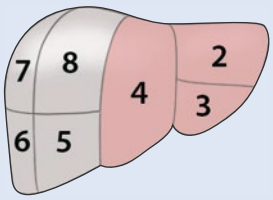


Fig. 40.1 Overall view of successive orders of division based on the hepatic artery or bile ducts. This is also the order of division of the portal vein according to Goldsmith and Woodburne. **a** First-order division of the liver into hemilivers or livers. The midplane of the liver is shown in *red*. **b** Second-order division of the liver into sections. The intersectional planes are shown in *green*. **c** Third-order division into the numbered segments of Couinaud

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Table 40.1 Resectional terminology for excision of a hemiliver or liver

Anatomical term	Couinaud segments	Term for surgical resection	Diagram (pertinent area is shaded)
Right liver **OR** Hemiliver	Sg 5–8	Right hepatectomy **OR** Right hemihepatectomy	
Left liver **OR** Hemiliver	Sg 2–4	Left hepatectomy **OR** Left hemihepatectomy	

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Table 40.2 Resectional terminology for excision of a section

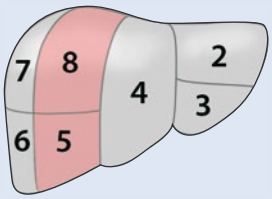
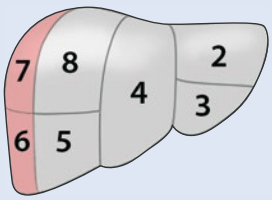
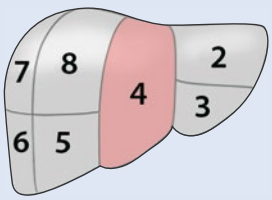
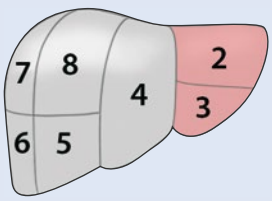
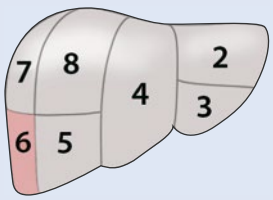
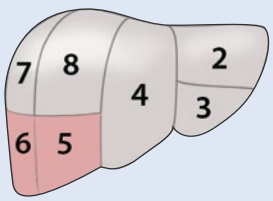
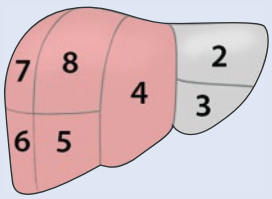
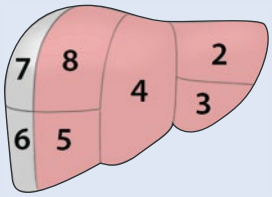
Anatomical term	Couinaud segments	Term for surgical resection Add (ectomy)- to any of the anatomical terms	Diagram (pertinent area is shaded)
Right anterior section	Sg 5,8	Right anterior sectionectomy	
Right posterior section	Sg 6,7	Right posterior sectionectomy	
Left medial section	Sg 4	Left medial sectionectomy	
Left lateral section	Sg 2,3	Left lateral sectionectomy	

Table 40.3 Resectional terminology for excision of a segment

Anatomical term	Couinaud segments	Term for surgical resection	Diagram (pertinent area is shaded)
Segments 1–8	Any one of Sg 1–8	Segmentectomy (e. g., segmentectomy 6)	
Two contiguous segments	Any one of Sg 1–8 in continuity	Bisegmentectomy (e. g., bisegmentectomy 5,6)	

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Table 40.4 Terminology for extended resections (trisectionectomies).

Couinaud segments	Term for surgical resection	Diagram (pertinent area is shaded)
Sg 4–8	Right trisectionectomy (preferred term) **or** Extended right hepatectomy **or** Extended right hemihepatectomy	
Sg 2,3,4,5,8	Left trisectionectomy (preferred term) **or** Extended left hepatectomy **or** Extended left hemihepatectomy	

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Techniques of Vascular Clamping, Vascular Exclusion, and Caval Resection in Liver Surgery

Përparim Limani, Mickaël Lesurtel

Vascular exclusion techniques in liver surgery include continuous inflow occlusion (Fig. 41.1a) (first described by J. H. Pringle in 1908), intermittent inflow occlusion (Fig. 41.1b) (first described by M. Makuuchi in the late 1970s), ischemic preconditioning (Fig. 41.1c) and (continuous) total vascular exclusion. The use of inflow occlusion varies considerably among centers: some use it routinely, whereas others use it only exceptionally. When using inflow occlusion, a low central venous pressure (CVP) (< 5 mm Hg) needs to be maintained to reduce bleeding caused by backflow from the hepatic veins. The effect of a low CVP associated with a Pringle maneuver can be equivalent to total vascular exclusion. Total vascular exclusion, on the other hand, can lead to cardiovascular instability by reducing cardiac preload. Therefore, adequate volume loading with a high CVP (> 10 mm Hg) must be maintained, or a venovenous bypass is sometimes required in this setting.

Table 41.1 Maximum safe duration (min) of hepatic inflow occlusion with different techniques

	Normal liver	Cirrhotic liver
Continuous inflow occlusion	60	30
Ischemic preconditioning	75	?
Intermittent clamping	> 90	> 60



Fig. 41.1

Indications and Contraindications

Indications

- Reduction of blood loss during parenchymal dissection
- Dissection in proximity of major vascular structures
- Tumor invading vena cava or all hepatic veins, central hepatectomy (for total vascular exclusion)

Contraindications

- Technical reasons (adhesions, etc.)
- Cardiac failure (for total vascular exclusion)

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Intraoperative Complications

- Splenic rupture (exceptional): Remove clamps and attempt conservative management of splenic rupture. If not possible, proceed with splenectomy.
- Cardiovascular instability (in total vascular exclusion): Ensure adequate fluid loading, open clamps, consider venovenous bypass.

Techniques of Vascular Exclusion

Pringle maneuver (inflow occlusion)

A right-angle clamp is passed under the hepatoduodenal ligament to allow a Mersilene band to be placed around it (Fig. 41.2a). A red rubber catheter is passed over the band. It is then pushed downwards as a tourniquet to occlude the ligament, and clamped in place (Fig. 41.2b). The time of inflow occlusion should now be noted. An alternative technique is to place a vessel clamp on the hepatoduodenal ligament (Fig. 41.2c). We prefer the tourniquet because it is mobile and does not get in the way when performing the hepatectomy. Another alternative is to selectively clamp portal venous and arterial branches when a dissection of the structures in the hepatoduodenal ligament has been performed, such as for cholangiocarcinoma.

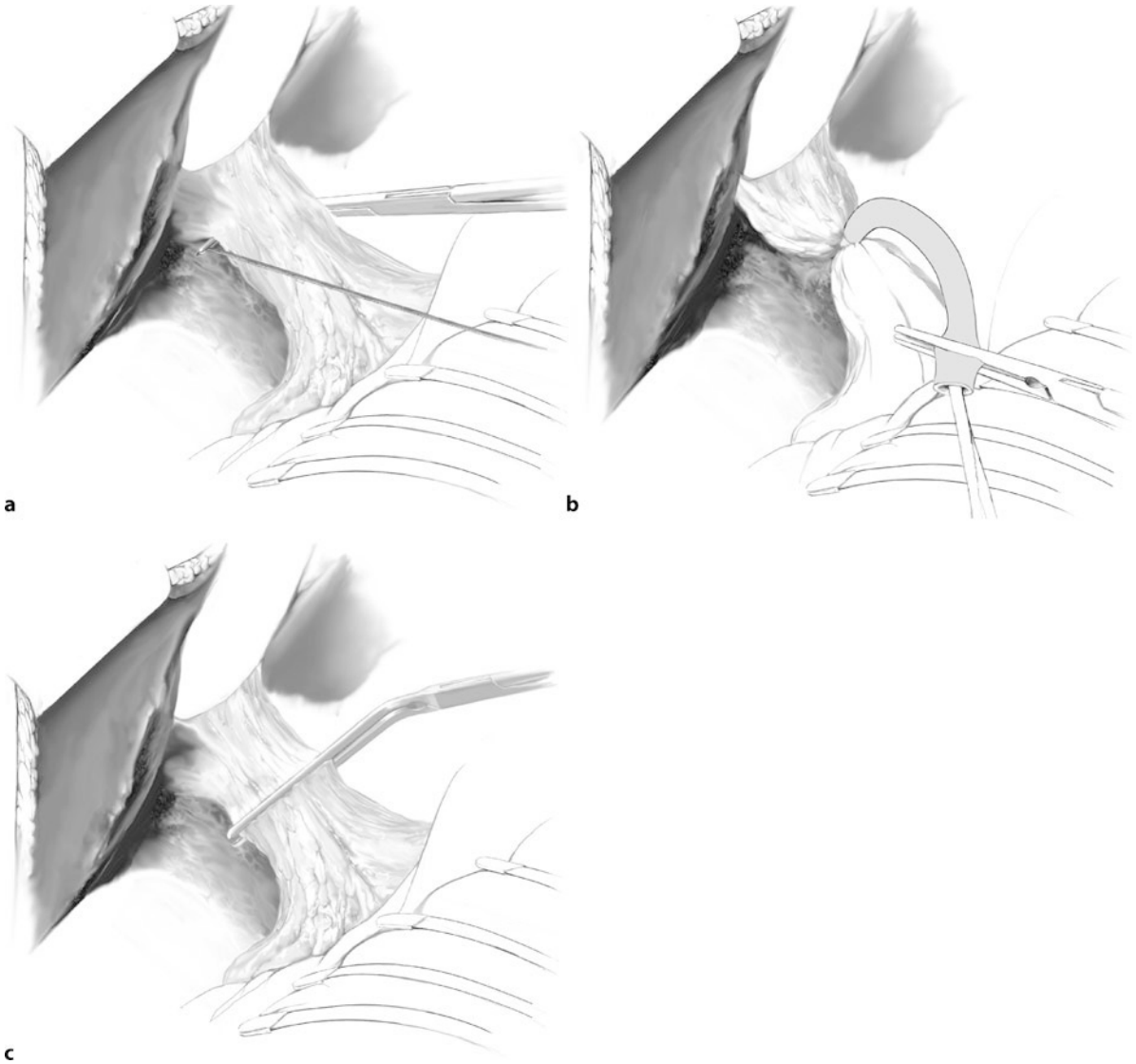


Fig. 41.2

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Total vascular exclusion

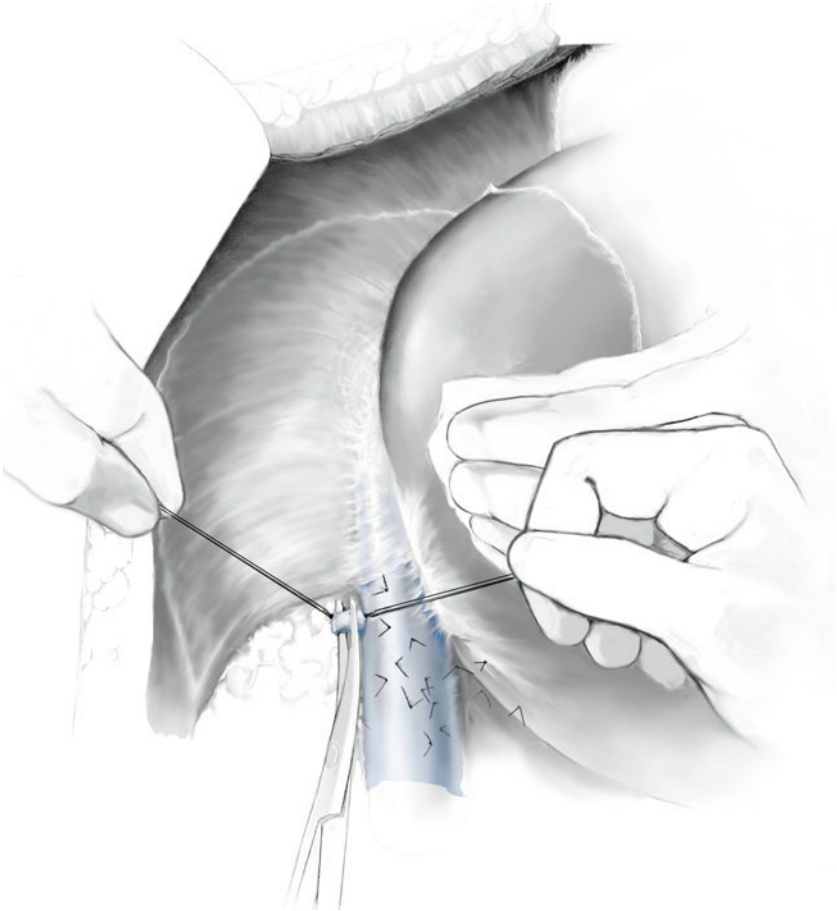
Before total vascular exclusion can be performed, the liver needs to be completely mobilized, as for a liver transplantation. (*See* ▶ Chap. 60, "Orthotopic Liver Transplantation".)

Step 1

The hepatoduodenal ligament is dissected and the tourniquet is placed around it without closing, as described for inflow occlusion.

Step 2

The infrahepatic vena cava is prepared on its right and left side for 2 to 3 cm. The right adrenal vein must be identified and transected through ligatures (◘ Fig. 41.3).



◘ Fig. 41.3

A finger is passed under the cava from the right to the left, and the connective tissue is dissected on the finger with electrocautery (◘ Fig. 41.4a). A large right angle is then passed under the infrahepatic vena cava (◘ Fig. 41.4b) and isolated with a Mersilene band (◘ Fig. 41.4c), which is then pulled through a catheter, as when performing inflow occlusion (tourniquet technique as in the Pringle maneuver discussed previously).

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Step 2 *(continued)*

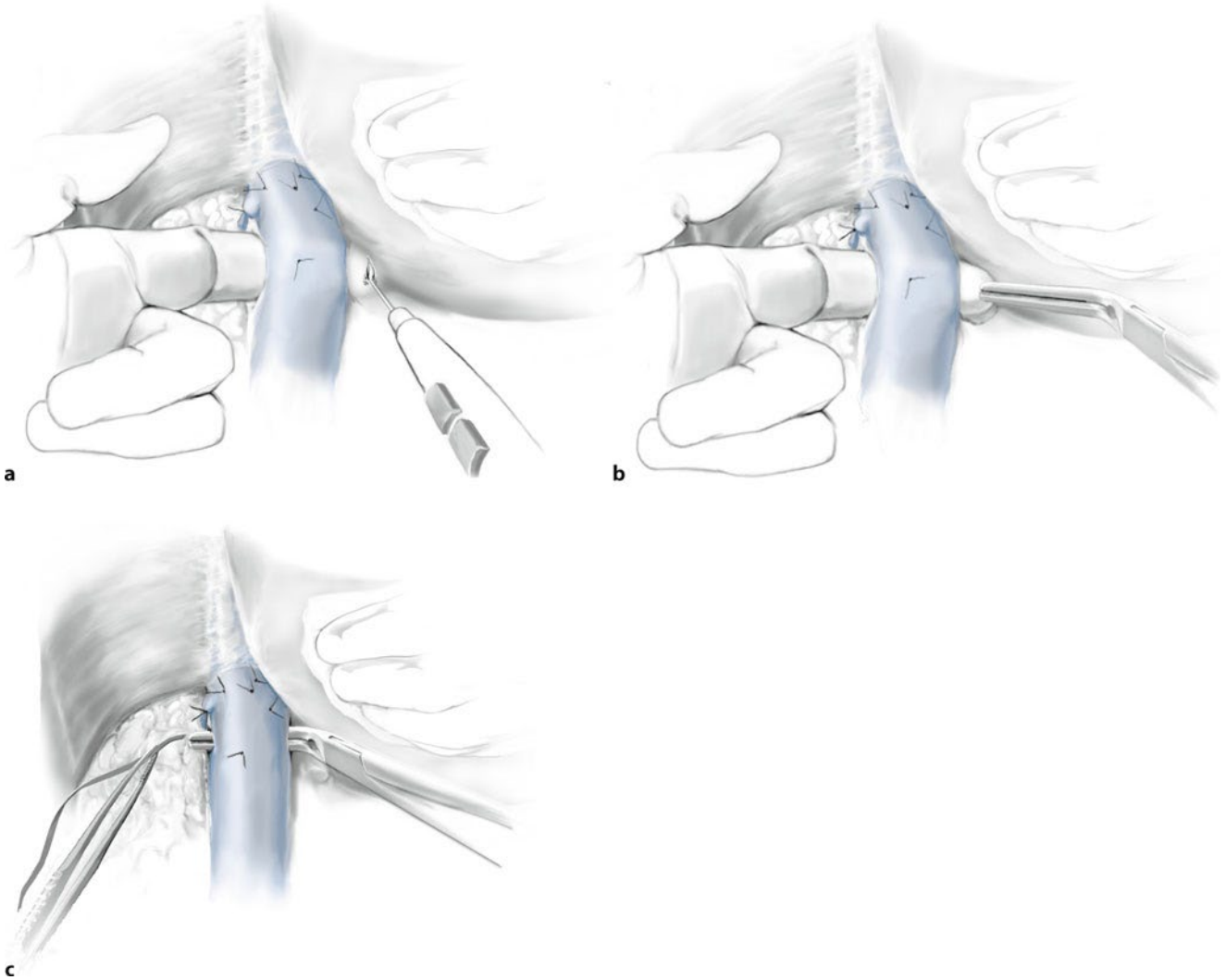


Fig. 41.4

۰۲۱-۶۶۱۹۸۵۱۴ www.myuptodate.com دریافت آخرین نسخه آپتودیت آفلاین

Step 3

Mobilize the retrohepatic and suprahepatic vena cava up to the diaphragm. This is accomplished by passing a finger behind the vena cava and cauterizing the connective tissue (Fig. 41.5). There are no venous branches in this area.

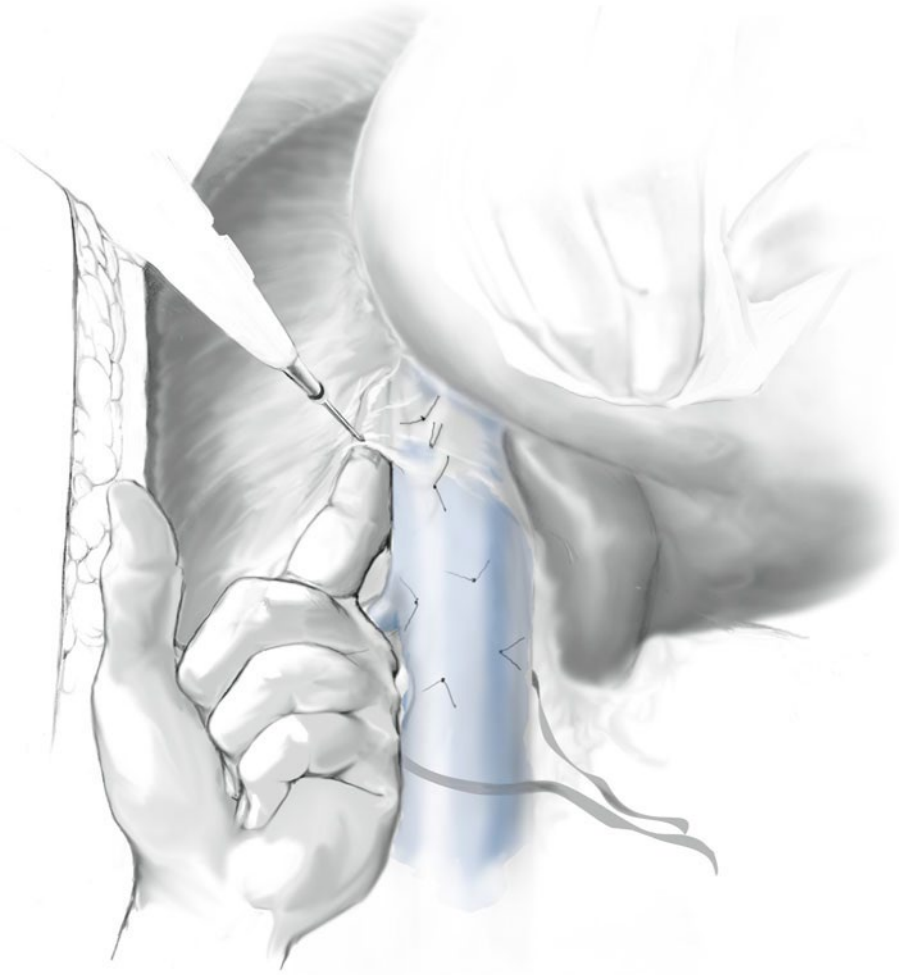


Fig. 41.5

Step 4

Clamp first the hepatoduodenal ligament to avoid any hypertension in the liver by occluding the outflow. Occlude the infrahepatic cava with the corresponding tourniquet. If this is not tolerated, total vascular exclusion cannot be performed. If it is tolerated, lift up the left hepatic hemiliver and place a large, curved vascular clamp from left to right on the suprahepatic cava, as high as possible. Check whether it can be closed. Clamp the suprahepatic vena cava, including a little bit of diaphragm, if possible (Fig. 41.6a). The liver is now in total vascular exclusion (Fig. 41.6b). We do not routinely use venovenous bypass in this setting. (See the section on venovenous bypass in ▶ Chap. 60, "Orthotopic Liver Transplantation".)

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Step 4 *(continued)*

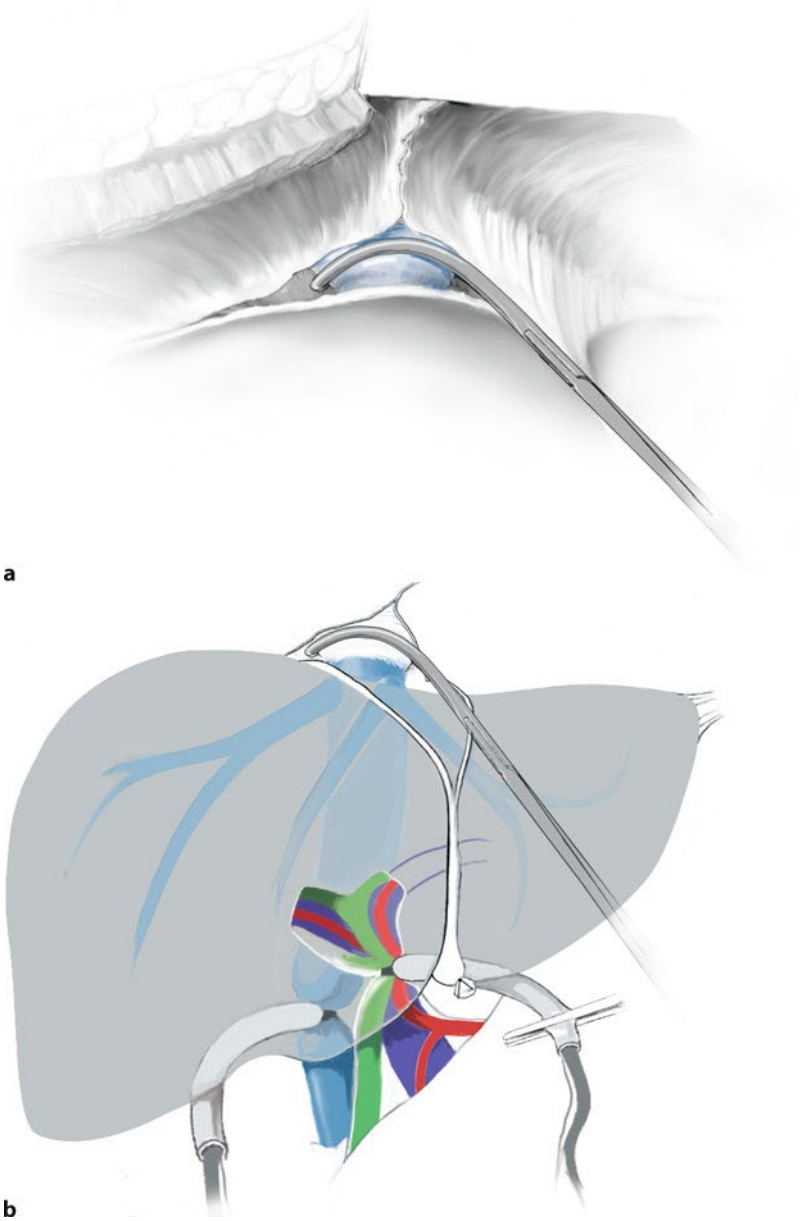


Fig. 41.6

۰۲۱-۶۶۱۹۸۵۱۴ www.myuptodate.com دریافت آخرین نسخه آپتودیت آفلاین

Hepatic vascular exclusion with preservation of the caval flow

Hepatic vascular exclusion with preservation of the caval flow excludes the liver from systemic circulation, thus avoiding caval occlusion. With this method, caval clamping is replaced by hepatic vein clamping. Inflow occlusion is accomplished by clamping of the portal triad, and outflow occlusion by clamping of the hepatic veins (and, if present, clamping of the right inferior hepatic vein) (Fig. 41.7a).

The benefit of this method is a combination of inflow and outflow vascular occlusion without the hemodynamic and biochemical disadvantages of total vascular exclusion or hemorrhage due to venous backflow during the Pringle maneuver alone.

The vascular exclusion can be partial (selective) to the left or the right parts of the liver.

Left partial hepatic vascular occlusion is achieved by selective clamping of the left and middle hepatic veins (outflow occlusion) and complete clamping of the portal triad (inflow occlusion) to avoid middle hepatic vein congestion (Fig. 41.7b). Right partial hepatic vascular occlusion is achieved by selective clamping of the right hepatic vein and right inferior hepatic vein, if present (outflow occlusion), combined with clamping of the right portal pedicle or portal triad (Fig. 41.7c).

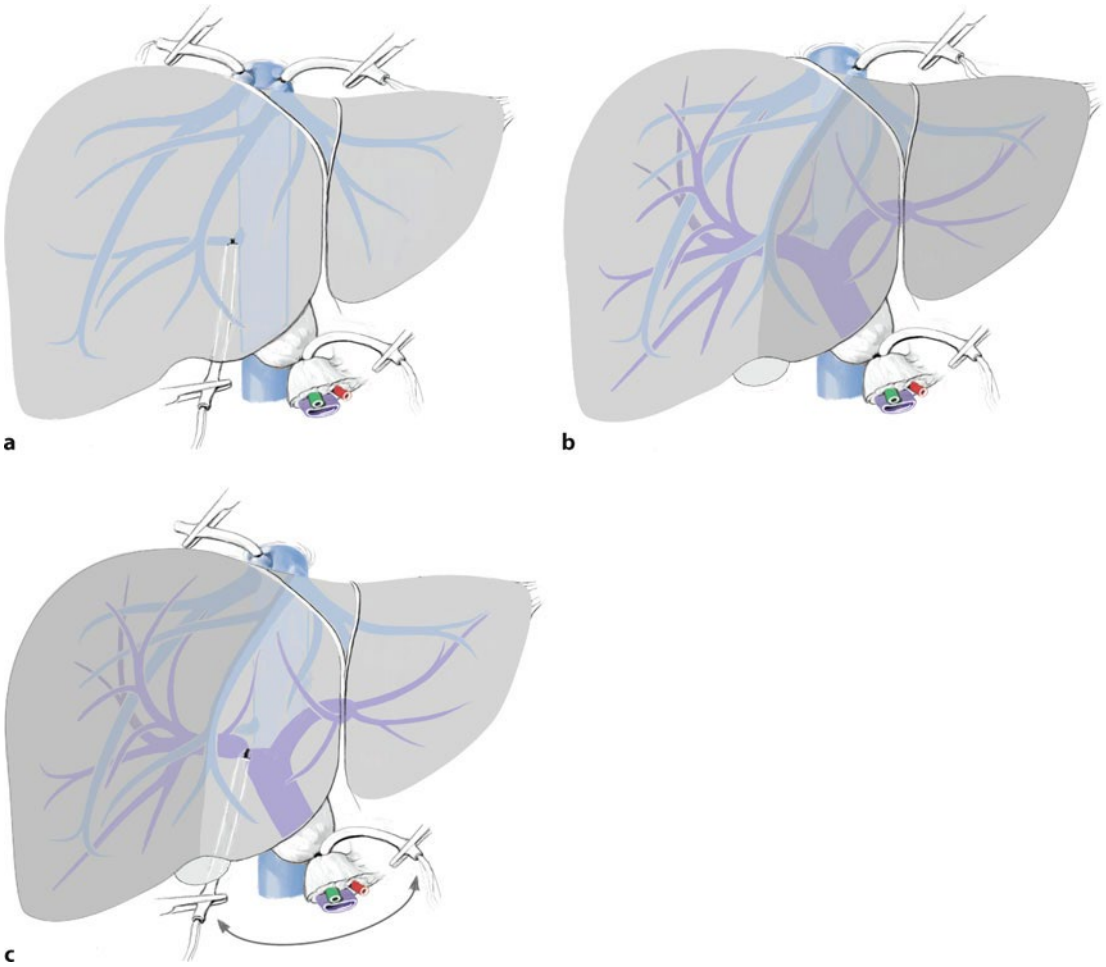


Fig. 41.7

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Reconstruction of the Vena Cava

This technique is an alternative to associated cava reconstruction. It restores liver perfusion while working on the vena cava.

Step 1

Open hepatic outflow by releasing the clamp on the suprahepatic vena cava. Clamp the vena cava again below the hepatic veins (Fig. 41.8).

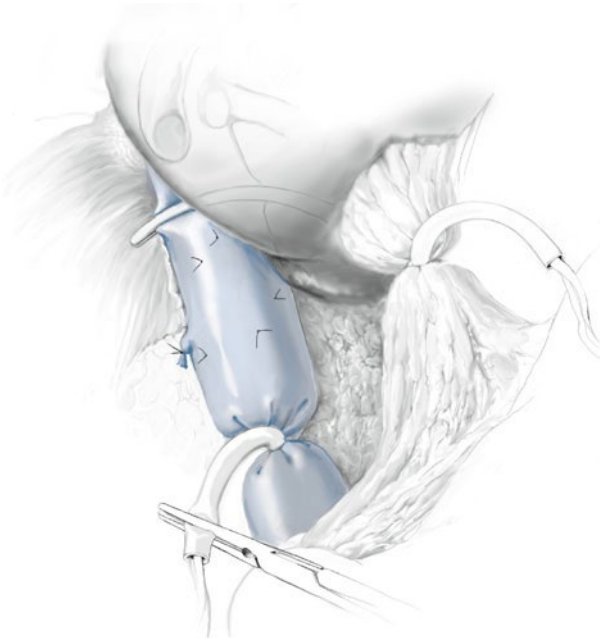


Fig. 41.8

Step 2

Open hepatic inflow by releasing the tourniquet on the hepatoduodenal ligament. Now the retrohepatic cava is occluded while the liver is perfused.

Step 3

The retrohepatic vena cava can now be resected. Reconstruction is accomplished with a Gore-Tex interposition graft in an end-to-end fashion. Then release the cava clamp and the tourniquet on the lower cava (Fig. 41.9).

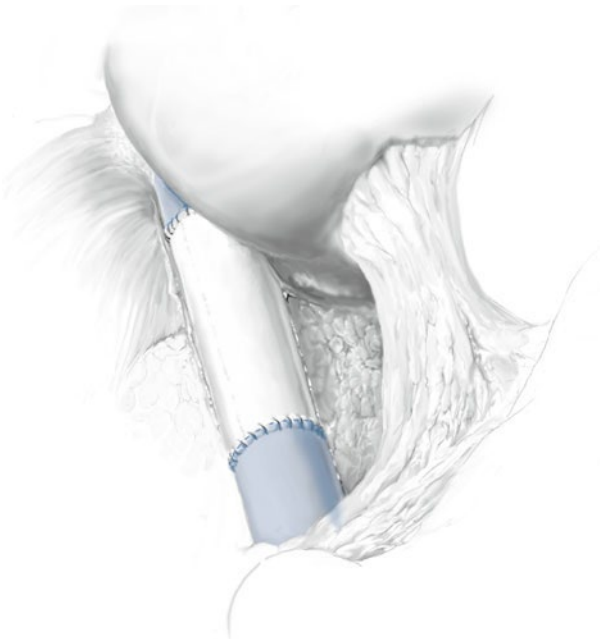


Fig. 41.9

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Tricks of the Senior Surgeon

- Always search for anatomic variants, especially an aberrant left hepatic artery. This artery must be selectively clamped in addition to occlusion of the ligament.
- Best inflow occlusion is accomplished by pushing down the tourniquet, clamping the band right behind it to hold the tension, and then pushing it down again with some force, before fixing it in position by clamping the tourniquet and the band. This can be repeated several times ("milking down technique"). When inflow occlusion is insufficient, especially in a very large hepatoduodenal ligament, a second tourniquet can be placed and occluded.
- When bleeding is encountered under total vascular exclusion, the most likely reason is incomplete inflow occlusion. If an obvious reason cannot be identified, open outflow (but keep inflow occlusion and infrahepatic caval occlusion) and ask the anesthesiologist to lower the CVP.

Acknowledgments

We would like to acknowledge Felix Dahm and Pierre-Alain Clavien who were the authors of this chapter in the first edition of the Atlas.

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Hanging Maneuver for Anatomic Hemihepatectomy (Including Living-Donor Liver Transplantation)

Jacques Belghiti

The hanging maneuver has gained wide acceptance to facilitate the anterior approach. It can be used for resective liver surgery or for living related liver donation.

The Hanging Maneuver

Step 1

Suprahepatic preparation

After the hilar preparation, the anterior leaf of the coronary ligament and the anterior part of the right triangular ligament are dissected to expose confluence between the right and middle hepatic veins. This space between the parenchymal capsula and the anterior surface of the vena is freed by means of a vascular clamp (Fig. 42.1). A nasogastric tube is gently pushed caudally to achieve the tunnelization of the space between the vena cava and the liver. After opening the peritoneum in front of the infrahepatic part of the vena cava, the tube is caught.

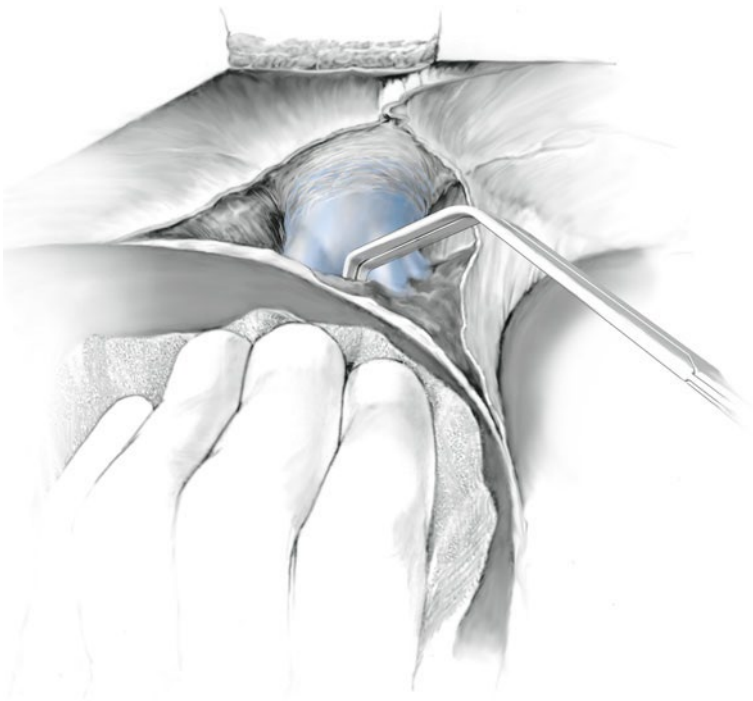


Fig. 42.1

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
DOI 10.1007/978-3-662-46546-2_42, © Springer-Verlag Berlin Heidelberg 2016

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Step 2

Infrahepatic preparation of the vena cava

This former approach was initially performed preparing the tunnel with ligation of one or two short veins to the caudate lobe if needed. The tunnel is prepared by carefully opening the avascular plane between the liver and the anterior surface of the vena cava with scissors. A tape is passed with an aortic clamp from the right side of the median hepatic vein along the retrohepatic inferior vena cava (IVC) to the inferior part of segment 1 (Fig. 42.2a), which is divided to place the tape near the right portal pedicle (Fig. 42.2b).

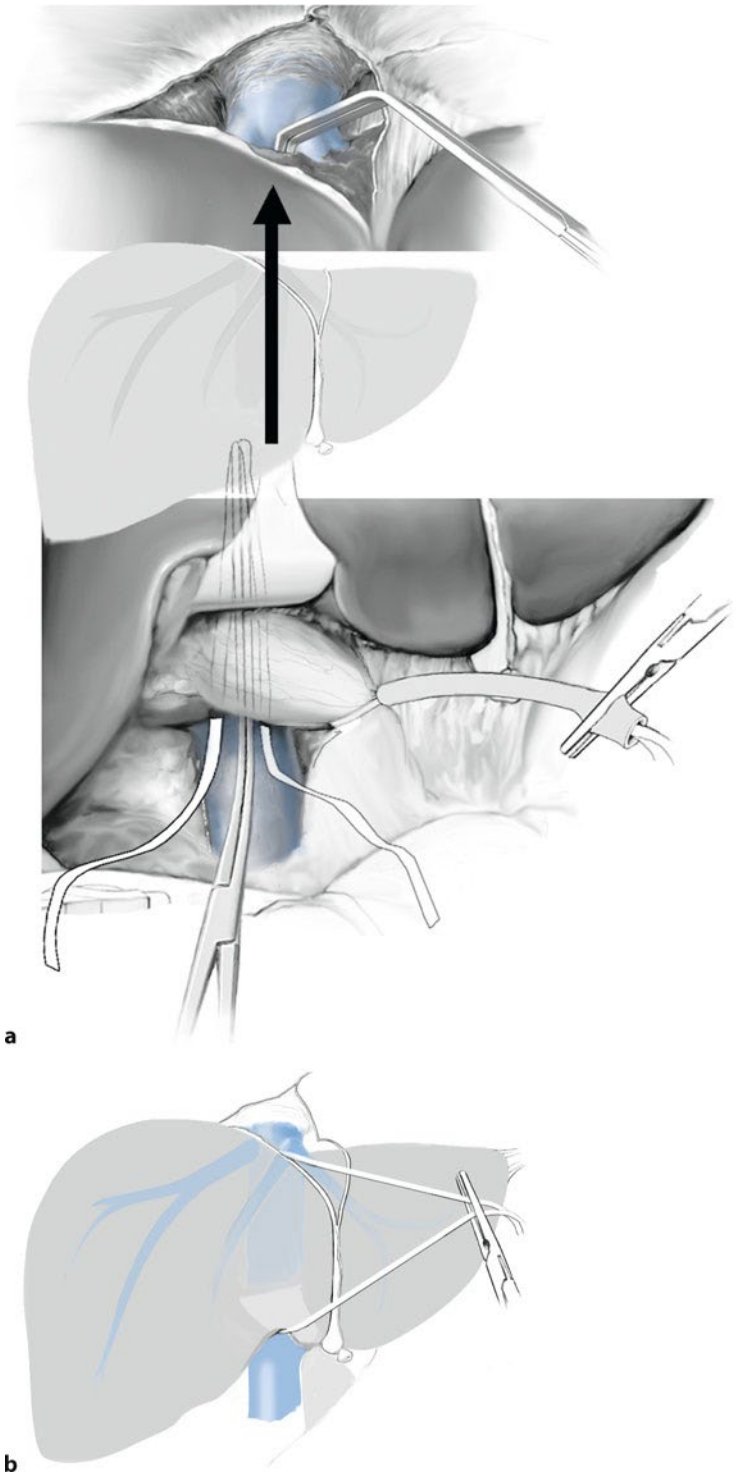


Fig. 42.2

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Step 3

Parenchymal transsection

Slight traction on the tape allows easy identification of the right plane of parenchymal transsection. The technique of parenchymal transsection is performed according to the surgeon's preference. The hanging allows elevation of the parenchyma in front of the vena cava, facilitating identification of vessels. Traction reduces the outflow from the middle and left hepatic veins, representing a localized total vascular occlusion when hanging is associated with inflow occlusion. In living liver harvesting, the inferior part of the tape is passed behind the right portal pedicle. At the end of the transsection, the two hemilivers are completely divided, joined together only by hilar vessels and hepatic veins (Fig. 42.3).

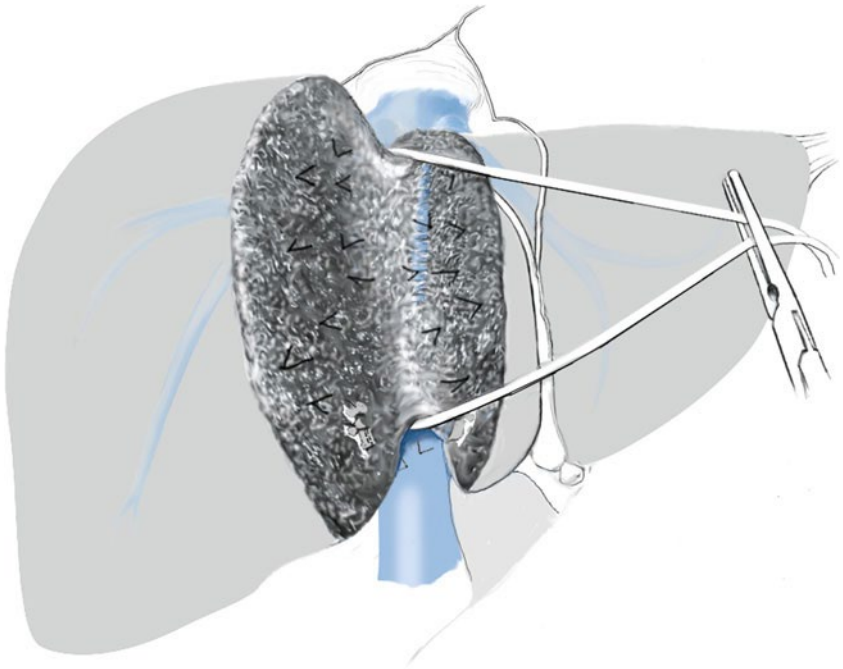


Fig. 42.3

۰۲۱-۶۶۱۹۸۵۱۴ www.myuptodate.com دریافت آخرین نسخه آپتودیت آفلاین

Modified Hanging Maneuver for Middle Hepatic Vein Harvesting

For the harvest of the middle hepatic vein in a living-donor procedure or for an oncologic extended resection, the hanging maneuver is adapted in order to facilitate transsection along the left side of the vein. First, the hepatotomy is started on the top, near the median hepatic trunk, which allows identification of the left hepatic vein and the median hepatic vein (Fig. 42.4a).

Once the median hepatic vein has been freed, the tape is switched to the left side of the middle hepatic vein (Fig. 42.4b), and the procedure is continued as described in Step 3.

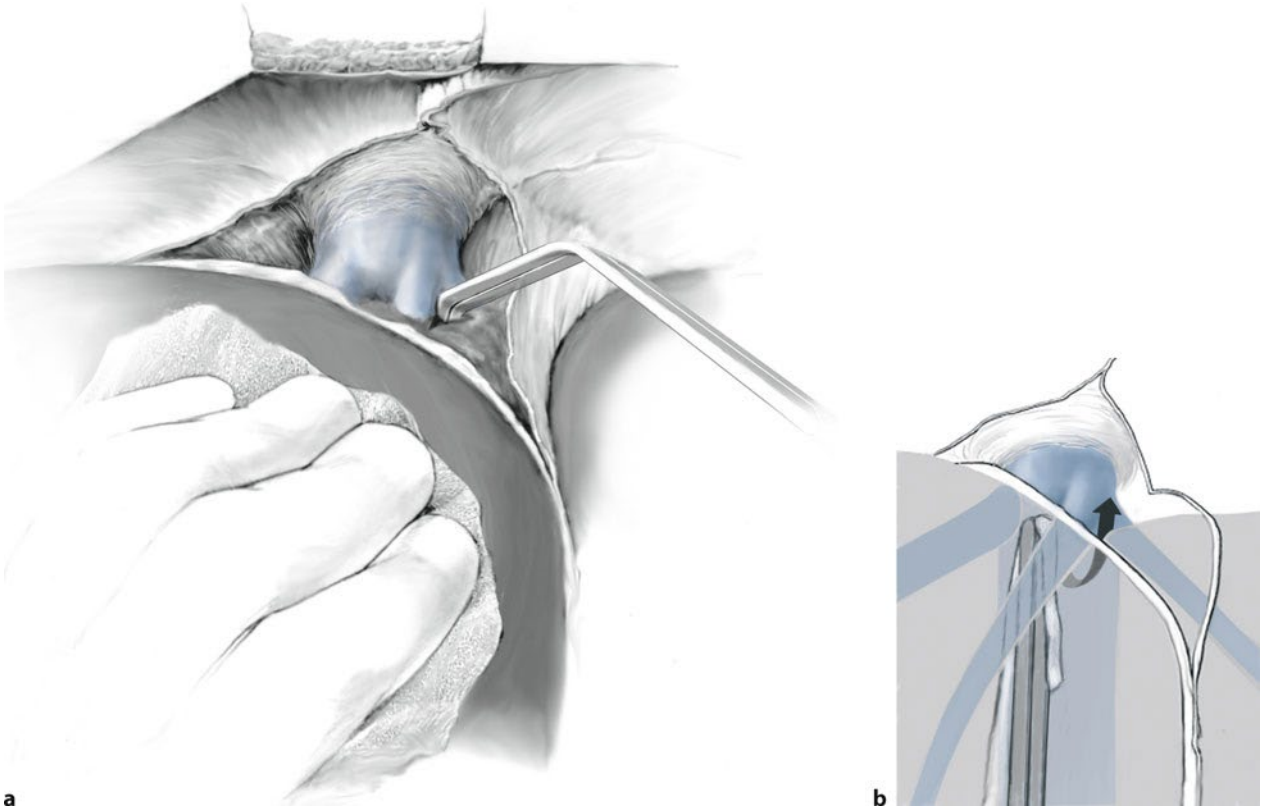


Fig. 42.4

Tricks of the Senior Surgeon

- Failures of this maneuver are mainly related to misplacement of the tube under the capsule of the liver which may cause bleeding. In these situations which account in inflammatory adhesions, in previous caval dissection or inflammatory process, the maneuver should simply be aborted and bleeding stop spontaneously.
- Dissection on the upper part of the liver should be favored, because it facilitates the identification of the right plane in front of the IVC.

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Anterior Approach for Liver Resections

See Ching Chan, Sheung Tat Fan

The anterior approach for liver resection is a no-touch technique that prevents iatrogenic rupture or compression of liver tumors. For right liver tumors that are large, this approach is necessary because rotation of the right liver to the left for division of short hepatic veins is not feasible. Such rotation is also undesirable, as the inflow and outflow of the remnant liver will be compromised. Avoidance of compression on the tumor also reduces the chance of shedding of tumor cells into the circulation and thus may confer a better survival for the patient.

Hilar dissection and division of the ipsilateral inflow are performed methodically and are followed by precise liver transection using the cavitron ultrasonic surgical aspirator (CUSA). Smaller vessels are controlled by titanium clips, and larger ones are plicated with Prolene sutures. For right hepatectomy, the transection follows the Cantlie line and may include the middle hepatic vein if it is oncologically indicated. On approaching the inferior vena cava (IVC), the short hepatic veins are divided between ligatures. Delivery of the liver resection specimen is preceded by division of the ipsilateral hepatic vein(s) by endovascular staplers. In the case of extended right hepatectomy, the middle hepatic vein is divided first, followed by division of the right hepatic vein and the inferior vena caval ligament, and then taking down of the right coronary ligament. Should the right adrenal gland be adherent to the right liver, bleeding from it must be controlled by plication with 4/0 sutures. To prevent rotation of the remnant left liver to the right subphrenic space, the falciform ligament is reconstituted by suturing with nonabsorbable sutures.

This chapter describes right hepatectomy using the anterior approach, but this approach is also applicable to left hepatectomy.

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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Procedure

Step 1

Access to the right liver

The abdomen is opened via a right subcostal incision with an upward midline extension. After division of the round ligament between ligatures, the falciform ligament is then taken down by electrocautery. A Bookwalter retractor will provide excellent exposure of the liver. A laparotomy is performed to identify any extrahepatic malignancies (Fig. 43.1).

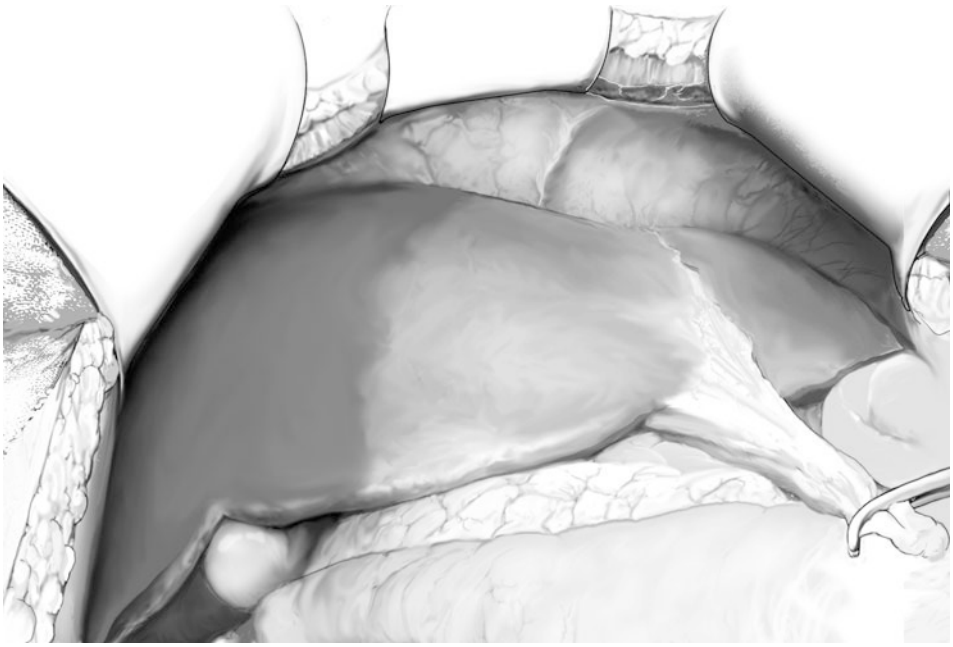


Fig. 43.1

Step 2

Assessment of resectability by intraoperative ultrasonography

Intraoperative ultrasonography (IOUS) is carried out to delineate the extent of a tumor, to detect the presence of multiple tumor nodules, and to exclude tumors in the left liver. Tumor involvement by hepatocellular carcinoma of the main or left portal vein should be identified. More proximal control of the portal inflow and the left portal vein has to be anticipated in such cases. Doppler ultrasonography will also register the patency, flow, and pulsatility of vessels in the future remnant left liver; these should be verified on completion of the right hepatectomy, to ascertain the viability of the left liver (Fig. 43.2).

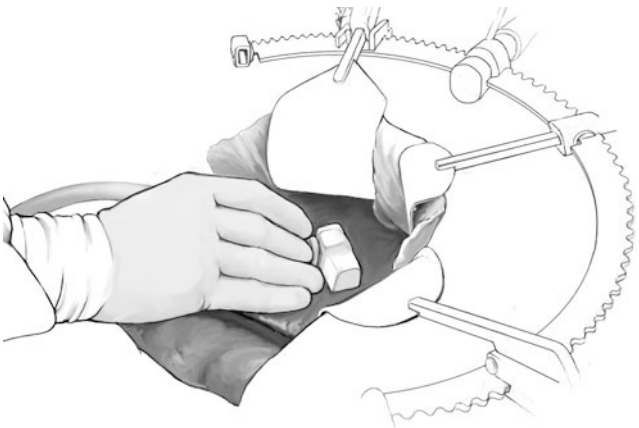


Fig. 43.2

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Step 3

Isolation and division of right portal vein and right hepatic artery

The right liver containing the tumor is not mobilized as in the conventional approach. The liver is gently retracted in the cephalic direction with a self-retained Dever retractor, or (even better) with a medium-size malleable retractor. After ligation and division of the cystic artery, the gallbladder is removed from its bed by cautery. The cystic duct is cannulated with a Fr 3.5 Argyle catheter. The gallbladder is then excised.

Hilar dissection is performed to expose and isolate the right hepatic artery and right portal vein. Temporary control of these vessels will demonstrate the demarcation between the right and left livers (Cantlie line). The patency of the left hepatic artery and portal vein is then confirmed by IOUS. For tumors confined to the right liver, the Cantlie line will be the liver transection line and can be marked with electrocautery. A tumor crossing the middle hepatic vein (MHV) and involving segment 4 necessitates resection of segment 4. The liver transection line to be marked is thus made with reference to the left border of the tumor as guided by IOUS (Fig. 43.3).

The transection line on the inferior surface of the liver is marked accordingly. On approaching the stumps of the already divided right portal vein, the planned line of transection must be on the right side of the common hepatic duct to avoid injuring it.

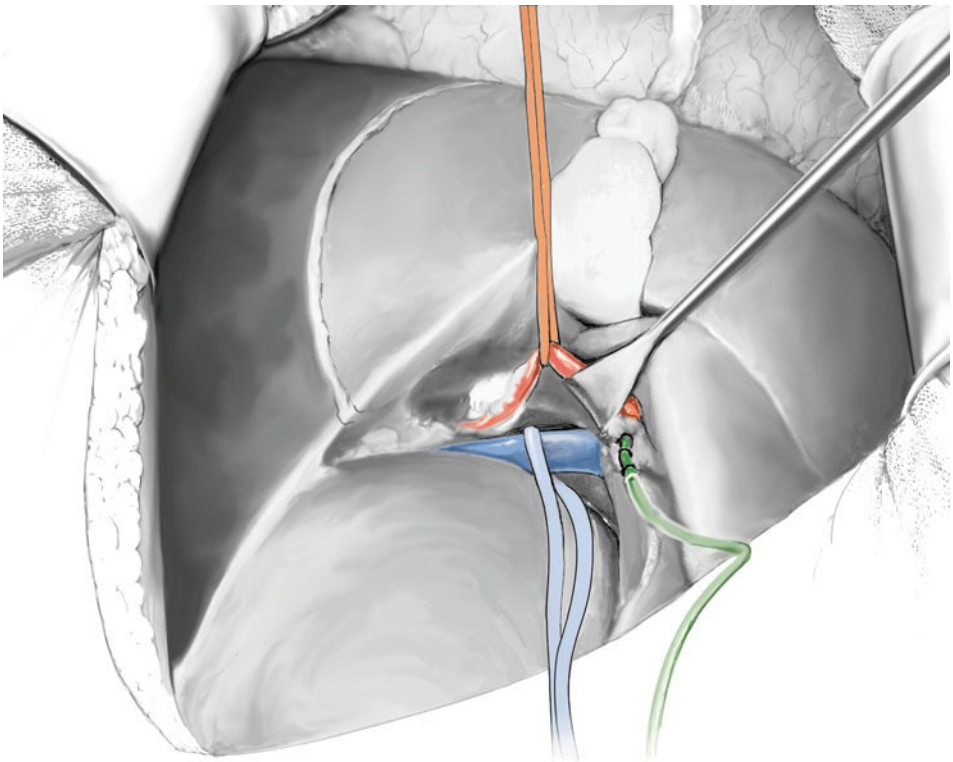


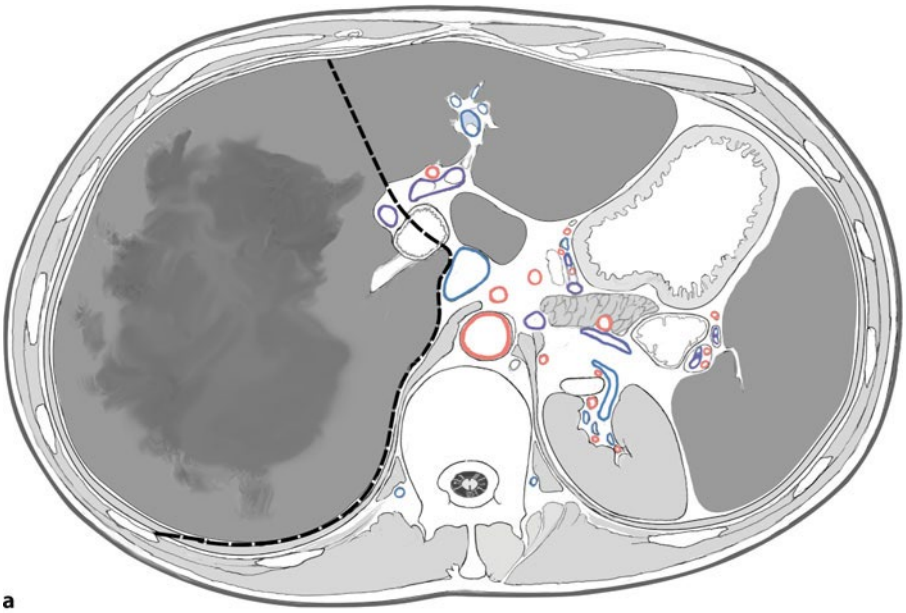
Fig. 43.3

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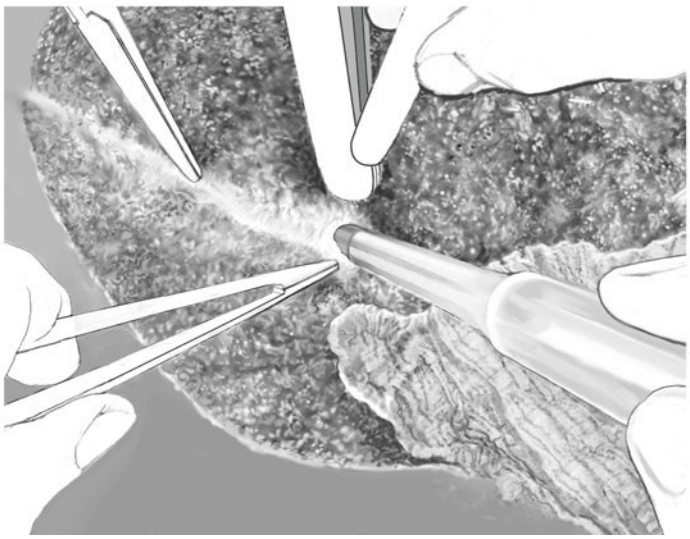
Step 4

Parenchymal transection with ultrasonic dissector

Liver transection is performed using the CUSA (Fig. 43.4a). The Pringle maneuver for inflow control is usually not required. By inserting a 4/0 Maxon suture on each side of the liver transection line, gentle traction is provided to facilitate liver transection. Starting from the liver edge, the liver transection is along the plane defined by the marking on the anterior and inferior surfaces of the liver (Fig. 43.4a). Tiny vessels are cauterized and fine vessels are clipped before dividing with scissors. A low central venous pressure facilitates the liver transection by reducing bleeding and thus providing a clearer view. For right hepatectomy sparing the MHV, the right side of the MHV is exposed without leaving ischemic liver tissue on it. The MHV serves as a guide for the liver transection. IOUS is repeated to guide transection with an adequate margin from the tumor.



a



b

Fig. 43.4

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Step 5

Division of right hepatic duct

As liver transection continues to the liver hilum, the right hepatic duct surrounded by the hilar plate will be encountered. Use of cautery for hemostasis in this area is avoided in order not to damage the hilar plate and render the suture applied to the right hepatic duct stump in due course insecure. Right portal vein branches with early bifurcation or in trifurcation with the left portal vein are often associated with a right posterior duct inserting separately into the left hepatic duct. If the tumor is near the right hepatic duct and requires higher precision in right hepatic duct division, an operative cholangiogram will become useful. The planned line of right hepatic duct division is marked with a large metal clip (Fig. 43.5).

Given the normal anatomy of caudate branches inserting into the hilar plate posteriorly, isolation of the right hepatic duct prior to its division is not always practical, but it is always feasible to divide the right hepatic duct by a pair of scissors, starting anteriorly. Any arterial bleeders encountered are plicated with 6/0 Prolene in the process of duct division. The right hepatic duct orifices are sutured with 5/0 polydioxanone suture (PDS).

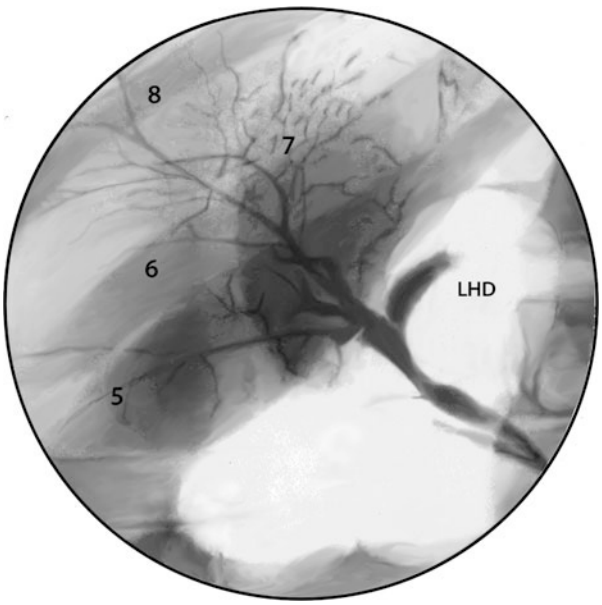


Fig. 43.5

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Step 6

Division of short hepatic veins

The paracaval portion of the caudate lobe is then transected with the CUSA, thus exposing the infrahepatic portion of the IVC. With blunt dissecting forceps, the plane between the back of the caudate lobe and the IVC is separated. By lifting up the liver tissue using the dissecting forceps, transection of the caudate lobe is expedited. The liver transection is completed, and the right side of the IVC is exposed.

If the tumor encroaches on the caudate lobe, necessitating resection of the caudate lobe and segment 4, then, after detachment of the right hepatic duct, the transection proceeds to the junction between the left lobe and the caudate lobe. The MHV is exposed at the junction with the left hepatic vein and divided by an endovascular stapler. The caudate lobe is now exposed, and it is then detached from the hilar plate and from the left and anterior surface of the IVC by dividing the short hepatic vein branches and ligamentum venosum (Arantius ligament). The caudate lobe is retracted toward the right side.

Continued dissection in the plane between the caudate process and the right side of the IVC will expose the inferior right hepatic vein, middle right hepatic vein, and right hepatic vein. The short hepatic veins and the inferior and middle right hepatic veins, if present, are ligated and plicated as necessary (Fig. 43.6).

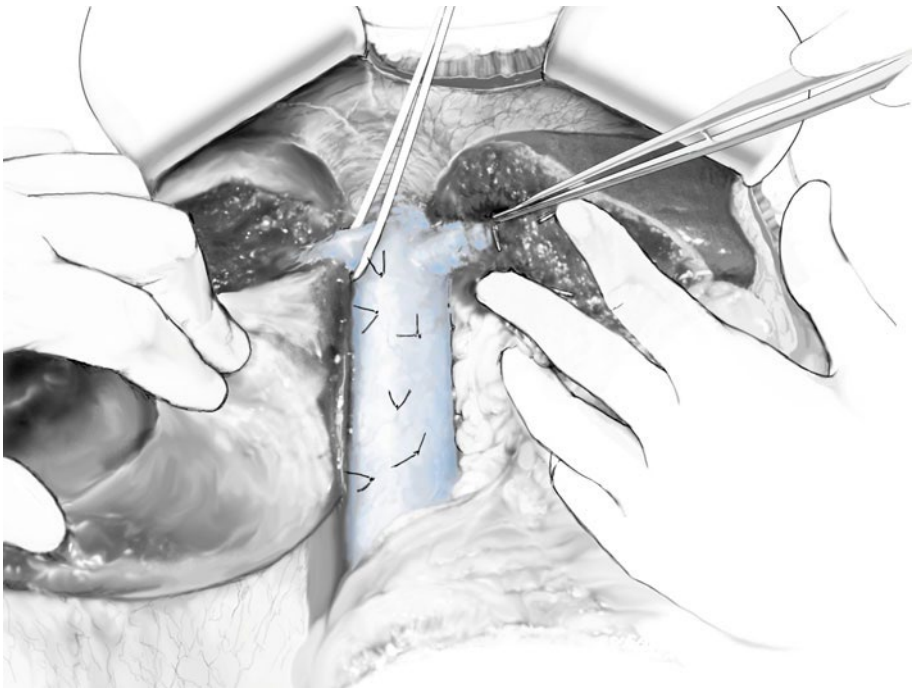


Fig. 43.6

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Step 7

Division of right hepatic vein

The right hepatic vein is divided with an endovascular stapler (ATW35, Ethicon EndoSurgery, Inc, Cincinnati, Ohio). The IVC ligament is ligated and divided on the right side of the IVC. It is mandatory to plicate the stump of the IVC ligament with 5/0 Prolene to prevent bleeding from later dislodgement of the ligature (Fig. 43.7).

When the right liver is completely disconnected from the IVC, the right liver is mobilized from the right abdominal cavity by dividing the triangular ligament, and it is delivered. Tumor invading or in close proximity to the right diaphragm requires resection of the portion of the diaphragm in continuity with the right liver.

If the right liver has a large tumor with established collateral blood supply from the diaphragm, the tumor will swell after division of the right hepatic vein. The engorged right liver may compress the IVC, leading to reduced venous return to the heart and hypotension. Lifting up the right liver and swiftly separating it from the retroperitoneum with electrocautery is necessary. If difficulty is encountered, cutting into the diaphragm will facilitate lifting the specimen out of the abdominal cavity. The diaphragmatic defect is closed with 2/0 Prolene; a chest drain is not necessary.

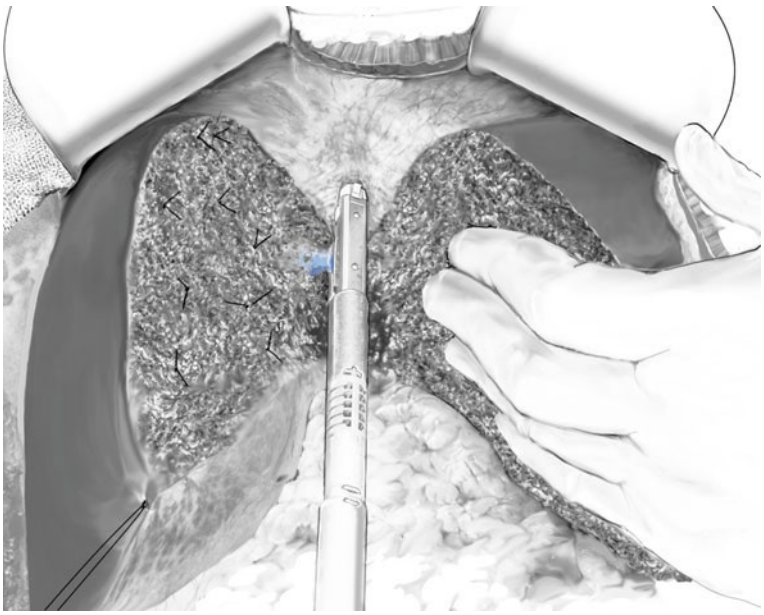


Fig. 43.7

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Step 8

Checking hemostasis and bile leak

At this time, the central venous volume can be restored by administering intravenous fluid. Doing so enhances the identification of bleeding from venules that have collapsed because of low central venous pressure. Indigo carmine is instilled gently via the Argyle catheter in the cystic duct to show any defect in the duct system (Fig. 43.8a). The cystic duct is ligated with 2/0 Vicryl.

IOUS is performed to ascertain patency of the left portal vein and left hepatic artery, as well as good pulsatility of the left hepatic vein. The falciform ligament is reconstituted by suturing with mattress sutures of 5/0 Prolene (Fig. 43.8b).

The abdomen is closed; deployment of an abdominal drain is seldom necessary.

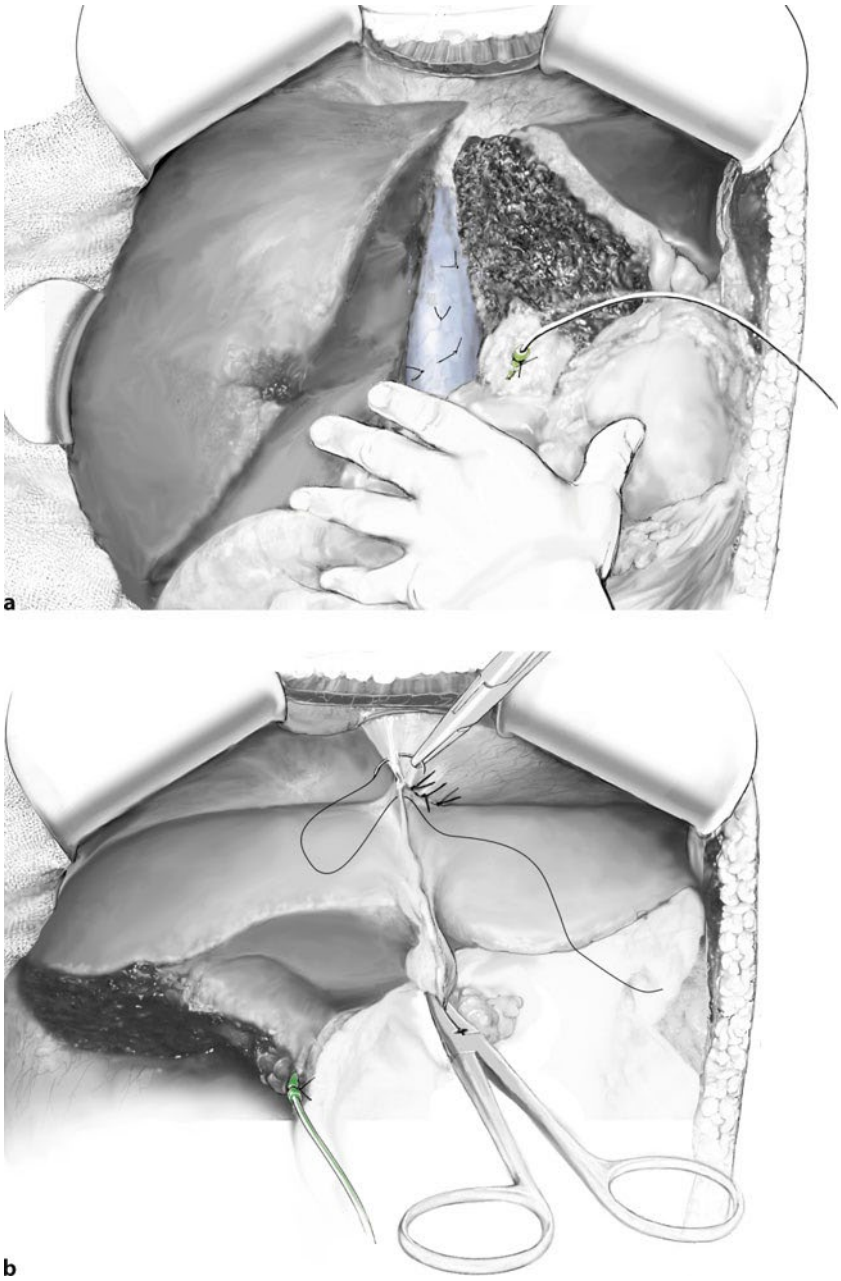


Fig. 43.8

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Tricks of the Senior Surgeon

- Low central venous pressure (by fluid restriction, muscle relaxation, head-up position, and deep anesthesia) minimizes blood loss during liver transection.
- Adequate cooling of the tip of the CUSA by saline maintains good functioning of the instrument for efficient parenchymal transection.

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Techniques of Liver Parenchyma Transection

Christoph Tschuor, Mickaël Lesurtel

Dissection of liver parenchyma may cause complications including blood loss, hematoma, infection, bile leakage, and liver failure. Various surgical techniques have been developed for careful and safe transection of the liver parenchyma to prevent intraoperative and postoperative complications.

The aim of this chapter is to give an overview of the techniques and devices frequently used to perform parenchyma transection of the liver.

Preparation for Parenchyma Dissection

The liver capsule is incised with diathermy on the resection line. For a better exposure, two stay sutures (2-0 silk) can be placed at the inferior margin of the liver, one on each side of the resection line. These stay sutures are used to lift up the liver and better expose the resection line. Care should be taken not to pull and tear the liver parenchyma, leading to bleeding.

To prevent unnecessary liver ischemia, the Pringle maneuver for continuous or intermittent inflow occlusion is applied individually, depending on the intraoperative surgical situation. Indeed, the techniques other than the clamp-crush were developed to avoid use of the Pringle maneuver and to minimize the risk of liver ischemia.

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Techniques and Devices

Clamp-crush technique and bipolar forceps

A small clamp (Kelly) is used to crush parenchyma between its blades in order to isolate vessels and bile ducts (Fig. 44.1a,b). Fine branches of Glisson's tree or tiny tributaries of hepatic veins (< 3 mm) are coagulated using an irrigated bipolar forceps and are cut by scissors (Fig. 44.1c). Bipolar forceps cautery is equipped with a channel for water dripping, which prevents adhesion of debris to the cautery blades. Bigger identified vessels or bile ducts (> 3 mm) are ligated or clipped on the remnant liver slice before cutting. The alternative is to use clips only to secure vessels and bile ducts.

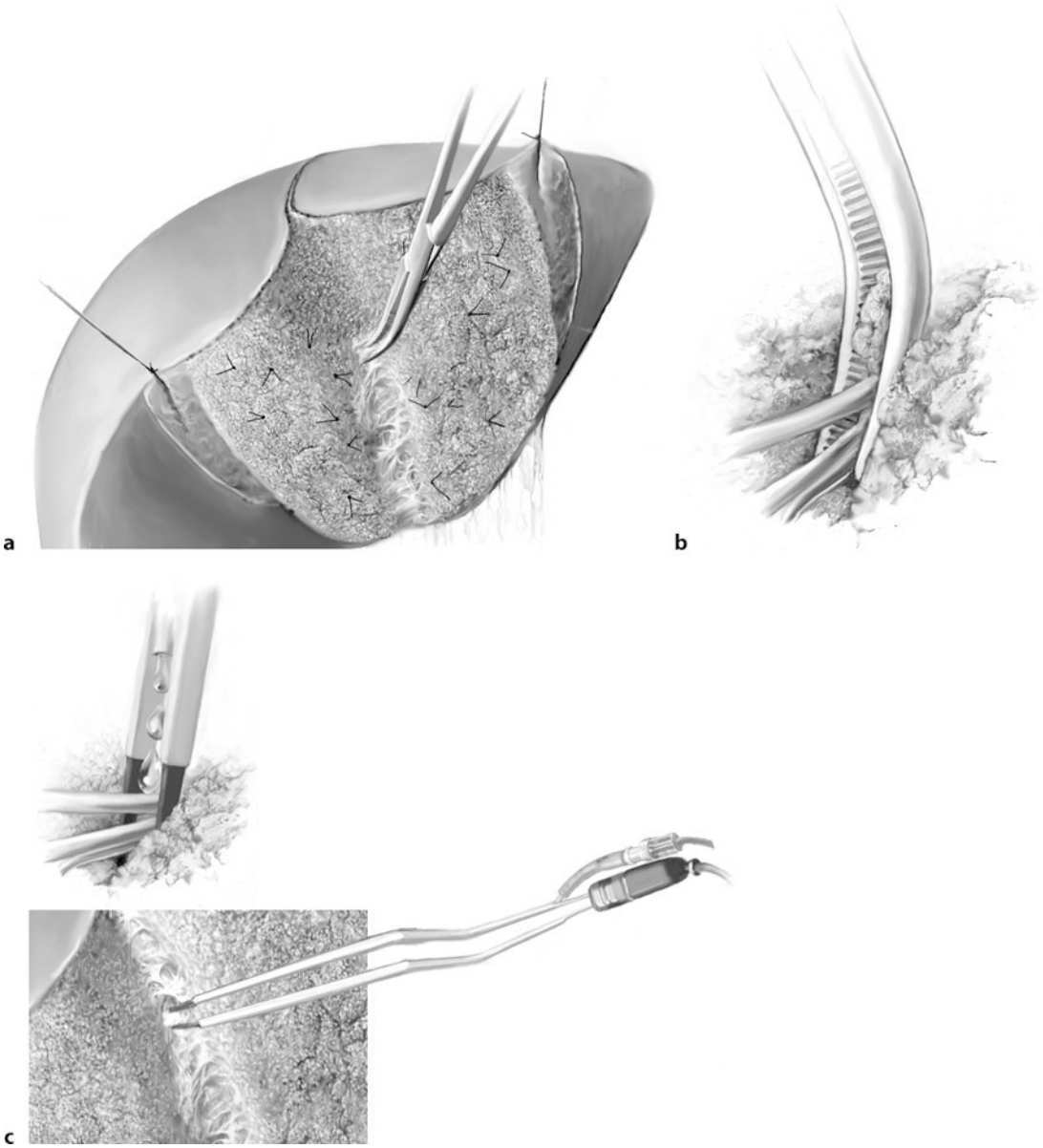


Fig. 44.1

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Water jet dissection (Helix Hydro-Jet, ERBE)

With this device, the liver parenchyma is dissected by a jet of water (Fig. 44.2a). Saline is pressurized by a high-pressure pump and is conducted by a high-pressure hose to the nozzle. Here the pressure is converted into kinetic energy. For liver parenchyma, pressures of 30–50 bar should be used. The soft liver tissue is washed off the more resistant vessels and bile ducts (Fig. 44.2b). The applicator should be used in direct contact with the tissue and moved like a paintbrush. It can be used in combination with suction and with an electrosurgical unit. Vessels and bile ducts are isolated and can be secured using bipolar forceps, clips, or ligatures, as with the clamp-crush technique. They can then be transected under controlled conditions.

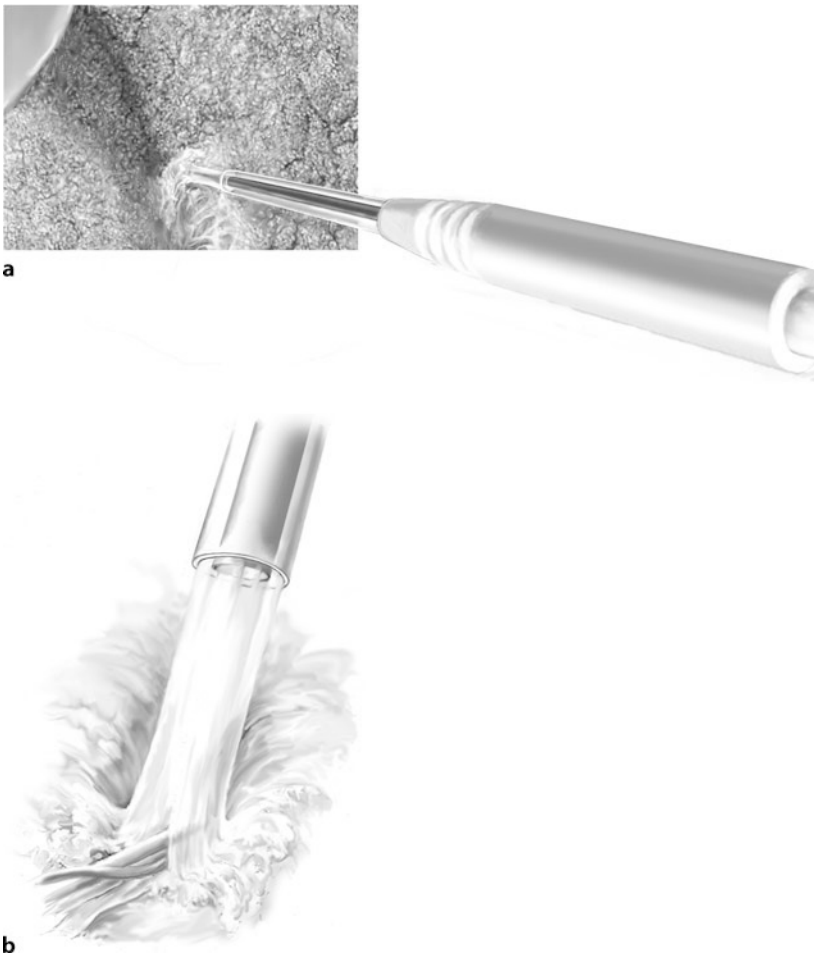


Fig. 44.2

Ultrasonic dissection (Cavitron ultrasonic surgical aspirator [CUSA] or Dissectron, Integra NeuroSciences)

The principle of ultrasonic dissection is that a cavitational effect occurs at the tip of the vibrating rod of the device. The handpiece delivers ultrasonic vibration and provides simultaneous aspiration and irrigation (Fig. 44.3a). The ultrasonic probe divides parenchymal cells (because of their high water content) by the cavitational effect with less injury to structures with a high content of fibrous tissue, such as bile ducts and blood vessels (Fig. 44.3b). Once skeletonized by the probe, these elements are then clipped, ligated, or coagulated, as with the other techniques. Additional electrocoagulation functions are optionally available. The ultrasonic and high-frequency currents can be activated simultaneously to divide and coagulate vessels, ducts, and nerves.

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Fig. 44.3

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Ultrasound cutting (Harmonic, Ethicon EndoSurgery)

The ultrasound cutting system includes an ultrasound generator with a foot switch, a reusable handle for the scalpel, and the cutting device with scissors. The electrical energy provided by the generator is converted into mechanical energy by the handpiece through a piezoelectric crystal system. The blade or tip of the instrument being used vibrates axially with a constant frequency of 55,500 Hz (Fig. 44.4). The longitudinal extension of the vibration can be varied between 25 and 100 mm in five levels, by adjusting the power setting of the generator. The cutting derives from a saw mechanism in the direction of the vibrating high-frequency blade. The intracellular generation of vacuoles (cavitation) brings about the correct transection of the liver parenchyma. Blood vessels up to 2 or 3 mm in diameter are coagulated on contact of the tissue with the vibrating metal. For coagulation of larger vessels, exertion of pressure between blades for 3 to 5 is required. Especially in the periphery, the harmonic scalpel allows the liver parenchyma to be divided without causing bleeding, bile leakage, or trauma. It is especially used for laparoscopic transection because of its speed of action and ease of use. Its use in the depth of the liver may lead to vascular injury, however, especially to hepatic veins. For this reason, larger vessels in depth should be secured with clips or sutures.

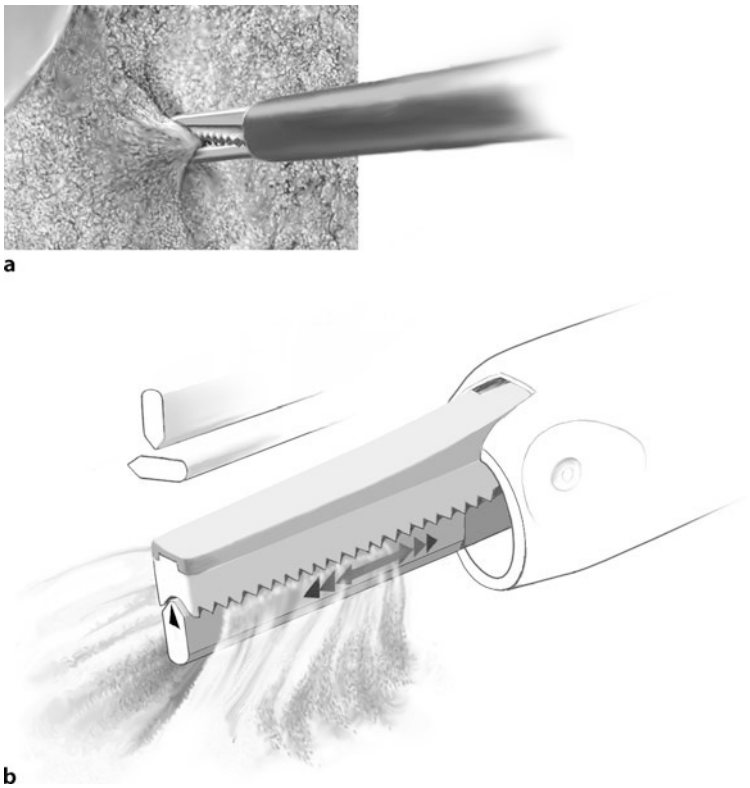


Fig. 44.4

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Dissecting sealer (TissueLink or Aquamantys; Medtronic; Minneapolis, MN, USA)

The Medtronic dissecting sealer uses proprietary technology to coagulate and seal tissue to provide hemostasis before and after transection. It delivers radiofrequency (RF) energy through a conductive fluid (saline) to coagulate and seal tissue (Fig. 44.5). The saline couples the RF energy into tissue and cools the tissue so that the temperature never exceeds 100 °C. The result is hemostasis via collagen shrinking without the tissue desiccation, smoking, arcing, and char of conventional electrosurgery. The dissecting sealer is applied directly to the target tissue. It is important to maintain constant contact with the liver and to move the device in a "painting" motion to ensure effective application of energy. Vessels less than 5 mm in diameter encountered through skeletonization can be completely coagulated within 10 seconds and can thereafter be transected. Larger vessels should be secured by clips or sutures.

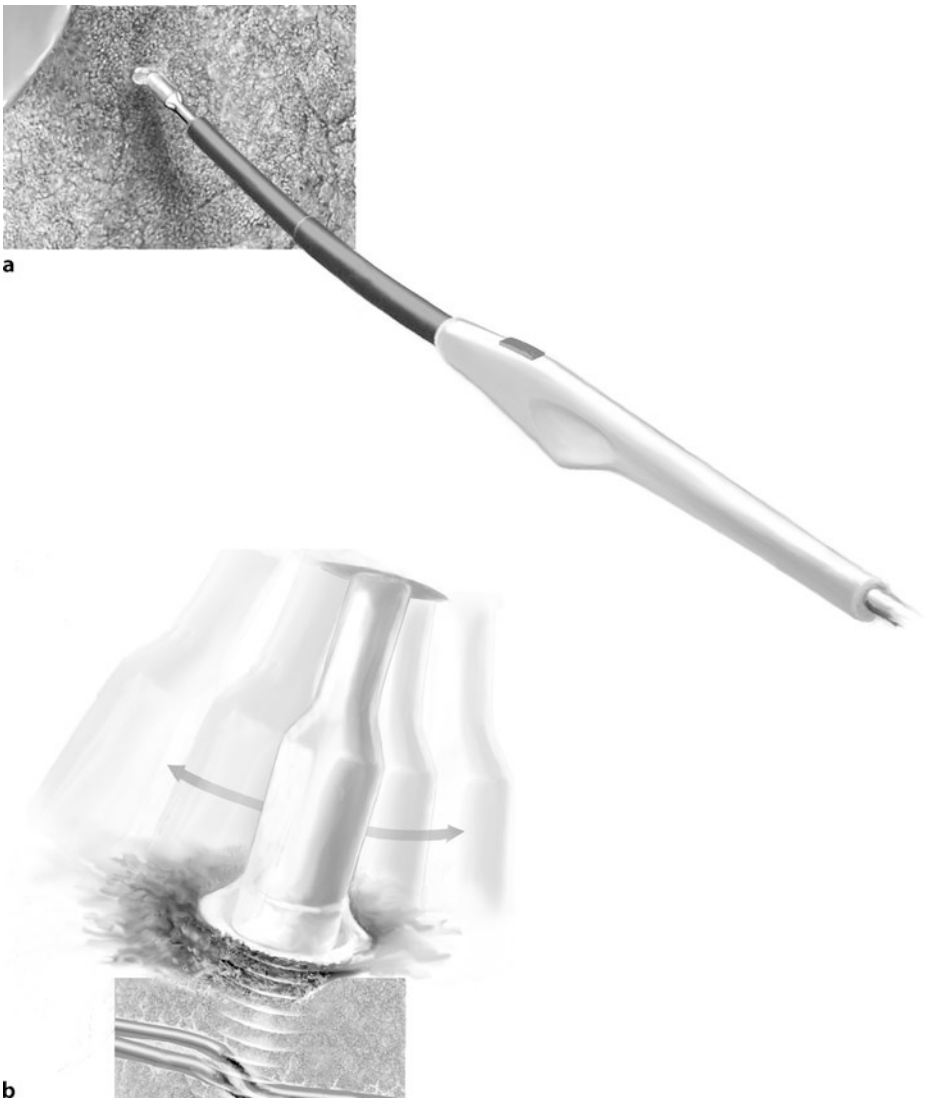


Fig. 44.5

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Bipolar resection device (Habib 4X, AngioDynamics)

The Habib 4X device is used to transmit bipolar radiofrequency energy to provide intraoperative coagulation of tissue by a four-electrode bipolar resection device. The device creates a plane of coagulative necrosis along the intended line of transection by heating cells, causing them to dehydrate and denaturate. The tissue can subsequently be divided with a conventional scalpel through this zone of necrosis. The advantages of the Habib 4X bipolar resection device are reduced blood loss, shorter operating time, and the ability to perform nonclamping surgery, avoiding adverse effects from warm ischemia. There is also a laparoscopic variant of the Habib 4X device (Fig. 44.6).

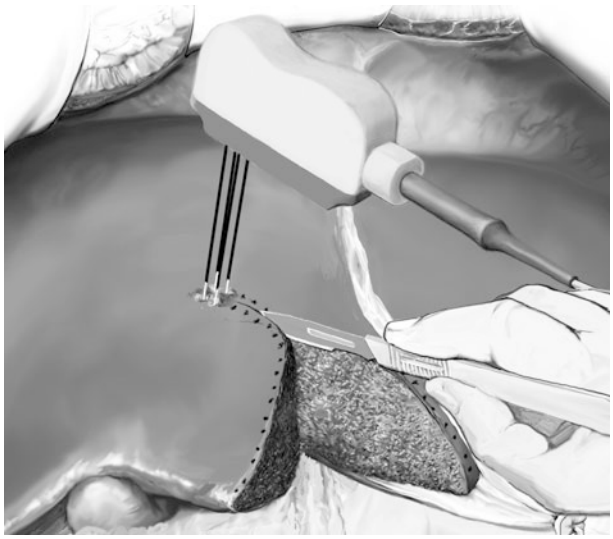


Fig. 44.6

Tricks of the Senior Surgeon

- The different devices can be used in the same intervention, as they may offer different and cumulative advantages.
- During laparoscopic liver resection, the harmonic scalpel is useful because it can coagulate and divide the hepatic parenchyma during the same application, avoiding the need to change instruments.
- Regardless of the technique used, central venous pressure must be kept low (< 5 mm Hg) during parenchyma transection to minimize blood loss.
- Regardless of the device used, inflow occlusion should be used loosely in case of significant bleeding during transection.

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Liver Resections

Dimitri A. Raptis, Pierre-Alain Clavien

Indications and Contraindications

Indications

- Primary and secondary malignancy (e. g., hepatocellular carcinoma, intrahepatic cholangiocarcinoma, colorectal metastases, neuroendocrine tumors)
- Benign neoplasia (*eg*, adenoma, giant hemangioma)
- *Echinococcus multilocularis* (*alveolaris*)
- Abscesses refractory to conservative management
- Other benign diseases (e. g., Caroli syndrome)
- Living-donor liver transplantation (modified technique; see ▶ Chap. 63, "Living-Donor Transplantation: Left Hemiliver Donor Procedure and Implantation")
- Klatskin's tumor (modified approach to the bile duct; see ▶ Sect. 4)
- Traumatic liver lesions

Contraindications

- Acute hepatitis (viral or alcoholic)
- Severe chronic hepatitis
- Poor liver reserve (*e.g.*, Child-Pugh class C cirrhosis)
- Severe portal hypertension (*eg*, esophageal varices, ascites, or hepatic venous pressure gradient > 10 mm Hg)
- Severe coagulopathy despite vitamin K administration
- Severe thrombopenia (platelet count < 30,000/mm^3)

Preoperative Investigation and Preparation for the Procedure

- *History:* Alcohol, hepatitis, and hepatotoxic medication, blood transfusions, tattoos, etc.
- *Clinical evaluation:* Encephalopathy, ascites, jaundice, nutritional status, signs of portal hypertension
- *Laboratory tests:* ALT, AST, bilirubin, alkaline phosphatase, albumin, coagulation parameters (PT, platelets), tumor markers, and serologies (e. g., hepatitis, echinococcus) when indicated
- *CT scan or MRI:* Assessment of liver volume (for major resections) and resectability of the lesion
- *PET scan:* Searching for extrahepatic lesions (e. g., colorectal metastases)

Postoperative Tests

- Postoperative surveillance in an intensive or intermediate care unit
- Coagulation parameters and hemoglobin for at least 48 h
- Daily check for clinical signs of liver failure, such as jaundice and encephalopathy

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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Postoperative Complications

- **Short-term:**
  - Pleural effusion
  - Ascites
  - Liver failure
  - Intra-abdominal bleeding
  - Bile leak
  - Subphrenic abscess
  - Portal vein thrombosis

- **Long-term:**
  - Biloma
  - Biliary stricture
  - Bronchobiliary fistula

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Right Hemihepatectomy

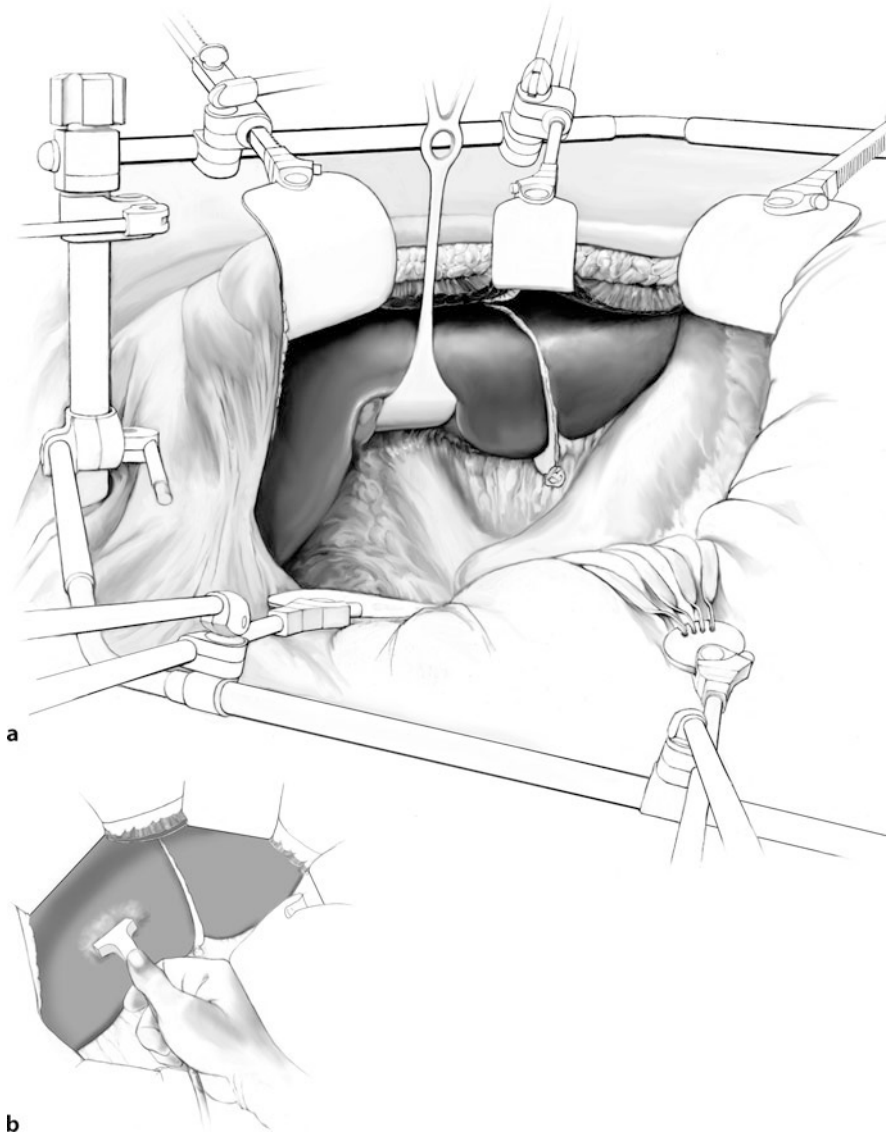
Christoph Tschuor, Pierre-Alain Clavien

Procedure

Step 1

Access, exposure, and exploration

After the right subcostal incision, the falciform and round ligaments are divided. The retractor (e. g., Thompson) is installed and the site is exposed (◘ Fig. 46.1a). The abdomen is explored and the tumor number and size, as well as their location in relation to vascular structures, are evaluated by intraoperative ultrasound. A definitive decision regarding resectability of the lesion is made (◘ Fig. 46.1b).



◘ **Fig. 46.1**

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery*,
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Step 2

Mobilization of the right lobe

The right lobe is mobilized by dissecting the anterior leaf of the coronary ligament and the right triangular ligament. Therefore the assistant retracts the liver inferiorly and to the left using a gauze swab. The Thompson finger blade retracting the stomach and the duodenum should be removed during this step of the procedure.

Approaching the cava, the ligament can be exposed using a right angle or a Kelly clamp (Fig. 46.2a). Ligaments can be well presented by passing a finger between the diaphragm and the coronary ligament (Fig. 46.2b). Care must be taken to protect the phrenic vessel and secure hemostasis from phrenic collaterals.

Next, the Pringle maneuver is prepared as shown in ▶ Chap. 41, "Techniques of Vascular Clamping, Vascular Exclusion, and Caval Resection in Liver Surgery". The falciform, round, and right coronary ligaments are divided and the gallbladder is removed as described in ▶ Chap. 67, "Laparoscopic Cholecystectomy, Open Cholecystectomy, and Cholecystostomy".

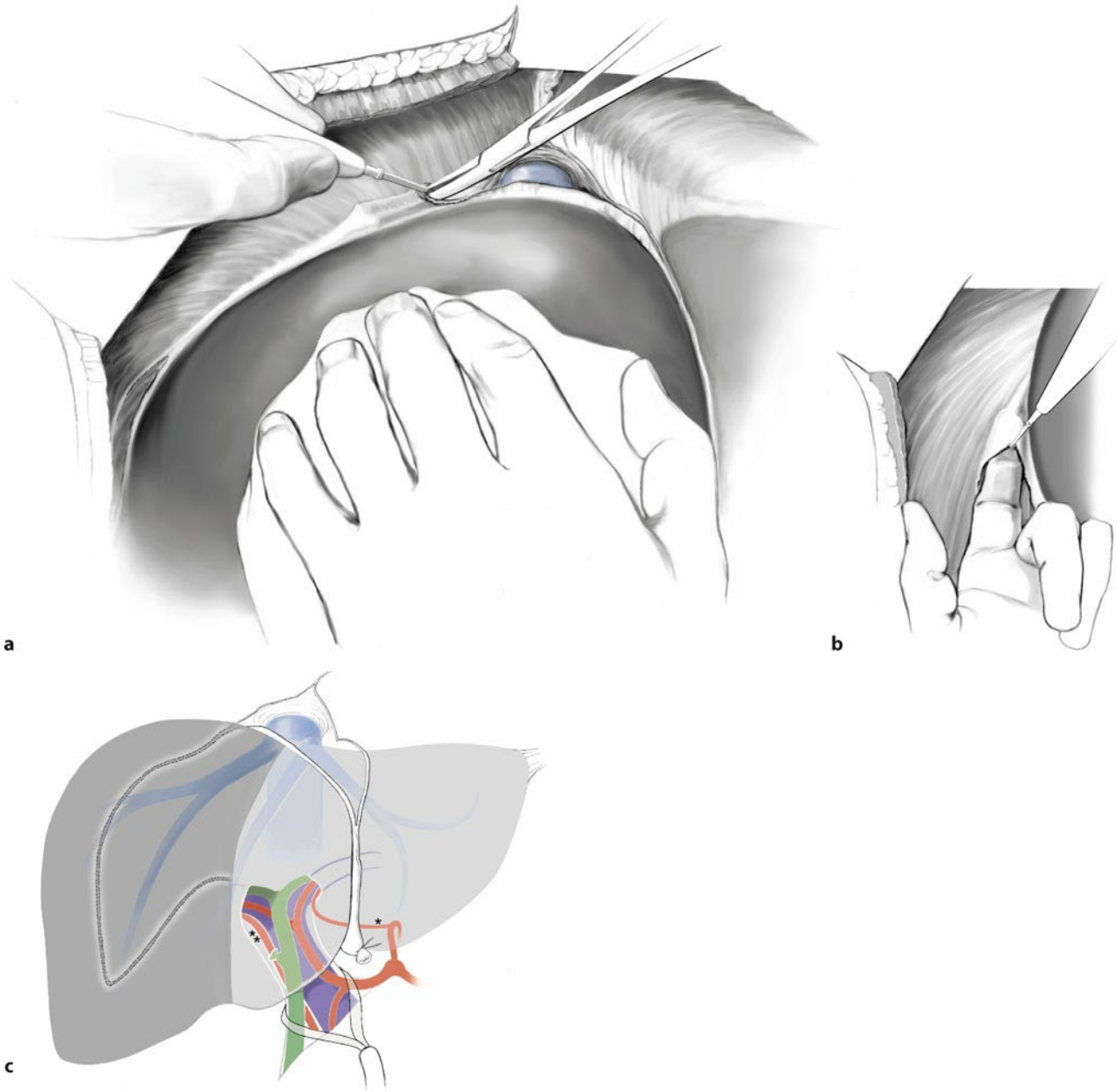


Fig. 46.2

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Step 2 ***(continued)***

First, the suprahepatic vena cava and the right hepatic vein should be identified. ◘ Figure 46.2c depicts the mobilized liver and the structures that must be identified during the next steps: the hepatic artery, the portal vein, and the bile duct. An aberrant left hepatic artery (*single asterisk*) is found in about 20 % to 25 % of patients. It should be isolated for later possible inflow occlusion. An aberrant right hepatic artery (*double asterisk*) is present in 10 % to 15 % of patients.

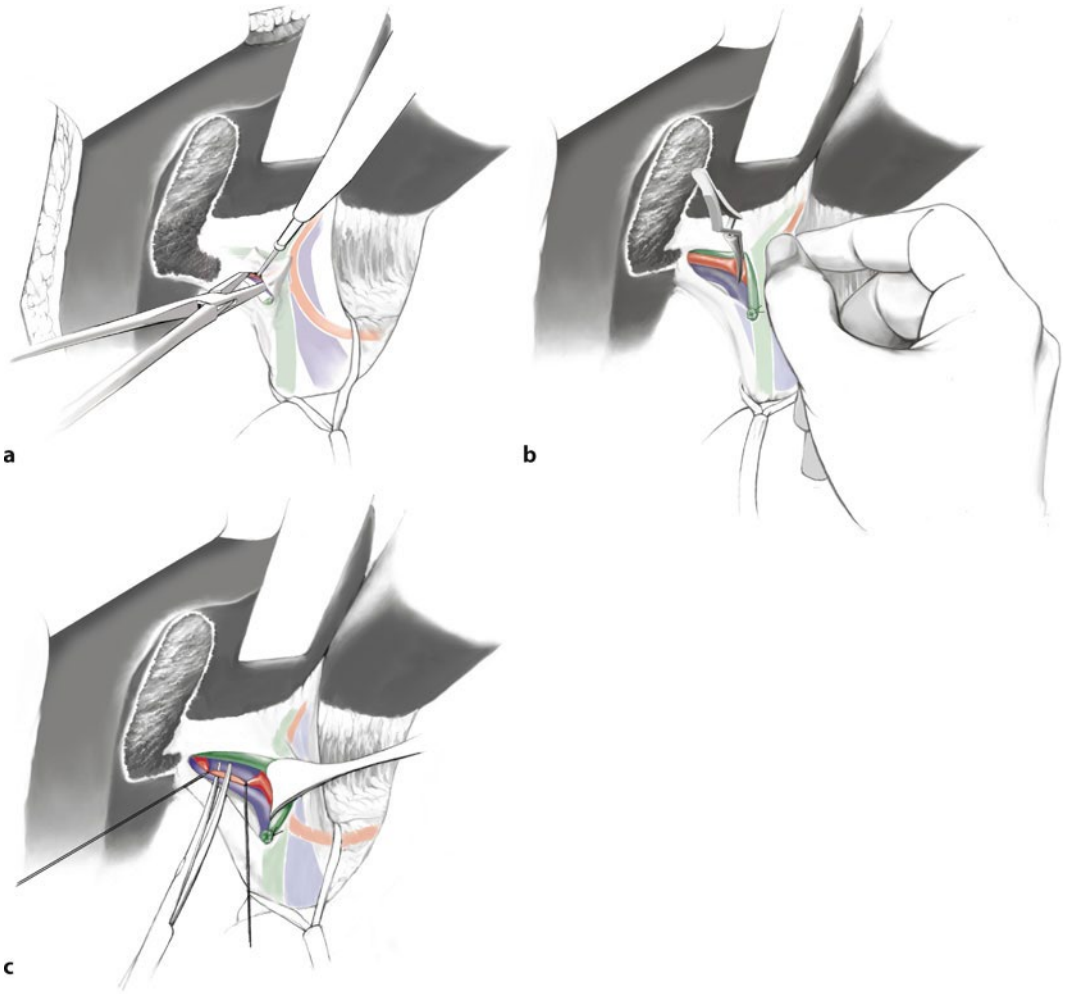
Step 3

Preparation of the hilar structures and transsection of the right hepatic artery

The hepatoduodenal ligament is divided from the cystic duct to the left in order to identify the common hepatic duct and the right branch of the hepatic artery. No attempt is made to visualize or even secure the right hepatic duct (◘ Fig. 46.3a).

To test the patency of the arterial blood supply to the left hemiliver, a "bulldog" is placed on the right branch of the hepatic artery. The patency of the left branch of the hepatic artery can now easily be assessed by palpating it through the hepatoduodenal ligament (◘ Fig. 46.3b). Search for an aberrant right hepatic artery from the superior mesenteric artery, posterior and right to the portal vein (*double asterisk* in ◘ Fig. 46.2c) should be routinely performed prior to identification of the right portal vein.

Once the arterial anatomy is clearly identified, the right branch of the hepatic artery is divided between ties (◘ Fig. 46.3c). In the presence of an aberrant right hepatic artery, the same maneuver should be applied.



◘ Fig. 46.3

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Step 4

Transsection of the right portal vein

The bifurcation of the portal vein should be identified. A small branch to the caudate process is often present. By ligating it, about 2 cm of length along the right portal vein is obtained, facilitating a safe ligation of the right portal vein (Fig. 46.4a).

Once the right branch of the portal vein is freed from the adventitial tissue, a right-angle clamp is passed around the vein (Fig. 46.4b).

A vascular clamp (e. g., small Satinsky clamp) is placed distally. The right portal vein is ligated with 1-0 silk (Fig. 46.4c). The distance to the bifurcation should be about 5 mm to avoid portal vein stenosis and subsequent thrombosis. The portal vein on the liver side is controlled through suture ligation, as a single ligature could slip away and cause bleeding. Now the demarcation line between the left and right hemiliver can be observed.

An alternative (e. g., in the case of a short right portal vein) is to use a small Satinsky clamp on the proximal right portal vein and a running Prolene 6-0 suture (Fig. 46.4d). As another alternative, a vascular stapler can be used in this position, but usually the small window in the porta hepatis through which the dissection is performed lends itself more to a suture ligation than to stapling.

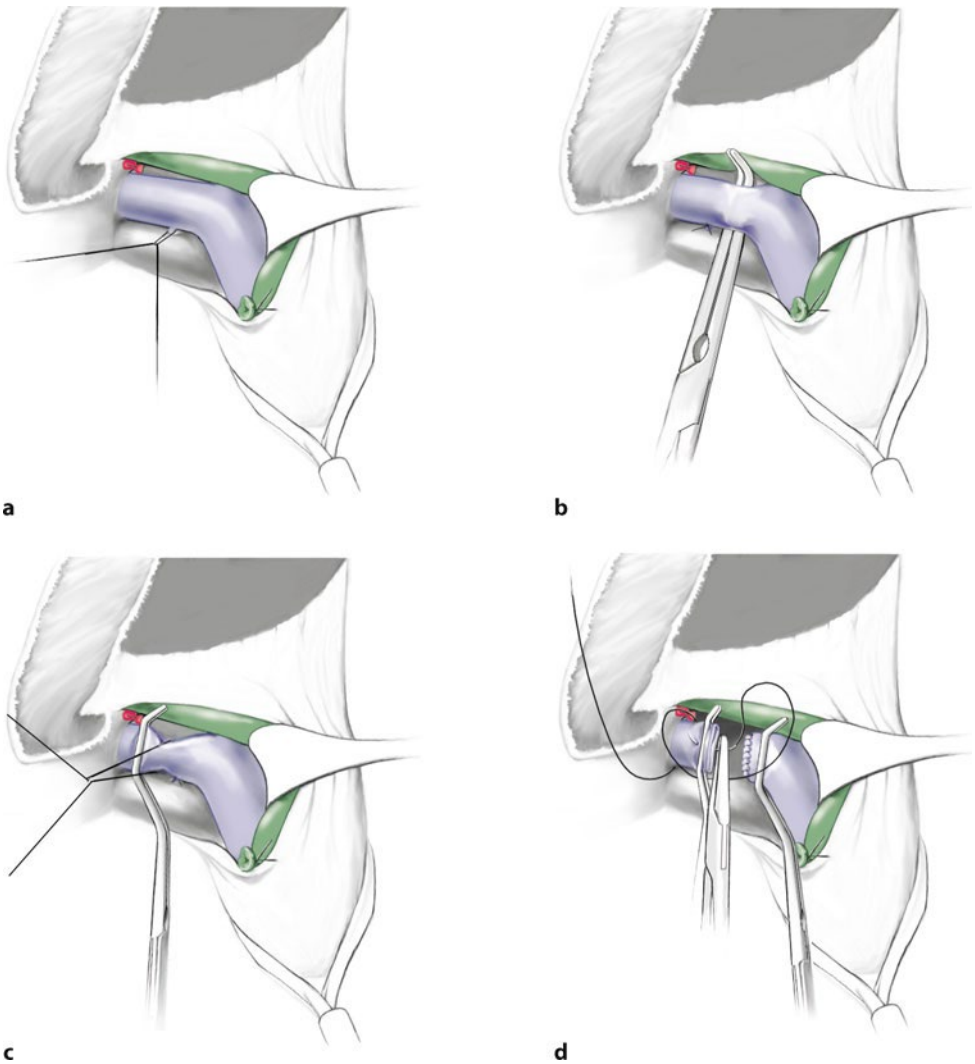


Fig. 46.4

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Step 5

Transsection of short hepatic veins

The short hepatic veins on the right side are divided between ties. Clips should be avoided particularly on the caval side, as the clip can detach once the low central venous pressure (CVP) has been corrected postoperatively (Fig. 46.5).

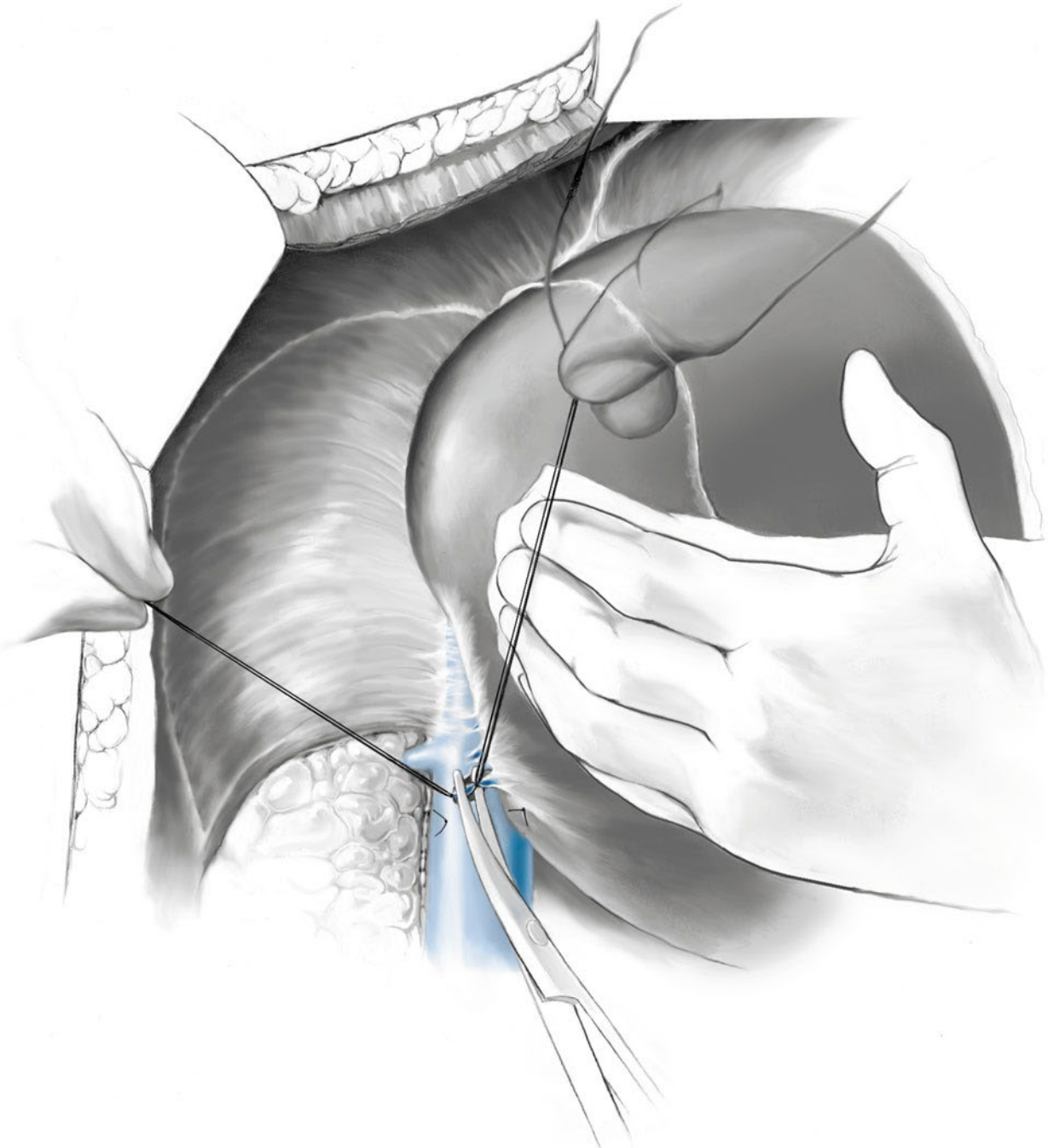


Fig. 46.5

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Step 6

Transsection of the right hepatic vein

The right hepatic vein is prepared (separated from the mid and left hepatic vein) from the top and below on the cava by means of a Kelly clamp (Fig. 46.6a).

A 1-0 silk or vessel loop is placed around the right hepatic vein. The transsection can be performed using a vascular stapler (Fig. 46.6b).

An alternative technique is to occlude the right hepatic vein with a vascular spoon clamp and ligate the proximal hepatic side with a 1-0 silk ligature in combination with a large clip (Fig. 46.6c). Should bleeding occur despite the combined ligature and clip, it can easily be controlled by putting a finger on the transected right hepatic vein. Continue on the caval side, which is secured by a running 4-0 polypropylene suture. Once the caval side is secured, the bleeding on the transected proximal hepatic vein can be controlled by a suture ligature.

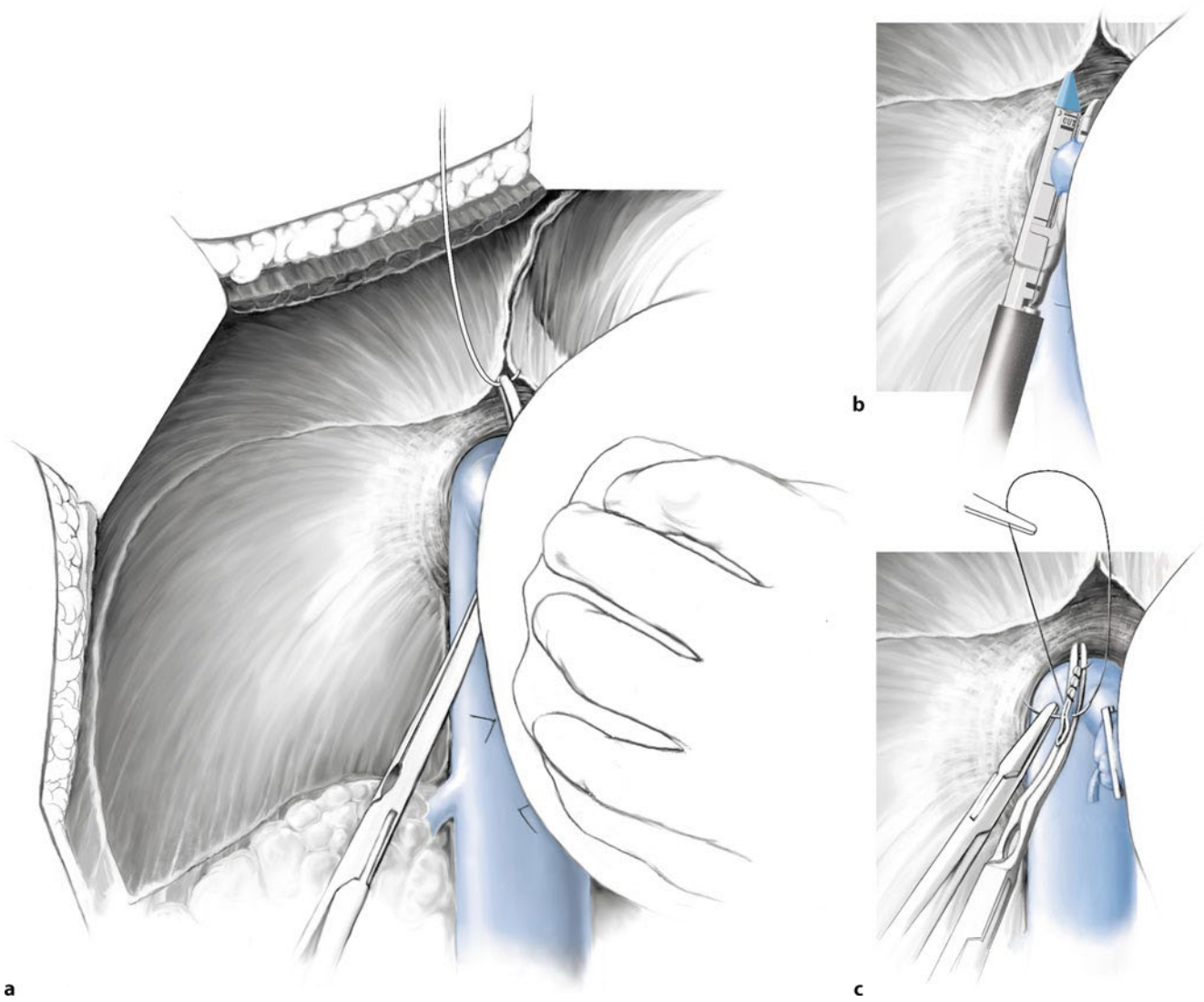


Fig. 46.6

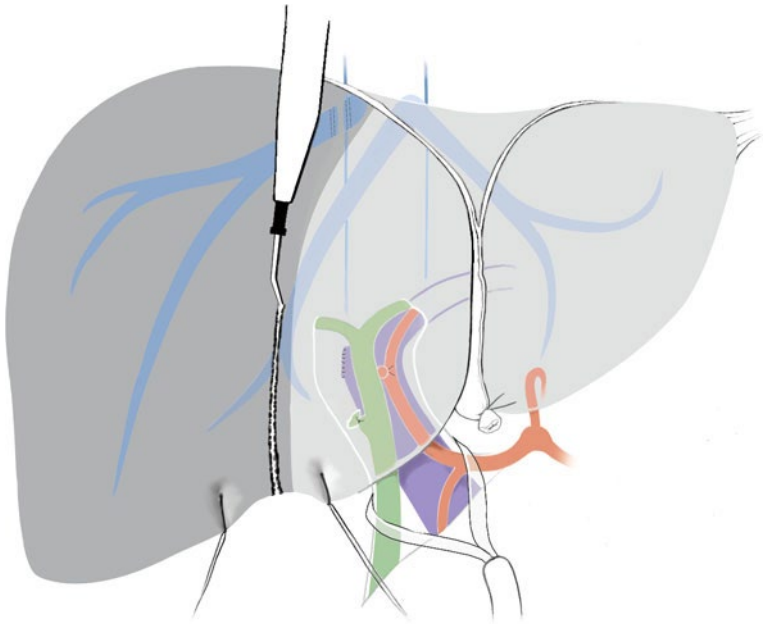
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Step 7

Transsection of the liver parenchyma

Two stay sutures (2-0 silk) are placed at the inferior margin of the liver, one on each side of the demarcation line. At this point, verify that CVP is low (below 3 mm Hg). If the CVP is higher, ask the anesthesiologist to correct it and wait. The liver capsule is incised with diathermy a few millimeters on the ischemic side (◘ Fig. 46.7).

The dissection of the parenchyma is started at the inferior margin between the stay sutures. The possible techniques for parenchyma dissection are described in ▶ Chap. 44, "Techniques of Liver Parenchyma Transection". The Pringle maneuver for continuous or intermittent inflow occlusion is used if needed. The dissection is continued posteriorly, then inferiorly, preserving the mid hepatic vein.



◘ Fig. 46.7

The technique using bipolar forceps and Kelly clamp to transect is shown in ◘ Fig. 46.8. A loop can be placed between the cava and the liver to allow lifting and better exposure (see also ▶ Chap. 42, "Hanging Maneuver for Anatomic Hemihepatectomy (Including Living-Donor Liver Transplantation)").

As an alternative, the left hand of the surgeon can be placed between the liver and the cava. All identified bile ducts or vessels (> 3 mm) are ligated on the left side and divided. In the hilum, the right bile duct is divided away from the main confluence above the caudate process.

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Step 7 *(continued)*

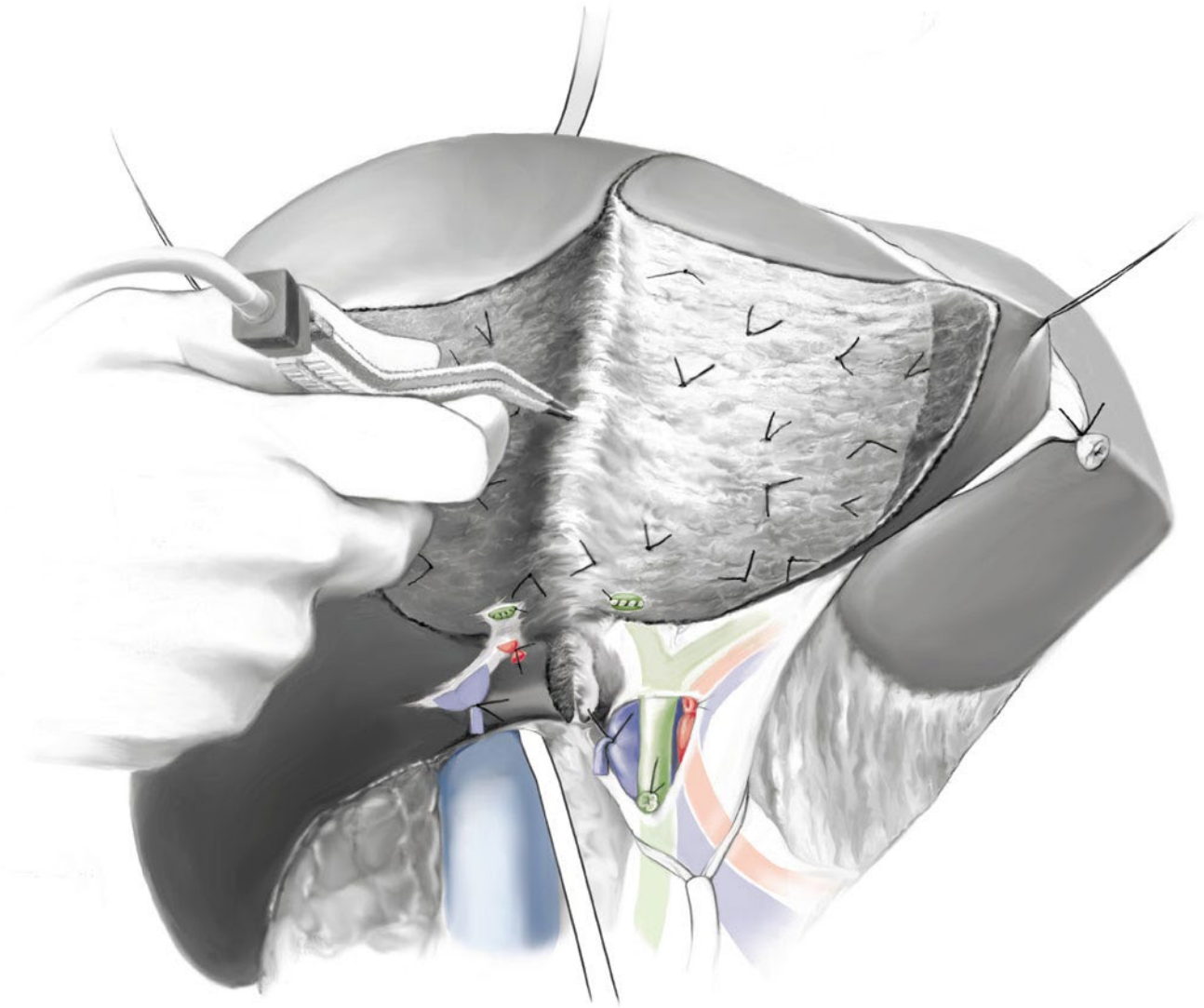


Fig. 46.8

A gauze swab is placed on the resection surface while slight compression is maintained for a few minutes in case of diffuse bleeding. Each bleeding site on the cut surface should be suture-ligated.

At the end of the procedure, the gauze swab is removed and, together with the resection site, inspected carefully. Any bile leaks (represented by yellow spots on the gauze swab) are oversewn by PDS 4-0 or 5-0. Some surgeons routinely inject methylene blue in the common bile duct to identify bile leaks.

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Step 7 ***(continued)***

In order to prevent rotation of the left hemiliver, the falciform ligament must be reattached (Fig. 46.9).

The abdomen is closed without drainage.

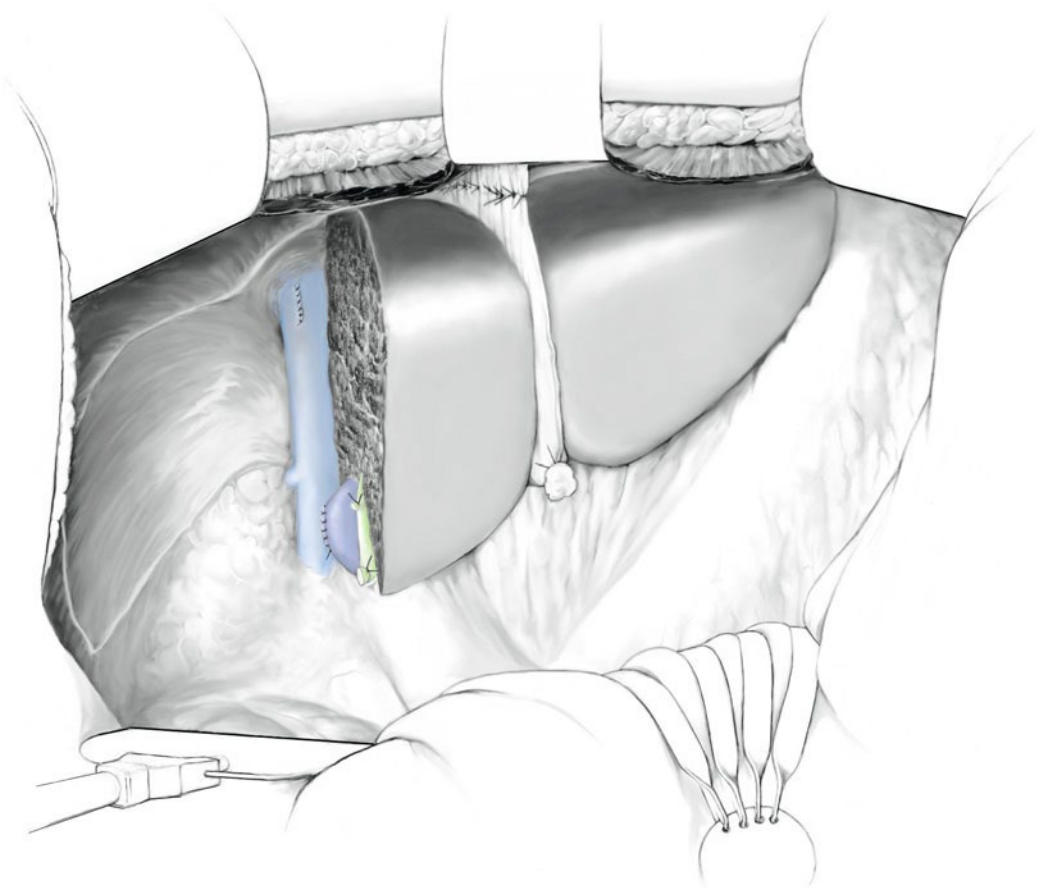


Fig. 46.9

Tricks of the Senior Surgeon

- Optimal exposure by a retractor is of utmost importance for evaluation, assessment, and success of surgery.
- Ask the anesthesiologist early in the procedure for a low CVP; this significantly reduces overall blood loss.
- If you use a ligature to secure the right hepatic vein on the liver side, add a large clip to the ligature–This prevents bleeding! If it bleeds despite the clip, do not panic. Compress the right hepatic vein with your finger and continue on the caval side.
- While you dissect the liver parenchyma, hold the right hemiliver with your left hand or a band for optimal exposure and protection of the cava.

Acknowledgments

We would like to acknowledge Panco Georgiev, who co-authored this chapter in the first edition of this Atlas.

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Left Hemihepatectomy

Christopher Soll, Pierre-Alain Clavien

Procedure

Step 1

Access and mobilization of the left hemiliver

The abdomen is opened through a subcostal incision, and the round and falciform ligaments are divided. The left hemiliver is mobilized by dividing the left triangular and coronary ligament (Fig. 47.1). Once the left hemiliver is mobilized, the liver can be evaluated by ultrasound. After confirmation of resectability, the Pringle maneuver is prepared for by opening the hepatogastric ligament, as shown in ▶ Chap. 41, "Techniques of Vascular Clamping, Vascular Exclusion, and Caval Resection in Liver Surgery." At this point, an aberrant left hepatic artery can be isolated for later clamping with a bulldog clamp.

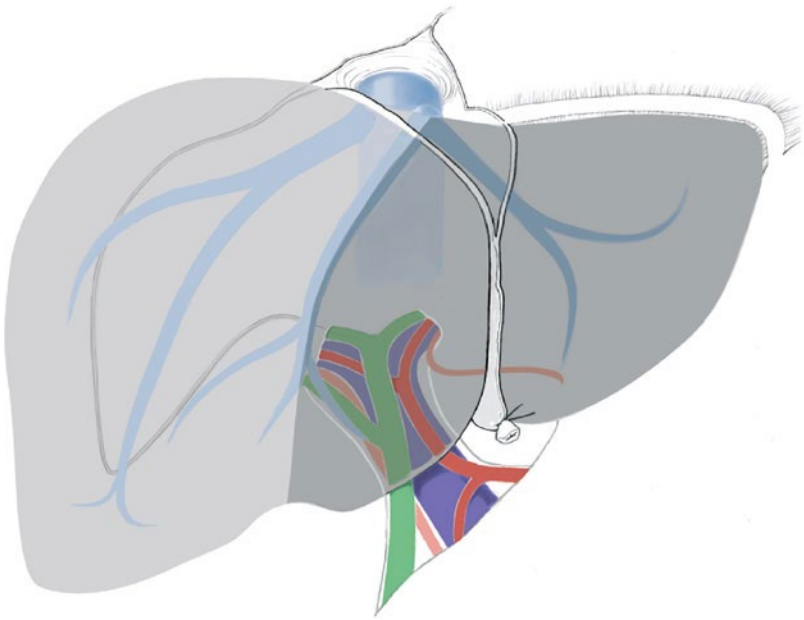


Fig. 47.1

In contrast to the right side, the anterior and posterior leafs of the left coronary ligaments are attached to each other and are separated close to the cava. The ligaments can be divided easily by electrocautery while the posterior structures (spleen, stomach, esophagus) are protected with a wet gauze swab (or a finger) placed behind the ligament (Fig. 47.2). Alternatively, the ligament can be divided over a right-angle clamp.

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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Step 1 *(continued)*

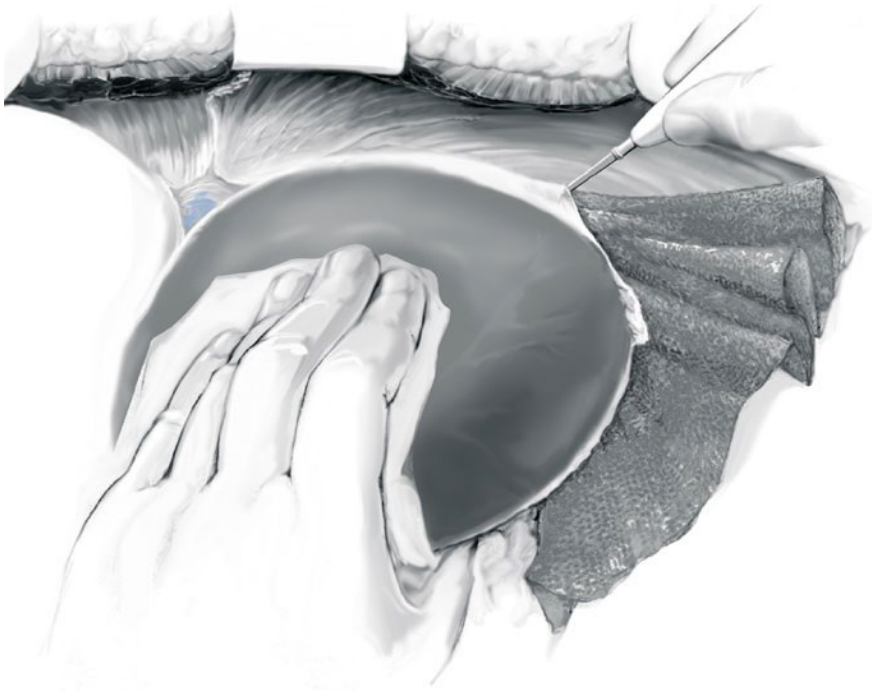


Fig. 47.2

Step 2

Opening of the hepatoduodenal ligament

Cholecystectomy is usually performed, as it facilitates parenchymal dissection at the mid plane, known as the Rex-Cantlie line; the right and left portal veins pass through the gallbladder bed towards the vena cava. Next, the hepatoduodenal ligament is opened from the left by means of a Kelly clamp and electrocautery, as illustrated (Fig. 47.3). The common bile duct, the artery, and the portal vein are visualized; the common bile duct is dissected sparingly, not to compromise the blood supply from the small branches. During this step, preparation of the left hepatic duct is not mandatory because the identification of the complete bifurcation and ligation of the left hepatic duct are performed during parenchymal dissection (see Step 6).

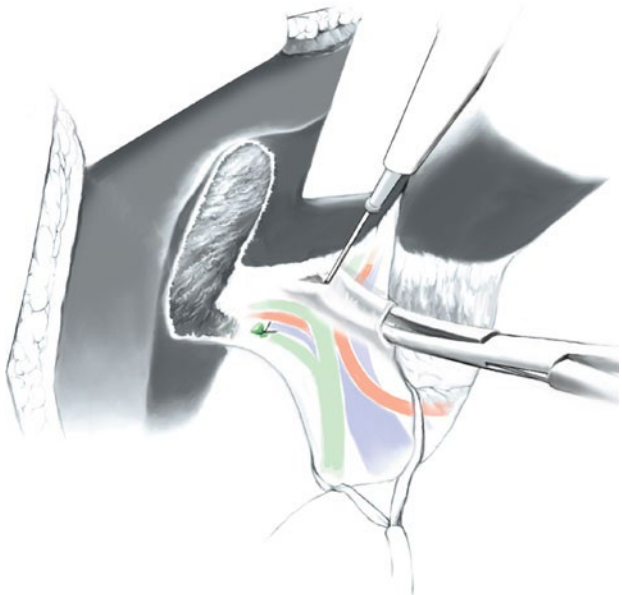


Fig. 47.3

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Step 3

Identification and disconnection of the arterial blood supply to the left hemiliver

At this point, the arterial anatomy has to be clarified. A possible aberrant left artery should be secured by means of a bulldog clamp. An aberrant right artery can be identified by palpation of the right border of the hepatoduodenal ligament. The left hepatic artery is identified left to the common and left bile duct and can then be isolated and clamped. The patency of the arterial blood supply to the right hemiliver can now easily be assessed by palpation of the right hepatic artery and/or an aberrant right artery (Fig. 47.4).

Once the arterial anatomy is clear, the left hepatic artery (and an aberrant artery to the left hemiliver, if present) are divided between ties.

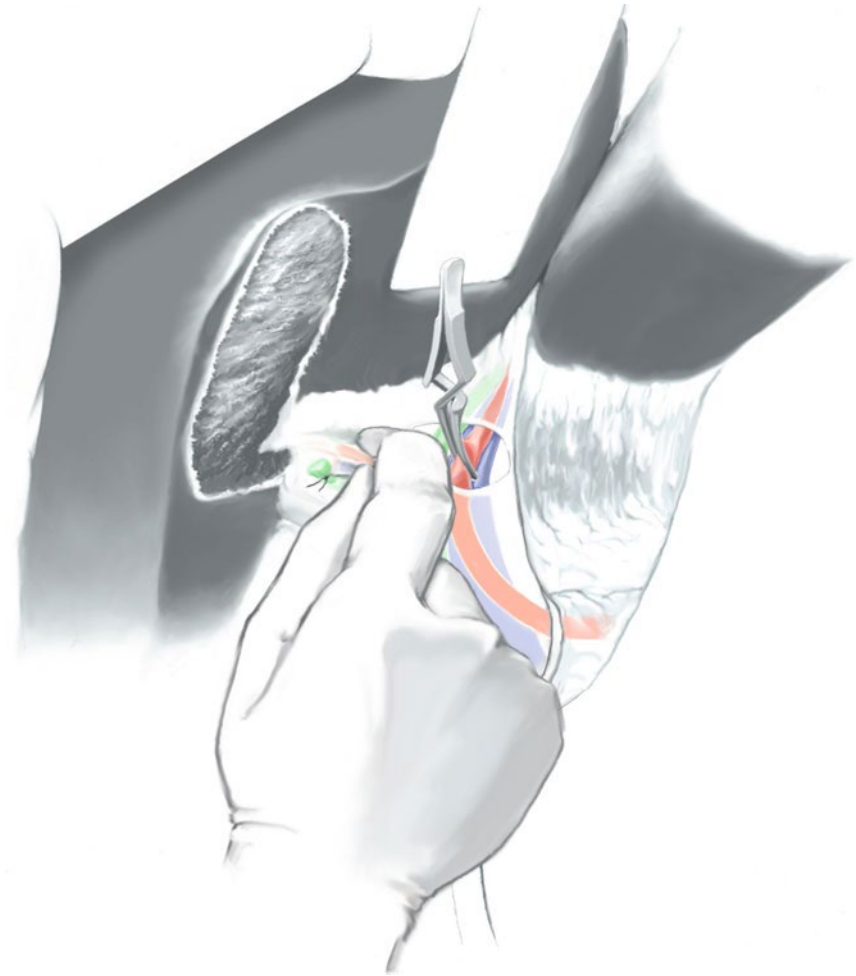


Fig. 47.4

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Step 4

Preparation and ligation of the left portal vein

As the left portal vein typically is situated behind the left branch of the hepatic artery, it is easily identified. Following convincing identification of the bifurcation, the left portal vein should be freed from the adventitial tissue. The short branch to Sg1 on the back-left side can be divided between ties because of the dual portal blood supply from the right and left portal vein. The vein can now be ligated with a 1-0 silk suture on both sides (Fig. 47.5). The distance to the bifurcation should be at least 5 mm to avoid stenosis of the remaining right portal vein. Suture ligation with 5-0 Prolene or transsection by means of a vascular stapler are alternatives to a simple ligation. (See the illustration in ▶ Chap. 46, "Right Hemihepatectomy.")

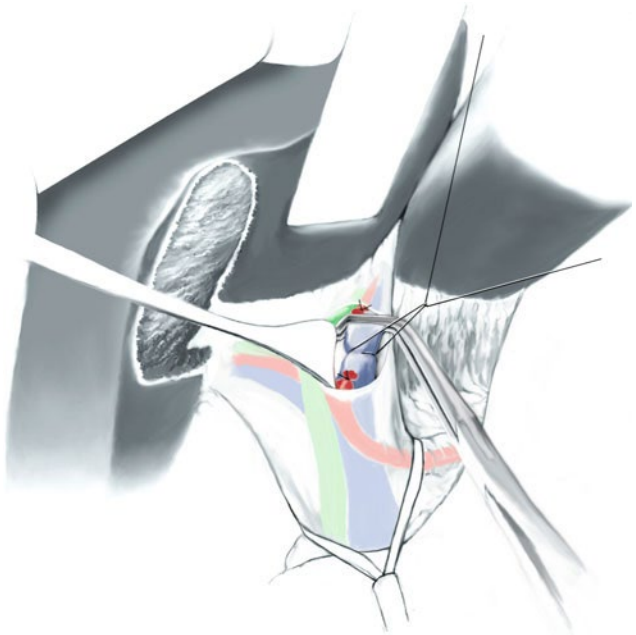


Fig. 47.5

Step 5

Dissection of the Arantius' ligament and exposure of the left hepatic vein

The anterior walls of the left and middle hepatic vein are usually exposed by extending the dissection of the falciform and coronary ligament to the vena cava. To access the posterior wall, the left hemiliver is lifted and the lesser omentum is cut, up to the diaphragm. Next, the Arantius' ligament (ligamentum venosum) is identified between the left hemiliver and Sg1 (Fig. 47.6). It runs from the left portal vein to the left hepatic vein or to the junction between the left and the middle hepatic veins and is divided at its portal origin between ties (a remnant of the ductus venosus may be present). The stump of the ligament can now be grasped and dissected upward toward the inferior vena cava until the ligament broadens into its attachment. By traction of the ligament cephalad and to the left, an avascular plane between the left hepatic vein and Sg1 can be seen and developed. The left hepatic vein can be isolated by means of a right angle or a Kelly clamp. The left hepatic vein can be disconnected at this stage, but it is also possible to divide it at the end of the parenchyma dissection, as shown in Step 7.

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Step 5 *(continued)*

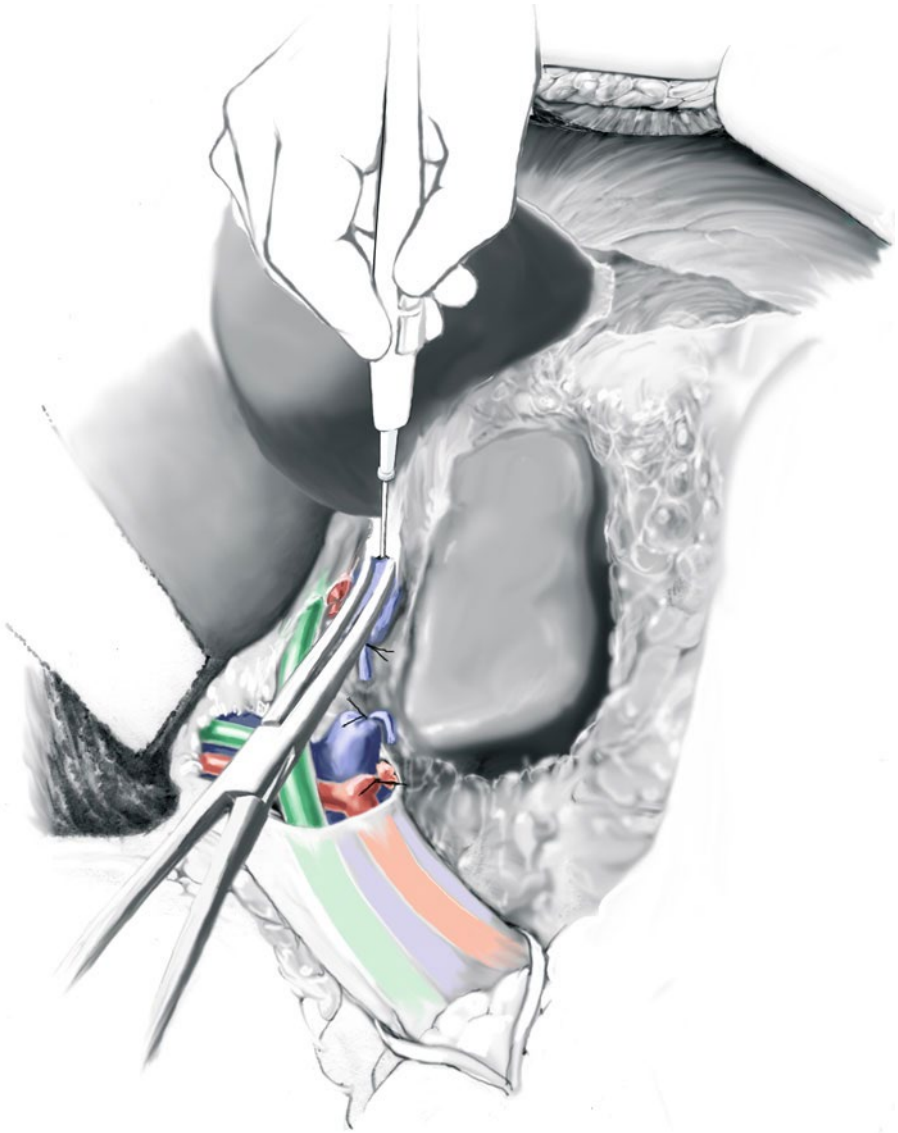


Fig. 47.6

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Step 6

Dissection of the liver parenchyma

As the blood supply to the left hemiliver is now interrupted, a clear demarcation between the left and the right hemiliver is seen and identifies the line of resection along the main portal plane. Two stay sutures (2-0 silk) are placed at the inferior margin of the liver, one on each side of the demarcation line. At this point, verify that central venous pressure (CVP) is low (below 3 mmHg). The liver capsule is incised with diathermy a few millimeters on the ischemic side (Fig. 47.7). The Pringle maneuver for intermittent or continued inflow occlusion is used as needed. The dissection starts on the inferior margin of the liver and is continued first on the caudate lobe, then right onto the surface of the vena cava. During the parenchyma dissection, care must be taken to protect the mid hepatic vein. The left bile duct is isolated and carefully ligated within the parenchyma. Before the ligation of the left bile duct, a right sectional bile duct inserting into the left hepatic duct must be ruled out. To avoid an injury in this biliary anomaly, the left bile duct should be divided close to the umbilical fissure.

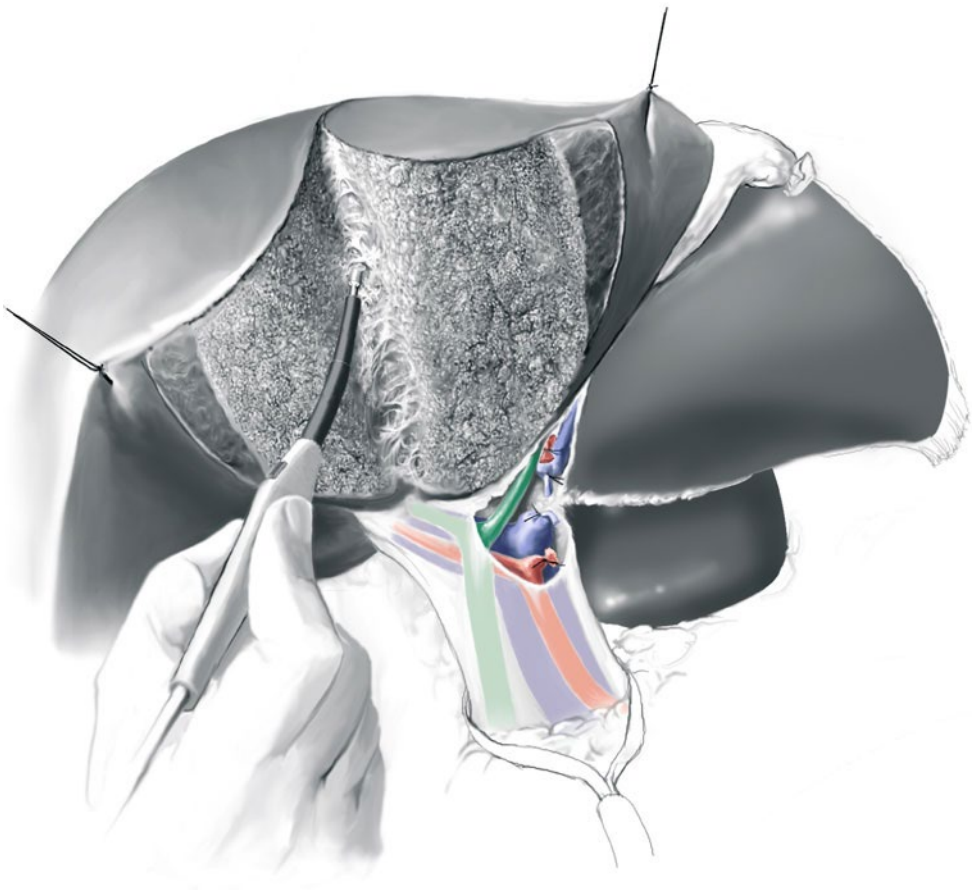


Fig. 47.7

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Step 7

Transsection of the left hepatic vein

If the left hepatic vein has not been divided prior to the transsection of the parenchyma, care should be taken while approaching the top of the liver (2–3 cm from the top). At this point, a vascular stapler can be used to transect the left hepatic vein. An alternative would be to use a spoon clamp (Fig. 47.8). When a more accurate identification is necessary (e. g., a tumor in proximity), fine preparation of the vein can be achieved by palpation or devices such as the CUSA or HydroJet (see ▶ Chap. 44, "Techniques of Liver Parenchyma Dissection").

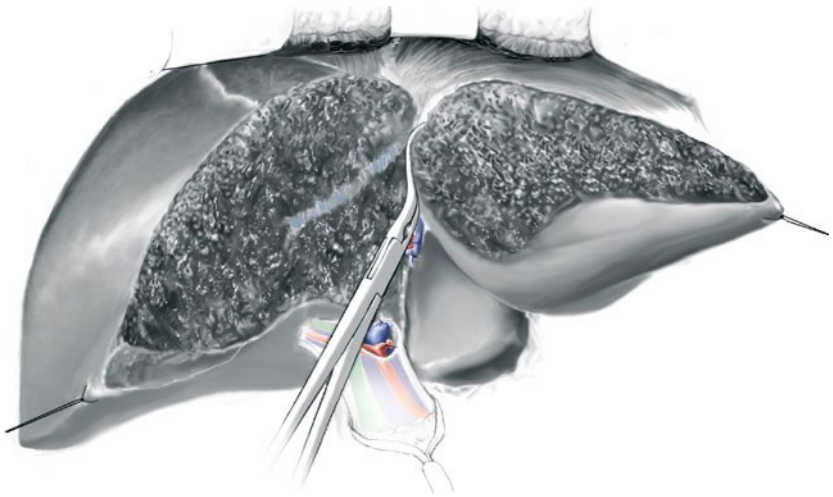


Fig. 47.8

Step 8

Situs at the end of the left hemihepatectomy with preservation of Segment 1.

A gauze swab is placed on the resection surface and slight compression is maintained for a few minutes, or longer in the case of diffuse bleeding. Each instance of bleeding on the cut surface should be suture-ligated. At the end of the procedure, the gauze swab is removed and inspected carefully. Any bile leaks (revealed by yellow spots on the gauze swab) are oversewn by PDS 4-0 or 5-0. Alternatively, bile leaks can be identified by injecting methylene blue into the common bile duct through the stump of the cystic duct (Fig. 47.9).

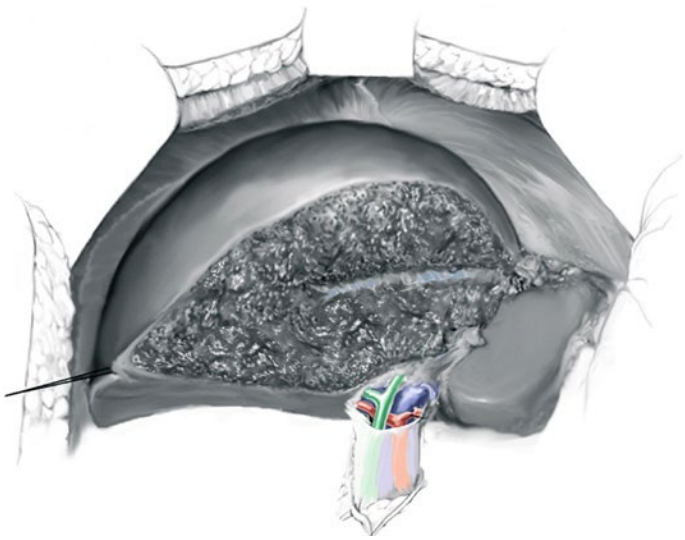


Fig. 47.9

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Tricks of the Senior Surgeon

- Early in the procedure, ask the anesthesiologist for a low CVP, which significantly reduces overall blood loss.
- Isolation and transsection of the left hepatic vein before the parenchyma dissection are not absolutely required. Forcing through the parenchyma or middle hepatic vein may cause severe bleeding. Thus, if difficulty is encountered in isolating the left hepatic vein, repeated attempts should be avoided; the transsection can be performed at the end of the parenchyma dissection. The results in terms of blood loss are the same, if a low CVP is maintained.

Acknowledgments

We would like to acknowledge Panco Georgiev, who co-authored this chapter in the first edition of this Atlas.

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Extended Hemihepatectomy

Stefan Heinrich, Pierre-Alain Clavien

Extended Right Hemihepatectomy (Right Trisectionectomy)

The extended right hemihepatectomy (also called a right trisectionectomy) includes resection of segments 4 through 8. For cholangiocarcinoma of the liver hilum (Klatskin's tumor) or carcinoma of the gallbladder, an en bloc resection including segments 1 and 9 is usually performed. This procedure should be performed only if the remnant liver (segments 2 and 3) provides sufficient liver function. Therefore, preoperative assessment of liver function, a volumetric assessment of the expected remnant liver volume, and exclusion of liver fibrosis or cirrhosis are essential before extended resections.

Dependent on the vascular anatomy, two different approaches can be used for the anatomic resection of Sg4 in addition to segments 5 through 8. The classic anatomic resection of Sg4 is performed by selective ligation of the pedicle to Sg4 prior to tissue transsection. Alternatively, tissue transsection can be performed first, with ligation of the pedicle to Sg4 during parenchymal transsection. Here, we describe the classic approach of resection (Fig. 48.1).

Steps 1 through 7 are the same as for a right hemihepatectomy.

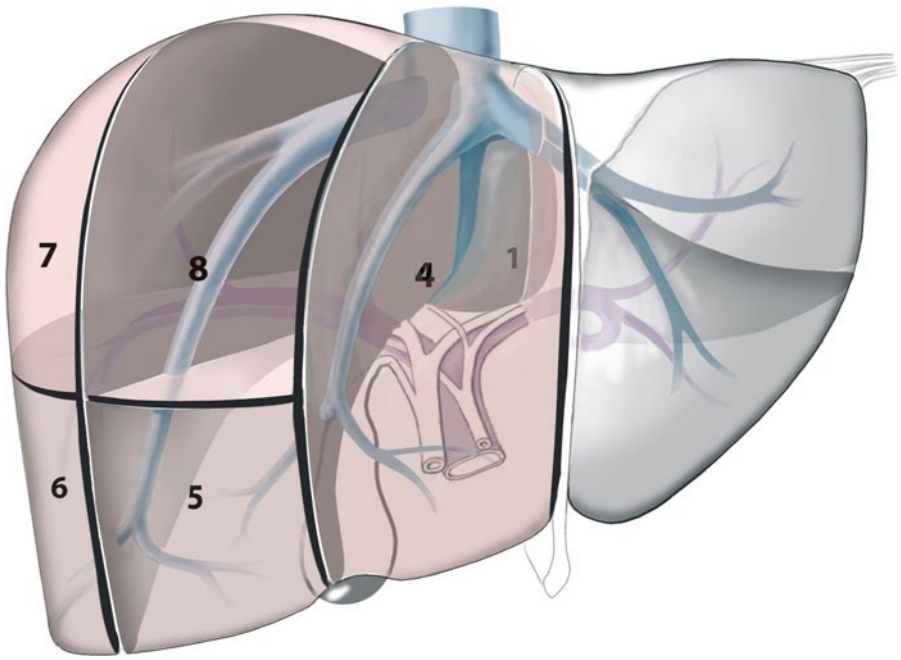


Fig. 48.1

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery*,
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Step 8

Selective ligation of the pedicle to segment 4

After mobilization of the right liver and ligation of the right branches of the hepatic artery and portal vein, careful blunt dissection along the left portal sheath is performed (Fig. 48.2a). The pedicle to segment 4 is then identified, is carefully dissected, and the vessels are selectively ligated (Fig. 48.2b).

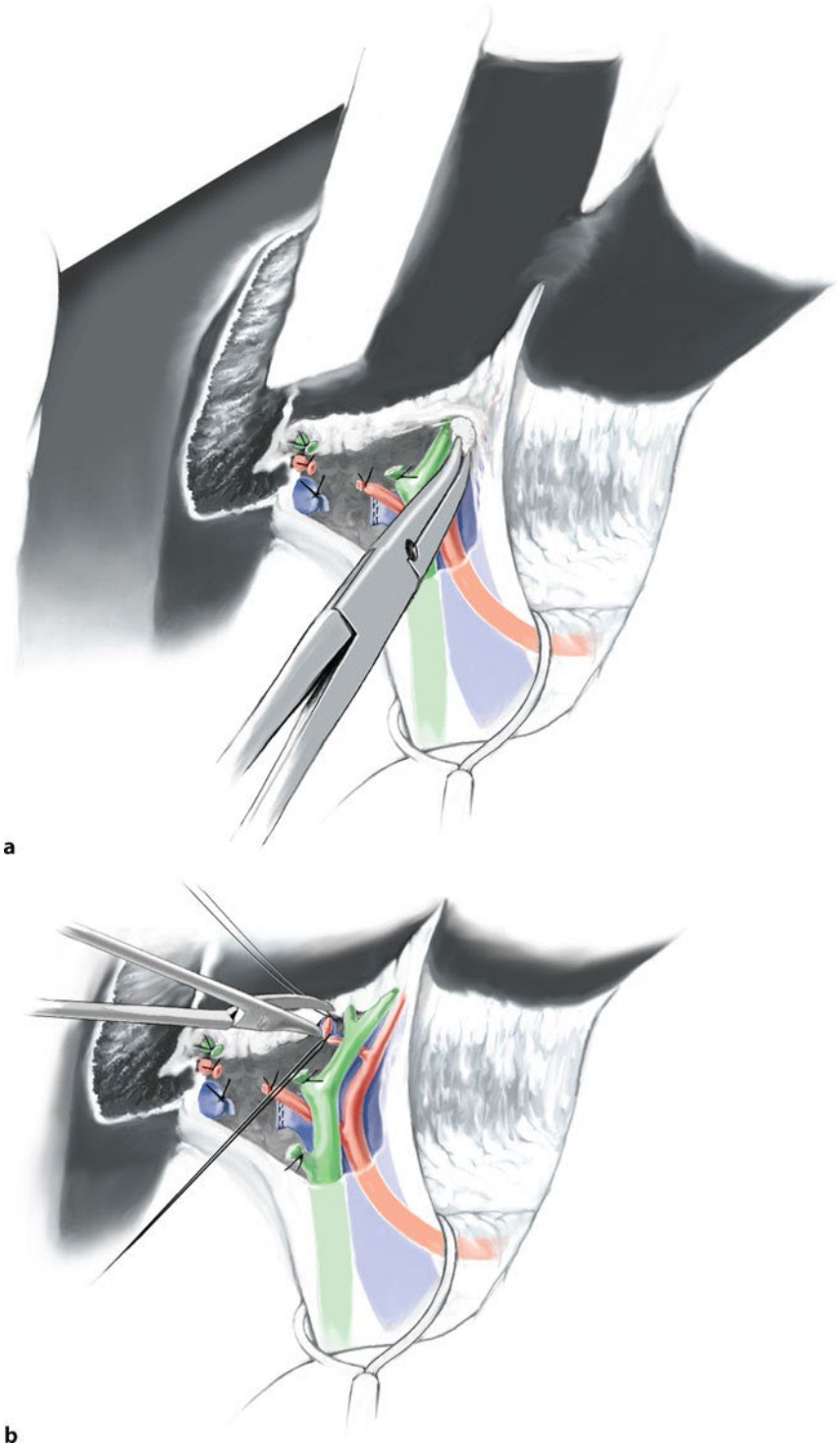


Fig. 48.2

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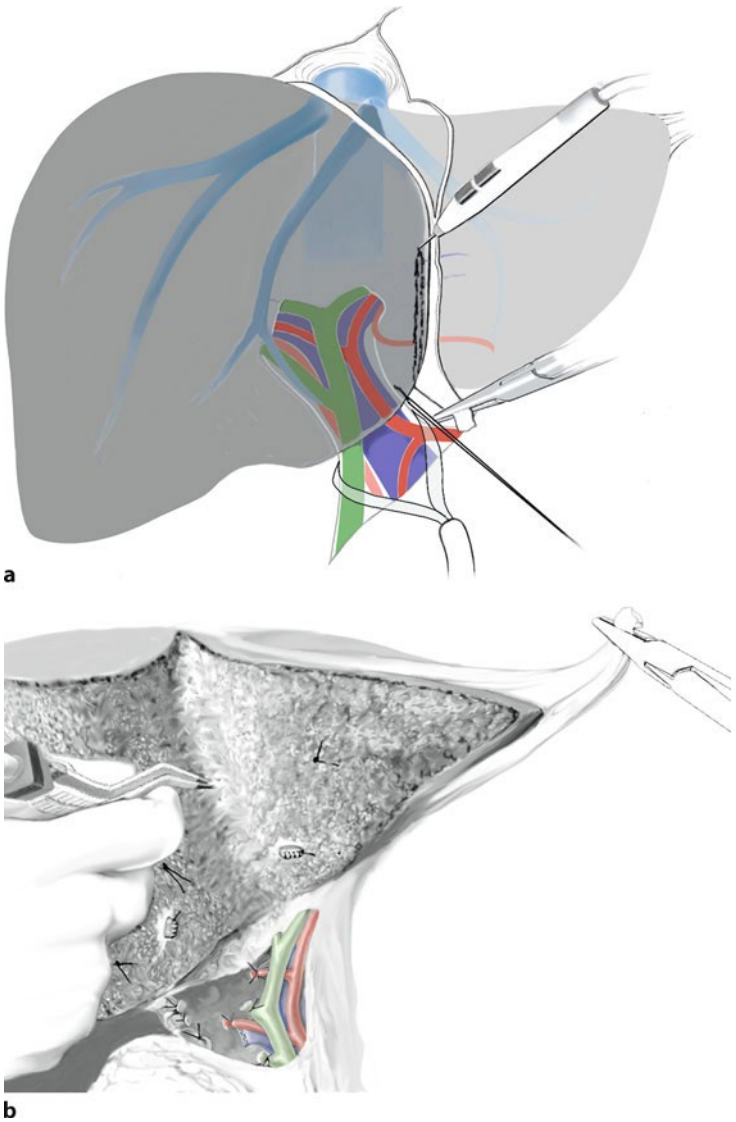
Step 9

Exposure of the right hepatic vein and parenchymal transsection

The right hepatic vein is isolated from below and marked with a rubber band as for a right hepatectomy. If the transection will be performed with a suspension technique, the right and middle hepatic veins can be isolated from the top as described in ▶ Chap. 42, "Hanging Maneuver for Anatomic Hemihepatectomy."

The resection margin for the extended right hepatectomy is the right side of the falciform ligament. Because the round ligament harbors the fetal connection of the umbilical cord with the left hepatic vein (Arantius' duct), it can be used as a guide. It is fixed with a Kelly clamp and retracted to the left, and a stay suture is placed to the right (◘ Fig. 48.3a). Intraoperative ultrasound is routinely performed to define the exact extent of the lesion and to identify vascular anatomy.

Tissue transsection is started just to the right of the round ligament. All branches from the right side of the round ligament into the liver need to be ligated selectively (◘ Fig. 48.3b). If it was not done prior to the parenchymal transsection, the pedicle to segment 4 can now be selectively ligated. (This approach can be advantageous for tumors involving the left portal sheath.) The right bile duct and the bile duct to segment 4 can now be ligated safely.



◘ Fig. 48.3

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Step 10

Ligation of the right and middle hepatic veins

Approaching the hepatic veins, the middle hepatic vein is now isolated. The right hepatic vein was previously prepared, so both veins can be divided at the end of the parenchymal dissection by means of a vascular stapler (Fig. 48.4). Of note, the middle and left hepatic veins usually share a common trunk. Make sure that the left hepatic vein is preserved!

In addition to this extended right hemihepatectomy, the caudate lobe (segments 1 and 9) can be approached and resected en bloc, if needed.

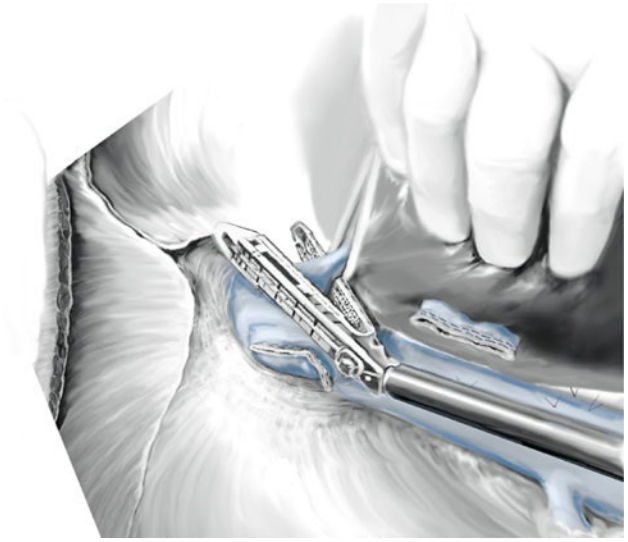


Fig. 48.4

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Step 11

Reattachment of the falciform ligament

The falciform ligament must be reattached to prevent rotation of the remnant liver (Fig. 48.5). Rotation can result in an acute Budd-Chiari syndrome (obstruction of the venous outflow of the liver), a fatal complication after extended right liver resections.

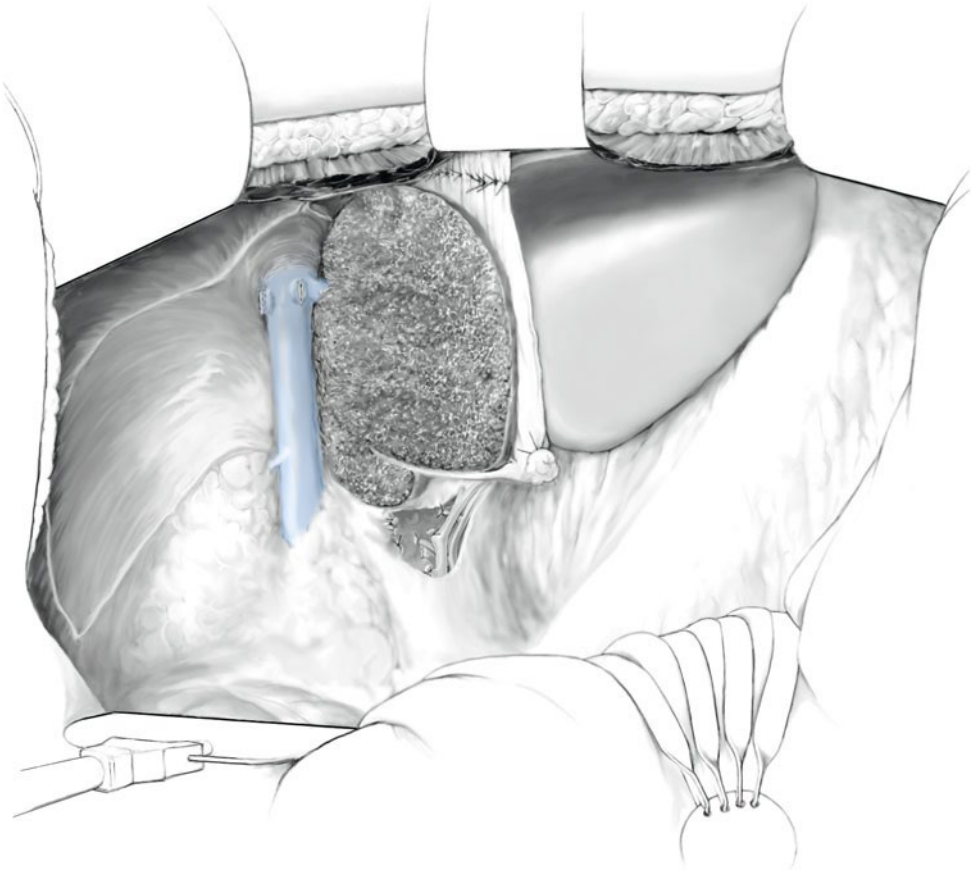


Fig. 48.5

Extended Left Hemihepatectomy (Left Trisectionectomy)

The extended left hemihepatectomy includes resection of segments 2, 3, 4, 5, and 8 (Fig. 48.6). This procedure should be performed only if the remnant liver (segments 1, 9, 6, and 7) provides sufficient liver function. Preoperative assessment of liver function, volumetric evaluation of the expected remnant liver volume, and exclusion of liver fibrosis or even cirrhosis are essential.

Depending on the vascular anatomy, two different approaches can be used for the anatomic resection of segments 5 and 8 in addition to the left liver. The classic anatomic resection of segments 5 and 8 is performed by selective ligation of the pedicle to these segments prior to tissue transsection. Alternatively, tissue transsection can be performed with ligation of the pedicle to segments 5 and 8 during parenchymal transsection. This chapter describes the classic approach to resection.

Step 1 trough 7

STEPS 1 through 7 are the same as for a left hemihepatectomy. To prepare an extended left hemihepatectomy, the right liver must be mobilized as for a formal right hemihepatectomy, including the division of the short hepatic veins. (See ▶ Chap. 46, "Right Hemihepatectomy.")

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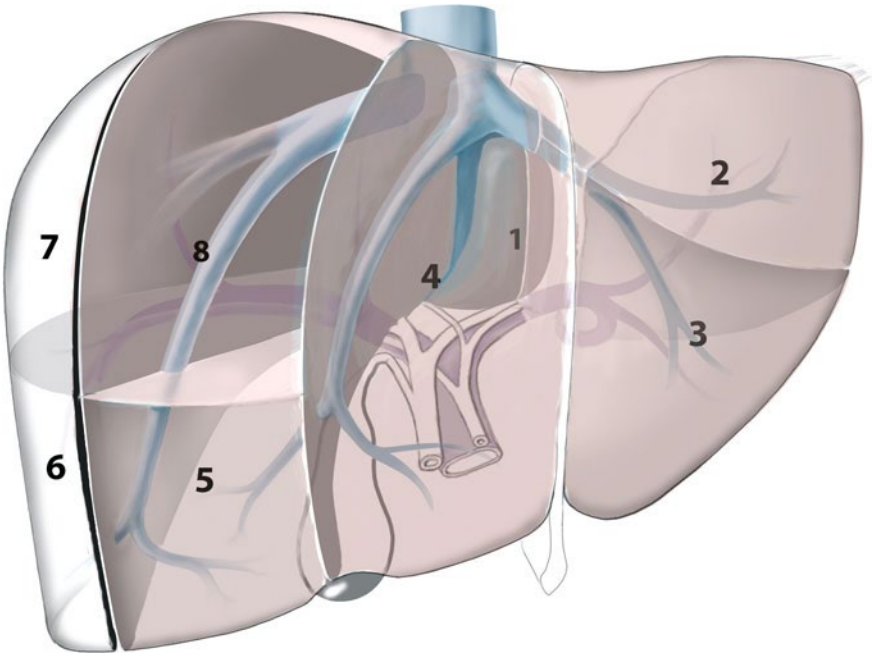


Fig. 48.6

Step 8

Selective ligation of the pedicle to segments 5 and 8

The pedicle to segments 5 and 8 (right anterior pedicle) is identified by careful blunt dissection on the right portal sheath. The vessels are selectively ligated; the right posterior pedicle must be preserved (Fig. 48.7). For tumors involving the right portal sheath, the anterior pedicle should not be dissected in the hilum, but should be ligated during tissue transsection. Intraoperative ultrasound is a helpful tool to define the exact extent of the lesion and to identify vascular anatomy.

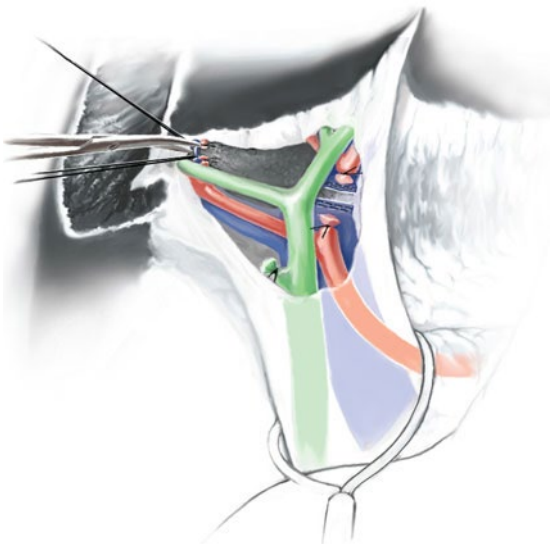


Fig. 48.7

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Step 9

Exposure of the left and middle hepatic veins

The middle and left hepatic veins, which usually share a common trunk, are isolated by careful dissection from above and are marked with a rubber band for later dissection (Fig. 48.8). The right hepatic vein is identified and preserved.

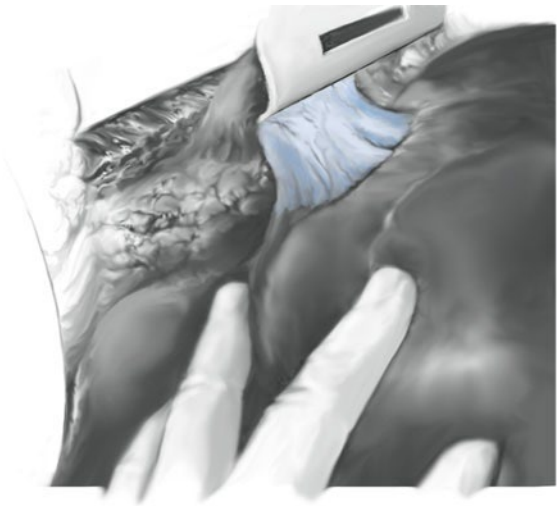


Fig. 48.8

Step 10

Parenchymal transsection

The resection is performed along the demarcation line, which can be seen after ligation of the pedicles to segments 5 and 8. Stay sutures allowing gentle traction are placed on each side of the demarcation (Fig. 48.9). If the pedicle cannot be ligated first, the plane of transsection is about 1 cm to the left of the right hepatic vein as defined by intraoperative ultrasound. Particular attention must be paid to the right hepatic vein; its course must be known during the whole period of tissue transsection. The left bile duct and the bile duct to segments 5 and 8 can be safely ligated at the end of parenchyma dissection.

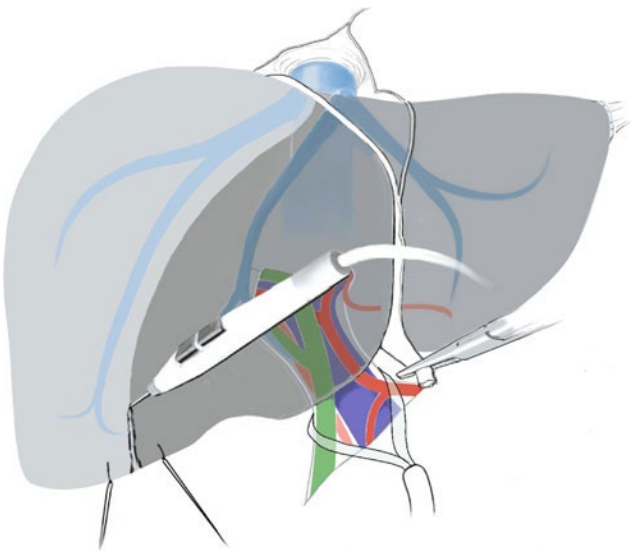


Fig. 48.9

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Step 11

Ligation and transsection of the left and middle hepatic veins

At the end of tissue transsection, the left and middle hepatic veins are transected by means of a vascular stapler and the resected part is removed, leaving segments 6 and 7 and the caudate lobe (Fig. 48.10). In addition to this formal extended left hemihepatectomy, the caudate lobe can be approached and resected en bloc, if needed.

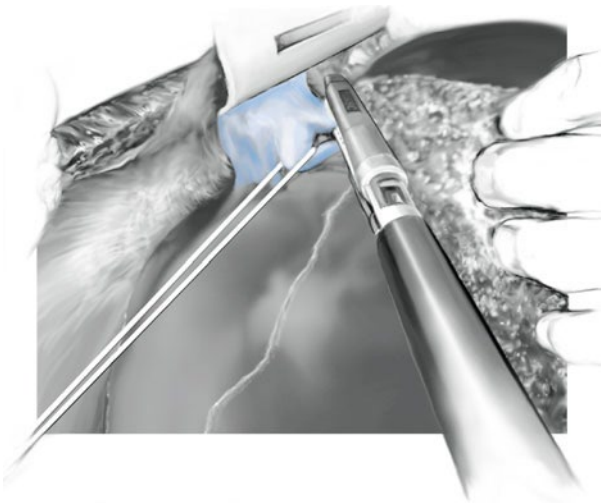


Fig. 48.10

Tricks of the Senior Surgeon

- Extended hemihepatectomies are typically performed for large tumors partially invading segment 4 (extended right hemihepatectomy) or segments 5/8 (extended left hemihepatectomy), or for hilar cholangiocarcinoma. In these cases, we do not selectively ligate the pedicles to segment 4 or segments 5 and 8, respectively, but rather perform a formal hemihepatectomy and extend the resection margin into the contralateral liver (extended wedge resection). This approach may spare liver parenchyma and operative time.
- In the case of tumor involvement of the hilum, dissection and selective ligation of segmental pedicles should be performed during tissue transsection.
- Similarly, preparation and transsection of the hepatic veins may prove difficult in some situations. Two strategies should be considered:
  - Transsection of the hepatic veins during parenchymal transsection without previous isolation
  - Total vascular exclusion
- Portal vein embolization with delayed hepatectomy (about 4 weeks) should be considered prior to resection if the remnant liver is judged too small.

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Segmentectomies, Sectionectomies, and Wedge Resections

Norihiro Kokudo, Masatoshi Makuuchi

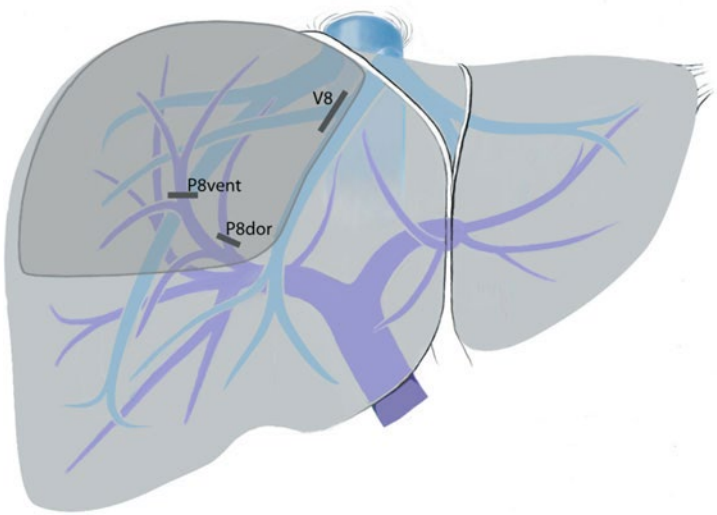
Hepatocellular carcinoma and intrahepatic cholangiocarcinoma spread via intrahepatic portal branches. Anatomical resections of a tumor-bearing portal area or of a segment or a section are basic procedures for treating liver tumors.

This chapter features the anatomical resection of segment 8, segment 7, and the right anterior sectionectomy as typical procedures, containing most of the basic techniques for anatomical liver resection. Other procedures, including left lateral sectionectomy, left medial sectionectomy, central hepatectomy, and wedge resection, are briefly presented.

Anatomical Resection of Segment 8

The standard three-dimensional anatomy of Sg8 is shown in ◘ Fig. 49.1.

The portal venous branches in Sg8 consist of two main branches, the dorsal branch (P8*dor*) and the ventral branch (P8*vent*), in 92 % of patients. P8*vent* and one to three branches of Segment 5 (P5) form a trunk in 62 % of patients. Between P8*vent* and P8*dor*, a thick branch of the middle hepatic vein (MHV) runs and drains Segment 8 (V8).



◘ **Fig. 49.1**

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery*,
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Step 1

Access and identification of Sg8

A J-shaped thoracoabdominal incision is made entering via the 9th intercostal space. Using the operator's left hand, the right liver is easily lifted up together with the diaphragm. This way a wide surgical field for the right liver is obtained (Fig. 49.2a).

Under hepatic arterial occlusion with a soft jaw clamp, P8*vent* and P8*dor* are punctured with a 22G needle using the intraoperative ultrasound. Approximately 5 mL of indigo carmine is slowly injected into each vessel (Fig. 49.2b). The liver surface of Sg8 is stained blue and the border is marked with electrocautery. Cholecystectomy and hilar dissection are performed when hemihepatic vascular occlusion is applied during hepatic parenchymal transection. No hilar dissection is needed when Pringle's maneuver is applied.

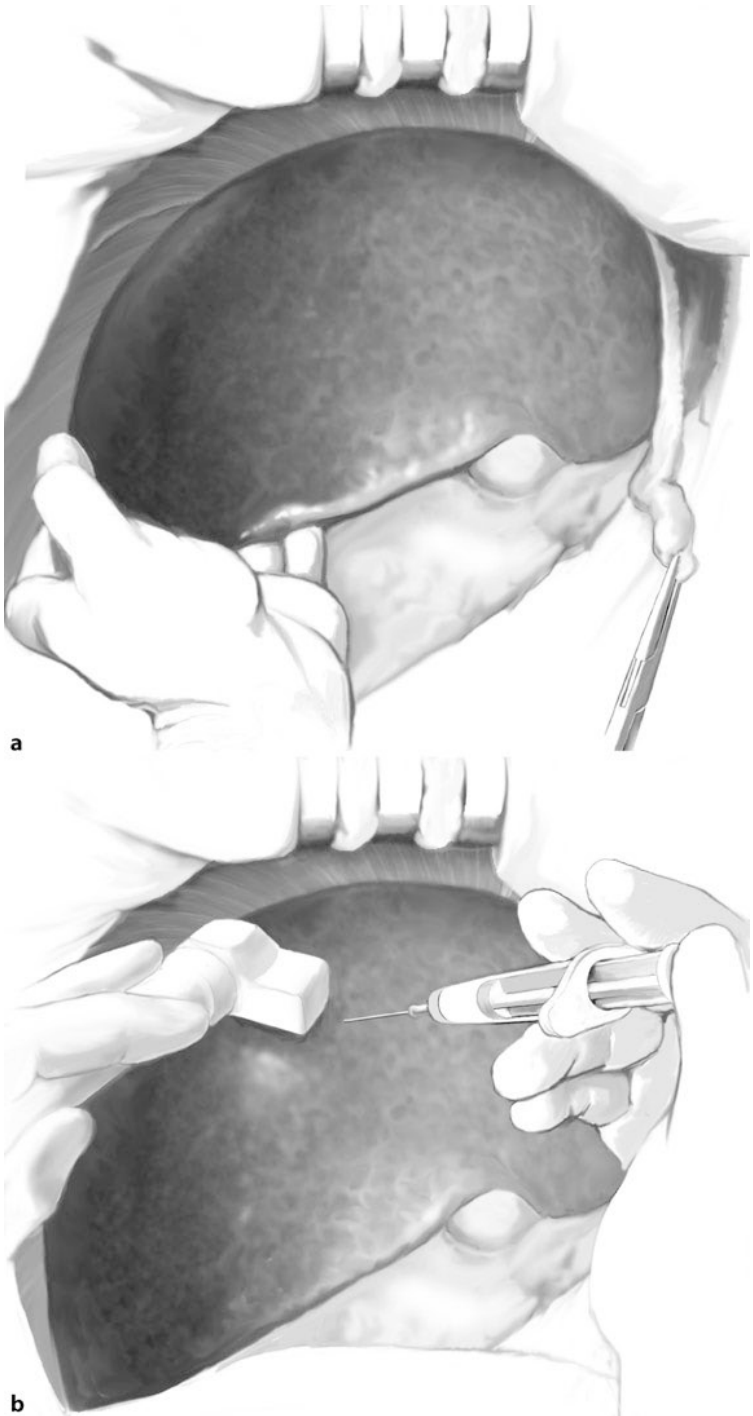


Fig. 49.2

۰۲۱-۶۶۱۹۸۵۱۴ www.myuptodate.com دریافت آخرین نسخه آپتودیت آفلاین

Step 2

Hepatic parenchymal transection along the main portal fissure

Using a curved forceps, hepatic parenchymal transection begins along the main portal fissure following the burned mark on the liver surface (Fig. 49.3a).

The trunk of the MHV is exposed and its tributaries draining Segment 8 are carefully ligated and divided (Fig. 49.3b).



Fig. 49.3

۰۲۱-۶۶۱۹۸۵۱۴ www.myuptodate.com دریافت آخرین نسخه آپتودیت آفلاین

Step 3

Division of the portal pedicles for Segment 8

The intersegmental plane between Sg8 and Sg5 is dissected and the portal pedicle for the ventral part of Sg8 (P8*vent*) is isolated and divided. The dorsal portal pedicle (P8*dor*) is then ligated. Hepatic parenchymal transection along the right portal fissure is done and the right hepatic vein (RHV) is exposed (Fig. 49.4).

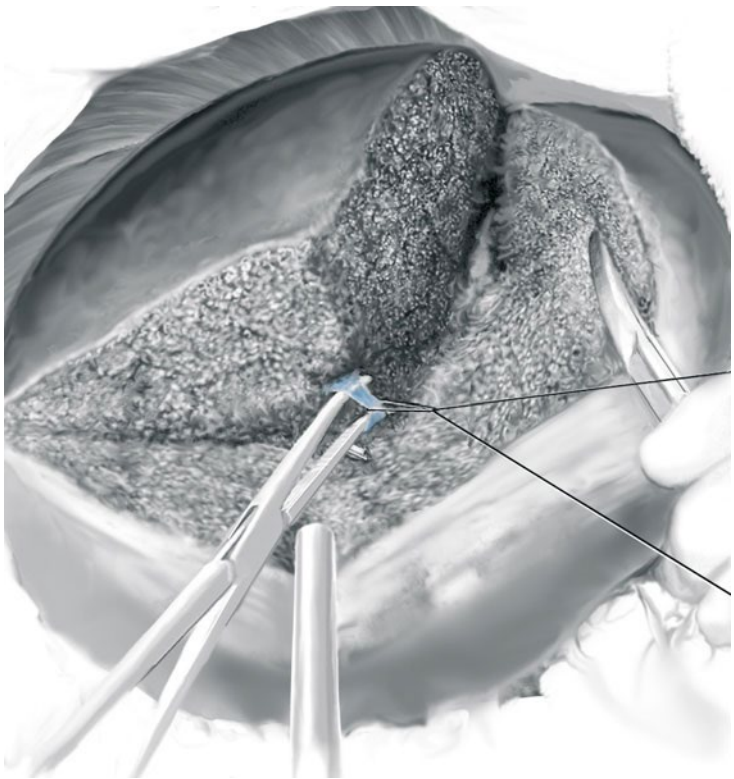


Fig. 49.4

۰۲۱-۶۶۱۹۸۵۱۴ www.myuptodate.com دریافت آخرین نسخه آپتودیت آفلاین

Step 4

Exposure of the RHV trunk

The root of the RHV is exposed and a thick venous tributary draining Sg8 is divided. The specimen can now be removed, and the procedure is completed with careful hemostasis and suture ligation of bile leaks. After removal of Segment 8, landmarks including MHV, RHV, and stumps of P8*vent* and P8*dor* are exposed (Fig. 49.5).

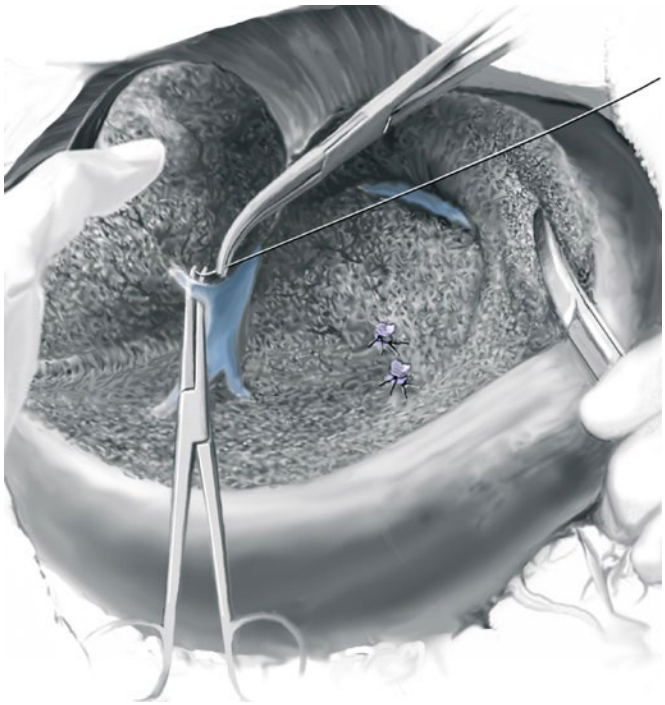


Fig. 49.5

Procedure: Anatomical Resection of Segment 7

Access to Sg7 is gained through a straight thoracoabdominal incision via the 8th intercostal space (left semilateral position) or through a right subcostal incision. An overview of the important anatomical structures is shown in Fig. 49.6.

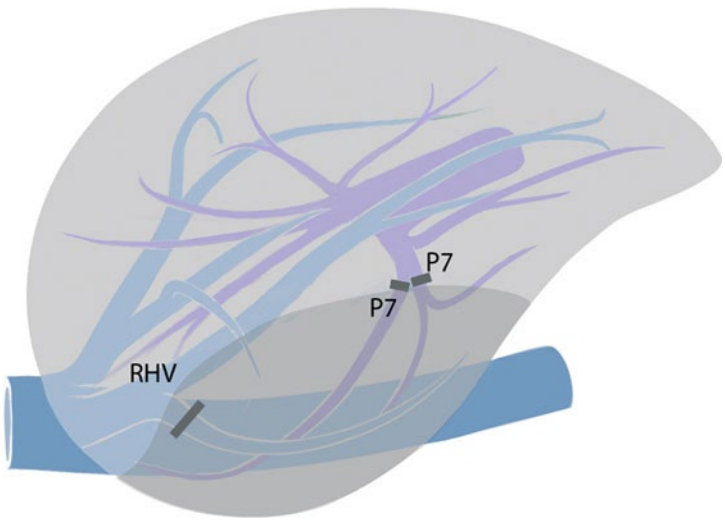


Fig. 49.6

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Step 1

Identification of the intersegmental plane and ligation of small hepatic vein branches

The intersegmental plane between segments 7 and 6 is identified by injecting the dye into P6 (a counterstaining technique). A crushing method is applied using Pringle's maneuver (Fig. 49.7a).

When a peripheral branch of the RHV is exposed, it is carefully traced proximally and the trunk of the RHV is exposed. Tiny branches of the RHV are carefully ligated with 4-0 silk (Fig. 49.7b).

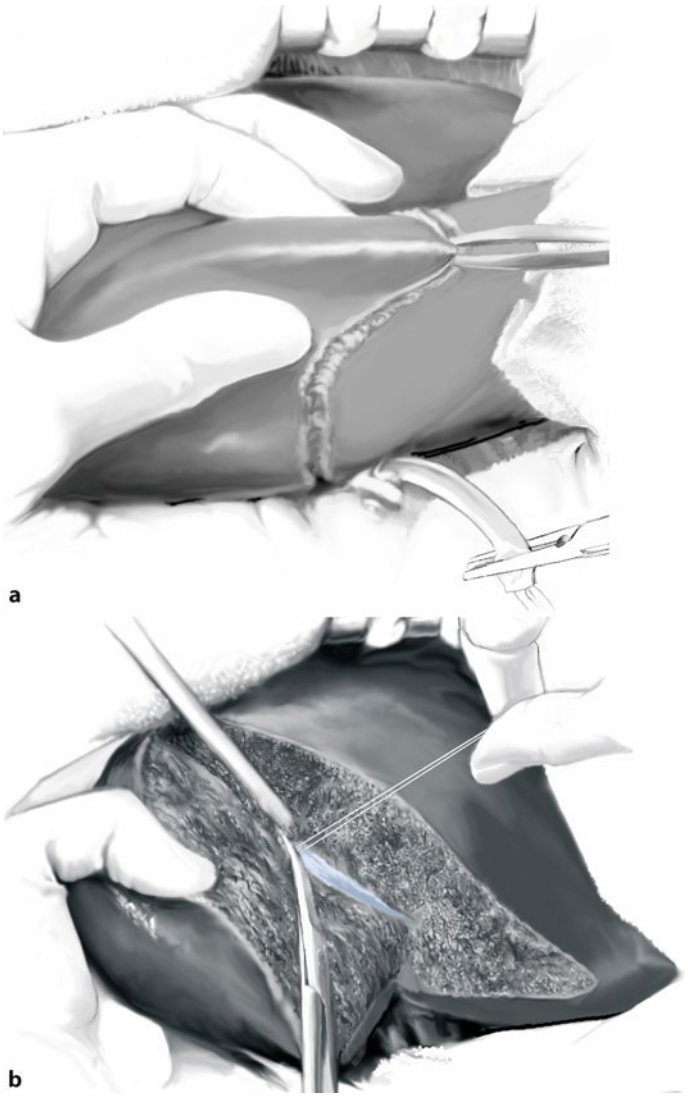


Fig. 49.7

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Step 2

Division of the portal pedicles for Segment 7 and exposure of the RHV

The two major portal pedicles are exposed. Both are ligated and divided (Fig. 49.8a). The RHV is exposed and a thick drainage vein of Sg7 is ligated (Fig. 49.8b). After removal of Sg7, landmarks including the RHV and stumps of P7 are exposed.

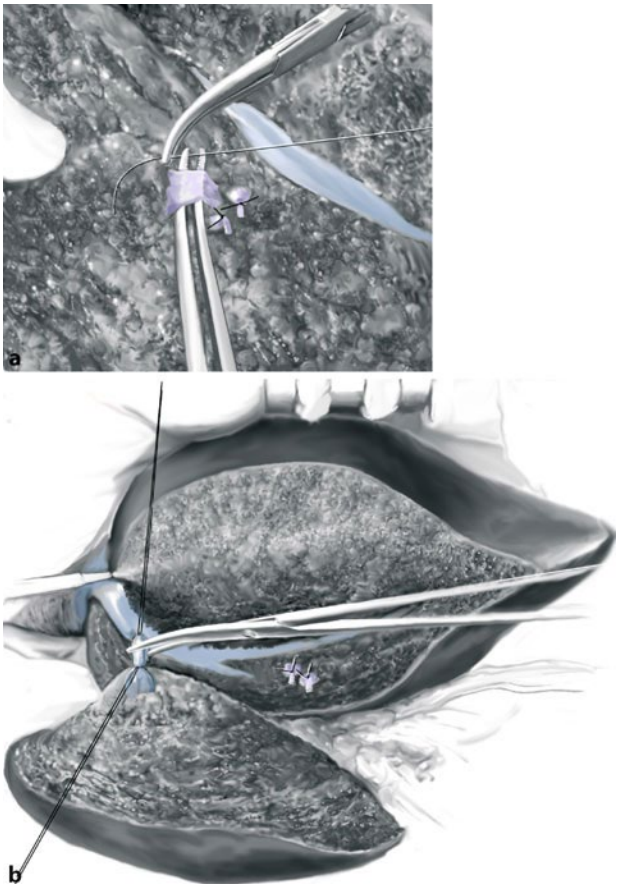


Fig. 49.8

Procedure: Right Anterior Sectionectomy (Right Paramedian Sectoriectomy, Anatomical Resection of Segments 5 and 8)

This procedure requires complete division of the main and right portal fissure, and thus the area of parenchymal transection of this procedure is the widest among all anatomical liver resections (Fig. 49.9).

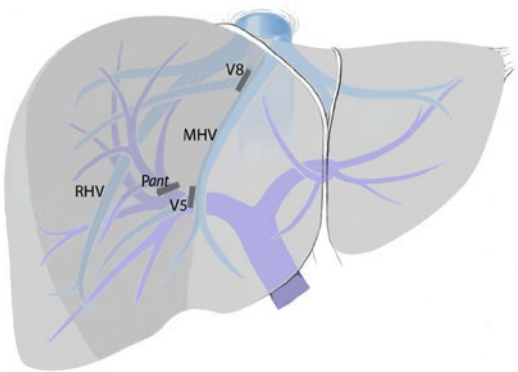


Fig. 49.9

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49

Step 1

Hilar dissection and identification of the anterior section; transection along the midplane of the liver

After cholecystectomy, the hepatic hilum is dissected and the right hepatic artery (RHA), the right portal vein (RPV), and arterial and portal branches for the anterior and posterior section (A*ant*, A*post*, P*ant*, P*post*) are isolated (Fig. 49.10a). (For access to the hilum and preparation of the right portal vein and right hepatic artery, see also the discussion of right hemihepatectomy [▶ Chap. 46] and extended right hemihepatectomy [▶ Chap. 48].)

After clamping A*ant* and P*ant*, the liver surface of the anterior section is discolored and the demarcation lines are marked with electrocautery. This procedure confirms the sectional vascular anatomy, and A*ant* and P*ant* can now be ligated and divided.

Next, under selective vascular occlusion by soft vascular clamps of the left liver and anterior section, the hepatic parenchymal transection along the midplane of the liver is started (Fig. 49.10b). The MHV is exposed and tiny tributaries are carefully ligated and divided (Fig. 49.10c).

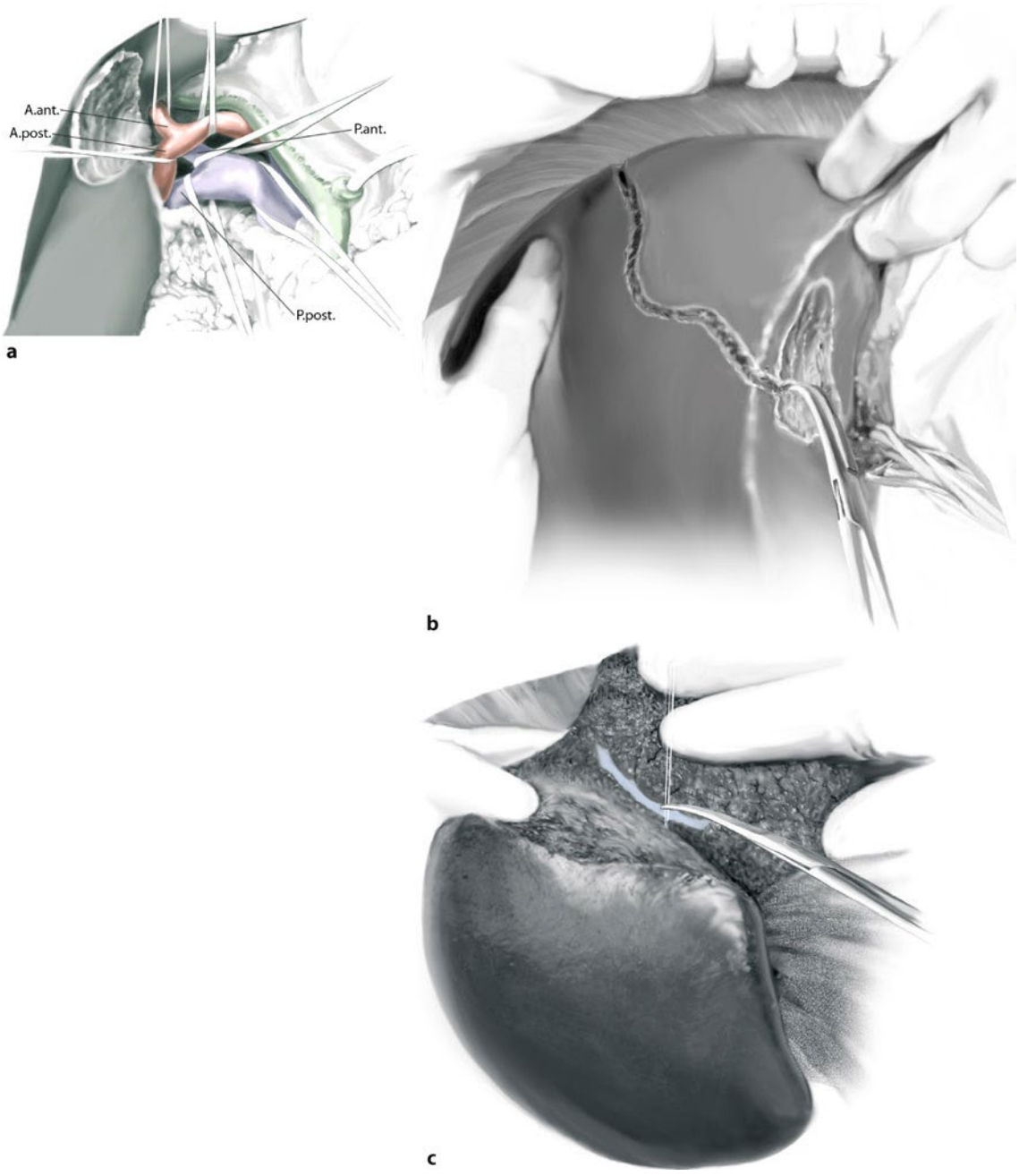


Fig. 49.10

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Step 2

Hepatic parenchymal transection along the right intersectional plane

Under a right hemihepatic vascular occlusion, hepatic parenchymal transection along the right intersectional plane is started (Fig. 49.11a). The anterior section is lifted with the operator's left hand and the portal pedicle for the anterior section (P*ant*) is ligated and divided (Fig. 49.11b).

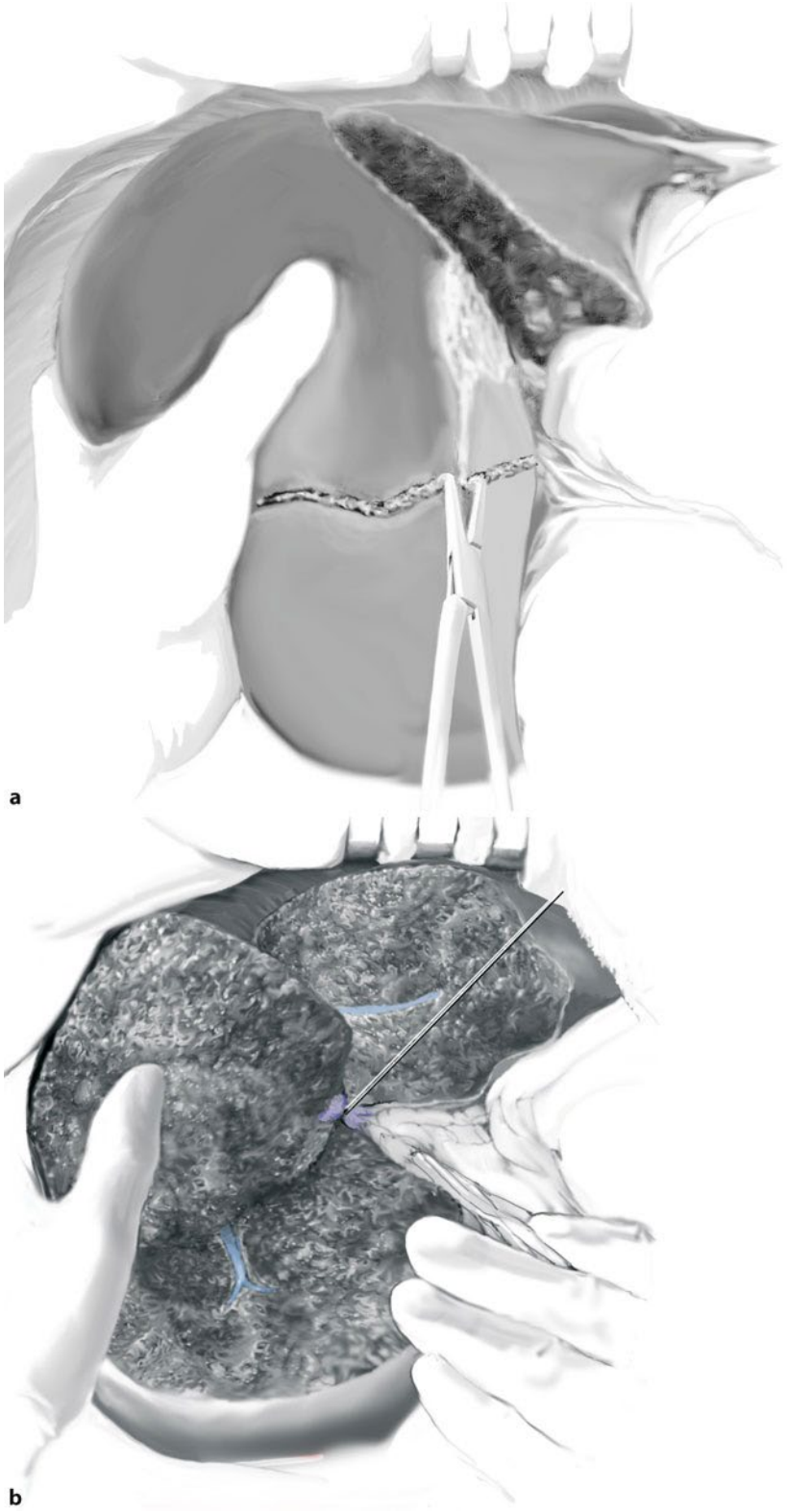


Fig. 49.11

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Step 3

Transsection of the RHV branch

The RHV is exposed and a thick venous branch draining the anterior section is divided. After removal of the anterior section, landmarks including the MHV, RHV, and the stump of P*ant* are exposed (Fig. 49.12).

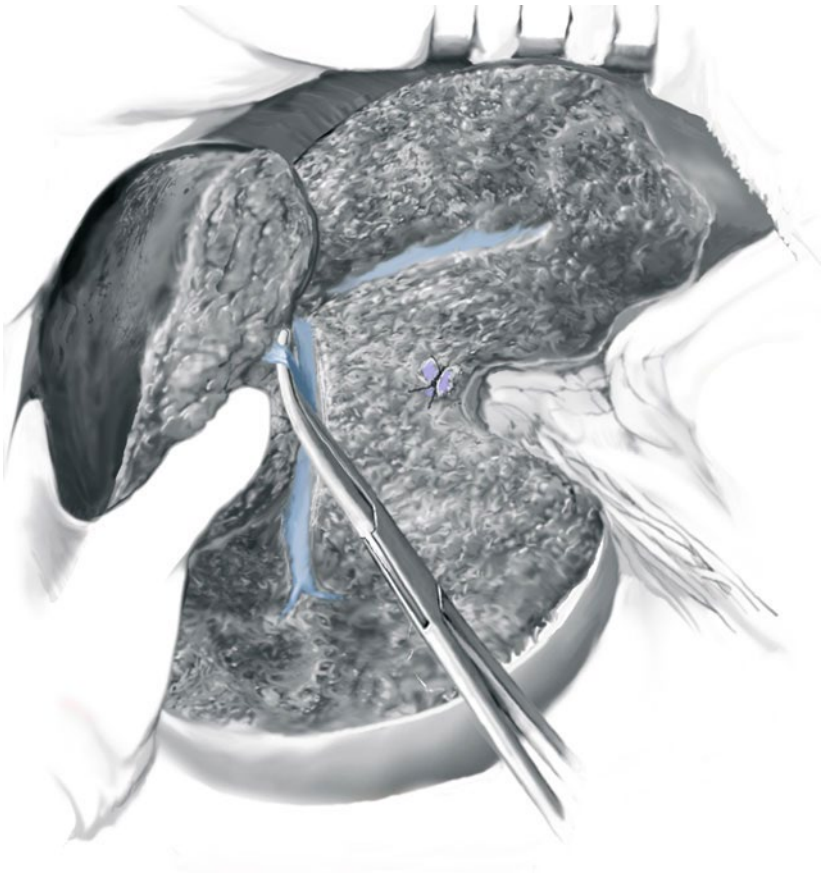


Fig. 49.12

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Procedure: Left Lateral Sectionectomy (Anatomical Resection of Segments 2 and 3)

Figure 49.13 depicts the important anatomical structures for this procedure.

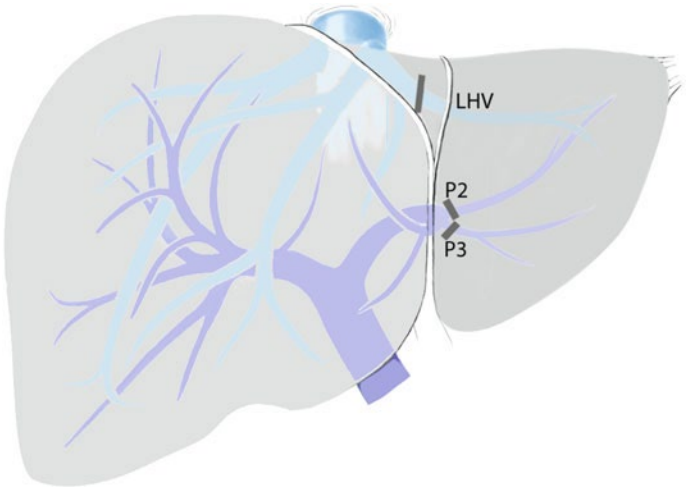


Fig. 49.13

Step 1

Hepatic parenchymal transection along the left edge of the falciform ligament (the left intersectional plane)

By pulling up the left liver via the round ligament, hepatic parenchymal transection is done along the left edge of the falciform ligament. The left wall of the portal pedicle for the umbilical portion of the portal vein is exposed, and all of the tributaries running into the lateral section are ligated and divided. When liver parenchyma of segment 3 and 4 is connected in the visceral side of the umbilical portion, the connecting part is divided during parenchymal transection.

Step 2

Division of portal pedicles for segment 2 and 3

Along the left wall of the umbilical portion of the portal vein, there are a few thick portal pedicles for segment 3 (P3). All of them are ligated and divided. Portal pedicles for segment 2 (P2) are located in the cranial edge of the umbilical portion of the portal vein. They are usually thicker than P3s and only 2 or 3 cm caudal to the root of the left hepatic vein (LHV). They are ligated and divided.

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Step 3

Division of the left hepatic vein (LHV)

At the end of the hepatic parenchymal transection, the root of the left hepatic vein (LHV) is exposed and divided. The stump of the LHV is ligated or is closed by running suture. Figure 49.14 shows the situation at the end of the procedure.

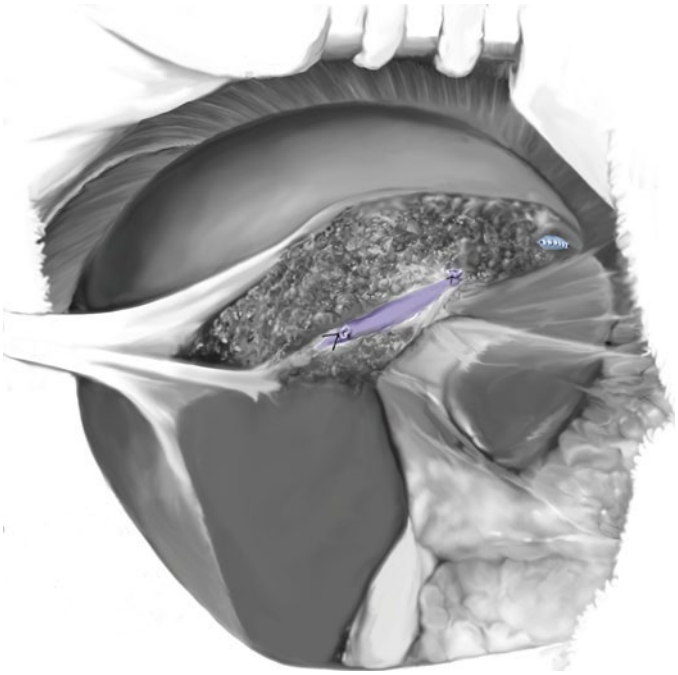


Fig. 49.14

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Procedure: Left Medial Sectionectomy (Anatomical Resection of Segment 4)

Figure 49.15a depicts the important anatomical structures for this procedure.

Hepatic parenchymal transection is done along the midplane of the liver and the right side of the umbilical portion of the portal vein (the left intersectional plane). After removal of the left lateral section, landmarks including the MHV and stumps of P4s are exposed (Fig. 49.15b).

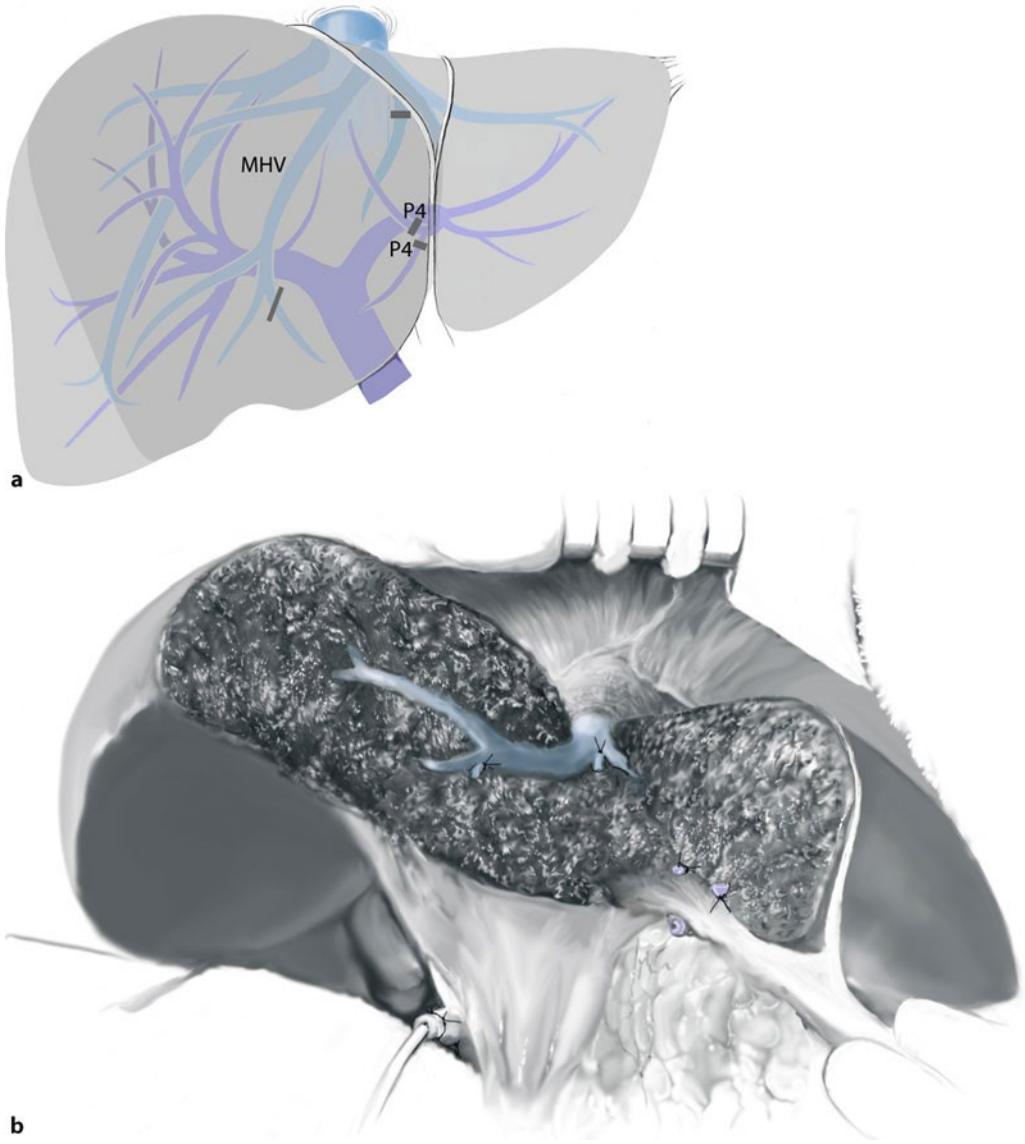


Fig. 49.15

Procedure: Central Hepatectomy (Anatomical Resection of Segments 4, 5, and 8)

Figure 49.16a depicts the important anatomical structures for this resection.

Hepatic parenchymal transection is done along the right and left intersectional plane (i. e., the umbilical portion of the portal vein). The MHV is divided at its root. After removal of the left lateral section, landmarks including the RHV and stumps of P*ant* and P4s are exposed (Fig. 49.16b).

For preparation of the right and anterior portal vein and right hepatic artery, and identification of the right intersectional plane, see also the steps for Right Anterior Sectionectomy.

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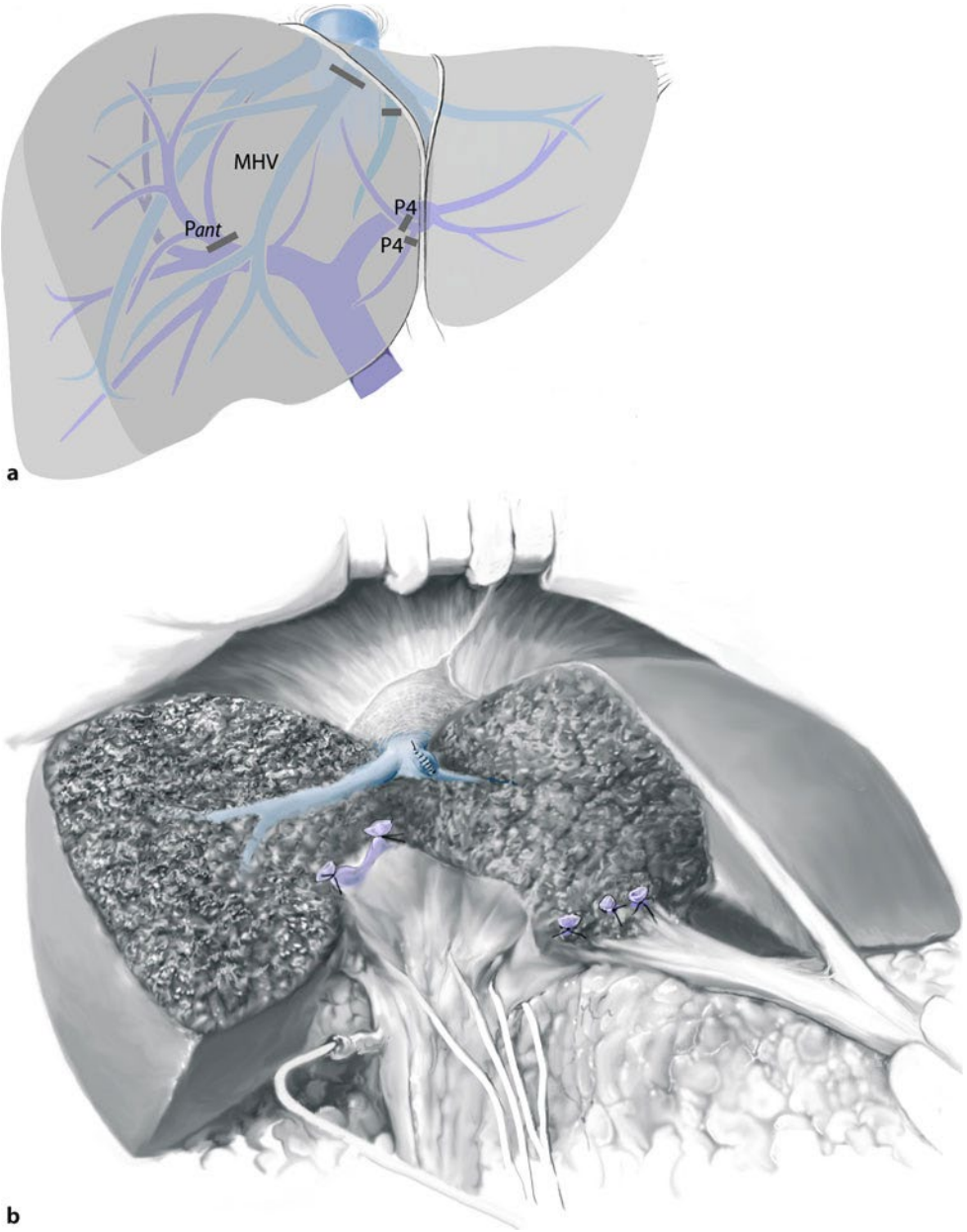


Fig. 49.16

Procedure: Wedge Resection (Limited Resection)

The aim of this procedure is a non-anatomical complete removal of the tumor with sufficient margin. A wide surgical margin (e. g., > 10 mm) is not necessary, but care should be taken not to expose the tumor on the cut surface.

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Tricks of the Senior Surgeon

- Complete exposure of major hepatic veins, the landmarks for the intersegmental planes, is the key for successful segmentectomy and sectionectomy.
- Before starting hepatic parenchymal transection, branching patterns of the major hepatic veins in each patient should be examined thoroughly with intraoperative ultrasound.
- Major hepatic veins are first exposed at their root and distal edge in the cut surface. Then the middle part of the venous trunks is exposed from both ends.
- A tip of the Metzenbaum scissors is useful for dissecting hepatic veins, and all venous branches larger than 1 mm should be ligated.
- Very tiny branches can be pulled out from the parenchyma (not from the venous wall) with vascular pickups.
- Central venous pressure should be kept low (< 3 mm Hg) to reduce blood loss during the parenchymal transection.

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Laparoscopic Liver Resection

Michael D. Kluger, Daniel Cherqui

Different laparoscopic resections require varying levels of expertise, but all require familiarity with preoperative planning and perioperative care of the liver patient, open liver surgery, hepatic anatomy, and advanced laparoscopic principles. The 2008 Louisville Statement divides these operations among pure laparoscopy, hand-assisted laparoscopy, and a hybrid technique. Pure laparoscopy involves complete mobilization and resection via laparoscopic ports, although an incision may be used for specimen extraction. Hand-assisted laparoscopy involves the elective placement of a hand-port for mobilization or resection, which is then used for specimen extraction. In the hybrid technique, the resection is performed through a mini-laparotomy, though laparoscopy with or without hand assistance is utilized for mobilization. Historically, about 25 % of liver resections may be considered for a laparoscopic approach.

Indications and Contraindications

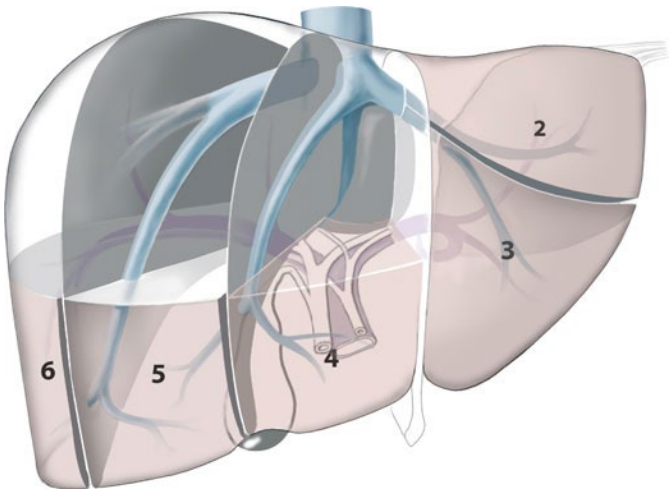
Indications

The indications for laparoscopic liver resection are the same as for open liver resections. High-quality MRI or CT imaging with vascular reconstruction should be reviewed to evaluate for intrahepatic arterial and portal anomalies and to determine if the lesion is amenable to a laparoscopic resection.

Based on tumor size and location of the lesion, the following situations are most suitable for a laparoscopic approach: 1) nonpedunculated lesions less than 5 cm in diameter; 2) pedunculated lesions of any size that do not obscure safe working space; and 3) lesions located in the anterior segments of the liver (Segments 2–6; ◘ Fig. 50.1), especially lesions requiring a left lateral sectionectomy.

Contraindications

Contraindications are mainly anatomical: 1) large, nonpedunculated tumors (> 5 cm in diameter); 2) lesions located in proximity to the major hepatic veins, the inferior vena cava, and the hepatic hilum; 3) hilar cholangiocarcinoma, or inability to achieve a sufficient margin for any lesion; and 4) patient unlikely to tolerate or recover from an open operation because of chronic medical conditions.



◘ **Fig. 50.1**

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery*,
DOI 10.1007/978-3-662-46546-2_50, © Springer-Verlag Berlin Heidelberg 2016

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Patient Position, Port Sites, and Case Preparation

- For atypical and anatomical resections in segments 2 through 5, right hepatectomy, left hepatectomy, and left lateral sectionectomy: Supine position with lower limbs apart and five ports (Fig. 50.2a)
- For limited resection of segment 6: A left lateral decubitus position with three or four ports may be considered (Fig. 50.2b)
- All laparoscopic equipment should be state-of-the-art:
  - A 10-mm 30° laparoscope with high-definition camera, xenon lighting, and high-definition monitors improve the visual safety of the operation.
  - Comfortable, ergonomic laparoscopic instruments, including ratcheted, atraumatic bowel graspers, curved and right angle dissectors, scissors, needle holders, and a liver retractor, are necessary.
  - Devices including laparoscopic staplers, ultrasonic dissector, ultrasonic shears or a vessel-sealing device, clip appliers, suction-irrigator, bipolar diathermy forceps, and a monopolar diathermy hook are all critical.
  - B-mode and D-mode ultrasound and a high-frequency laparoscopic transducer probe are required.
- Low central venous pressure anesthesia
- Low-pressure (12 mm Hg) CO_2 pneumoperitoneum to prevent gas embolism

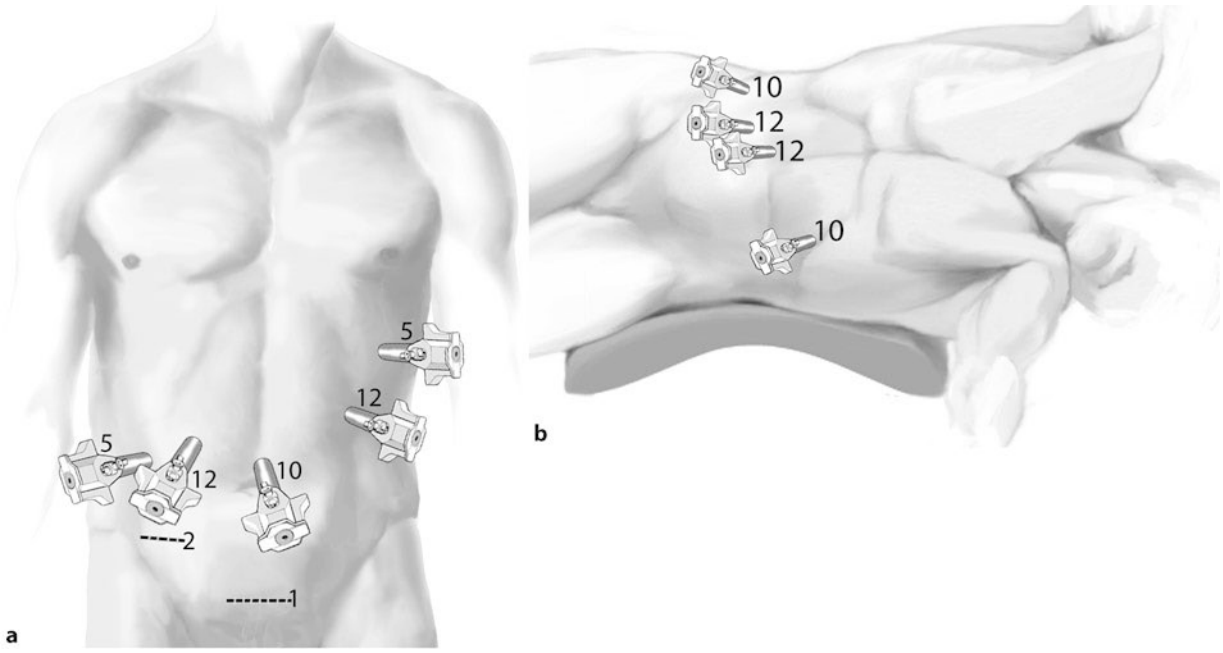


Fig. 50.2

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Procedures

A note on parenchymal transection: From a simplistic view, the operator dissects through three layers of liver parenchyma perfused and drained by vascular and biliary structures of various sizes. The first layer, the capsule, is easily penetrated and made hemostatic using monopolar diathermy. The second layer comprises the superficial 2 to 3 cm of parenchyma, which can be transected with ultrasonic shears or a vessel-sealing device. For the deep parenchyma, dissection is best accomplished with an ultrasonic dissector. Vascular and biliary structures encountered during the dissection of the superficial and deep parenchyma are ligated and transected with different devices based on their diameter. Vascular and biliary structures less than 3 mm are ligated and transected using ultrasonic shears, a vessel-sealing device, or bipolar diathermy. Larger structures such as the hepatic artery and bile ducts are ligated using plastic locking clips. Laparoscopic staplers with 2.5 mm depth loads are used for Glissonian pedicles, portal branches, and hepatic veins.

Procedure: Left lateral sectionectomy

This is the anatomic liver resection most commonly performed laparoscopically. It also illustrates many of the techniques necessary for more difficult laparoscopic procedures.

Step 1

Access, exploration, and mobilization of the left lateral section

After placement of the ports, the liver is explored by laparoscopic ultrasound to determine the size and location of the tumor, to detect additional lesions, to assess the quality of surrounding liver tissue, and to confirm the feasibility of a laparoscopic resection. First, the round ligament is divided, and then the falciform ligament is divided down to the inferior vena cava where the hepatic veins insert. Finally, the left triangular and coronary ligaments are divided and the lesser omentum is opened. When present, an accessory or replaced left hepatic artery originating from the left gastric artery should be ligated and divided. Additionally, a parenchymal bridge covering the inferior aspect of the round ligament should be divided.

Step 2

Preparation for the Pringle maneuver and parenchymal transection

If pedicle occlusion is anticipated, the pars flaccida is opened and an instrument is passed from the most lateral right port behind the portal triad in order to encircle it with an umbilical tape (Fig. 50.3a). The ends of the tape are then extracorporeally passed through the lumen of a 16 French rubber tube 4 to 5 cm in length and returned to the abdomen. If pedicle clamping is required, a laparoscopic instrument grasps the ends of the tape, pulling it taut, while a laparoscopic locking clip applier pushes the tubing toward the pedicle and applies a clip, thereby maintaining the Pringle (Fig. 50.3b). We favor 15 min of clamping interrupted by 5 min of pedicle flow.

Parenchymal transection follows the left margin of the round and falciform ligament from the anterior edge of the left lateral section up to the level of the origin of the left hepatic vein. The exposure during transection is maintained by traction of the round ligament superiorly and to the right and traction of the left lateral segment superiorly and to the left, using atraumatic bowel graspers (Fig. 50.4a). It is important that the line of transection remains on the left side of the falciform ligament, to avoid injury to the pedicles of Segment 4. Posteriorly, the line of transection follows the anterior margin of Arantius' ligament. The technique of parenchymal transection includes division of the liver with step-by-step control and division of the encountered pedicles (Fig. 50.4b). The parenchyma to be divided during a left lateral sectionectomy is usually thin enough that ultrasonic shears or a vessel-sealing device is sufficient for transection. These devices are also sufficient for minor vessels up to 3 mm. Structures larger than 3 mm in diameter are clipped before division. Portal pedicles to Segments 2 and 3 are divided using two or three firings of the linear stapler (Fig. 50.5). The stapler must be applied on the left side of the round ligament. The Pringle maneuver in Fig. 50.3, 50.4, 50.5 is for purposes of demonstration, and is typically unnecessary for left lateral sectionectomy.

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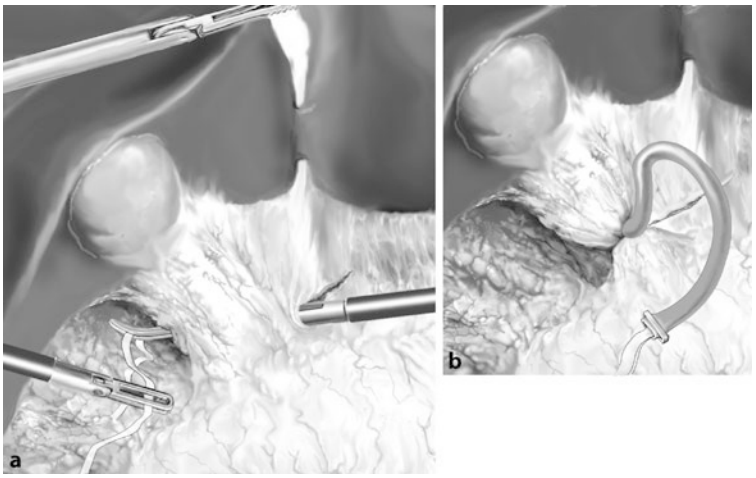


Fig. 50.3

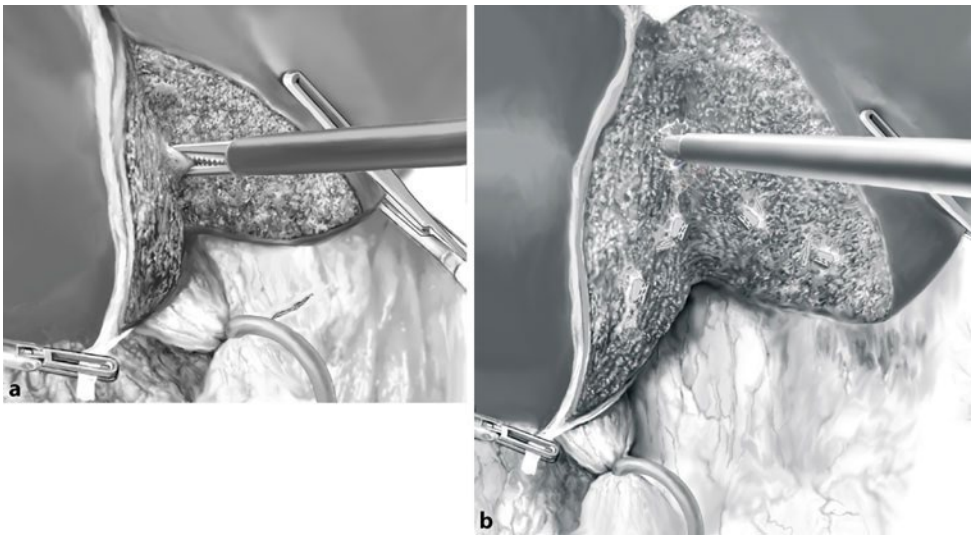


Fig. 50.4

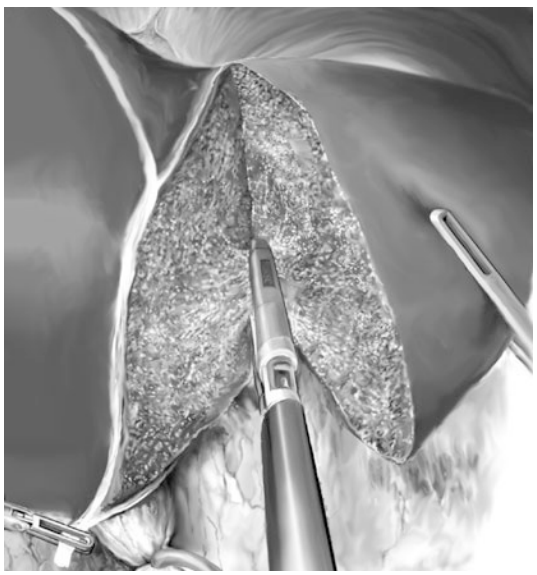


Fig. 50.5

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Step 3

Transection of the left hepatic vein and extraction of the specimen

Once the portal pedicles have been divided, dissection progresses cephalad to identify the left hepatic vein, which can then be divided using a linear stapler, finishing the transection (Fig. 50.6a). Additional hemostasis of the transected surface can be achieved by monopolar or bipolar diathermy, clipping, or suturing.

Lesions can be removed through preexisting scars, or through a 5-cm Pfannenstiel incision in the virgin abdomen (Fig. 50.6b). Regardless of the chosen incision, the abdominal wall is incised to the fascia and a 15-mm trocar is inserted at the center of the incision. A large-capacity endoscopic bag is introduced and the specimen retained (Fig. 50.6c). The specimen is then retracted against the fascia, and the fascia and peritoneum are opened only as much as necessary for retrieval. The fascial layers are anatomically approximated and the pneumoperitoneum is reintroduced. The operative site is again examined for hemostasis and biliary stasis.

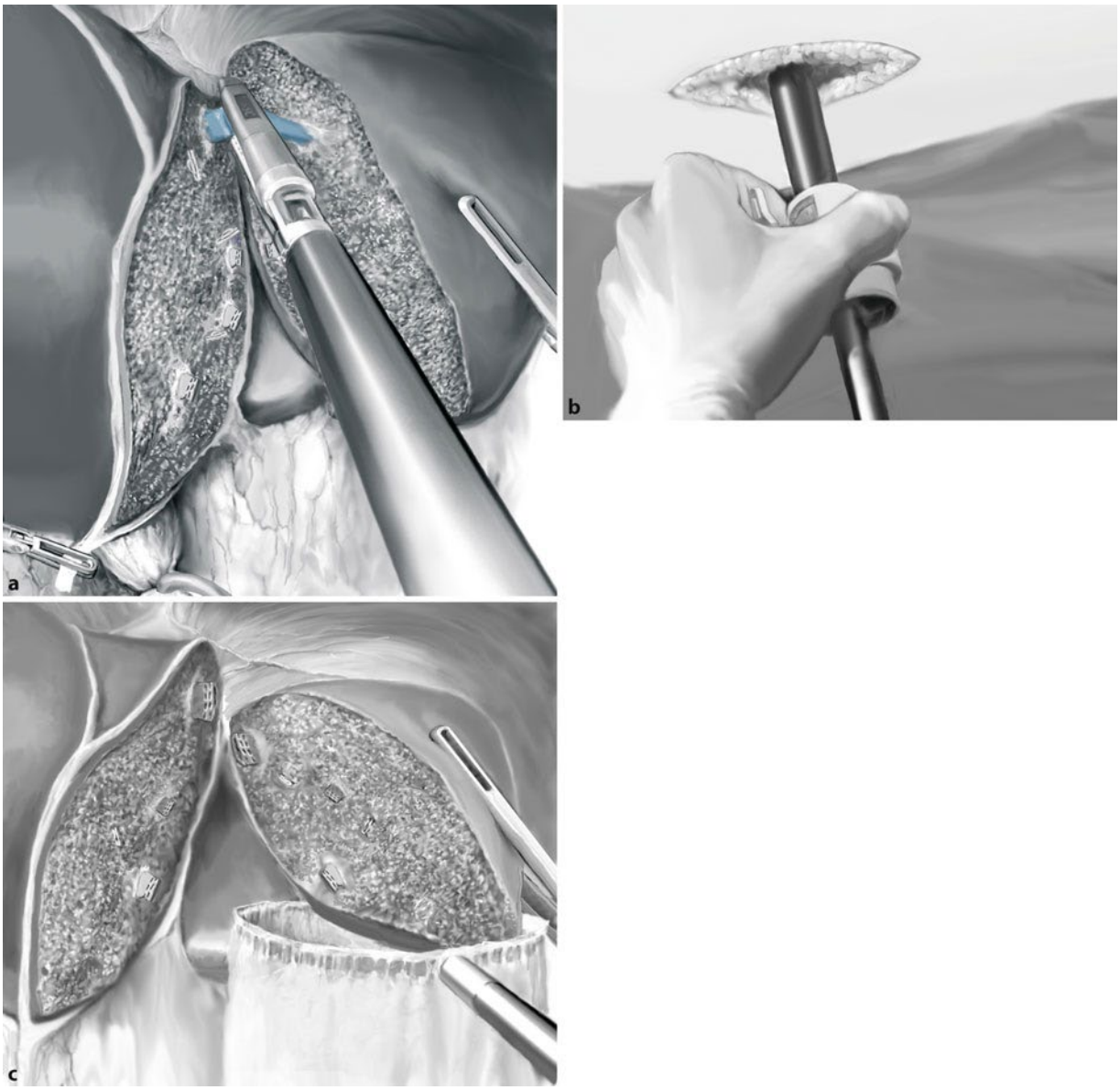


Fig. 50.6

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Procedure: Non-anatomical resections

These resections are for small lesions located on the edge of the anterolateral segments of the liver. The liver is exposed and explored as for a left lateral sectionectomy; ligaments need to be transected only if it will improve exposure. Although a Pringle maneuver is rarely necessary for these resections, it is a safety measure to prepare for the possibility of bleeding. Resection limits are marked on the liver surface with diathermy after ultrasonography confirmation (Fig. 50.7). Wide margins are not required for benign lesions, but a 10-mm margin is recommended for malignant tumors of the liver. Dissection should proceed circumferentially at equal depths. Dissecting a hole in one area should be avoided, because depth may be underappreciated and vascular or biliary structures inadvertently violated. A 4-0 Prolene suture can be used to lift the lesion away from the surrounding parenchyma to promote circumferential, consistent-depth dissection.

Parenchymal transection follows the margins marked on the liver surface by diathermy. Because this is a peripheral resection, either the ultrasonic shears or a vessel-sealing device is sufficient. Additional hemostasis is achieved by bipolar diathermy and according to the size of the encountered pedicles. Staplers are usually unnecessary except for pedunculated lesions, whose pedicles can be divided by stapler applications. Depending on lesion size, the specimen is extracted through extension of a port incision or in the same way as for the left lateral sectionectomy.

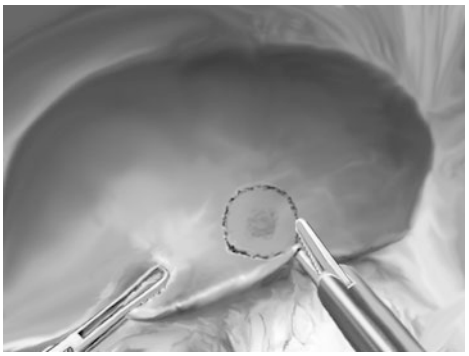


Fig. 50.7

Procedure: Laparoscopic right hepatectomy

This procedure can be performed from an anterior or conventional approach. Although the hilar dissection is the same for both approaches, the conventional approach entails extensive pretransection mobilization and extrahepatic control of the right hepatic vein; the use of a hand-port may be useful in this setting. Additionally, hand-assisted laparoscopy can be utilized as needed for failure of case progression or to aid in obtaining hemostasis. A gas-tight port is placed in the right lower quadrant and the incision is later used for specimen extraction (Fig. 50.8). The pure laparoscopic anterior approach is described below.



Fig. 50.8

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Step 1

Access, exploration, mobilization, and vascular control

Ports are placed and the round and falciform ligaments are transected as previously described; ultrasonography is performed. After partial cholecystectomy, the distal cystic duct is retracted to the patient's left and the gallbladder to the right, exposing the short course of the extrahepatic right pedicle. If the patient has had a prior cholecystectomy, the right and left hemilivers are retracted using atraumatic graspers. The right hepatic artery is circumferentially dissected for a distance of 1 to 2 cm and encircled with a tape to retract it away and protect the other hilar structures. The right hepatic artery is divided between plastic locking clips (Fig. 50.9a). The right portal vein is visualized posterior to the artery and dissected and taped in a similar manner. The bifurcation and left portal branch must be clearly visualized (Fig. 50.9b). When transecting the right portal vein with a linear stapler, the tape should be pulled to the patient's left, to displace the bifurcation to the left and lengthen the right branch (Fig. 50.9c). Plastic locking clips may also be placed. This prevents narrowing of the left portal branch. It will often be necessary to ligate a portal branch from the right portal vein to the anterior-right side of Segment 1 with an electrosurgical device to safely dissect the right portal branch.

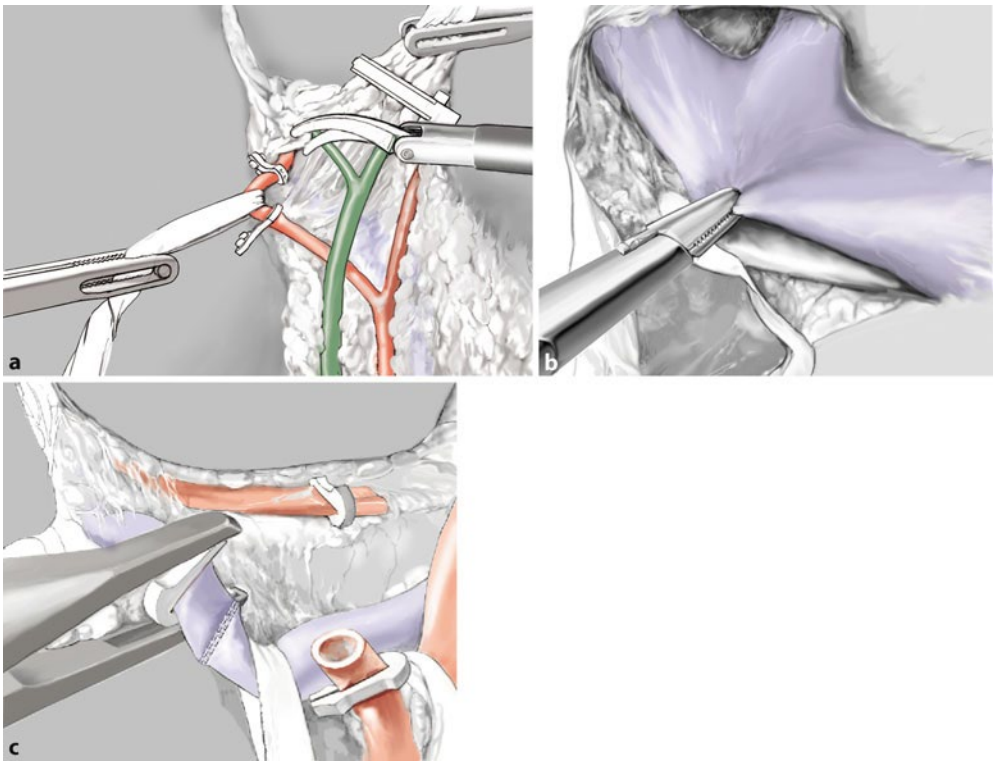


Fig. 50.9

Step 2

Parenchymal transection

The extrahepatic vessel ligation delimits the plane of ischemia and thus transection, and is outlined on the liver capsule with monopolar diathermy. Parenchymal transection is started at the inferior edge of the liver in the anterior-to-posterior and caudad-to-cephalad directions along the demarcation line. At the hilar plate, the right bile duct is circumferentially dissected until the anterior and posterior branches are visualized, at which point the duct can be divided with locking clips or the stapler. Division of the hilar plate allows the dissection plane to be opened wide for easier parenchymal transection. It will be necessary next to divide the connective tissue junction between the right lobe and Segment 1 with electrosurgery to fully expose the retrohepatic cava. As parenchymal transection progresses, Glisson's capsule is divided along the anterior surface of the cava, with systematic clipping and dividing of the small bridging veins.

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Step 3

Transection of the right hepatic vein and extraction of the specimen

As progress is made cranially, the proximal hepatic veins draining segments 5 and 8 toward the middle hepatic vein are exposed, clipped, and divided. The right hepatic vein is identified at its insertion into the cava, taped, retracted to the patient's right, and transected with an articulating linear stapler (Fig. 50.10). The specimen is now retracted to the right as the triangular and coronary ligaments are divided from the diaphragm with electrosurgical instruments, and then retracted to the left as the cava and hepatocaval ligament are divided with clips and staplers. The specimen is removed as previously discussed. For right hepatectomy, a 10 French closed-circuit suction drain is placed in the subphrenic space.

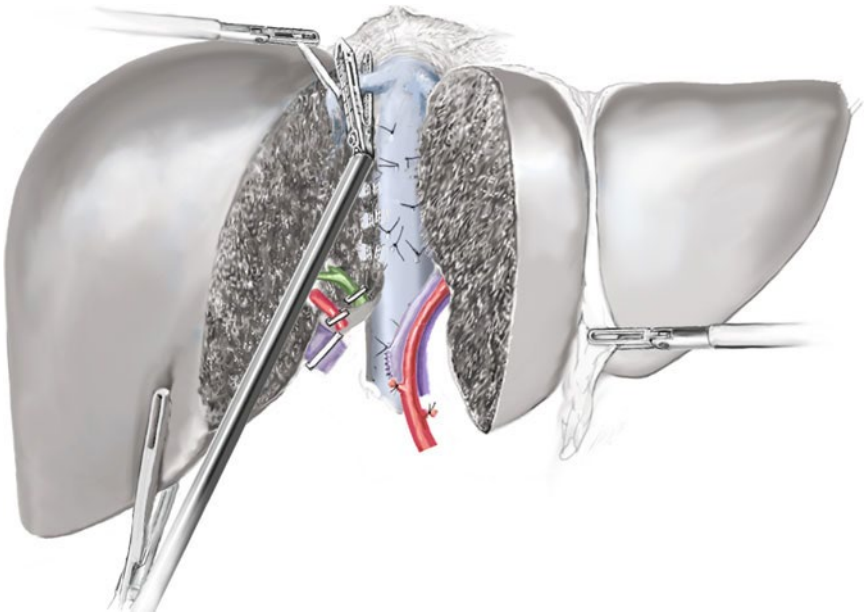


Fig. 50.10

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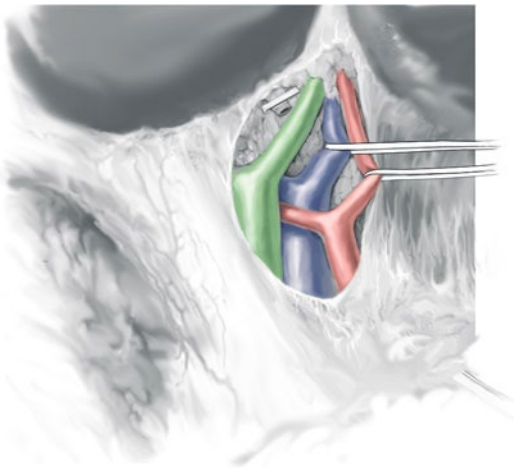
Procedure: Laparoscopic left hepatectomy

Step 1

Access, exploration, mobilization, and vascular control

Ports are placed and the round and falciform ligaments are transected as previously described; ultrasonography is performed. The left triangular and coronary ligaments are divided close to the liver from laterally to medially, as is the attachment of the lesser omentum. The left lateral segment is mobilized and the suprahepatic cava cleared of fibrous tissue so that the insertions of the hepatic veins into the vena cava are identified. The peritoneum above the caudate is next opened to expose the cava and the insertion of the left hepatic and middle veins. If a replaced or accessory left hepatic artery is present, it should be transected between clips.

The extrahepatic left Glissonian pedicle is exposed and carefully dissected using endoscopic scissors and bipolar diathermy. The left hepatic artery and left portal vein are individually isolated using right-angled forceps (◘ Fig. 50.11), elevated with umbilical tapes, and ligated with locking clips and a linear stapler, respectively.



◘ Fig. 50.11

Step 2

Parenchymal transection

Parenchymal transection proceeds anterior-to-posterior and caudad-to-cephalad. Once dissection enters the hilar plate, the left bile duct is divided with a linear stapler or between clips. Parenchymal transection continues cranially until the insertion of the left hepatic vein into the common trunk, at which point it is transected using an articulating stapler without encroaching upon the middle hepatic vein. Parenchymal transection is completed and the specimen is removed as previously discussed.

Procedure: Laparoscopic living-donor left lateral sectionectomy

This procedure consists of a laparoscopic left lateral sectionectomy without early vascular clamping or division in order to minimize parenchymal ischemia. General principles of patient preparation, instrumentation, and mobilization are the same as for the left lateral sectionectomy.

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Step 1

Preparation of the left portal pedicle

The left arterial and portal branches are dissected in the hepatoduodenal ligament as discussed for left hepatectomy, and encircled with a vessel loop, as was demonstrated in the previous figure for left hepatectomy. Arterial and portal branches to Segment 1 are divided between clips (Fig. 50.12).

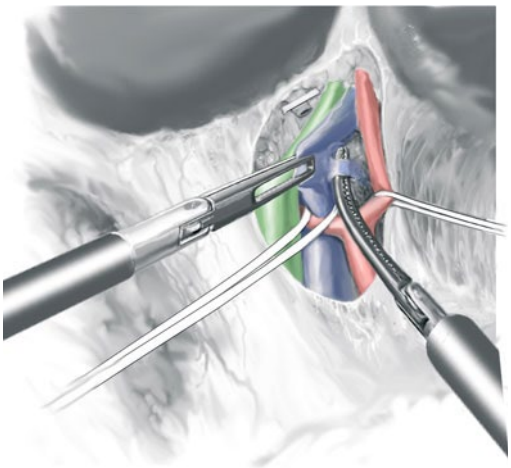


Fig. 50.12

Step 2

Parenchymal transection

In contrast to the conventional resection of the left lateral section, the parenchymal transection for living donation needs to be performed along the right of the falciform ligament. Ultrasonic shears or a vessel-sealing device is used for the superficial part of the transection, and an ultrasonic dissecting device is necessary for the deeper transection. Bleeding is controlled by using bipolar diathermy and clips, without vascular clamping. Segment 4 portal pedicles are divided inside the liver parenchyma with locking clips.

Step 3

Left bile duct division

Once parenchymal transection has reached the hilar plate and the left hepatic duct becomes visible, the left bile duct proximal to the Segment 4 insertion is divided using sharp scissors (Fig. 50.13). The remnant stump is sutured using absorbable running 5-0 monofilament sutures, with the graft stump being left patent.



Fig. 50.13

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Step 4

Completion of transection and isolation of the left hepatic vein

After bile duct division, transection progresses cephalad along Arantius' line, and complete circumferential dissection of the left hepatic vein is performed. At this stage, the graft is attached only by its vessels (Fig. 50.14).

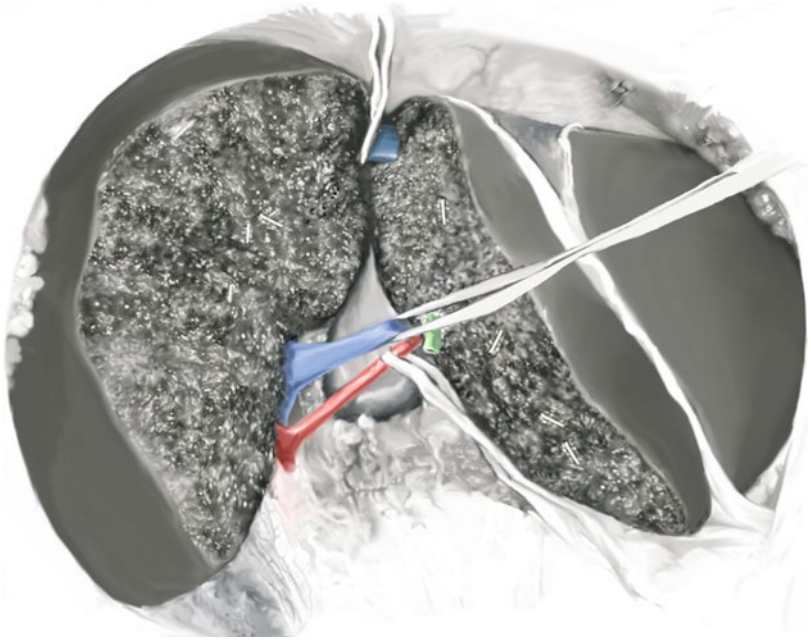


Fig. 50.14

Step 5

Graft harvesting

An extraction incision is made as previously discussed, but larger (typically 8–10 cm) so as not to compress the specimen. The left lobar arterial branch is clipped and divided. The left portal branch is then divided, initiating warm ischemia. To preserve an adequate length of the graft portal vein, an endovascular-TA stapler is used for the proximal transection. A bulldog clamp is placed on the graft side to prevent bleeding. Finally, the left hepatic vein is stapled with the endovascular-TA stapler. Through a 15-mm port, an endo-bag is placed for capture of the graft, which is extracted after incision of the fascia. The graft is handed to another team for perfusion with cold preservation solution. Warm ischemic time is usually less than 10 min.

Tricks of the Senior Surgeon

- Laparoscopic hepatectomy is a technically challenging procedure, but it can be performed safely for both benign and malignant lesions by those with expertise in both hepatic and advanced laparoscopic surgery.
- Patient selection and indications must be carefully assessed.
- A state-of-the-art laparoscopy suite and equipment are required.
- Ultrasonic shears or a vessel-sealing device are sufficient for superficial transection (2–3 cm in depth), whereas an ultrasonic dissector is recommended to identify deeper structures and avoid vascular injuries, especially of hepatic venous branches.
- In cases of persistent bleeding, insufficient exposure, failure to progress, risk of tumor rupture, or violation of margins, one should convert to an open procedure. Conversion (in contrast to a poor outcome) is not a procedural failure.

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Cryosurgery

Keh Min Ng, David L. Morris

The goal of hepatic cryosurgery is complete destruction of tumors for curative or palliative reasons, as an alternative to resection when resection is not feasible.

Indications and Contraindications

Indications

Malignant liver tumors in the case of:

- Cirrhosis, if risk of resection is excessive
- Extensive disease, where resection would not leave enough hepatic parenchyma
- Debulking of neuroendocrine tumors
- As an adjunct to resection (i. e. resect one side and cryoablate the other side)
- Edge cryotherapy, when resection margins are involved or are less than 1 cm

Contraindications

- Extrahepatic disease that is not amenable to surgery or ablation (except neuroendocrine tumors)
- High number of lesions (for example, more than nine; some centers may consider more than five lesions to be a contraindication)
- Tumors larger than 3 cm
- Synchronous bowel resection and hepatic cryoablation (increased risk of liver abscess)

Preoperative Investigation and Preparation for the Procedure

In addition to the preoperative investigations before liver resections:

- In the case of neuroendocrine tumors: H1 and H2 blockers and somatostatin (double existing dose or 100 mg twice daily if not on it) 48 hours preoperatively
- Bowel preparation (facultative)
- Ensuring that there is liquid N_2 in the machine

Procedure

Step 1

Evaluation of the tumor

To exclude extrahepatic disease, the procedure is started with a diagnostic laparoscopy or a minilaparotomy. The liver is examined bimanually and the tumors are investigated by ultrasound with respect to number, size, and distance from bile ducts and vascular structures. Next, the lesser sac is opened and suspicious lymph nodes are sent for histological examination. Heated bed blankets should be used to prevent hypothermia.

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Step 2

Insertion of the probe and applying cryotherapy

Access to the liver is gained by a bilateral subcostal or triradiate incision. For safety reasons, the probes need to be checked for leaks under water with liquid N_2 running. Using ultrasound guidance (Fig. 51.1a), the probes (3–10 mm in diameter) can be inserted at the center of the tumor (Fig. 51.1b).

For larger tumors, multiple probes in a predetermined relationship are used (Fig. 51.2a). Cryosurgery can also be combined with a partial hepatectomy. In such cases, an edge probe is used to destroy the remnant tumor at the resection surface. This probe does not need to be inserted into the liver (Fig. 51.2b).

The ice ball made by cryoablation should extend at least 1 cm beyond the tumor margin, as demonstrated with ultrasound guidance. Because it is not possible to see through the ice, the posterior margin is visualized by ultrasound from behind the liver.

After demonstration of a 1-cm margin, we thaw passively, waiting for 1 cm to thaw out, and then refreeze. Twin freeze-thaw cryotherapy lowers the local recurrence rate. A single cryoablation cycle takes approximately 7 to 10 min, depending on the size of the lesion.

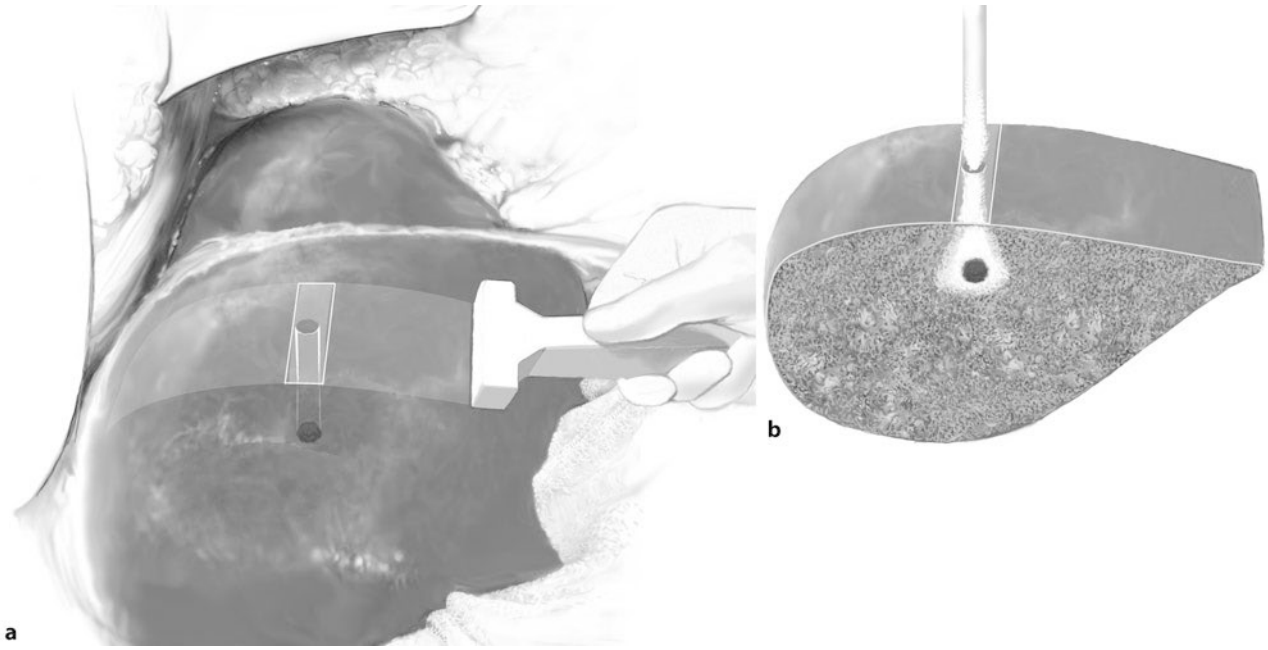


Fig. 51.1

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Step 2 ***(continued)***

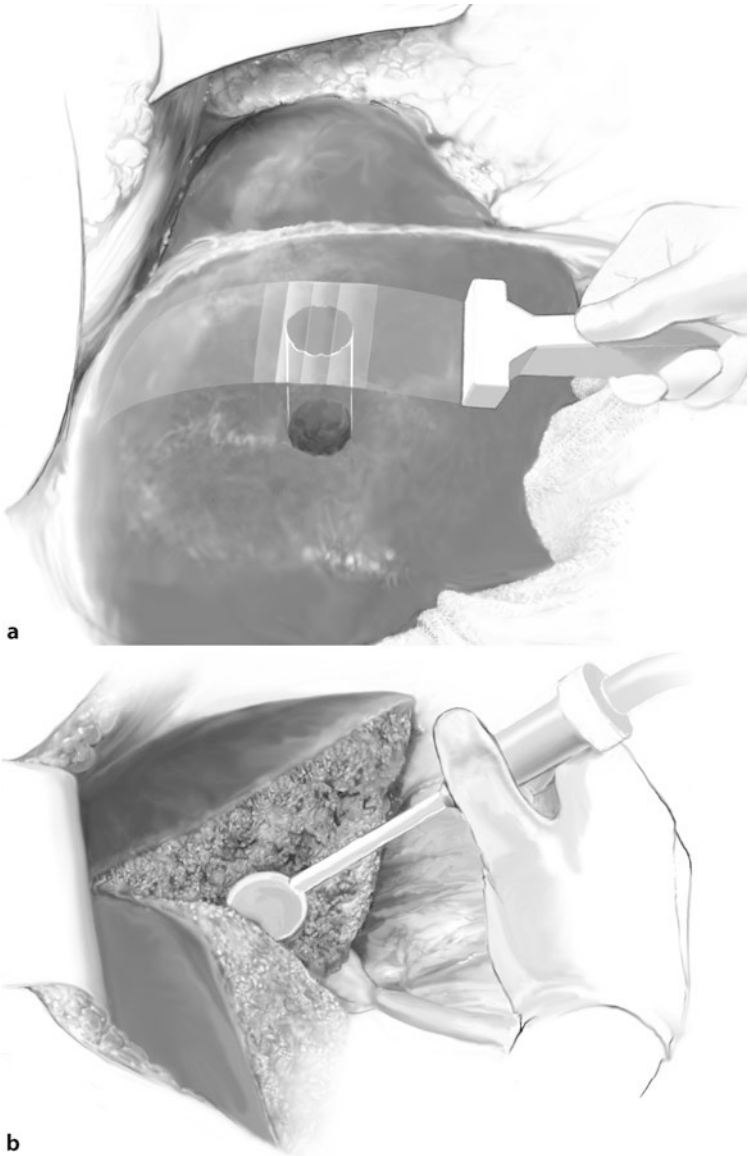


Fig. 51.2

Step 3

Removing the probes

Before the probe can be taken out, it must be rewarmed with warmed nitrogen gas. Then the probe can be pulled gently out of the liver, and the tract can be filled with surgical or alternate hemostatic foams.

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Step 4

Cracks

The changes in temperature can cause fractures in the liver, which can cause bleeding. These "cracks" need to be managed by liver sutures and packs (Fig. 51.3).

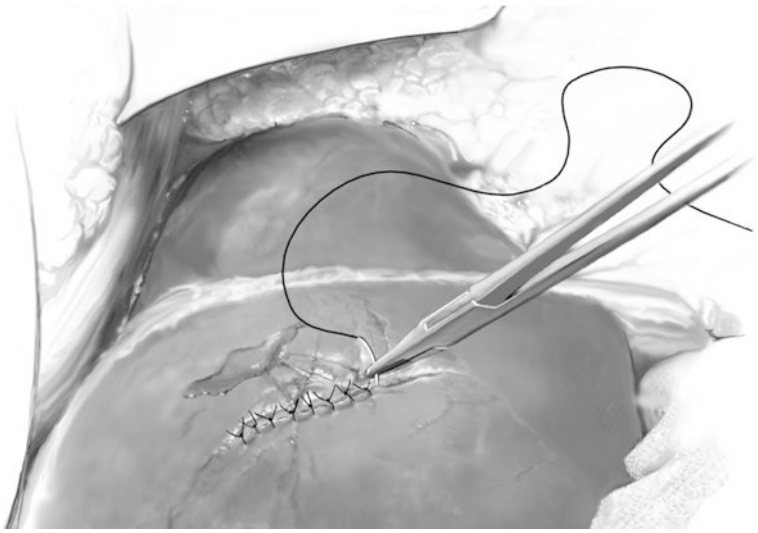


Fig. 51.3

Postoperative Tests

Tests are performed for the prediction of cryoshock:

- Full blood count, looking for thrombocytopenia particularly on day 3
- Liver function test (LFT), especially aspartate aminotransferase (AST) (highest rise on day 1)
- Kidney function tests

Postoperative Complications

- *Cryoshock:* Cryoshock is a syndrome of multiorgan failure including renal impairment, pulmonary edema, coagulopathy, and disseminated intravascular coagulation. The incidence of cryoshock is about 1 %; it is seen only with large volume distraction and especially with the complete twin freeze-thaw technique.
- *Hepatic abscess:* Very rare, except with synchronous bowel resection and cryoablation.
- *Pleural effusion:* Common, especially during right-sided hepatic ablation.
- *Biloma or biliary leak.*
- *Biliary strictures:* Biliary strictures can occur but are very rare within the liver. The main risk is for large lesions in segment IV lying at the bifurcation of the portal veins.

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Tricks of the Senior Surgeon

- Do not wash the lesion or the abdominal cavity with warm saline to speed thawing; doing so can result in dramatic cracking.
- Make sure there is liquid N_2 in the machine before you start the procedure.
- Use multiple probes for multiple lesions simultaneously to increase the speed of the procedure. However, single lesions are better treated by one large probe than by several small probes because of the risk of cracking between small probes.
- Large lesions need more than one probe.
- Before closing the abdomen, make sure the ice ball has thawed completely and there is no bleeding from any cracks.
- Aim for a high intraoperative and postoperative urine output to prevent kidney failure.

Acknowledgments

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ALPPS (Associating Liver Partition with Portal Vein Ligation for Staged Hepatectomy)

Erik Schadde, Pierre-Alain Clavien

Indications

- Colorectal liver metastases, primarily un-resectable due to a too small liver remnant
- Non-colorectal liver metastases, primarily un-resectable due to a small liver remnant, if resection is oncologically indicated
- Primary liver tumors like HCC and intrahepatic cholangiocarcinoma in specific situations in which primary resection is impossible due to remnant volume and function considerations

Contraindications

- Patients with cholestasis
- Risk of mortality increases with older age and poor physiologic reserve

In the field of surgery for liver malignancies, significant progress has been made to expand the criteria of resectability. The importance of the size on imaging ("volumetric size") of the future liver remnant (FLR) that will support the patient after resection is well established. For normal livers, 25 % to 30 % of healthy liver tissue should remain in order to support the patient hemodynamically, metabolically, and in terms of synthetic function. Several strategies have been developed to increase the size of the FLR before resection. Portal vein embolization followed by resection after an interval to allow for growth of the liver became popular in the 1990s (Fig. 52.1a). Two-stage hepatectomies to allow for recovery and growth between stages were introduced 20 years ago. Adding portal vein embolization to the waiting interval between two stages (Fig. 52.1b) or adding portal vein ligation to the first stage of two-stage resections (Fig. 52.1c) has been successfully used and reported. All these interventions have in common that the interval between the two stages extends over several weeks, and up to one third of the patients do not progress to the second stage operation because of tumor progression in the interval.

In 2012, a muticentric study from Germany introduced a new two-stage hepatectomy technique to obtain extensive and rapid volumetric growth of the FLR in patients requiring right extended hepatectomies. The new technique consisted in adding a liver parenchymal partition to the portal vein ligation in the first step of a two-staged resection. The waiting interval was reduced to about 1 week (Fig. 52.1d). In the inaugural study the authors presented the results of this new technique in 25 patients and reported a median volume increase of 74 % over only 1 week, as assessed by CT volumetry. This complex procedure was labelled as "Associating Liver Partition with Portal Vein Ligation for Staged Hepatectomy" (ALPPS). Other centers have been able to replicate these results, and the relative benefit of this accelerated two-stage approach compared with the earlier methods of portal vein occlusion in two-stage operations to induce volume growth is currently a matter of debate and investigation.

This chapter presents the ALPPS procedure as practiced by the Zurich group. It explains the surgical approach to preparation of the hepatoduodenal ligament, the hepatic veins, and parenchymal transection with preservation of arterial inflow and biliary drainage during Stage 1 of the ALPPS procedure, as well as removal of the deportalized part of the liver during Stage 2.

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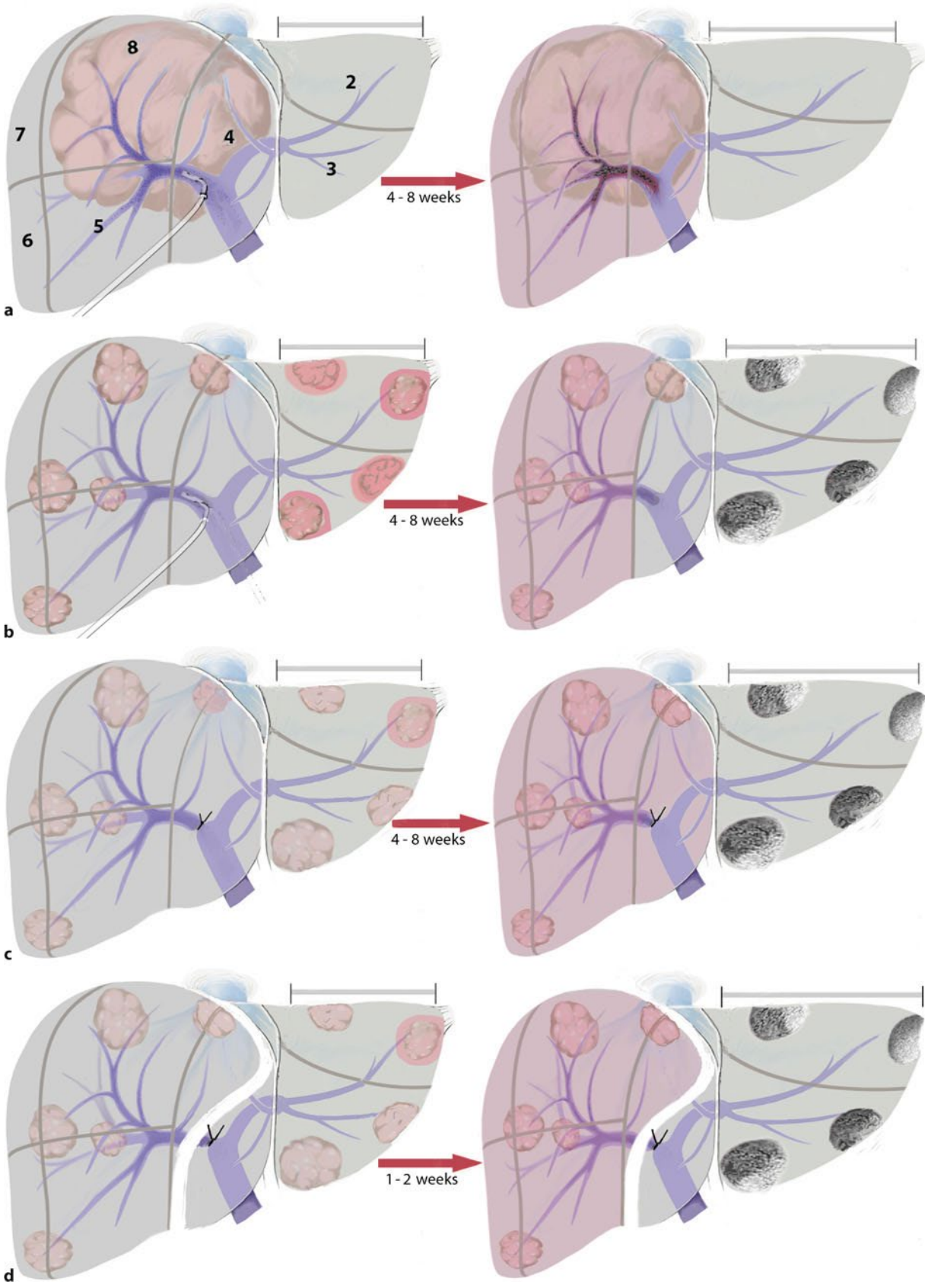


Fig. 52.1

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The Concept of ALPPS

ALPPS combines portal vein ligation *and* parenchymal transection along the line of the deportalized part of the liver to be removed. The volumetric growth observed appears more rapid, and generally the second-step removal of the deportalized lobe may be performed after 1 to 2 weeks. This operation requires careful preparation of the inflow structures at the hepaticoduodenal ligament, ligation of one portal vein branch, and preservation of the arterial inflow and bile ducts of both the FLR and the deportalized lobe, with meticulous avoidance of bile leaks.

ALPPS volumetric planning

For a successful ALPPS procedure, careful volumetric planning is important. The FLR is the part of liver that will remain after its tumor burden is removed and the deportalized part of the liver has been removed. The size of the FLR may be expressed in different metrics (Table 52.1). If the FLR in healthy livers without cirrhosis or cholestasis is below 30 % or the ratio of FLR to body weight is below 0.5, the risk for postoperative liver failure is likely increased. For diseased livers, higher cut-offs are required (Table 52.2). The hypertrophy induced by the ALPPS procedure is shown in Table 52.3 in three scenarios. We observed volumetric growth of 50 % to 80 % in 1 week and 120 % to 200 % after 14 days. The volumetric increase required to reach a safe FLR volume of 30 % must be determined and the expected waiting time to reach this volume estimated.

Commonly the FLR resides within the left lateral segments 2 and 3 (Fig. 52.2a). As long as the portal inflow can be preserved and there are no tumors in segment 1, segment 1 may be preserved (Fig. 52.2b). In some cases, segments 4A (Fig. 52.2c) and B (Fig. 52.2d) may be preserved as well. Although the FLR more frequently resides in the left lobe, because the right lobe is larger overall, most ALPPS procedures have been performed with the FLR on the right side.

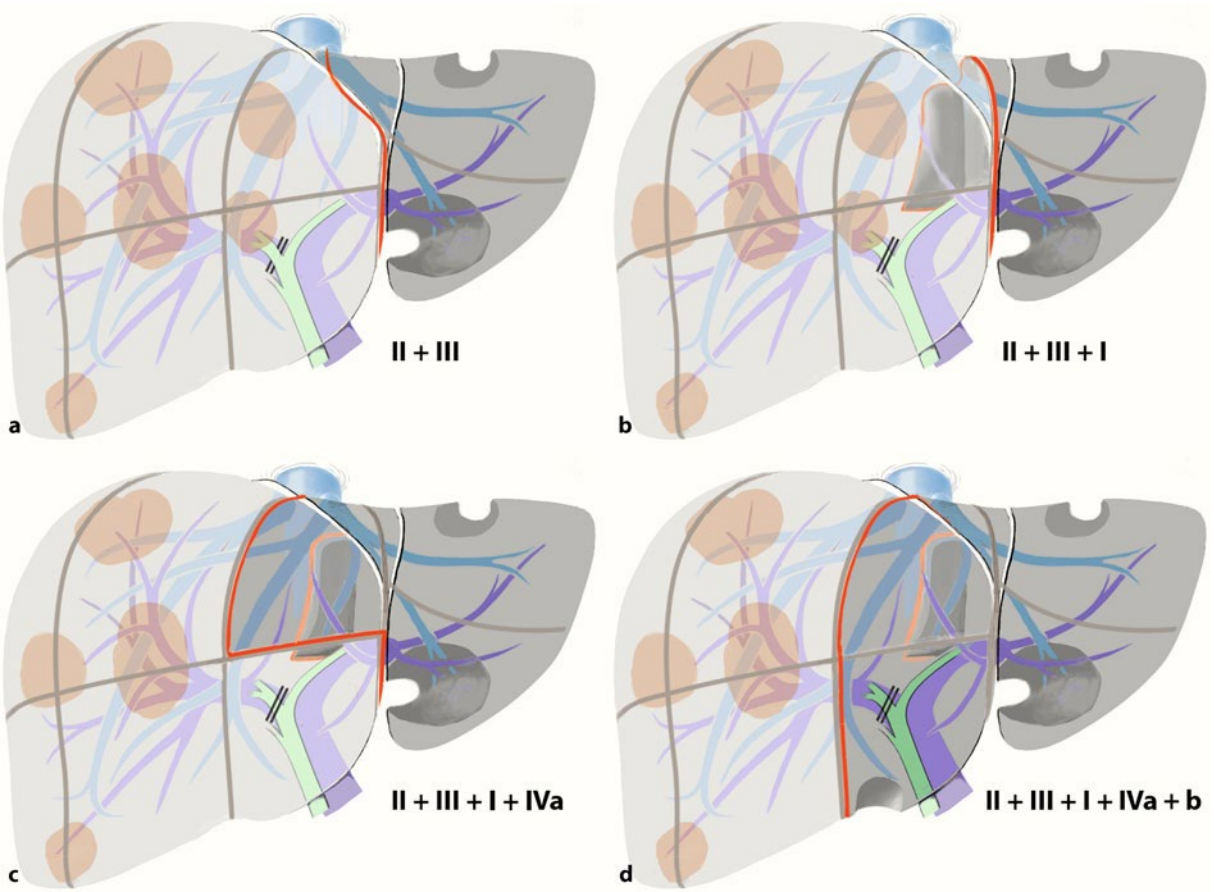


Fig. 52.2

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Table 52.1 Definitions

FLR	"Future liver remnant" Proportion of the volume of the future liver remnant minus the tumor load to be removed (FLR) divided by the volume of total liver measured
sFLR	"Standardized future liver remnant" Proportion of the volume of the future liver remnant minus the tumor load to be removed divided by the standardized total liver volume (sTLV) according to Vauthey
FLR/BW ratio	"Remnant to body weight ratio" Ratio of the volume of future liver remnant in cubic centimeters minus the tumor load to be removed (FLR) by the body weight (BW) in kg

Table 52.2 Volumetric Requirements for Stage 2 resection

Volume required in normal livers	Volume required in injured livers (fibrosis, cirrhosis, SOS, CASH)
FLR/TLV> 0.3	FLR/TLV> 0.4
sFLR/TLV> 0.3	sFLR/TLV> 0.4
FLR/BW ratio> 0.5	FLR/BW ratio> 0.8

Table 52.3 Expected Volumetric Increase of FLR

FLR prior to stage 1	Additional FLR required (% of TLV)	Hypertrophy required (%)	FLR prior to stage 2	Expected time for volumetric increase (days)
0.2	0.1	50	0.3	6
0.15	0.15	100	0.3	10
0.1 %	0.2	200	0.3	14

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Procedure: ALPPS Stage 1

Step 1

Intraoperative ultrasound and planning

A bilateral subcostal incision is performed and the round and falciform ligaments are transected as described in previous chapters. Tumor extension, number, and relation to intrahepatic vascular structures are established by intraoperative ultrasound. Lesions that will have to be removed from the FLR with nonanatomical resections are marked by electrocautery on the liver surface (Fig. 52.3a). The line of transection is marked, with careful attention to a safe margin (Fig. 52.3b).



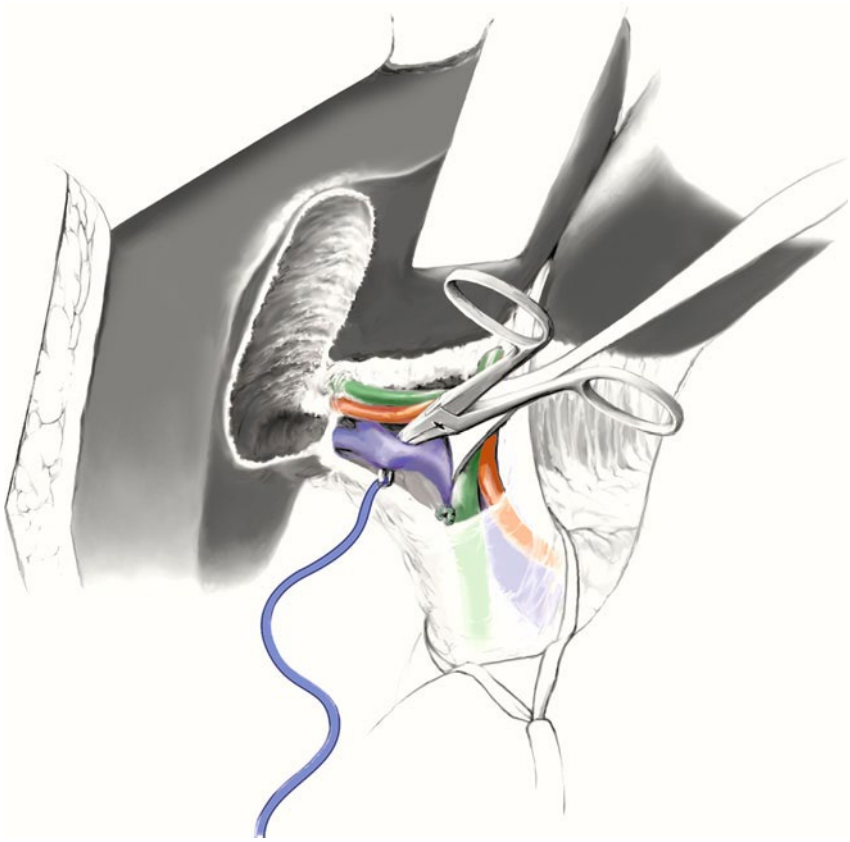
Fig. 52.3

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Step 2

Portal vein ligation

For right portal vein ligation, the infundibulum of the gallbladder is followed to the cystic duct and cystic artery. Both are ligated and the right hepatic artery and common hepatic duct are identified as described in ▶ Chap. 46, "Right Hemihepatectomy." The hepatic artery is retracted carefully with a lid hook to dissect the portal bifurcation. The right portal vein is dissected free and ligated proximally and distally (◘ Fig. 52.4).



◘ Fig. 52.4

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Step 3

Preparation of the hepatic veins

If the right and middle hepatic veins are isolated together to preserve middle hepatic vein outflow for the FLR, the right lobe of the liver is mobilized from the diaphragm and segment 1 is taken off the vena cava as described in ▶ Chap. 46 "Right Hemihepatectomy". The space between middle and right hepatic veins is dissected from below with a right angle dissector. The tip of the right angle is found between the caudate lobe and vena cava and an umbilical tape is pulled through to establish the superior part of the hanging maneuver, if a hanging maneuver is used. The umbilical tape is then pulled down to the hilar structures (◘ Fig. 52.5). If the middle hepatic vein needs to be excluded from the FLR, the space between middle and left hepatic vein may be isolated for the hanging maneuver.

Anterior approach to ALPPS. Anterior approach with or without the additional hanging maneuver may be used as well. Mobilization of the right lobe and dissection of the triangular ligament are not necessary when the anterior approach is used.



◘ Fig. 52.5

Step 4

Transection of the hepatic parenchyma

The transection line previously marked with the help of ultrasound is incised with electrocautery, and the parenchyma is transected using one of the techniques described in ▶ Chap. 44, "Techniques of Liver Parenchyma Dissection." In Zurich, we use clamp crush technique. The Pringle maneuver for intermittent or continuous inflow occlusion is performed, as described in ▶ Chap. 41. Once the umbilical tape is encountered at the end of the parenchymal transection, the split of the liver in situ is complete (◘ Fig. 52.6a).

In the early days of ALPPS many groups used to suture a plastic cover is sutured to the FLR (◘ Fig. 52.6b). Now we use absorbable hemostatic patches or fleece instead. Drains may be placed, and the abdomen is closed.

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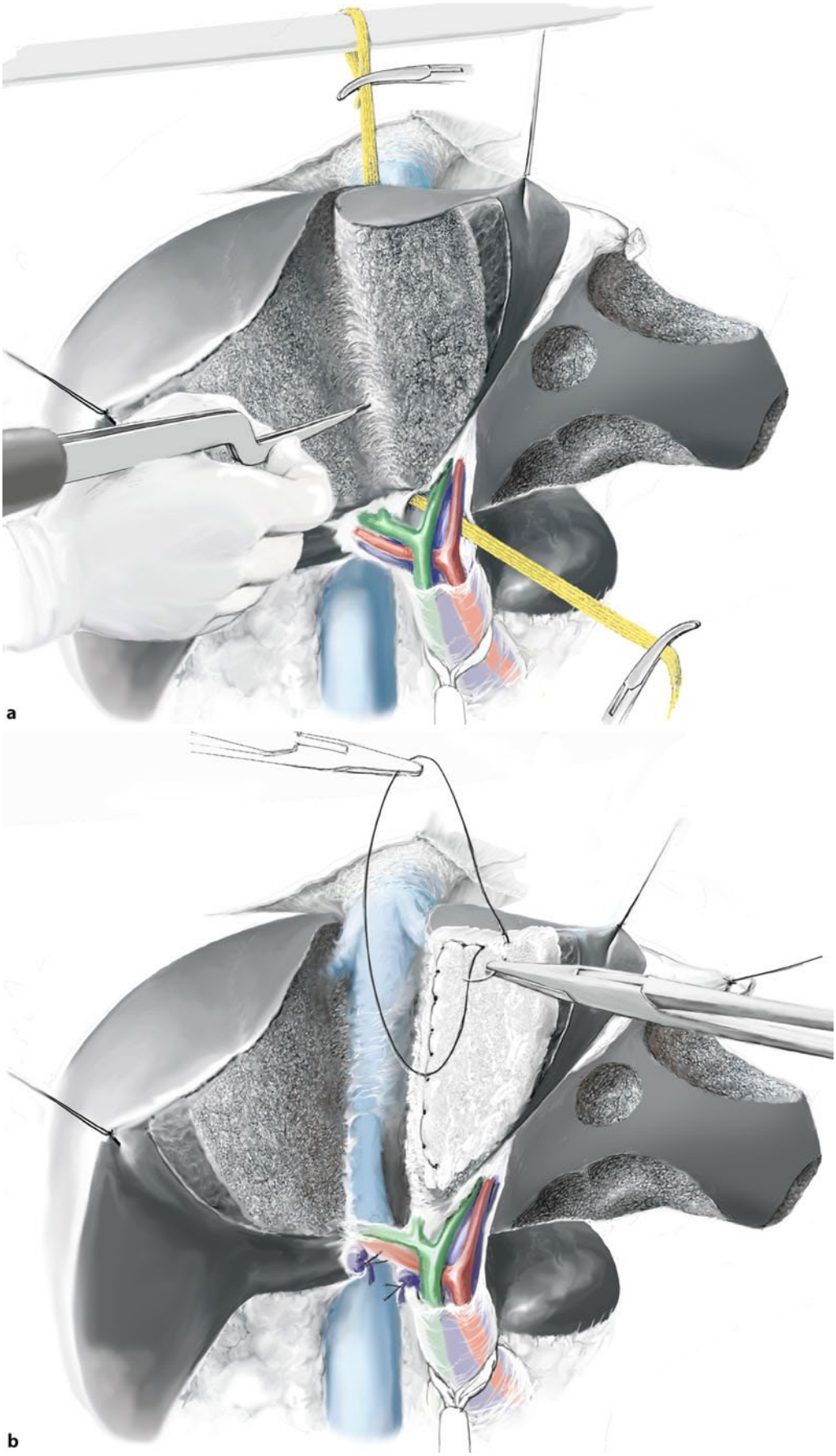


Fig. 52.6

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Procedure: ALPPS Stage 2: Hepatectomy of the Deportalized Lobe

Native MRI or CT is performed for volumetry first on day 6 and then weekly until the volume is sufficient to go to stage 2. Once the FLR volume exceeds 30 %, the deportalized lobe may be removed. The previous subcostal incision is reopened and retractors are placed. The artery and bile duct of the deportalized lobe are found and suture ligated (Fig. 52.7a). The right hepatic vein is then transsected using the laparoscopic endovascular stapler (Fig. 52.7b). If the right lobe has been mobilized and the small liver veins of the right lobe have been ligated during stage 1, the liver may now be removed

If the anterior approach is being used, transsection of the short hepatic veins by ligatures and clips, suture ligatures and of the respective hepatic veins by placement of clamps and oversewing is performed through the parenchymal split of the liver. The triangular ligament on the right side is then taken down and the deportalized lobe is removed and the abdomen closed. We do not use drains after the second step of ALPPS.

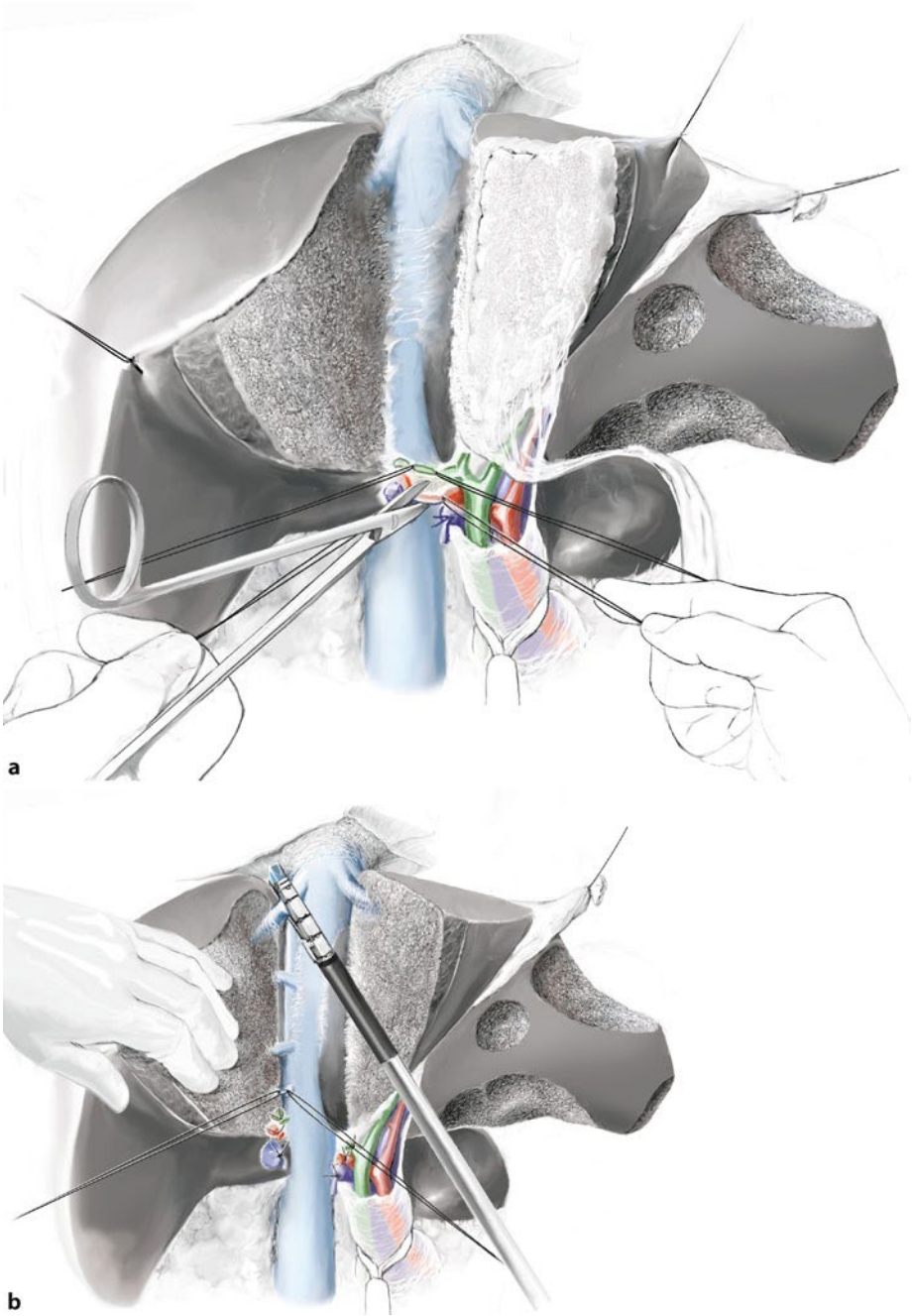


Fig. 52.7

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Tricks of the Senior Surgeon:

- ALPPS is a powerful surgical tool to induce hypertrophy and has the highest feasibility among Two-Stage Hepatectomies because of its profound and robust effect on liver hypertrophy but also has a high morbidity and mortality when used non-selectively
- Consider alternative techniques like partial transection (vs. complete transection) or delayed portal vein embolization (vs. portal vein ligation) or tourniquet ALPPS in patients with contraindications to classic ALPPS
- Familiarize yourself with the split techniques in liver transplantation before embarking on ALPPS resections
- Delay the second stage when bilirubin and INR are not normal and perform the second stage only if the MELD score is less than 10
- Perform liver function testing like ICG, HIDA or other test and do not perform stage two until liver function has normalized after stage 1.
- Do not feel compelled to perform stage 2 resections if there are any doubts about volume or function of the liver remnant.

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Ablation Therapy of Liver Tumors

Michael A. Choti, Michelle L. de Oliveira

Thermal Ablation

Indications and Contraindications

Indications

- Unresectable malignant tumors of the liver (e. g., hepatocellular carcinoma, colorectal metastases, neuroendocrine tumors, selected other types of metastases)
- Tumors < 5 cm in size (most effective for lesions < 3 cm)
- Palliative treatment of symptomatic tumors (e. g., neuroendocrine metastases)
- Bridge to liver transplantation (hepatocellular carcinoma)

- **Open approach**
- In combination with resection
- When resection is planned, but unresectability is found at time of laparotomy
- In difficult locations or in selected cases when multiple ablations are required

- **Laparoscopic approach**
- Patient fulfills basic requirements to undergo surgery
- Lesion(s) amenable to laparoscopic approach

- **Percutaneous approach (not discussed in this atlas)**

Contraindications

- Extrahepatic disease (unless extrahepatic sites are resectable or when there is palliative indication for symptoms)
- Perihilar tumor localization
- Significant coagulopathy or thrombocytopenia
- Ascites
- Previous bilio-enteric anastomosis such as pancreaticoduodenectomy (relative contraindication because of increased risk of hepatic abscess following ablation)

Preoperative Investigation and Preparation for the Procedure

CT or MRI: Assessment to rule out resectability and determine if lesions are candidates for ablation

Consider PET/CT: Evaluation for presence of extrahepatic disease (e. g., colorectal metastases)

In operating room:

- Place grounding pads if needed (for radiofrequency ablation)
- Prepare the patient for surgery as usual
- Helpful to have the cross-sectional imaging of the lesion(s) viewable in the operating room during the procedure

Guidance Imaging Modality

Imaging is used for lesion localization, probe guidance, and ablation monitoring. The following features of each imaging modality must be considered:

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- **Ultrasound**
  - Method most commonly used, regardless of approach
  - Intraoperative US (IOUS) typically utilizes a low/mid frequency range probe (4–8 MHz)
  - Real-time feedback
  - Sometimes difficult to visualize lesion adequately
  - Increased echogenicity from microbubbles during thermal ablation
  - Microbubbles are not a true representation of zone of coagulation necrosis
  - Altered echogenicity may obscure further needle positioning

- **Alternatives: CT or MRI (percutaneous approach)**
  - Transaxial needle track required
  - CT fluoroscopy is a useful adjunct
  - For MRI, a compatible ablation needle is required

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Ablation Methods

Radiofrequency ablation

Radiofrequency ablation (RFA) is currently the most commonly used method of ablation. It uses alternating current to induce active tissue heating around a probe, resulting in coagulative necrosis.

A number of different probes are commercially available for performing RFA (Fig. 53.1a–d). Probes are typically 14 to 17.5 gauge, 15 to 25 cm long, insulated cannulas straight needle electrodes or deployable multi-tine probes. Some probes have a closed cooled-tip system (Covidien; Mansfield, MA) or local saline infusion (Angiodynamics).

Problems with RFA include susceptibility to heat sink in proximity to major vasculature. A single application of RFA is less effective for tumors larger than 3 cm.

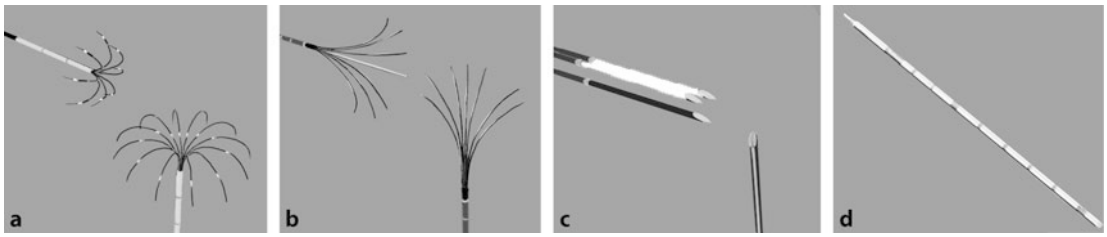


Fig. 53.1

Microwave ablation

Microwave ablation (MWA) is the most recent thermal ablation development with increasing favorable preference. It uses microwave energy to induce active tissue heating around a microwave antenna, resulting in coagulative necrosis. Advantages of MWA include more rapid ablation times and no need for grounding pads. In addition, MWA relies less on conductive heating for tumor ablation, which theoretically results in more predictable burns with less heat sink effect.

There are two distinct MWA systems: 915 MHz and 2.45 GHz. The first employs between one to three 13-guage antennae with multi-antenna configuration, but with independent connection to the generator. The 2.45 GHz system uses a single-antenna connected to a generator capable of delivering 100 watts of power. Both systems can be used in open, laparoscopic, and percutaneous approaches. Although both MWA systems provide equivalent tumor ablation, the 2.45 GHz seems to achieve a faster and more predictable ablation zone through a single antenna.

MWA antennas usually consist of a single-needle electrode with the active microwave-emitting part at the tip (Acculis-Angiodynamics, Evident/Emprint-Covidien). The MWA presents a non-conductive stainless steel shaft, a 16 mm ceramic tip and a feed point which is the center of ablation area. This feed point is visible under IOUS/CT guidance as a dark band. The MWA 2.45 GHz system offers ablation volume estimation based on power (30–100 W) and time settings (up to 8 min).

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Once the tumor is identified (*see* ▶ Step 1 – Procedures), the probe is inserted under image guidance until the feed point is central located in the tumor. The MWA generator is set up according to the coagulation size. The extent of the ablation is visualized as hypoechoic area with acoustic shadow. For large lesions, the overlapping ablation area is used to provide adequate margin.

More details about minimal invasive approach are provided below in ◘ Fig. 53.4.

Other ablation methods

- *Ethanol injection:* Technique using ethanol instead of heat to ablate tumors as hepatocellular carcinoma (2–3 cm). Less effective than thermal ablation such as RFA and MWA.
- *Cryoablation:* Induces necrosis by freezing and thawing tissue around probe. The most common complications are myoglobinuria and myoglobinuria, acute tubular necrosis and pleural effusions. Cryoshock phenomenon occurs in 1 % of the cases with 18 % mortality. Therefore, cryoablation should not exceed 30 % volume of cryo-tissue destruction.
- *Irreversible electroporation:* Induces cell apoptosis by irreversibly increasing the permeability of the cell membrane. As this method does not rely on thermal tissue destruction, it is less susceptible to variable ablation volumes due to heat sink effects.

Procedures

Open technique

Step 1

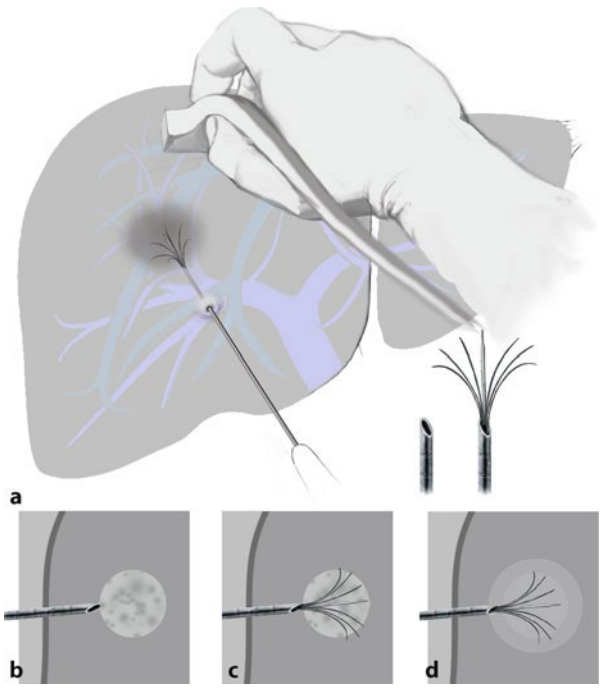
Access and assessment of tumors

Incision, evaluation, palpation, and mobilization of the liver are performed as for a liver resection. The abdomen is explored for the presence of extrahepatic disease, and the evaluation is completed by IOUS to identify/confirm the location and the size of the lesions (◘ Fig. 53.2a). The feasibility of the ablation is determined and the number of needed ablations is calculated.

Step 2

Placement of the probe and ablation of tumors

The probe is aligned so that its trajectory lies in the plane of the ultrasound image and does not intersect vital structures such as blood vessels and bile ducts. It is advanced under IOUS guidance until the tip is either close to the proximal edge of the tumor or near the distal edge, depending on the probe type (◘ Fig. 53.2b). The (deployed) probe is visualized in perpendicular view to confirm adequate tip position and deployment (◘ Fig. 53.2a). The probe tines are deployed and thermal energy is applied according to the manufacturer's directions (◘ Fig. 53.2c,d).



◘ Fig. 53.2

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Step 3

Ablation of large or irregularly shaped lesions and tract ablation

For large or irregularly shaped lesions, multiple ablations may be needed (Step 2 is repeated as necessary). A pattern of overlapping spheres or cylinders is used to cover the lesion while maintaining adequate margins.

With some devices, tract ablation is performed to cauterize the tract and to minimize seeding. The probe is withdrawn 1 cm at a time in tract ablation mode on the radiofrequency generator, allowing the temperature to reach > 70 °C at each step. This process is continued until the probe is completely removed (Fig. 53.3).

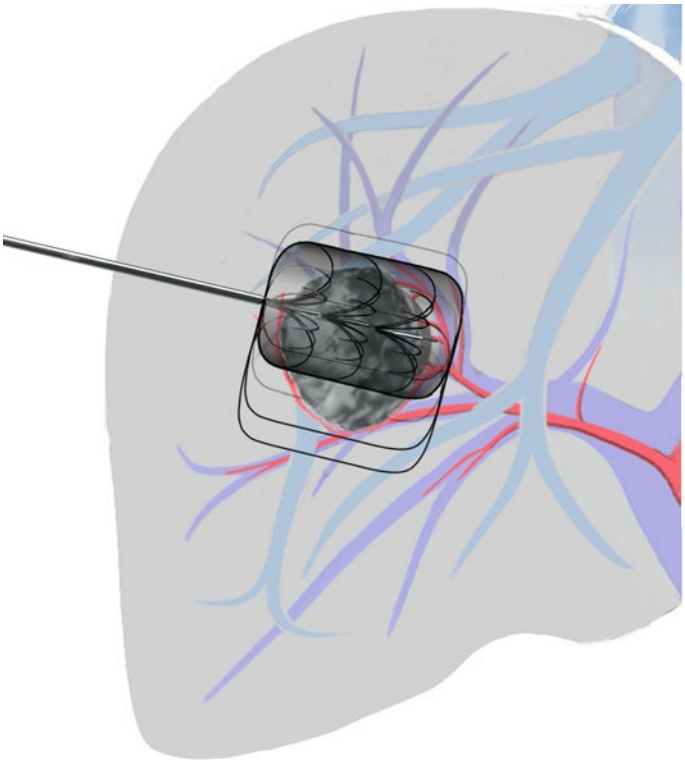


Fig. 53.3

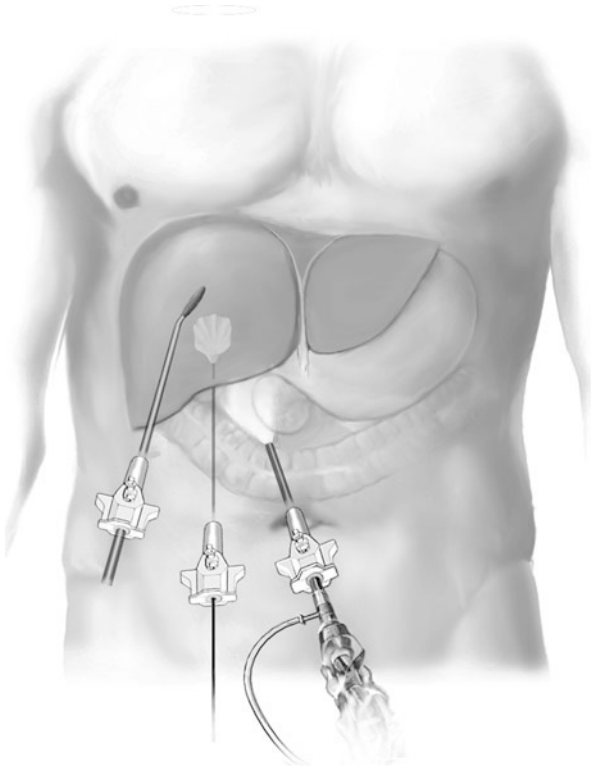
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Laparoscopic approach

Step 1

Positioning of the patient and access

Depending on the location of the tumor or tumors, the patient is placed in the supine or left lateral decubitus position. A minimum of two laparoscopic trocars are placed: a 12-mm periumbilical camera port and a 12-mm laparoscopic ultrasound port in the right flank. The RFA or MWA probe can be placed percutaneously, through a sheath, or through a 5-mm right subcostal port. More ports may be required if additional procedures are to be performed (e. g., liver mobilization, partial resection) (◘ Fig. 53.4).



◘ Fig. 53.4

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Step 2

Assessment of tumors and ablation

Laparoscopic intra-abdominal ultrasound is performed by either rigid or flexible IOUS probes to identify/confirm the location and the size of the lesions.

The abdomen is explored for the presence of extrahepatic disease. As described for the open technique, the probe is oriented parallel with the IOUS crystal to facilitate probe guidance (Fig. 53.5a and 53.5b). Limited mobility can make this more difficult than with the open technique. The ablation process and monitoring are otherwise performed as described for the open approach.

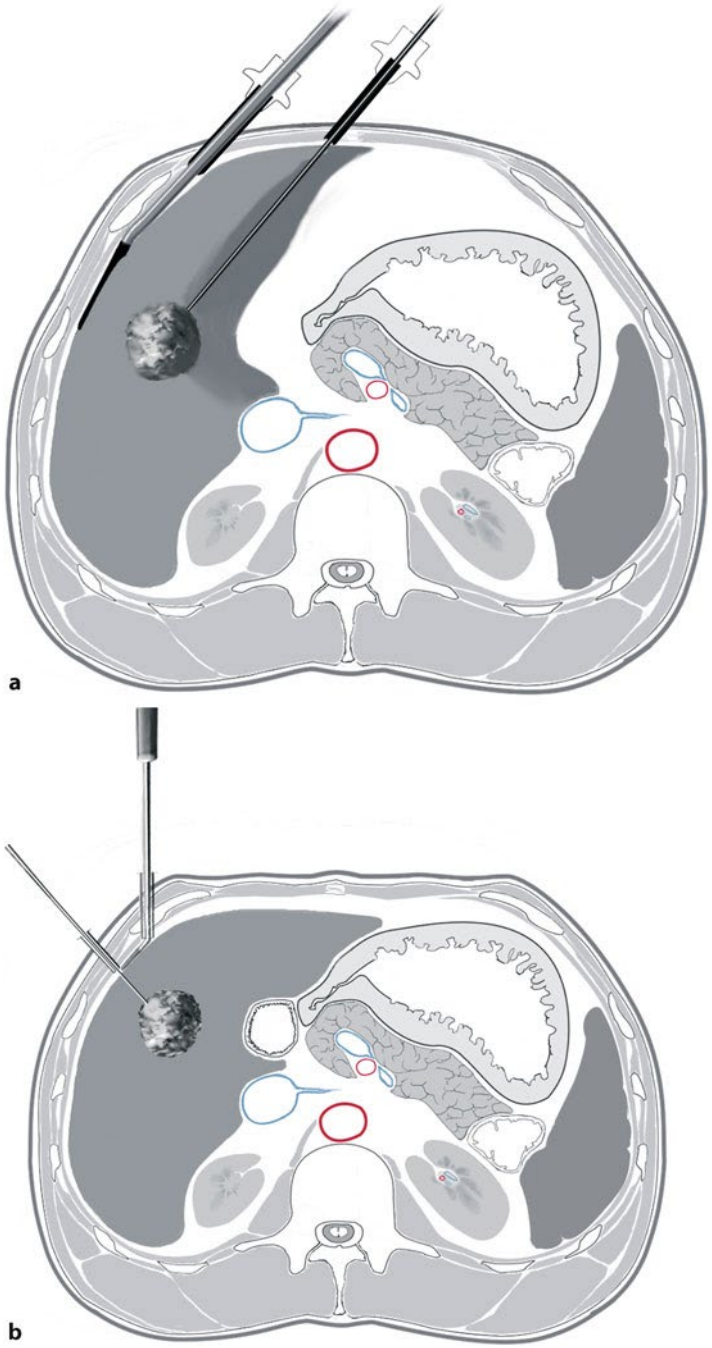


Fig. 53.5

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Postoperative Evaluation

Follow-up post-ablation imaging (CT or MRI) is performed 3 to 30 days after the procedure to assess the completeness of ablation.

Postoperative Complications

- **Short-term**
  - Pleural effusion
  - Regional hemorrhage into needle track or into RFA lesion
  - Fever
  - Hepatic abscess (more common with enterobiliary anastomosis)
  - Biliary stricture secondary to ablation near major bile duct
  - Grounding pad burns

- **Long-term**
  - Biloma
  - Biliary fistula
  - Ascites
  - Hepatic insufficiency
  - Arteriovenous fistula

Non-thermal Ablation: Irreversible Electroporation (IRE)

This novel technology offers the possibility for non-thermal ablation procedure for unresectable tumors in the liver, hilum, and pancreas. It uses an electric field to change the electrochemical potential of the membrane, forming nanopores leading to cell membrane instability followed by cell death. It is applied using short pulses of high energy (1,500–3,000 V), applying electrical field to tissue between the probes. Access is either laparotomic or percutaneous.

Indications and Contraindications

Indications

IRE is indicated for unresectable malignant tumors located on surrounding hepatic veins or perihilar area (Fig. 53.6).

IRE seems not to damage connective tissue, preserving vascular structures and bile ducts. This is the most relevant advantage of IRE compared to other ablative techniques. Of note, lesions located in areas other than the hilum and hepatic veins should be treated by thermal ablation (MWA or RFA).

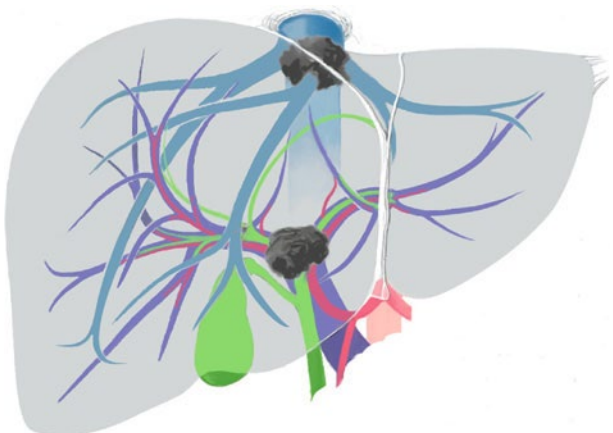


Fig. 53.6

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- **Access**
  - Open: under intraoperative ultrasound (IOUS) guidance
  - Laparoscopic: multiple needle insertion under IOUS guidance may be demanding, as needles usually bend and must be re-inserted
  - Percutaneous: under CT guidance

Contraindications

Similar to RFA and MWA: coagulopathy, ascites, and tumor progression under chemotherapy. Due to electric pulses delivered, it is also important to exclude history of cardiac arrhythmia (atrial fibrillation), recent myocardial infarction, and presence of any metal in the proximity of the ablation area.

Preoperative Investigation and Preparation for the Procedure

MRI, MDCT, and PET-CT: same preoperative image as used for thermal ablation.

53

Procedures

Step 1

General anesthesia

This is mandatory for all IRE cases (either via laparotomy or percutaneous access). Neuromuscular blockade with level 0 paralysis is paramount to avoid patient movement while pulses are delivered. Before starting, place the external synchronization device lids for ECG synchronization. The leads should be placed before draping and defibrillator pads.

Step 2

Ablation planning

Treatment plan is based on preoperative tumor dimensions, which should be further confirmed by IOUS. This information of tumor width, length and depth, as well as the tumor free desirable margin goes into the Ablation Zone estimator software. The IRE generator will calculate the number and spacing probes to ablate the tumor.

Step 3

Probe selection

Monopolar electrode probe is a 19-gauge needle with a depth-map echogenic surface. The active length ranges from 0.5 cm to 4.0 cm and should be adjusted for tissue type. Usually in the liver, 2 cm can be used (Fig. 53.7).

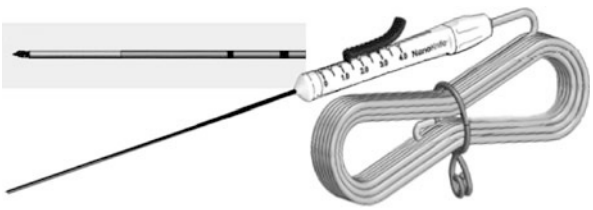


Fig. 53.7

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Step 4

Needle placement

Needle placement is guided by US or CT direct visualization The number of monopolar probes depends on tumor size, adequate margin, and area of ablation. Figure 53.8 demonstrates an ablation area using four needles.

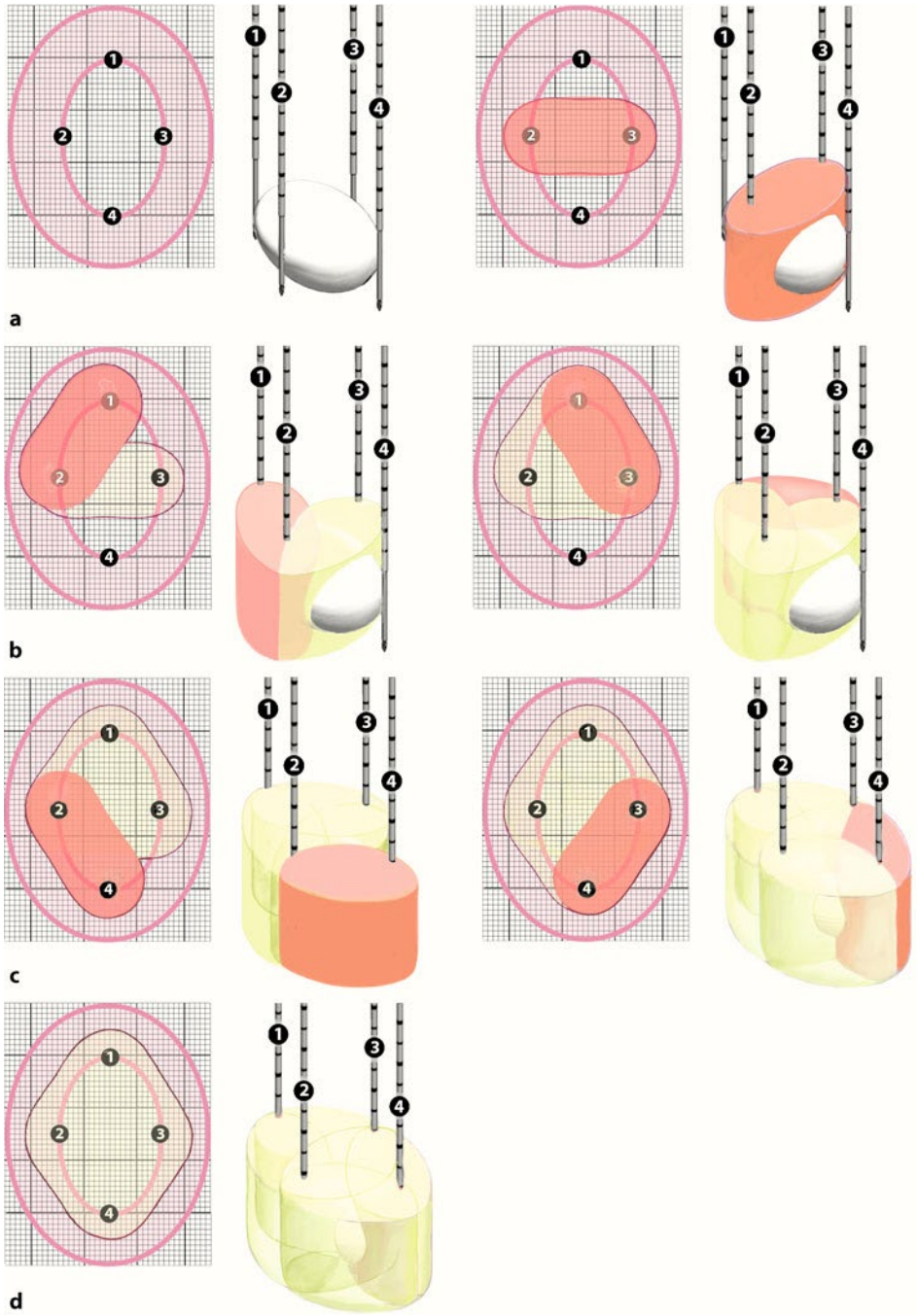


Fig. 53.8

One important fact for needle placement to achieve irreversible electroporation is the position of needles. They must be parallel, avoiding convergent or divergent-needled tips.

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Step 4 ***(continued)***

Procedure summary

- General anesthesia with full muscle relaxation is required for all cases
- Image guide of the liver to assess 3D tumor size
- Plan needle placement (Fig. 53.8). Needle insertion is around the tumor. When overlapping is requiring for lesions larger than 4 cm, active needle can be placed centrally. For lesions larger than 3 cm, pullbacks are required.
- Guidance imaging by IOUS or CT around the tumor (percutaneous ablation)
- IRE delivery: using deep paralytic upstart with 10 pulses test all needle pairs to assess tissue resistance, followed by 80 pulses for efficacy
- Check amperage graphic to verify IRE efficacy
- After ablation therapy, US Doppler or CT (percutaneous ablation) should confirm patency of vascular structures (Fig. 53.9)
- CT/MRI should be performed before discharge to exclude complications



Fig. 53.9

Postoperative Testing

- MDCT or MRI at the time of discharge to exclude complications
- Every 3 months for assessing ablation completeness using PET-CT (CT with contrast) or MRI or MDCT

Postoperative Complications

Short term

- Cardiac arrhythmia
- Cardiac arrest
- Bleeding
- Fever
- Portal vein thrombosis
- Fistula/stenosis when probe placed in contact with metal stents

Long term

- Tumor recurrence

Summary

- IRE (NanoKnife system) is more expensive than RFA and MWA
- Uses electric pulse energy
- Can be applied on bile ducts and large vessels
- Promising novel technology, however efficacy still under investigation

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Tricks of the Senior Surgeon

Thermal ablation

- When the lesion lies near a major blood vessel, thermal energy from the probe may be drawn away from the ablation zone, limiting ablation efficacy. This is known as the "heat sink" effect. This effect can be limited using in-flow occlusion techniques (e.g., Pringle maneuver) or repositioning the array closer to the vascular structure. The heat sink effect appears to affect RFA more than MWA.
- In case of a deployable probe, stabilization of the ablation probe at the skin or liver surface should be done during deployment to avoid "push back".
- Depending on the device, monitoring of the impedance pattern and tine deployment shape by ultrasound can confirm success of the ablation in real time.
- With some devices, temperature profiles can also be helpful in confirming successful ablation, including consistent tine temperatures and adequately slow cool-down temperatures.

Non-thermal ablation: irreversible electroporation

- Probes too far apart may result in low current and cause an inefficient ablation treatment. The optimal probe distance is from 1.5–1.8 cm.
- If the generator does not recognize the ECG signal, change the lead pair; check if the cable is properly connected.
- In case of troubleshooting, re-image needle placement and inter-probe distance.

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Selective Hepatic Intra-arterial Chemotherapy

Diane Goéré, Dominique Elias

Placement of a hepatic intra-arterial infusion pump (HAIP) provides liver-specific, continuous infusion of chemotherapeutic agents. The chemotherapeutic agents selected for use with the HAIP should exhibit a high degree of first-pass kinetics, to minimize systemic toxicity. Agents used include fluorodeoxyuridine (FUDR), oxaliplatin, cisplatin, 5-fluorouracil, mitomycin C, and Adriamycin.

Indications and Contraindications

Indications

- Unresectable hepatic metastatic colorectal carcinoma (to make lesions resectable)
- Liver-specific adjuvant chemotherapy following resection of colorectal metastases, in patients at high risk of hepatic recurrence (≥ 4 liver metastases or disappeared and missing metastases)
- Hepatocellular carcinoma and other metastatic carcinomas, under certain circumstances

Contraindications

- Portal hypertension (portal pressure > 12 mm Hg)
- Known extrahepatic malignancy
- Poor liver reserve (e. g., Child class B or C cirrhosis)
- Severe coagulopathy (e. g., platelets < 30,000/mL)
- Active hepatitis

Preoperative Studies

- *History:* Specific for hepatic function (e. g., alcohol use, hepatitis)
- *Clinical evaluation:* To rule out obvious extrahepatic malignancy (lymph node exam) and underlying liver dysfunction (ascites, nutrition status, signs of portal hypertension)
- *Imaging:*
  - Triple-phase CT scan: For definition of tumor and arterial anatomy
  - CT angiogram or MRI of abdomen
  - Chest CT scan: To rule out pulmonary metastases, except for colorectal carcinoma
  - FDG-PET: In cases of metastatic colorectal carcinoma
  - Hepatic arteriogram: Mandatory if HAIP will be placed laparoscopically and CT or MR angiograms have not been performed. Not mandatory if HAIP is to be placed via laparotomy (but it may decrease operative time)

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Procedure

Step 1

Incision and exposure

A right subcostal approach or a midline incision can be used. The falciform ligament is divided and the porta hepatis is exposed further by gentle superior retraction of the liver. Usually, a cholecystectomy is performed to eliminate the postoperative complication of chemical cholecystitis induced by infusional chemotherapy. (Cholecystectomy is not performed when the catheter is radiologically inserted.) The gastrohepatic ligament is divided with care to avoid injury to a replaced left hepatic artery (if present). All duodenal and antral vessels must be ligated to eliminate the possibility of reflux of chemotherapy into these regions, which may lead to chemical duodenitis or gastritis. The common hepatic, gastroduodenal, and proper hepatic arteries are identified by dissection of the hepatoduodenal ligament and marked with vessel loops (Fig. 54.1).

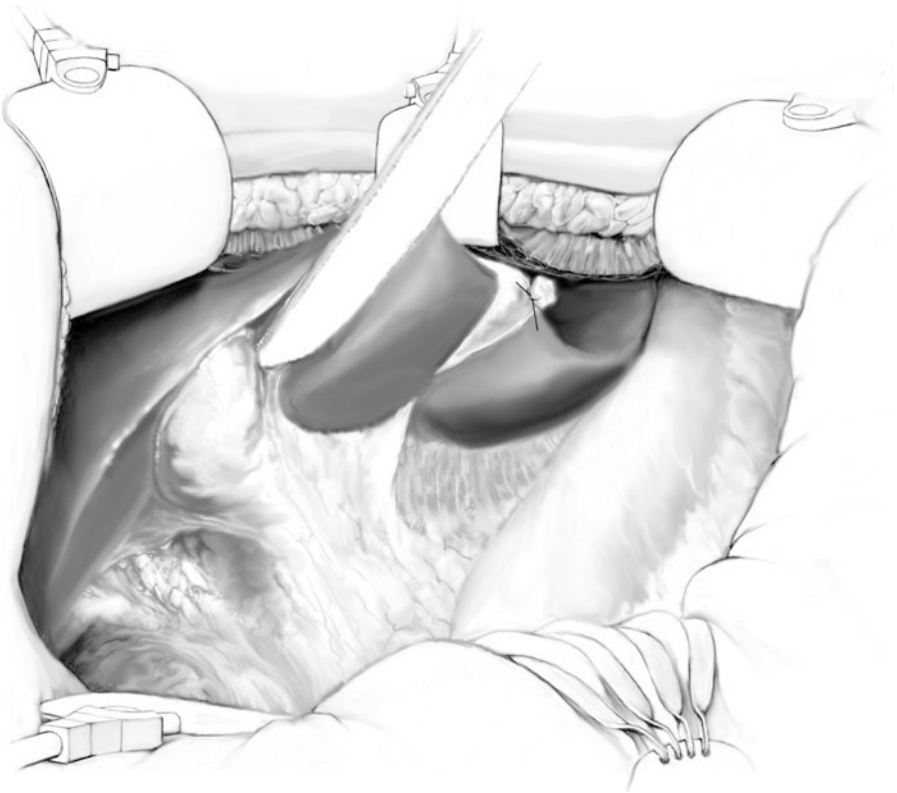


Fig. 54.1

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Step 2

Determination of arterial anatomy

At this point it is imperative to accurately determine the hepatic arterial anatomy if no preoperative arteriogram was performed. The more common variants in hepatic arterial anatomy are shown in the figures:

- The common hepatic artery may originate from the celiac trunk (typical) (Fig. 54.2a).
- A replaced right hepatic artery may arise directly from the superior mesenteric artery (Fig. 54.2b).
- A replaced left hepatic artery may arise directly from the left gastric artery (Fig. 54.2c).
- Common origin of the right hepatic artery, left hepatic artery, and gastroduodenal artery (Fig. 54.2d), commonly referred to as "trifurcation anatomy."

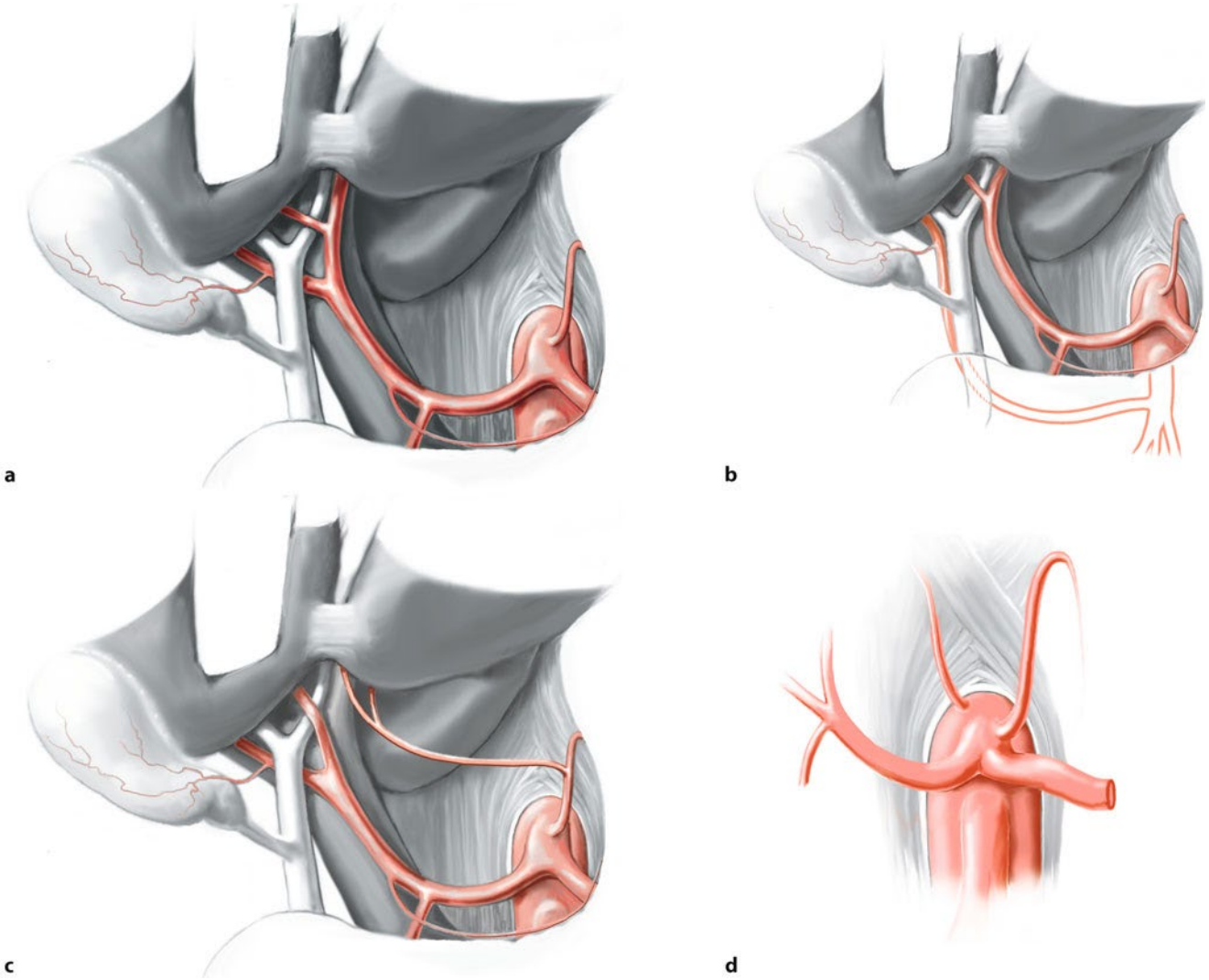


Fig. 54.2

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Step 3

Placement of the infusion pump or of a catheter connected to a subcutaneous port

The pump pocket is created in the right lower quadrant by making a transverse incision at the level of the umbilicus and dissecting to the anterior rectus sheath and the external oblique fascia. The pocket is extended laterally to near the iliac crest and inferiorly to just above the inguinal ligament. After insertion of a catheter (definitive), the subcutaneous port is located in a right prethoracic position and the catheter is connected to the port.

The pump is primed with heparinized saline and proper pump function should be established before anchoring it to the fascia with 2-0 nonabsorbable braided suture. The arterial catheter is passed into the pocket by direct puncture (Fig. 54.3).

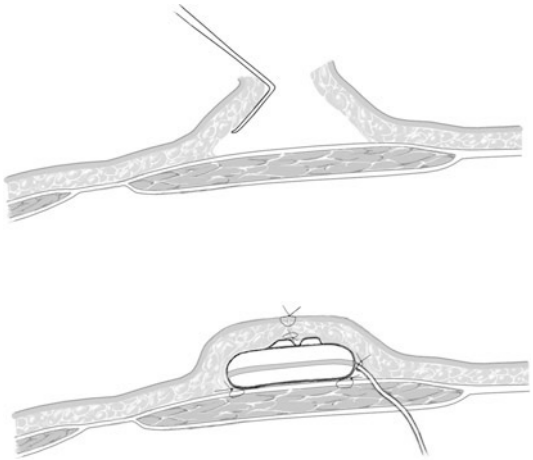


Fig. 54.3

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Step 4

Placement of the arterial catheter

Cannulation typically should be performed with a single catheter placed in the gastroduodenal artery (GDA). The origin of the GDA from the common hepatic artery is identified, and the proper hepatic artery from the GDA to the liver is skeletonized. Any branches leading to intestinal viscera are individually ligated and divided. This step prevents visceral misperfusion injuries. The GDA is further skeletonized for approximately 2 cm distal to its origin and then ligated near the pancreas. A noncrushing vascular clamp is used to occlude the GDA at its origin. A transverse arteriotomy is made in the GDA approximately 1.5 cm from its origin. The beaded infusion catheter is cut such that its port does not enter the common hepatic artery, but at least one bead is in the GDA. The catheter tip should not enter the common hepatic artery, to lessen the risk of catheter-associated common hepatic artery thrombosis. The GDA is secured around the catheter using 4-0 nonabsorbable suture both proximal and distal to the catheter bead, preventing advancement or retraction of the catheter (Fig. 54.4). To ensure proper hepatic perfusion, 1 to 5 cc of fluorescence is bolused into the catheter, and the liver is observed under a Woods lamp. Alternatively, 1 to 5 cc of methylene blue will also visually confirm adequate perfusion; this is a useful method when placing the HAIP laparoscopically.

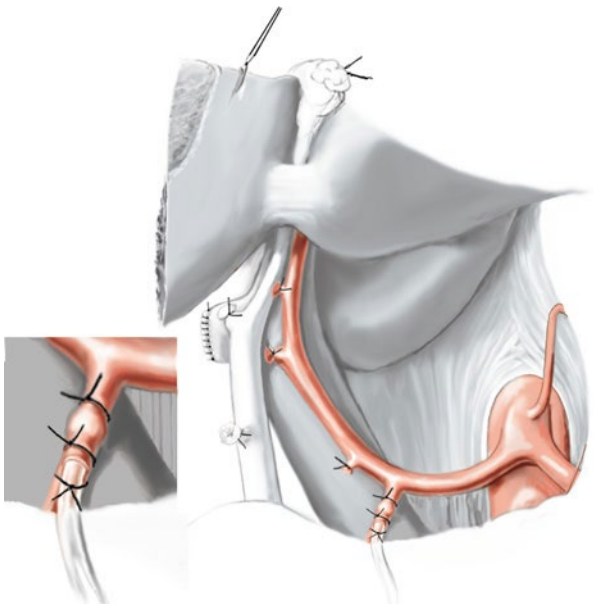


Fig. 54.4

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Step 5

Dealing with atypical arterial anatomy

Only one catheter is implanted in the single remaining hepatic artery. When ligation of hepatic branches is necessary, the immediate opening of intraparenchymal shunts allows a redistribution of the arterial flow through the remaining artery. In most cases, the catheter is sited in the origin of the GDA, and accessory or replaced hepatic arteries are ligated.

Following a hepatic resection, management of aberrant arterial anatomy is contingent upon the arterial supply of the remnant hepatic parenchyma.

Without a liver resection, the most common arterial variant is the presence of replaced hepatic arteries (right artery originating from mesenteric superior artery, or left from the left gastric artery); these can usually be ligated. Then the liver is perfused via the typical catheter placement (Fig. 54.5a).

When the replaced right hepatic artery is the only artery, the catheter must be inserted in the left branch, which is dissected in the hilum and then distally ligated (Fig. 54.5b).

When there is a trifurcation anatomy, the catheter can be inserted in the GDA, and the left branch is ligated to prevent thrombosis and unilateral preferential infusion (Fig. 54.5c).

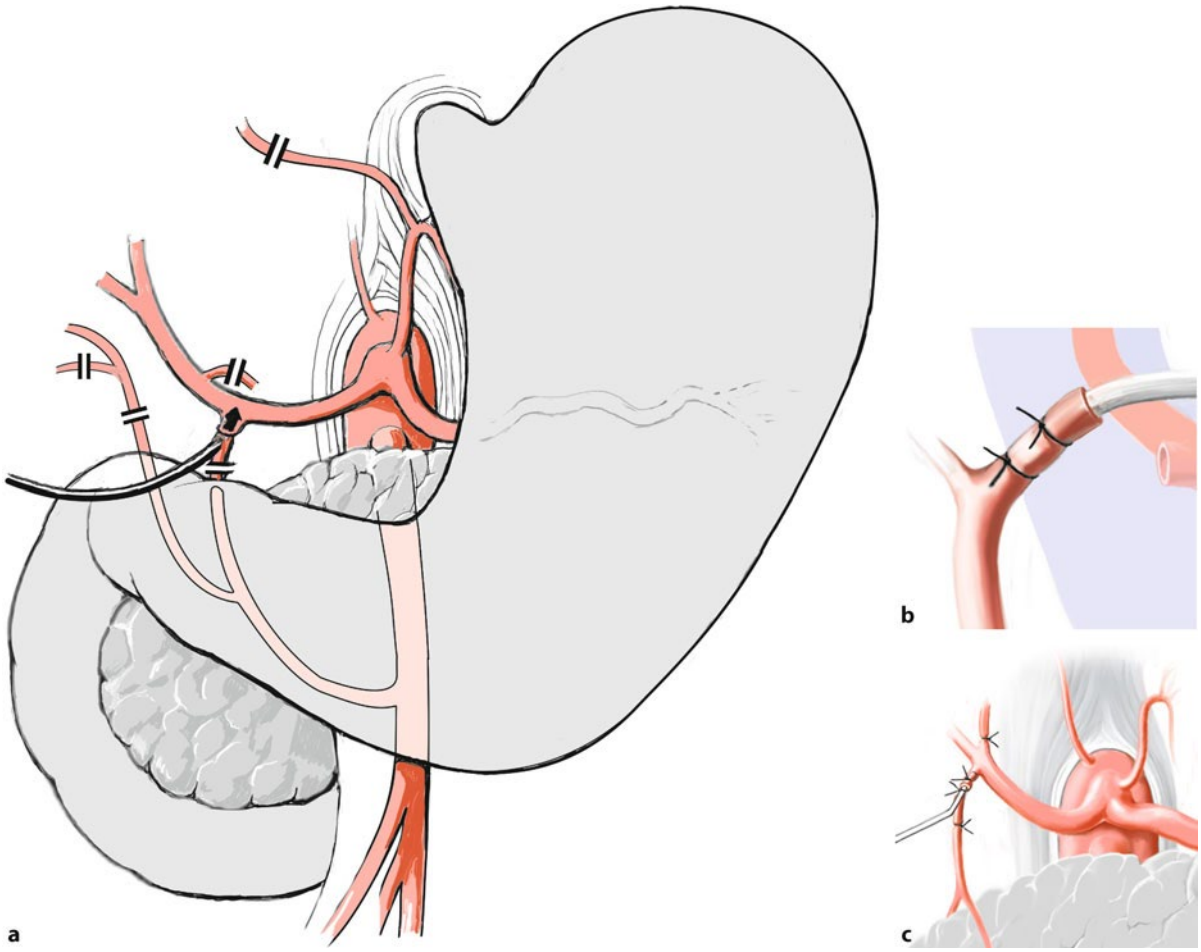


Fig. 54.5

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Postoperative Studies

Some centers routinely perform a nuclear medicine study of the HAIP on postoperative day 3 to 5, to rule out extrahepatic perfusion. This study consists of a sulfur colloid outline of the liver and then bolus injection of technetium microalbumin aggregate (MAA) via the pump bolus port. The two images are superimposed to ensure adequate hepatic perfusion and to rule out extrahepatic visceral perfusion. In cases of abdominal pain during infusion and/or extrahepatic perfusion, angiography must be performed to embolize accessory arteries.

Complications

- Early:
  - Visceral misperfusion
  - Arterial injury and postoperative bleeding
  - Hematoma or seroma of the pump pocket
- Late:
  - Biliary stricture
  - Hepatic artery thrombosis
  - Occlusion or displacement of the catheter
  - Pseudoaneurysm
  - Pump or port pocket infection

Tricks of the Senior Surgeon

- Prime the pump and test its function early in the case. Be familiar with the specifics of the various pumps and the needles used to bolus/prime and fill the pump.
- A postoperative MAA perfusion study is not essential and may be omitted if clear intraoperative studies indicate uniform hepatic perfusion with lack of reflux into the duodenum or stomach. An MAA study or angiography should be performed before the first infusion of chemotherapeutic agent, to demonstrate uniform perfusion of the hepatic parenchyma.
- With a port, it is possible to use any kinds of drugs, and the most frequent complication is dislodgment or artery thrombosis. With a pump, only FUDR can be used.

Acknowledgments

We would like to acknowledge Ravi Chari and Christopher D. Anderson, who authored this chapter in the first edition of this Atlas.

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Unroofing and Resection for Benign Nonparasitic Liver Cysts

Juan M. Sarmiento, David M. Nagorney

Hepatic cysts are classified according to the presence or absence of a parasitic etiology. They seldom lead to hepatic dysfunction and are mostly asymptomatic. The treatment is always individualized according to the origin and presence of symptoms. The choice between unroofing versus resection is dictated by site, number of cysts, malignant potential (cystadenoma/cystadenocarcinoma), and parasitic infection (see next chapter). Malignant potential is rare and is not a primary concern.

Indications and Contraindications

Indications

- Pain significantly affecting lifestyle
- Jaundice
- Infection
- Hemorrhage
- Portal hypertension
- Abdominal fullness or mass

Contraindications

- Asymptomatic patients
- Patients amenable to percutaneous cyst aspiration and/or alcohol sclerosis under ultrasound or CT guidance (simple cysts with little or no capsular extension, or cysts in segments 7 and 8)

Preoperative Investigation and Preparation for Procedure

- *History:* Polycystic disease of the kidney
- *Clinical evaluation:* Abdominal pain, jaundice, signs of portal hypertension
- *Laboratory tests:* AST, ALT, alkaline phosphatase, bilirubin, tumor markers (CEA, CA 19–9) and serologies (hydatid)
- *CT scan:* Location, accessibility to laparoscopic versus open approach, amount of remaining healthy parenchyma
- *Ultrasound:* Location, compression of main vessels (especially hepatic veins), biliary dilatation
- *MRI:* Polycystic liver disease or complicated cases

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Procedures

Laparoscopic unroofing of a simple cyst

Step 1

Access and exploration

Usually three ports are used: camera, grasper for the cyst wall, and cutting instrument (cautery, harmonic scalpel, or scissors). Placement varies according to the anatomic location of the cyst. One of the working ports should be 10 mm, for clip application (Fig. 55.1).

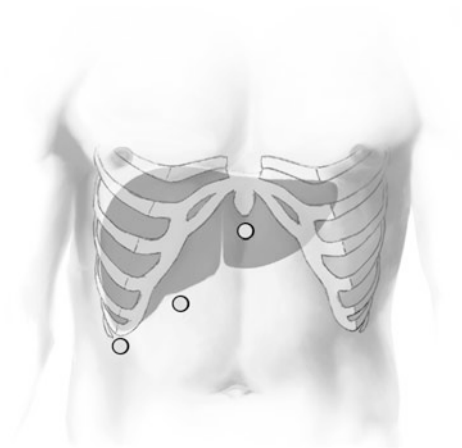


Fig. 55.1

Step 2

Unroofing

The dome of the cyst is elevated with a grasper. Incising the cyst and draining its contents makes the cyst wall flaccid and easier to handle (Fig. 55.2). The wall of the cyst is resented with electrocautery. Excision should be as close as possible to the interface between the cyst and the remnant liver. It is very important to resect the maximal amount of the wall of the cyst to enhance retraction of the remnant edge of the cyst, thus preventing reapproximation of the rim by contraction, with subsequent recurrence. Cytology of the aspirate is performed if indicated and if the cyst is complex, with mural nodules. Effaced ducts or vessels at the cyst-liver interface should be stapled or clipped. After removal, the cyst wall is assessed histologically.

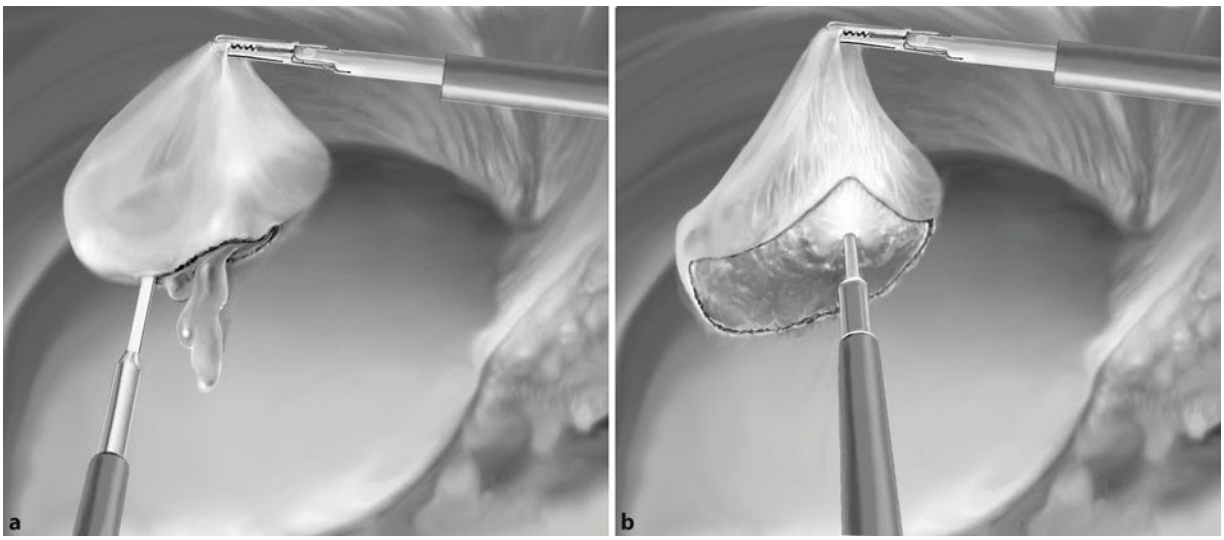


Fig. 55.2

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Step 3

Inspection of the cyst

After unroofing, the residual cyst wall is inspected carefully. A biopsy should be performed on irregularities within the concavity of the cyst. When less than 50 % of the cyst has been removed, ablation of the remnant cyst lining directly by cautery, argon beam coagulation, or topical sclerosant may reduce the incidence of recurrence. Omentum can be placed within the cyst remnant to prevent recurrence in this circumstance.

Open unroofing of a simple cyst

Step 1

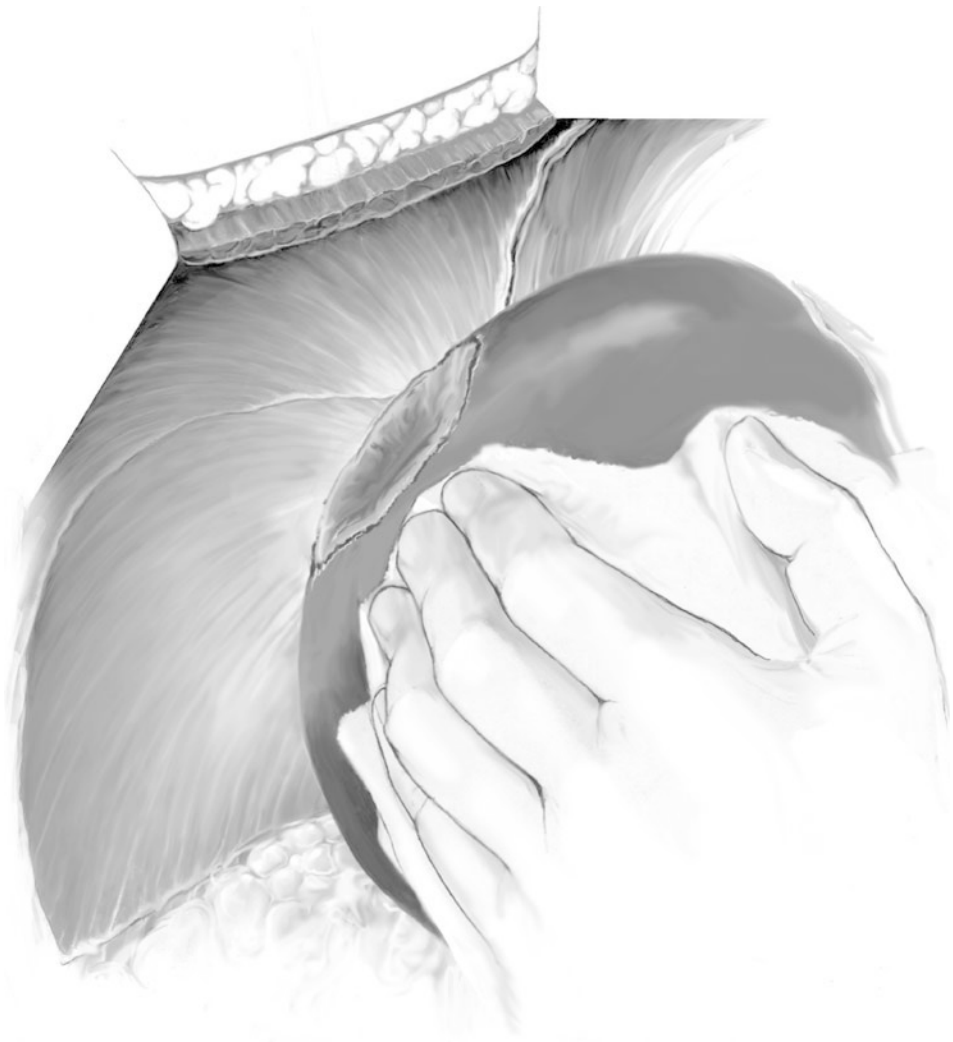
Access and approach

Cysts located superiorly in segments 7 and 8 are usually unroofed in an open fashion. A right subcostal incision is indicated in these cases; the triangular ligament and a portion of the coronary ligaments are divided to rotate the liver (see ▶ Chap. 46, "Right Hemihepatectomy"). Using the nondominant hand, the surgeon pulls the liver toward the midline to complete the exposure of the cyst. The same principles dictated for the laparoscopic approach are followed, and the cyst is unroofed. Alternatively, the cyst can be enucleated en toto.

Step 2

Inspection of the cyst

There is no cyst wall left above the level of the hepatic parenchyma. Occasionally, blood vessels or bile ducts can be seen on the cavity. No drains are necessary after cyst excision (◘ Fig. 55.3).



◘ Fig. 55.3

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Enucleation of biliary cystadenoma

Step 1

Enucleation of the cyst (Fig. 55.4a)

After mobilization of the liver, countertraction is maintained by the nondominant hand of the surgeon (Fig. 55.4b). The interface between the cyst and the hepatic parenchyma is identified and developed; the wall of the cyst is usually thick and rarely ruptures. With deeper dissection, compressed vessels and bile ducts become evident and should be preserved. The dissection is completed circumferentially; the cystadenoma is enucleated and sent for histologic analysis to exclude occult cystadenocarcinoma. Importantly, complete excision of the cystadenoma eliminates risk of recurrence.

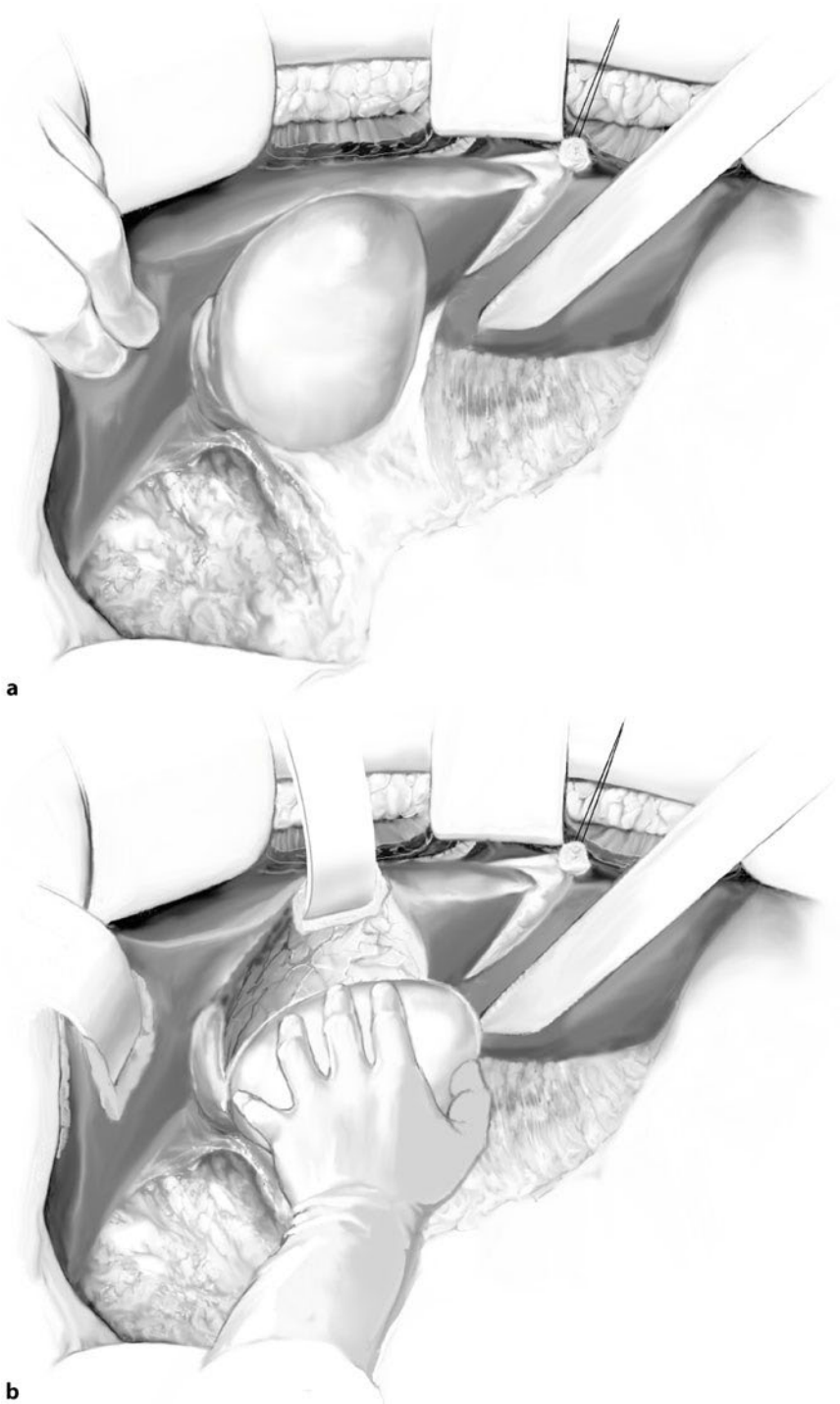


Fig. 55.4

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Step 2

Repair of vasculobiliary injuries

If the bile duct is inadvertently injured, a fine (4-0 or 5-0 absorbable) interrupted suture is used for repair. Abdominal drainage is optional (Fig. 55.5).

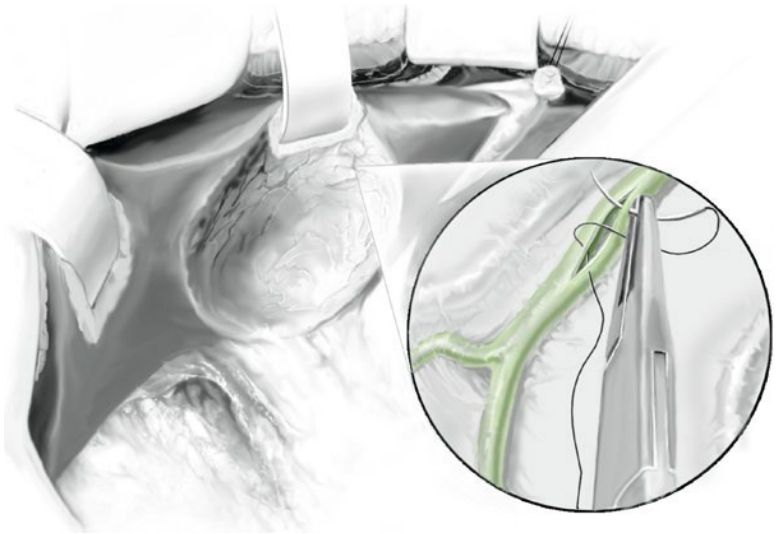


Fig. 55.5

Laparoscopic resection of cysts

Step 1

Access, approach, and parenchymal transection

Laparoscopic resection is used to treat peripheral cysts, especially those in the left lateral sector (Sg 2 and 3) or in the anterior segments (Sg 4B, 5, and 6). The CT scan and the picture illustrate a simple cyst in Sg 3. The approach described previously is undertaken. Three ports are usually used, and their placement depends on the site of the cyst.

The most common instruments used for this purpose are the Harmonic scalpel, TissueLink dissecting sealer, CUSA, and surgical staplers. The surgeon must determine the most direct route for positioning the instrument to achieve a complete cyst resection with sparing of healthy parenchyma. Because these lesions are usually peripheral and the parenchyma is thin, at times the stapler can tightly secure both the superior and the inferior edges of the line of transection, with a nearly bloodless margin. Identification of individual vasculobiliary structures in this situation is not necessary (Fig. 55.6a). When the tissue is too thick for stapling devices, the initial transection can be done with ultrasonic shears (Fig. 55.6b) or any other method of vascular sealing, and the pedicle taken with the staplers. The Pringle maneuver is usually not required for this type of transection.

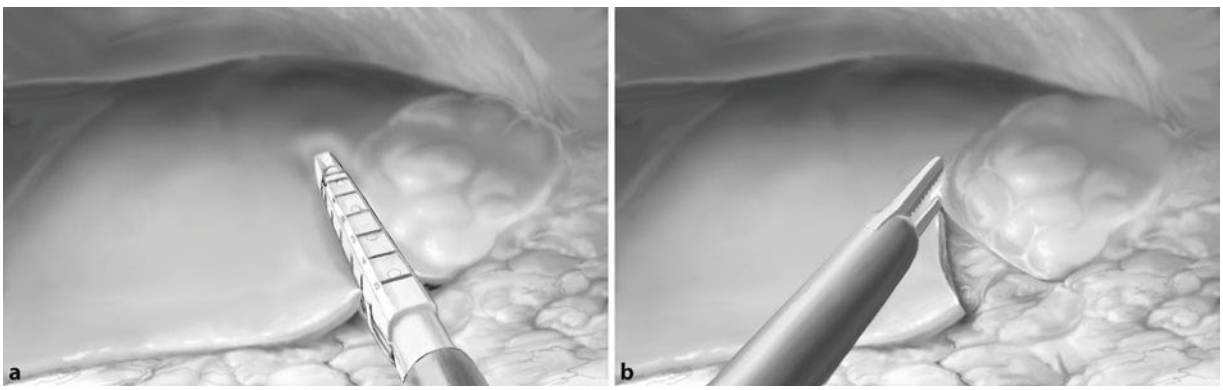


Fig. 55.6

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Step 2

Resection of the specimen

After the transection of the hepatic parenchyma is completed, hemostasis must be confirmed by direct inspection. Sometimes it is useful to "feel" or abrade the transection line to exclude a vessel that has stopped bleeding temporarily but may act as a site of remnant bleeding once the pneumoperitoneum is evacuated and normal intra-abdominal pressure returns. If such a vessel is identified, hemostasis is secured by electrocautery, surgical clips, and hemostatic agents or devices (Fig. 55.7).

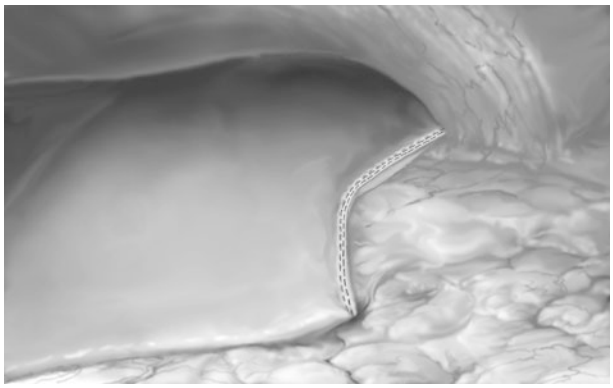


Fig. 55.7

Postoperative Tests

- Routine postoperative surveillance for most patients
- Intermediate care or intensive care units for complicated cases of polycystic disease of the liver

Postoperative Complications

See ▶ Chap. 46, "Right Hemihepatectomy."

Tricks of the Senior Surgeon

- Although unroofing is simple, enucleation carries risk of hemorrhage. Make certain the hepatic duct and ligament are accessible for a Pringle maneuver if needed.
- Look for small biliary radicals after enucleation; drainage is not a good alternative to repair or suture ligation.
- During laparoscopic resection of hepatic cysts, be aware that major pedicles may not be amenable to sealing devices. Surgical staplers are still the best mechanism to secure structures.
- As in any laparoscopic procedure with potential bleeding, do not hesitate to open up the patient in the presence of significant bleeding. Safety is still better than pride!

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Pericystectomy for Hydatid Liver Cyst

Lucas McCormack

Patients with hydatid cysts in the liver used to present a therapeutic challenge. Although surgical techniques have improved, considerable controversy still exists regarding the most effective operative technique. The main principle of the surgery is to eradicate the parasite and prevent intraoperative spillage of cyst contents, to avoid peritoneal spread. Pericystectomy provides a radical treatment, removing the whole cyst "en bloc" (including the adventitia), without resection of healthy liver tissue.

Preoperative Treatment

Albendazole (10–14 mg/kg per day) should be administered orally 2 to 4 weeks before and 2 to 4 weeks after liver surgery.

Indications and Contraindications

Indications

- Peripheral hydatid cyst of the liver

Contraindications

- Intrahepatic major vascular invasion
- Invasion of right or left hepatic duct
- Deep cyst within the liver parenchyma (> 2–3 cm from liver surface)
- General contraindication of liver resections

Procedure

Step 1

Incision, exposure, and staging

Access is performed as shown in the chapters on liver resection. Careful exploration of the abdominal cavity is done to exclude extrahepatic disease. The liver should be completely mobilized, as for a major liver resection. Because accidental opening of the cyst may occur during mobilization, always have a cup with povidone-iodine (or hypertonic saline solution) ready to use in case of intraoperative spillage of cyst contents.

Inspection and manual exploration of both lobes of the liver must be done with caution. Intraoperative ultrasound using a 5-MHz T-shaped probe is used to assess the number and location of the cysts. Particular attention is directed toward the relationship of the cysts with the portal veins, major hepatic veins, and the vena cava. In addition, meticulous examination of the cyst and the adjacent liver parenchyma can sometimes demonstrate a biliary communication.

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery*,
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Step 2

Definition of the surgical approach

Most of the cysts located in the right liver are easy to dissect away from the diaphragm. If this dissection is not safely feasible, a partial resection of the diaphragm must be performed. In patients with major vascular involvement or invasion of the left or right hepatic duct, an anatomical liver resection is indicated. If a cyst is located deep within the liver, liver resection is also recommended. If the depth from the liver surface is less than 2 to 3 cm, however, a hepatotomy allows the cyst to be reached, and a standard pericystectomy can be performed. For cysts located close to the vena cava in segments 6 or 7, the liver must be mobilized as for a right hepatectomy.

Step 3

Preparation prior to pericystectomy

The central venous pressure (CVP) should be below 3 mm Hg before starting the liver transection. A tourniquet is placed around the porta hepatis for inflow occlusion in case of bleeding. To prevent accidental spillage of the cyst contents, the whole space around the liver is packed using gauze swabs. A pack placed behind the right liver usually offers better exposure. The contents of the cyst should never be evacuated before resection. Stay sutures should not be placed in the cyst wall, but stay sutures with silk 2-0 are placed in the liver parenchyma around the emerging part of the cyst to enable traction and better exposure during resection (Fig. 56.1).

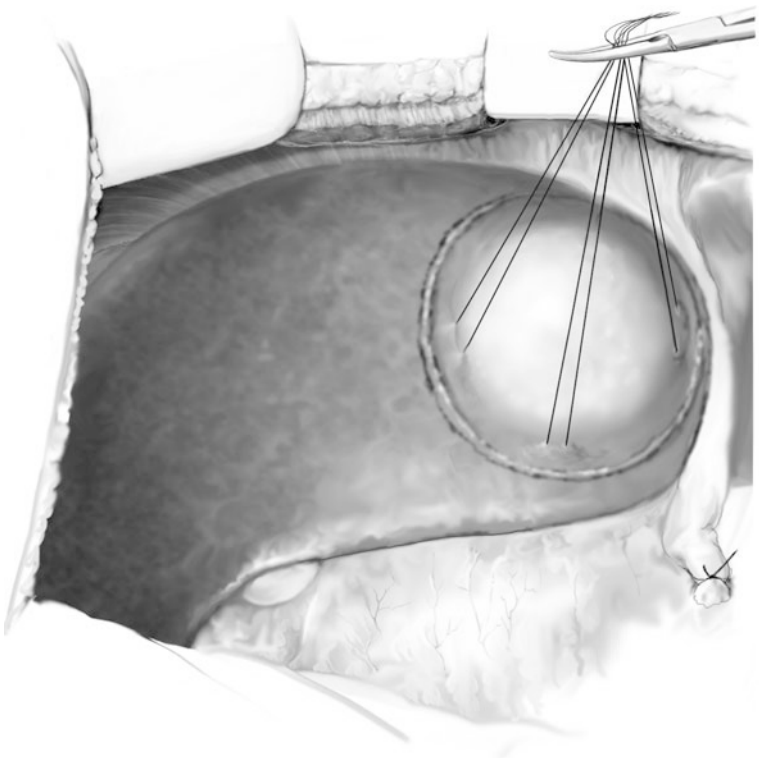


Fig. 56.1

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Step 4

Resection of the cyst

The liver capsule is incised with diathermy. Careful identification of the correct plane of cleavage is crucial to avoid bleeding or spillage of the cyst contents (Fig. 56.2a). Intrahepatic vessels are coagulated selectively with bipolar forceps or ligated with metallic clips, ties, or suture-ligatures, depending on their diameter. Although several possible techniques for liver parenchyma dissection can be used (see ▶ Chap. 44, "Techniques of Liver Parenchyma Dissection"), we prefer the water jet, which enables a selective and safe separation of the cyst wall from the liver parenchyma (Fig. 56.2b). Small bile ducts should be carefully identified and tied. Hemostasis of the exposed raw surface of the liver can be improved with an argon beam coagulator or topical fibrin derivates.

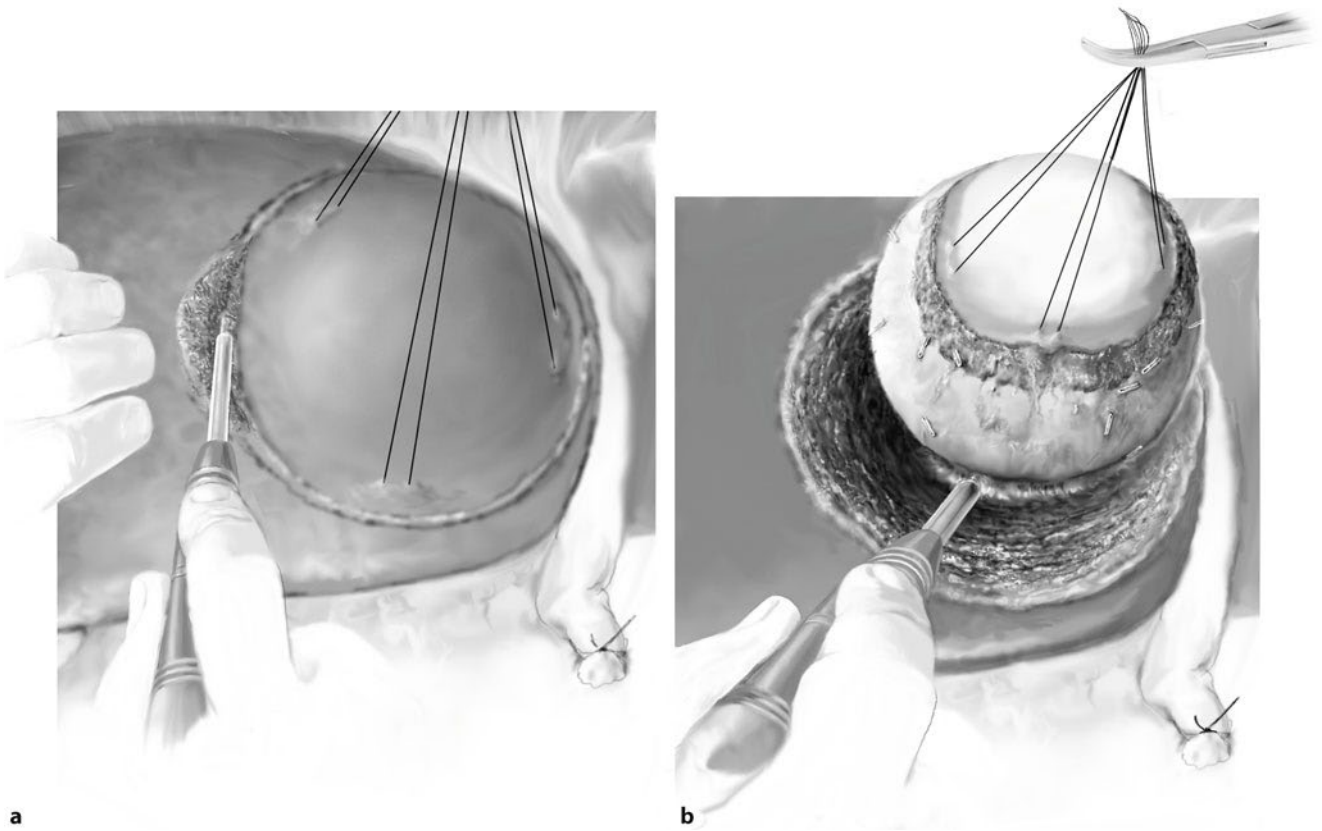


Fig. 56.2

Postoperative Complications

Possible complications are the same as in liver resections (see ▶ Chap. 45, "Liver Resections"), but biliary fistula is less common than in partial resection.

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Tricks of the Senior Surgeon

- Use magnification loops to control bile leaks after pericystectomy. Careful repair should be done with suture-ligatures with Prolene 4-0 to 5-0.
- At least two drains with powerful suction should be available in case of rupture of the cyst, to avoid peritoneal spread of the contents.
- Always have a cup with povidone-iodine (or hypertonic saline solution) ready to use in case of intraoperative spillage of cyst contents into the peritoneal cavity.
- In case of intraoperative bleeding and technical difficulties during surgery, remember that adequate conservative surgery (e. g., partial resection of the cyst) can also achieve excellent results. The strategy can be changed at any time!

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Special Maneuvers in Liver Trauma

Denis Castaing, Olivier Scatton, Antonio Sa Cunha, Marius Keel

Liver injuries most often (> 90 % of all cases) are associated with other injuries such as ipsilateral rib fractures, lung contusions, other intra-abdominal lesions, or injuries of the extremities, the pelvis, and the head. Hepatic injuries are graded according to the Organ Injury Scale of the American Association for the Surgery of Trauma (AAST-OIS) (Table 57.1).

Table 57.1 Grading of hepatic injuries according to the Organ Injury Scale of the American Association for the Surgery of Trauma (AAST-OIS)

Grade	Injury description	Incidence [%]	Mortality [%]
I	Subcapsular hematoma, < 10 % surface area	20	0
	Capsular tear, < 1 cm in depth		
II	Subcapsular hematoma, 10–50 % surface area	55	< 10
	Intraparenchymal hematoma, < 10 cm in diameter		
	Laceration, 1–3 cm in depth, < 10 cm in length		
III	Subcapsular hematoma, > 50 % surface area, expanding or ruptured with bleeding	15	25
	Intraparenchymal hematoma, > 10 cm in diameter or expanding		
	Laceration, > 3 cm in depth		
IV	Parenchymal disruption involving 25–75 % of lobe or one to three segments	7	45
V	Parenchymal disruption of > 75 % of lobe or more than three segments	3	> 80
	Juxtahepatic venous injury		
VI	Hepatic avulsion	< 1	Near 100

Because clinical examination of the abdomen is unreliable in trauma patients with an altered level or loss of consciousness, a Focused Assessment with Sonography for Trauma (FAST) should be undertaken as an adjunct to the primary survey. In hemodynamically unstable patients with free fluid in FAST, a diagnostic laparotomy without further investigation is indicated. In stable patients, CT scanning of the abdomen represents the gold standard with evaluation of hemoperitoneum and parenchymal fractures, as well as vascular mapping including a three-phase study (arterial, portal, and venous) as a preparation for a possible arterial embolization. The decision for operative or nonoperative management of blunt hepatic trauma after the CT scan is made according to the grade of liver injury and other abdominal injuries that are diagnosed or suspected, whereas for penetrating abdominal injuries, an operative exploration of the abdomen is still standard.

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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Indications for Nonoperative Management

Liver injuries of grades I through III should be treated nonoperatively. In case of active bleeding (diagnosed by CT scan), an angiographic embolization should be performed in patients with injuries of grades I through IV. However, the following conditions should be fulfilled:

- Patient without altered level or loss of consciousness
- Hemodynamic stability or rapid stabilization after initial fluid resuscitation
- Exclusion of hypothermia, acidosis, or severe coagulopathy
- No doubt about another abdominal lesion
- Intensive care unit available with continuous pulse and arterial blood pressure monitoring; repeated measurements of hemoglobin, hematocrit, and coagulation parameters; and careful follow-up clinical examination and sonography
- Availability of a surgical team
- Availability of arteriography and an experienced radiologist

Indications for Laparotomy

- Hemodynamic instability
- Peritonitis on physical examination
- Other abdominal injuries in diagnostic studies
- Failed nonoperative treatment

57

Procedure

Step 1

Incision and abdominal exploration

A midline incision is performed, as well as (depending on the type of injury) an extension into the chest by median sternotomy or left or right thoracotomy. The initial step in a trauma laparotomy is to pack all four quadrants of the abdomen in order to control hemorrhage as quickly as possible. The next step is to determine the site(s) of bleeding and injuries by exploration of the whole abdomen, with special attention to the pancreas and the right retroperitoneal area. Packs are removed from one quadrant at a time, starting in the noninjured area and ending in the most seriously injured area. Injuries of the small or large bowel and of the biliary tree are repaired.

In addition, a rapid transfusion device with warmed crystalloids and blood is essential. After exclusion of hollow-organ injuries, blood should be collected in the peritoneal cavity for autotransfusion (cell saver). Dilutional coagulopathy may follow massive blood transfusions, prompting the need for transfusion of platelets, fresh frozen plasma, and/or activated factor VII.

In general, three situations can be found after laparotomy:

- *Diffuse, severe active bleeding or cardiac arrest at the opening:* The control of massive exsanguinating hemorrhage requires clamping of the aorta and/or inferior vena cava (IVC). Aortic control can be approached through a sternotomy or left thoracotomy allowing supradiaphragmatic, intrathoracic aorta cross-clamping and open cardiac massage in situations with cardiac arrest. This is predictable if an external cardiac massage on a "dying person with a tense abdomen" is performed. Furthermore, the suprarenal abdominal aorta can be approached through the gastrohepatic ligament or after medial rotation of the splenic flexure of the colon (Mattox maneuver). The infradiaphragmatic IVC can be controlled by direct digital pressure or clamping after an extended Kocher maneuver or right-side-to-medial visceral rotation (Cattel Braasch maneuver).
- *No active bleeding from the liver:* Simple hepatic injuries such as grades I, II, or III without active bleeding do not require further operative investigation or treatment.
- *Active bleeding from the liver:* Proceed with Step 2.

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Step 2

Manual compression of the liver

In case of active hemorrhage from the liver, the surgeon (or ideally, the assistant) performs initial tamponade by manual compression for at least 10 min (Fig. 57.1). Then, two situations can be found:

- When the hemorrhage can be controlled by manual compression, a competent team is available for appropriate assessment, and the patient is hemodynamically stable without hypothermia or acidosis, a one-step intervention leading to definitive surgical repair can be decided (see Step 3).
- When the hemorrhage is not controllable and hemodynamic instability, hypothermia, acidosis, or coagulopathy occur, liver packing (see Step 9) with or without vascular control (see Step 10) must be performed.



Fig. 57.1

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Step 3

Mobilization of the liver

The liver can be fully mobilized to facilitate the examination and exploration of the posterior surface and the retrohepatic vena cava. Mobilization must be done carefully to avoid hepatic vein damage. After dissection of the falciform ligament, the right triangular, the coronary, and the left triangular ligaments are divided while the assistant is taking care of the fracture by manual compression (Fig. 57.2).

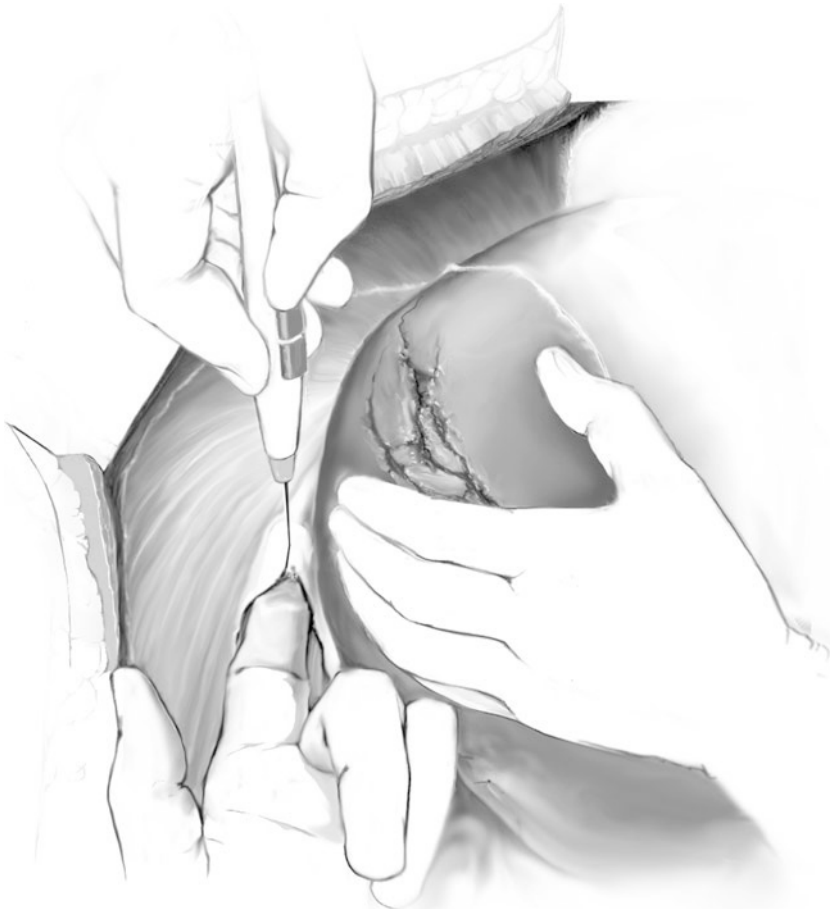


Fig. 57.2

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Step 4

Risk of hepatic vein damage during liver mobilization

When liver packing is needed (Step 9), hepatic mobilization is not recommended, as this maneuver increases the risk of hepatic vein damage and aggravates the initial liver injury.

Major hepatic lesions are usually caused by a deceleration trauma leading to a liver fracture at the level of the right triangular ligament along the right hepatic vein. This location is often difficult to access. To stop the bleeding, the fracture should be closed by placing the assistant's hand beyond the fracture; traction should be avoided (Fig. 57.3).

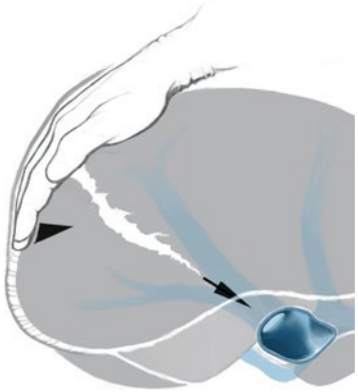


Fig. 57.3

Step 5

Vascular ligation

The wound may require enlargement to visualize the source of bleeding by utilizing finger-fracture technique and retractors (hepatotomy). Bleeding vessels can be controlled using sutures, surgical clips, and electrocautery. Deep stitches, which could lead to ischemic areas, should be avoided (Fig. 57.4).

A Pringle maneuver may be required, but prolonged pedicle clamping must be avoided whenever possible, as it may aggravate ischemic injury caused by hypotension. If pedicle clamping longer than 30 min is needed, intermittent clamping is recommended (15 min of clamping and 5 min of reperfusion).

Hepatic defects can be filled by vascularized omentum (omentoplasty). This helps to eliminate dead space, tamponades venous oozing, and may reduce the risk of a significant bile leakage.

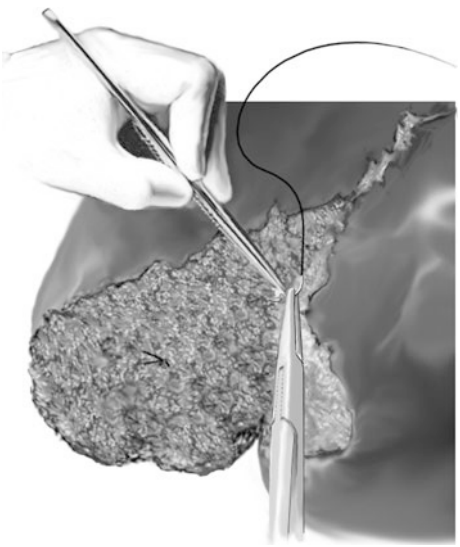


Fig. 57.4

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Step 6

Resectional débridement

Devitalized hepatic tissue must be removed because of the risk of abscess. The hepatic parenchyma is divided along the line of fracture in the plane between devascularized liver and the remaining parenchyma, using the back of the scalpel handle. When resistance is encountered, this indicates the elastic tissue of vessels or biliary ducts, which are doubly clamped, divided, and suture ligated (Fig. 57.5). In most instances, a nonanatomical resection rather than a standard anatomical hepatectomy is preferred. A major hepatectomy is rarely indicated in the presence of extended injuries.

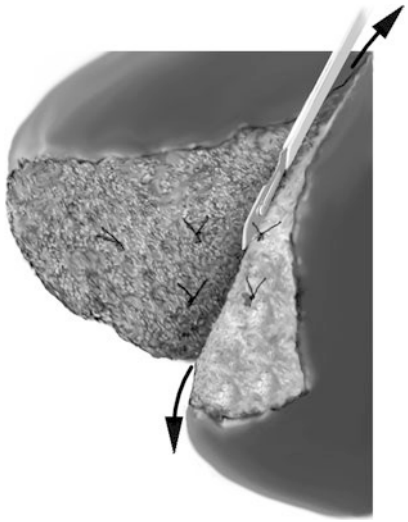


Fig. 57.5

Step 7

Ruptured subcapsular hematoma

In case of a ruptured subcapsular hematoma, hemostasis is performed using an argon beam coagulator, and the capsula is glued onto the bleeding parenchyma. The glue can be injected between the parenchyma and the glissonian capsule (Fig. 57.6). Alternatively, a TissueLink dissecting sealer can be used.



Fig. 57.6

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Step 8

Methylene blue test and cholangiography

After complete hemostasis, the integrity of the biliary tract is evaluated by a methylene blue test. The test can be performed through a gallbladder puncture combined with a manual choledochal compression. Biliary leaks are repaired by selective ligations (Fig. 57.7).

The opening of the gallbladder wall must be closed carefully (cholecystorrhaphy). In case of limited liver trauma, a cholecystectomy is preferred, allowing cholangiography through the cystic duct to detect biliary leaks into the fracture line.



Fig. 57.7

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Step 9

Packing

Packing is the mainstay of damage control. The principle is to perform a compression of the liver against the diaphragm (upper and posterior direction), which works very well for venous bleeding. Gauze swabs are placed around the liver – not inside the lesion – in order to compress the fracture and keep the compression against the diaphragm (Fig. 57.8). However, no pack should be placed between the liver and the diaphragm, to avoid compression of hepatic veins and vena cava compromising venous return and resulting in decreased cardiac inflow and a hepatic venous thrombosis. However, the elevation of the diaphragm leads to a high peak airway pressure with hypoventilation, which must be taken into account in the postoperative care.

The abdomen is closed under tension without drainage to maintain pressure on the packs. The increased intra-abdominal pressure represents a major risk for an abdominal compartment syndrome and therefore needs to be checked regularly.

If the hemorrhage is not controlled, manual compression is performed again and the liver is packed one more time. If this step does not lead to control of the bleeding, partial or total vascular exclusion of the liver needs to be performed (Step 10).

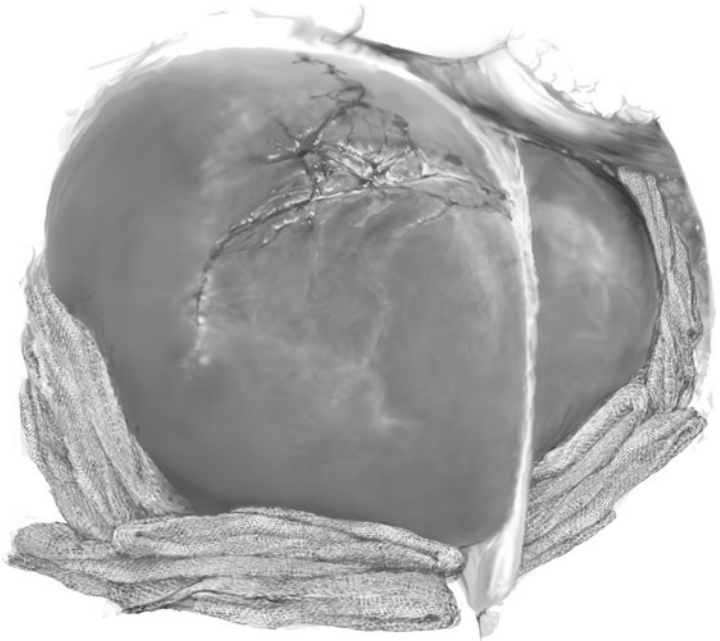


Fig. 57.8

Step 10

Vascular control

If packing fails to control hemorrhage in complex liver injuries, the Pringle maneuver allows control of hemorrhage from the hepatic artery and portal venous system. The technique also helps to rule out other sources of bleeding such as retrohepatic veins and the vena cava. If this maneuver does not lead to control of the bleeding (grade VI lesions), total vascular exclusion of the liver is performed by clamping the supradiaphragmatic IVC after sternotomy and the infradiaphragmatic IVC (see ▶ Chap. 41, "Techniques of Vascular Clamping, Vascular Exclusion, and Caval Resection in Liver Surgery"). The appropriate and early use of vascular control allows for accurate identification of the injury and the control of hemorrhage.

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Step 11

Hepatic venous exclusion

In case of a retrohepatic caval injury, an atrial-caval shunt to the superior vena cava or a hepatic venovenous bypass should be used in addition to the Pringle maneuver early in the operation, to preserve venous return during repair of the retrohepatic caval injury. An atrial-caval shunt can be performed with a large chest tube through the right atrial appendage placed and advanced into the IVC distal to the renal veins. Additional side holes are cut in the tube at the atrial level. Tourniquets are tightened around the vena cava at the level of the supradiaphragmatic and suprarenal cava levels and the atrial appendage.

Step 12

Intrahepatic balloon tamponade

Hemorrhage control for through-and-through penetrating liver injuries can be achieved by an intrahepatic balloon, avoiding an extensive hepatotomy (tractotomy) (Fig. 57.9). The intrahepatic balloon is created from a Penrose drain, which acts as a balloon and hollow catheter. Inflation of the balloon causes a tamponade within the liver parenchyma. Alternatively, a simple Foley catheter can be taken. The tamponade is maintained for 48 h.

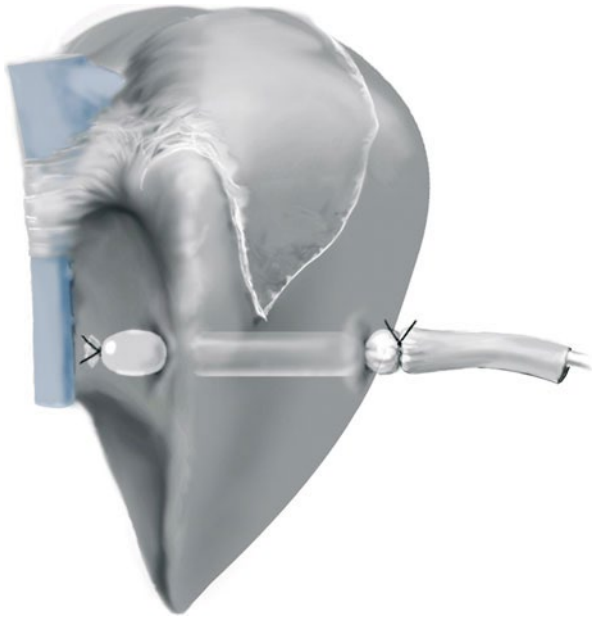


Fig. 57.9

Postoperative Management

- Postoperative care on the intensive care unit requires correction of hypovolemia and the "triad of death": hypothermia, acidosis, and coagulopathy.
- Intra-abdominal pressure should be measured frequently by means of a Foley catheter in the bladder after primary closure of the abdomen, to detect the development of an abdominal compartment syndrome.
- If packing is decided upon, a planned reintervention (second look) with removal of the packs, as well as repacking, definitive hemostasis, and definitive abdominal closure or abdominal vacuum-assisted closure, is necessary after the resuscitation period. The time point of the second look depends on rewarming and correction of acidosis and coagulopathy, which usually takes 24 to 48 hours.

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Postoperative Complications

- **Short-term:**
  - Hemorrhage
  - Abdominal compartment syndrome
  - Bile leaks
  - Liver failure
  - Acidosis, coagulopathy, and hypothermia with multiple organ failure

- **Long-term:**
  - Biloma
  - Biliary fistula
  - Biliary stricture
  - Abscess and hematoma infection

Tricks of the Senior Surgeon

- Do not hesitate to call for help from a hepato-pancreato-biliary (HPB) surgeon.
- Request experienced anesthesiologists.
- Ask regularly for temperature and quantity of transfusions.
- Do not mobilize the liver until volume replacement has been achieved.
- Alert the anesthesiologist prior to clamping of major vessels, as a sudden decrease in venous return is tolerated poorly by hypovolemic patients.
- A decision to use packing is usually the best in a complex situation.

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Robotic Hepatectomy

Hari Nathan, Yuman Fong

Laparoscopic liver resection is now standard for resection of peripherally located lesions. Laparoscopic wedge resections, segmental resections, and left lateral sectionectomies are routinely performed at many centers, and laparoscopic lobectomies are performed at specialty centers. Recent development of new instrumentation for robotic surgery now allows routine robotic liver and biliary surgery to be performed safely. Articulated instruments, sealers, and staplers allow liver surgeons to take advantage of the binocular vision, ease of suturing, and decrease in tremor afforded by robotic surgery. Data indicate that lobectomies are much more likely to be completed through the robotic approach than through the usual laparoscopic approach.

In this chapter, we present the standard positioning and conduct of a robotic liver resection. We use the left lobectomy as an example. This is clearly an evolving area, in which ever-changing instrumentation and improving expertise will likely bring great changes in the next few years.

Indications and Contraindications

Indications

- Primary malignancies of the liver
- Metastases malignancies of the liver
- Benign tumors of the liver
- Symptomatic cysts of the liver
- Abscesses of the liver

Contraindications

- Cardiopulmonary comorbidities
- Advanced tumors
- Patients older than 75 years (relative)

Preoperative Investigations/Preparation for the Procedure

Chest radiograph:	In cases of malignancies, to check for metastases
CT scan:	To check resectability. To plan port placement
MRI:	In patients with hepatosteatosis, to check presence and position of tumors
Risk analysis:	Cardiac, lung, liver function

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Step 1

Positioning and exposure

For most resections in the left or right liver, a supine position is best (Fig. 58.1). The patient-side cart (tower with the robotic arms) will be docked so that the cart, line of liver transaction, and camera ports are roughly in line. Thus, the cart is generally on the patient's left for left-sided resections and on the right for right-sided resections. For bilateral resections, the tower should be on the side of the dominant lesion or docked directly over the head of the patient.

The table is slightly rotated to the opposite side of the target lesion so that the liver to be removed is suspended on the ipsilateral triangular ligament. In addition, unlike in an open operation, a reverse Trendelenburg position is generally used. This allows the intestines to fall away from the liver to a dependent position. This also allows the liver to fall away from the diaphragm. Gravity is used for retraction.

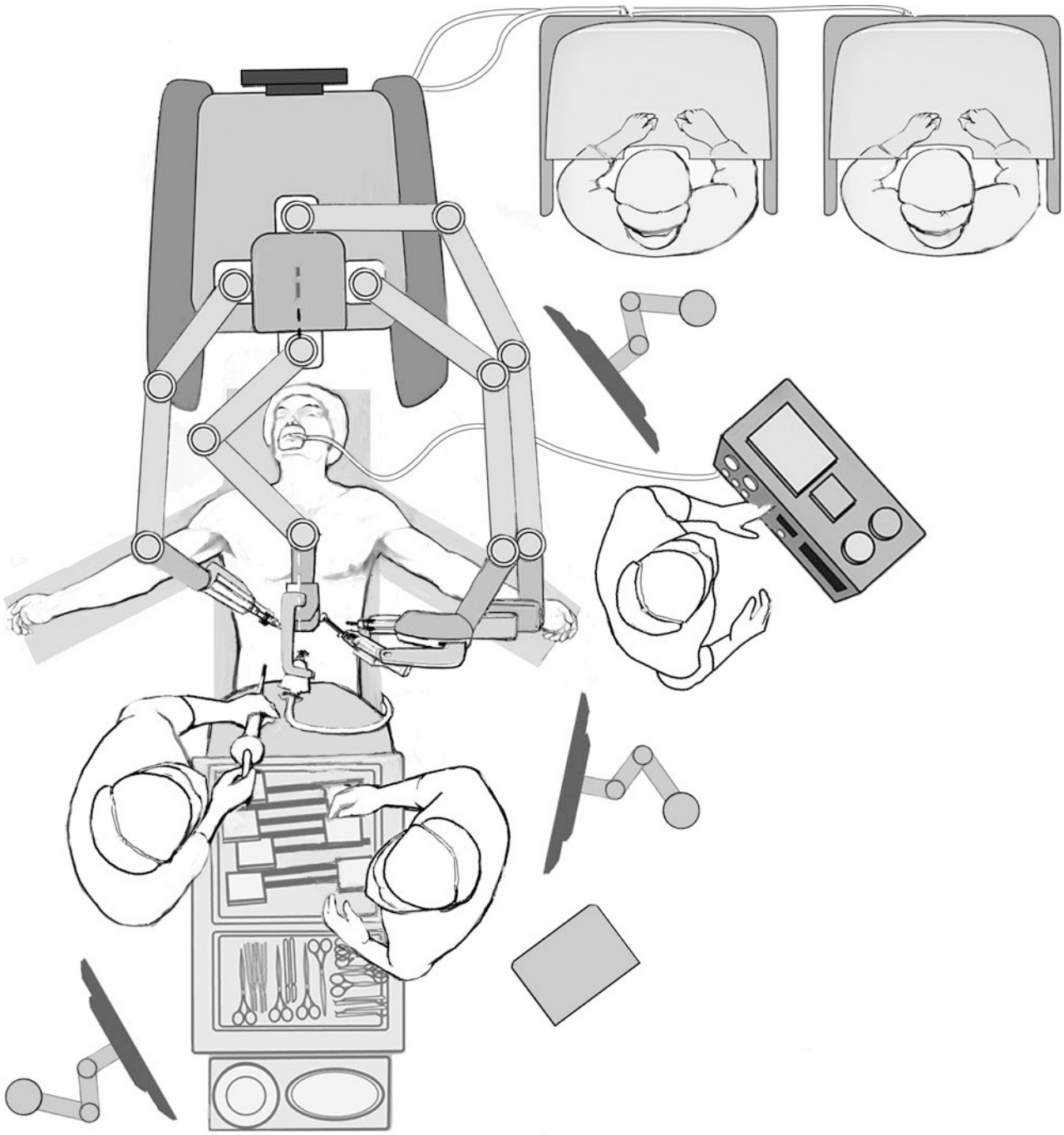


Fig. 58.1

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Step 1 ***(continued)***

Port placement for standard right or left hepatectomy is shown in Fig. 58.2. Generally, the camera port is placed in the umbilicus (black). A balloon port works well as the camera or accessory ports (umbilical or more medial ports). The 8-mm robotic ports are generally used for instrument ports. One other option is to use a 5- to 12-mm port in the right midclavicular line. A long 7-mm "bariatric" robotic port can be placed within the standard 12-mm laparoscopic port for robotic docking. This allows the flexibility of placing the camera in the midclavicular line as well as using the 12-mm port as an assistant port for smoke evacuation, suction, retraction, and stapling. For minor resections, four total ports may be all that is necessary. For major resections an additional assistant port may be placed (Fig. 58.3).

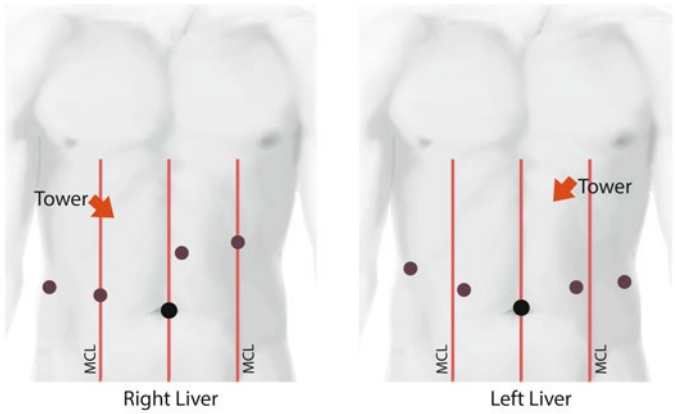


Fig. 58.2

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Step 1 ***(continued)***

Positioning for Right Posterior Lesions

For lesions in the right posterior sector (segment 6 or 7), patients should be placed in a left lateral decubitus position (Fig. 58.3). The patient should be positioned on the table such that the space between the costal margin and the iliac crest is at the break in the table. The table is then extended similar to the positioning for a renal or retroperitoneal operation. The table should also be in a reverse Trendelenburg position as explained earlier. The port sites are illustrated (Fig. 58.4) for camera port (*black*), robotic ports (*white outline*), and assistant port (*black outline*). The most posterior port in the space between the costal margin and the iliac crest is placed as posterior as possible and as low as possible (Fig. 58.4b). Both the umbilical port and the midclavicular assistant port should be 12-mm ports, so that the camera can be used in either, and staplers can be applied from either.

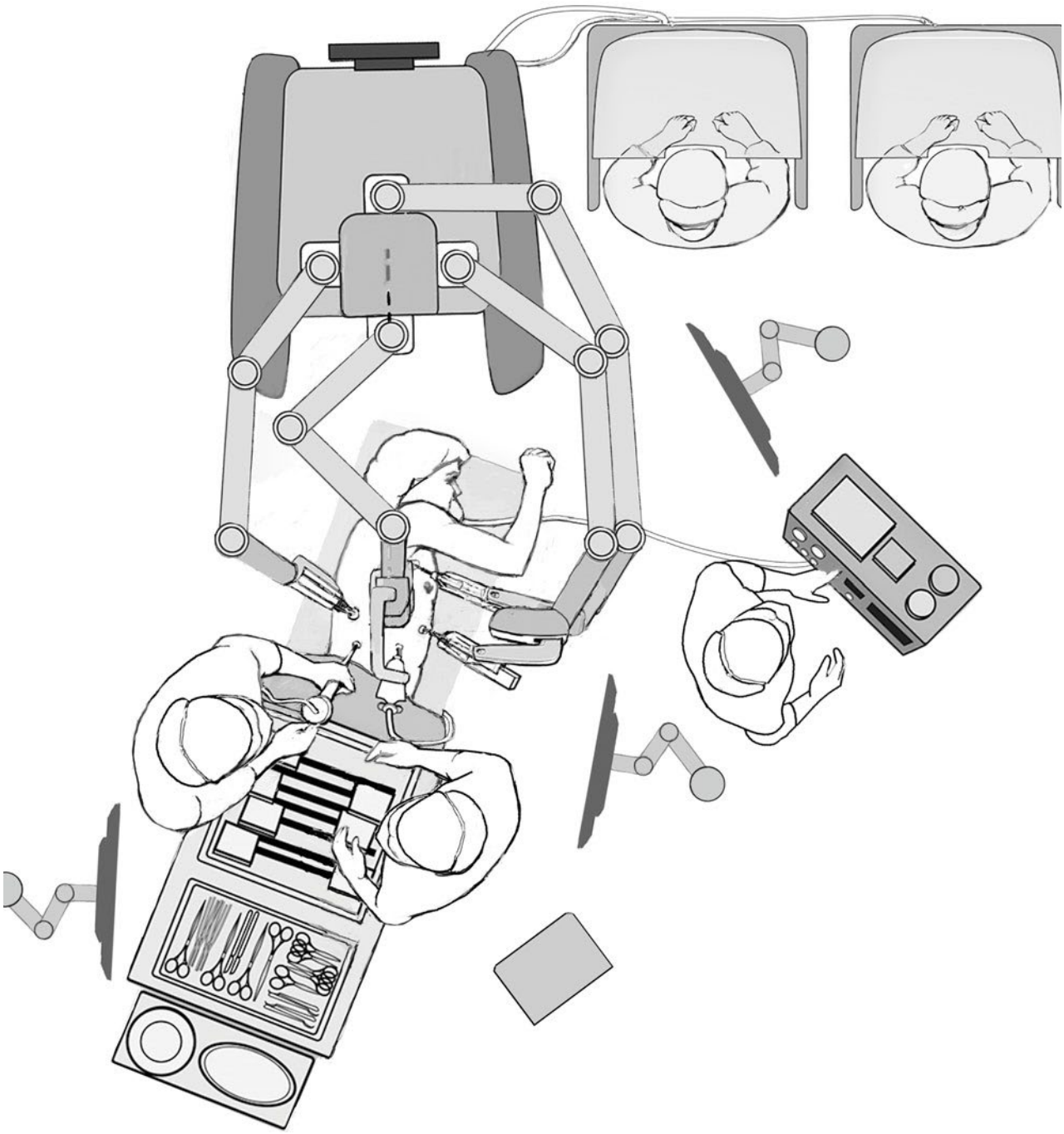


Fig. 58.3

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Step 1 *(continued)*

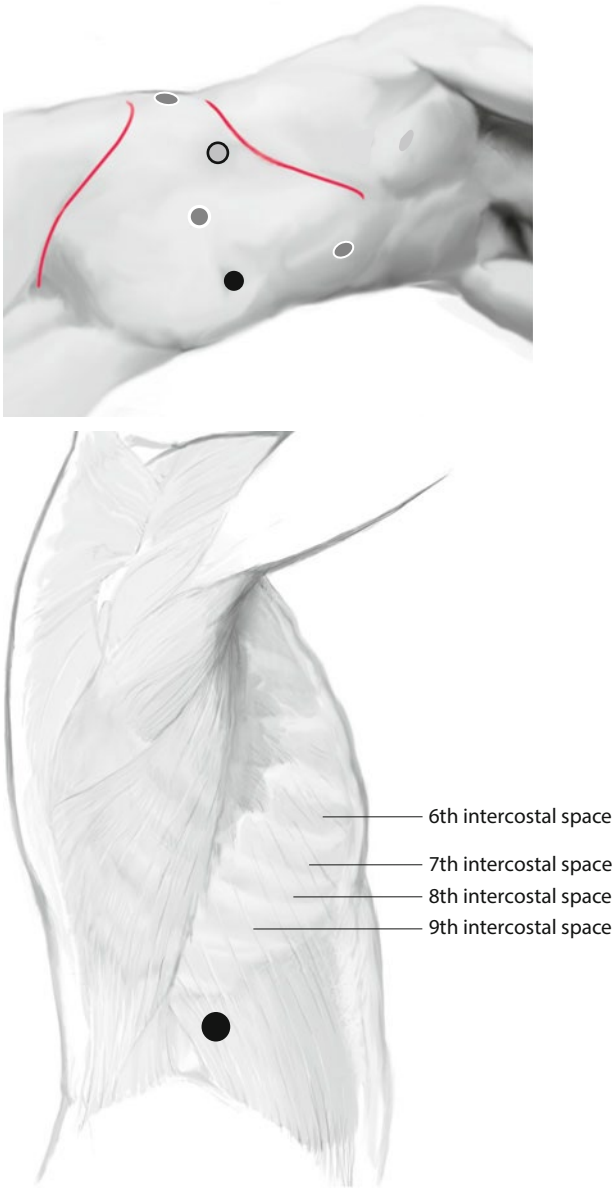


Fig. 58.4

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Step 2

Assessment and planning

After docking the robot, entire peritoneal cavity is assessed for ascites, location of pathology, and location of other organs. Resection planning is then performed. The direction of the camera is placed as close to the line of liver transaction as possible. An instrument with monopolar coagulation attached is used to mark the line of liver transaction (Fig. 58.5a). Ultrasound is then used to verify locations of tumors and major vasculature (Fig. 58.5b). For this purpose a drop-in probe that can be manipulated with the robotic arms is best.

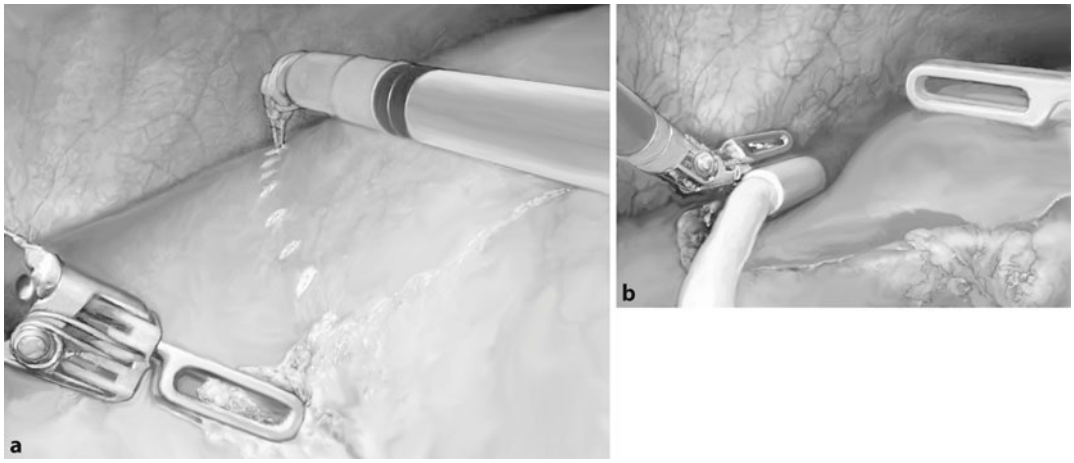


Fig. 58.5

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Step 3

Liver parenchymal transection

Superficial areas in the liver can be transacted with the scissors with monopolar coagulation attached (hot scissors). There are a number of options for transaction of deeper areas. A bipolar coagulation instrument such as a PK dissecting forceps can also be used (Fig. 58.6a). The parenchyma is then transected with scissors after sealing (Fig. 58.6b). Alternatively a vessel sealer with a built-in knife can be used (Fig. 58.6c). Such a vessel sealer can be used alone, or it can be used in conjunction with a blunt crushing instrument such as a Cadiere forceps. Clamp-clysis is then followed by sealing with the vessel sealer if only vessels less than 5 mm are seen. Larger vessels can be tied, clipped, or stapled. This method is akin to the Kelly clamp-clysis that is commonly used in open hepatectomy.

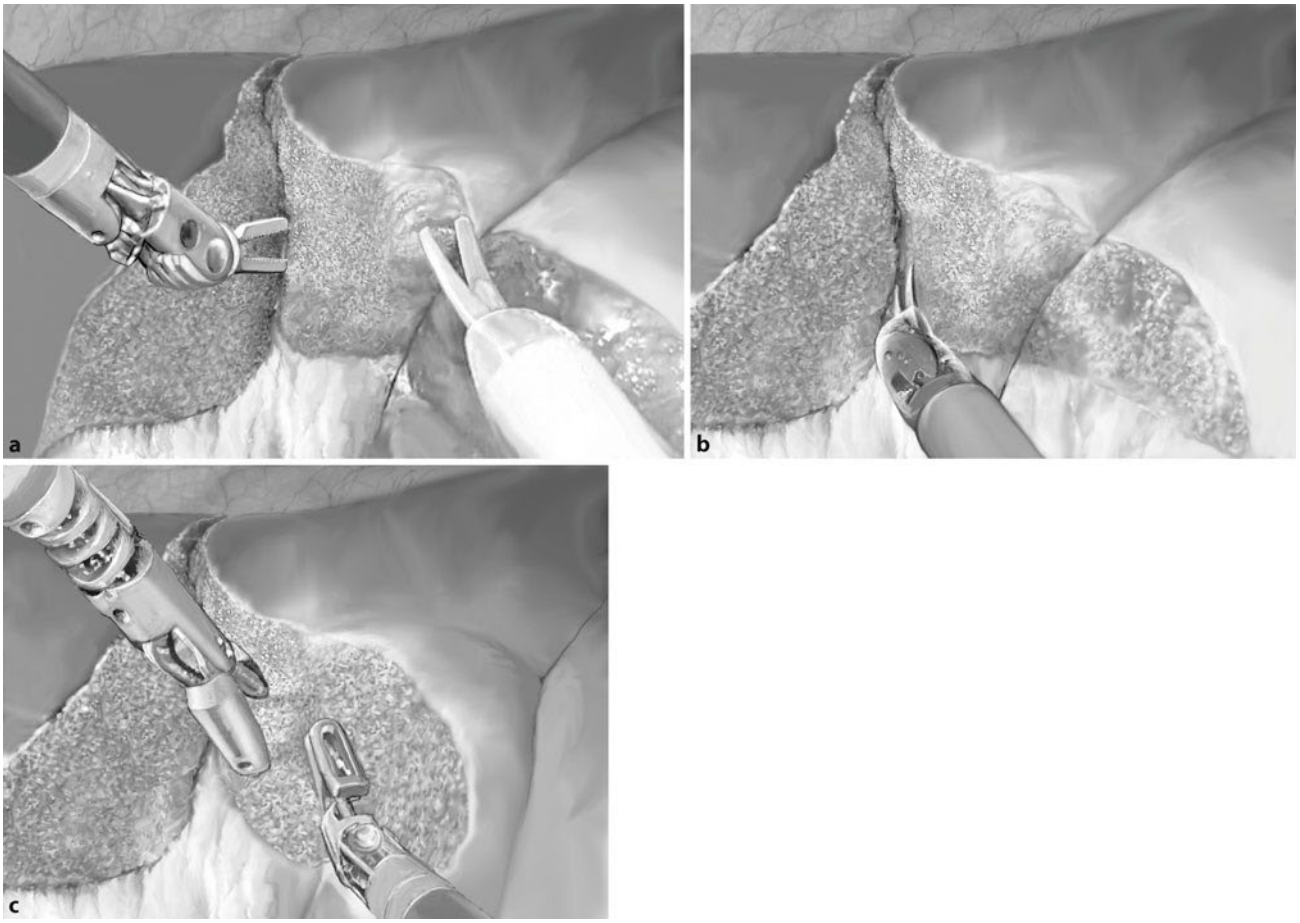


Fig. 58.6

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Step 4

Securing and ligating inflow vasculature

Individual components of the inflow pedicle can be dissected and ligated separately.

If it is a resection for benign disease or if the tumor is more than 2 cm from the junction of the left and right portal pedicles, however, the easiest way of securing the inflow to the piece of liver being resected is to leave the Glissonian sheath of the portal pedicle intact and staple it en masse.

Figure 58.7 illustrates a left portal pedicle ligation for a left lobectomy. The left portal pedicle is encircled. The vessel sealer is an instrument suited for this dissection because of the smooth, round, and atraumatic nature of this finger-like instrument. An umbilical tape is placed around this pedicle. The umbilical tape is then used as countertraction for application of a stapler. It is best to hold the umbilical tape with a very secure grasper such as the Pro-Grasp. An umbilical tape is used and not a vessel loop because there is little give in the umbilical tape and it allows the best traction to ensure that the vessels and biliary tree on the right cannot be accidentally ligated. The stapler is then applied and fired.

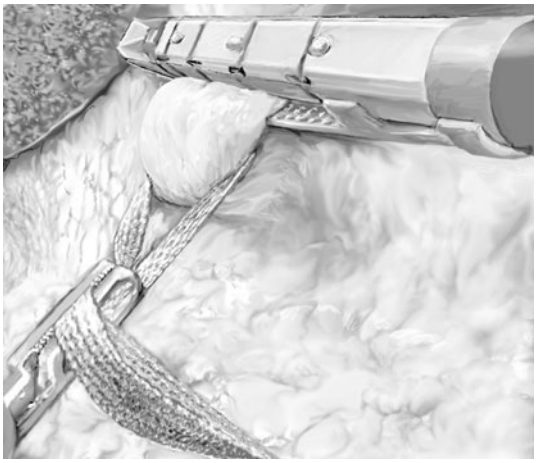


Fig. 58.7

Step 5

Control and ligation of outflow vessels

Parenchymal transaction is continued until the junction of the middle and left hepatic veins is encountered. The left vein is then dissected with care taken to protect the junction of the left and middle vein (Fig. 58.8a). Once the decision whether to save or not to save the middle vein is made, the hepatic vein(s) to be ligated are stapled or suture ligated (Fig. 58.8b).

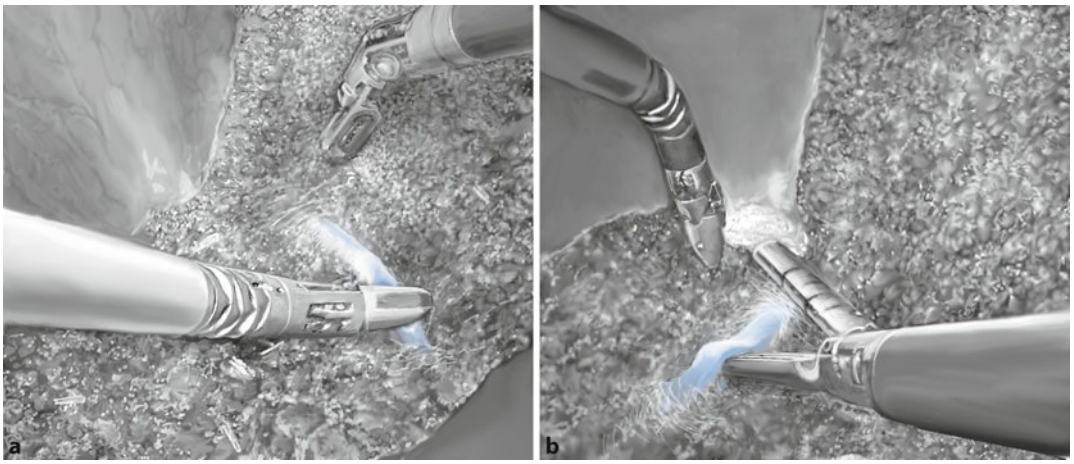


Fig. 58.8

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Step 6

Division of triangular and falciform ligaments

In general, as much of the triangular and falciform ligaments as can be left intact are left for division at the end of the resection (Fig. 58.9). This is because these ligaments can be used for countertraction during the surgery and allow the most atraumatic way of holding the liver for the surgery.

At the conclusion of the resection, the ligaments are divided. The tumor is then placed into a specimen retrieval bag and extracted.



Fig. 58.9

Standard Postoperative Investigations

- Complete blood count
- Phosphorous level
- Coagulation panel

Postoperative Complications

- Bleeding
- Pulmonary insufficiency from effusion or pneumothorax
- Liver failure
- Injury from positioning

Tricks of the Senior Surgeon

- Leave as many of the ligamentous attachments of the liver as possible until the end of the case.
- Convert early in case of bleeding or loss of orientation.
- Have sutures and stapler ready in case of bleeding to attempt repair.
- Most cases do not require application of the Pringle maneuver, but a laparoscopic bulldog clamp or a Rumel tourniquet can be used if necessary.
- A gel port can be placed if a large specimen extraction port is anticipated to be needed.
- Two or more ports can be placed in the gel port for use as robotic or assistant ports.
- Transcutaneous sutures can be used to suspend the liver for exposure.
- Most small bleeding vessels can be sutured or sealed with the vessel sealer.

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Technique of Multi-Organ Procurement (Liver, Pancreas, and Intestine)

Jan Lerut, Michel Mourad, Tom Darius

The growing success of liver transplantation led to the development of a flexible procedure for multiple cadaveric organ procurement as introduced by Starzl in 1984. The subsequent development of pancreas, multivisceral, and intestinal transplantation has required modification and improvement of the initially described technique. Different procedures, varying from isolated procurement of the different abdominal organs to total abdominal evisceration, were described during the 1990s.

Donation after circulatory death (DCD) became reactualized during the beginning of the 21st century as a means to increase the number of donor organs. (It should be noted that the term "Non-Heart-Beating Donation [NHBD]" has been abandoned recently.) In these donors, the diagnosis of death is based on the cessation of the heartbeat and/or blood circulation. According to the Maastricht classification, proposed in 1995 by Kootstra, four DCD categories exist: Category I means dead on arrival in hospital; category II, cardiac arrest after unsuccessful resuscitation; category III, cardiac arrest after withdrawal of organ support; and category IV, cardiac arrest occurring in a brain-death donor. DCD donation is restricted mostly to Maastricht category 3 and 4 donors.

Because surgical approaches in donation after cardiac death (DCD) differ somewhat from approaches in donation after brain death (DBD), both methods of organ procurement are described separately. The different clinical settings of uncontrolled DCD (Maastricht category 1 and 2) and controlled DCD (Maastricht category 3 and 4) also need some more specific procedural information.

It is important to note that in DCD donors, the first warm ischemia time, defined as the time from "switch off" to the start of the cold perfusion, must be kept as short as possible (preferably less than 30 min), to minimize ischemia reperfusion injury of the procured organs.

The aim of every multiple-organ cadaveric procurement should be the maximal use of organs, the minimal dissection of their cardinal structures, and an adequate repartition of their vascular axes. A technique combining minimal in situ dissection, rapidity, safe repartition of organs, and easy acquisition of technical skills should become standard in today's organ transplantation practice.

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Surgical Technique of Donation After Brain Death (DBD)

En bloc pancreas-liver procurement

Step 1

Access to the abdominal vessels

A midline xyphopubic incision is performed. After exploration of the abdominal organs for previously undiagnosed pathologies, the white line of Toldt is incised, the right colon is mobilized to the left, the duodenum and bowel are extensively kocherized, and the peritoneal root of the mesentery is divided from the right iliac fossa to the ligament of Treitz (Fig. 59.1).

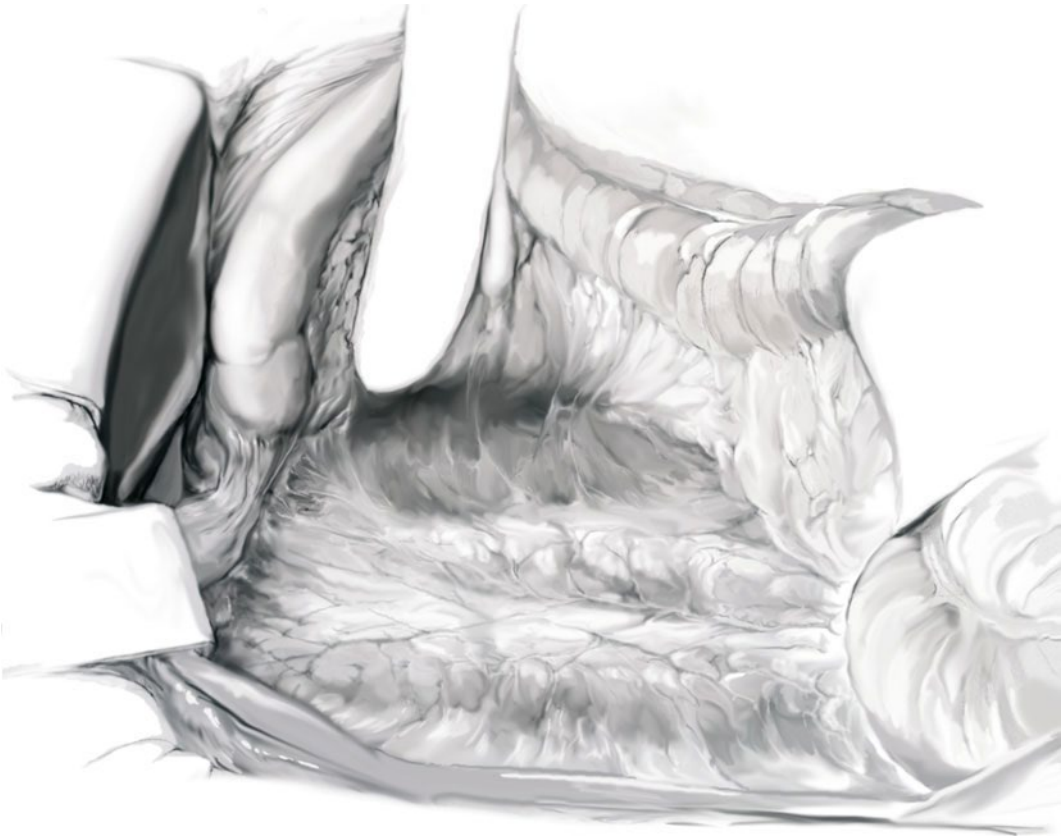


Fig. 59.1

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Step 2

Preparation of the major abdominal vessels

The distal abdominal aorta and the inferior vena cava (IVC) are freed from their bifurcation to the level of the left renal vein. Slight traction on the distal duodenum by the assistant allows the procurement surgeon to identify the superior mesenteric artery, located just above the left renal vein. The periarterial solar plexus is incised longitudinally on its left side in order to visualize the first 2 to 3 cm of the superior mesenteric artery. This maneuver allows aberrant liver vascularization to be individualized (*e.g.*, a right hepatic artery originating from the superior mesenteric artery) (Fig. 59.2a).

Next, the hepatoduodenal and hepatogastric ligaments are inspected for anatomic variants (*e.g.*, a left hepatic artery originating from the left gastric artery). The supraceliac part of the aorta is prepared for later occlusion by encircling it at the supradiaphragmatic or infradiaphragmatic level by means of a vessel loop (Fig. 59.2b).

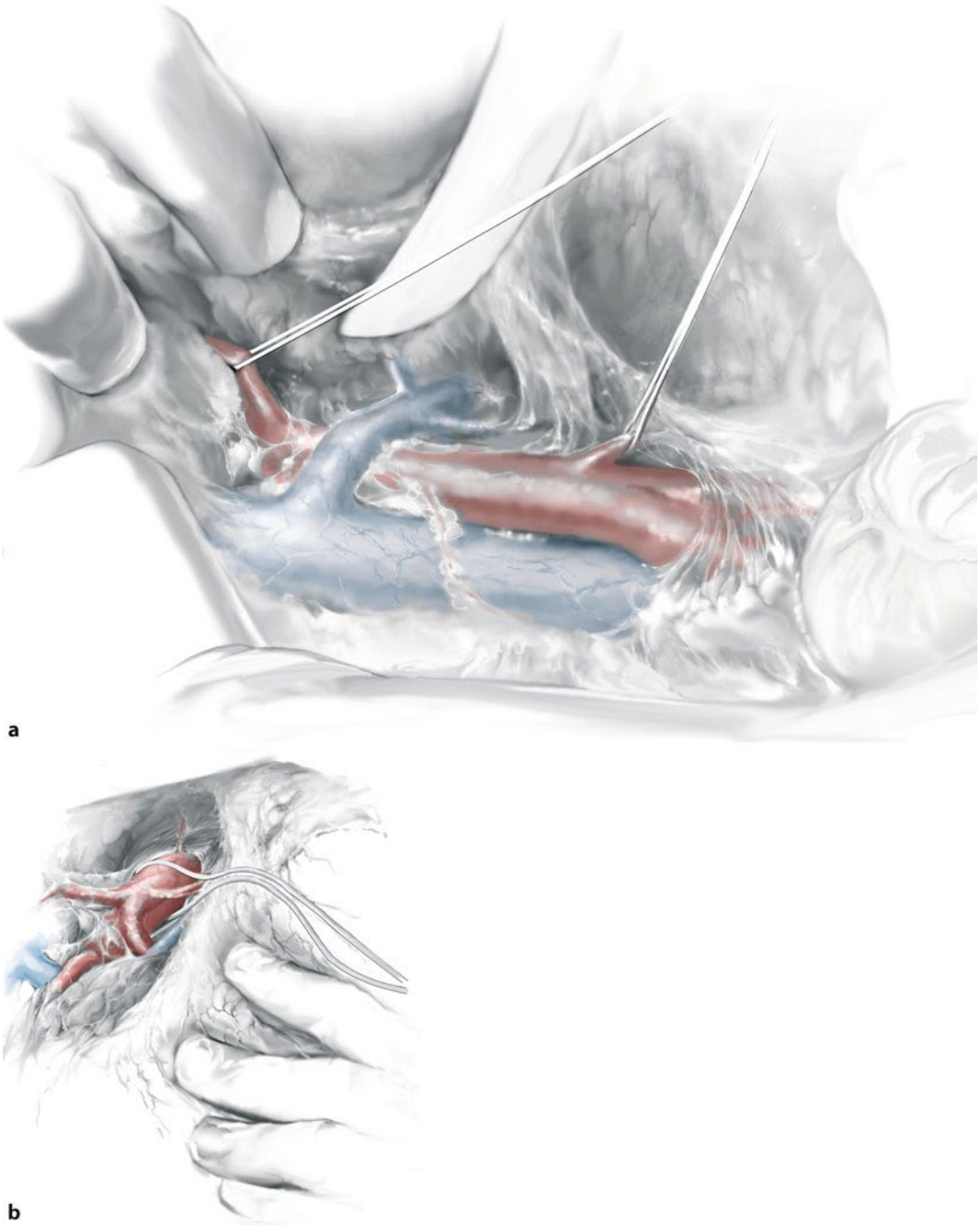


Fig. 59.2

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Step 3

Access to the pancreas

The stomach is gently separated from the transverse colon by dividing the gastrocolic ligament. This allows the whole pancreas to be visualized. The splenic artery can be encircled and marked close to its origin from the celiac trunk; this mark can be helpful during later ex-situ division of the pancreas-liver bloc (Fig. 59.3).

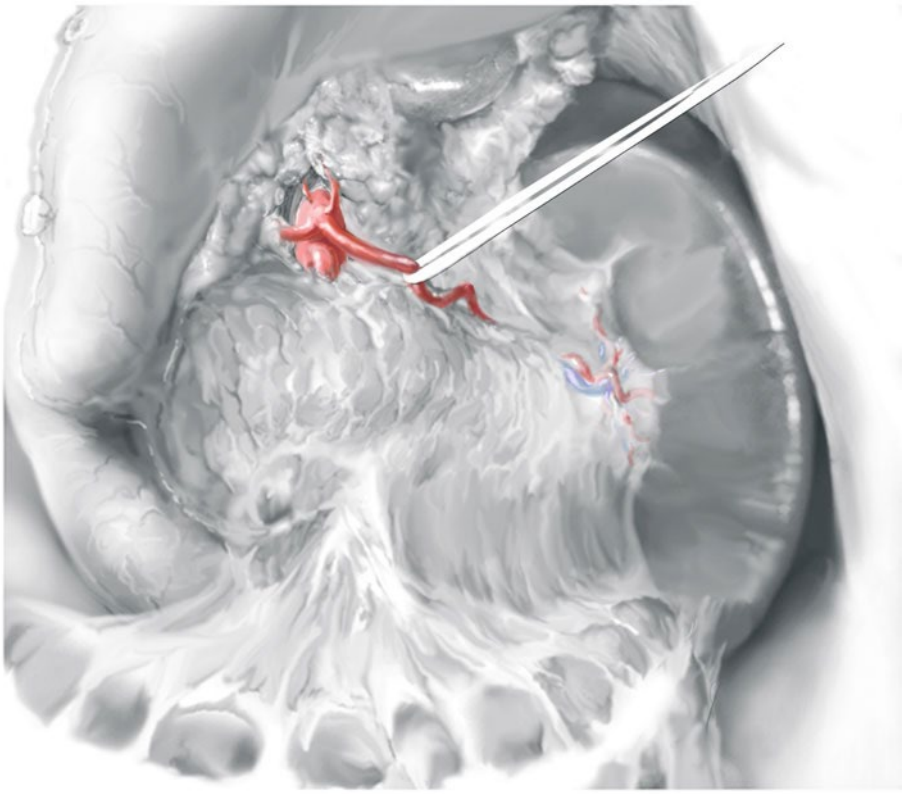


Fig. 59.3

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Step 4

Preparation and perfusion of the abdominal organs

The gallbladder fundus is opened with the electric cautery, and the gallbladder and bile ducts are flushed out with saline. Manual compression of the distal bile duct allows a better proximal duct cleansing, which should be completed through a small catheter once the bile duct is transected (Fig. 59.4a).

When the thoracic team is ready for procurement, heparin is given (500 units/kg body weight) and the aortic canula is inserted right above the aortic bifurcation. If the thoracic team prefers to clamp the suprahepatic IVC during the procurement, the IVC can be cannulated at the same level as the aorta in order to obtain better decompression and clean exsanguination. For both the aorta and the IVC, chest drains can be used (Fig. 59.4b). The portal vein does not need to be perfused in situ, but only during the back-table preparation.

The supraceliac aorta is clamped or ligated at the beginning of aortic perfusion with the preservation solution (*e.g.*, 60 mL/kg body weight of UW solution) and the intravascular cooling of the abdominal organs is completed by abundant topical irrigation using cold saline.

The bile duct is transected just above the duodenal arch and needs to be rinsed once more with saline through a small catheter.

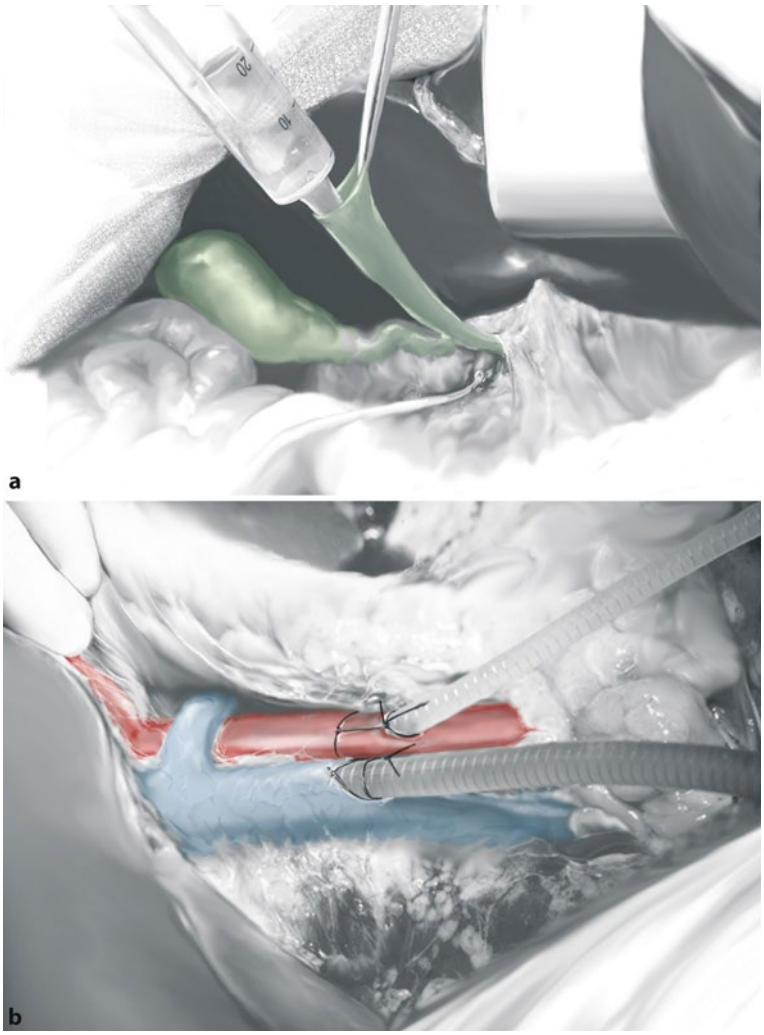


Fig. 59.4

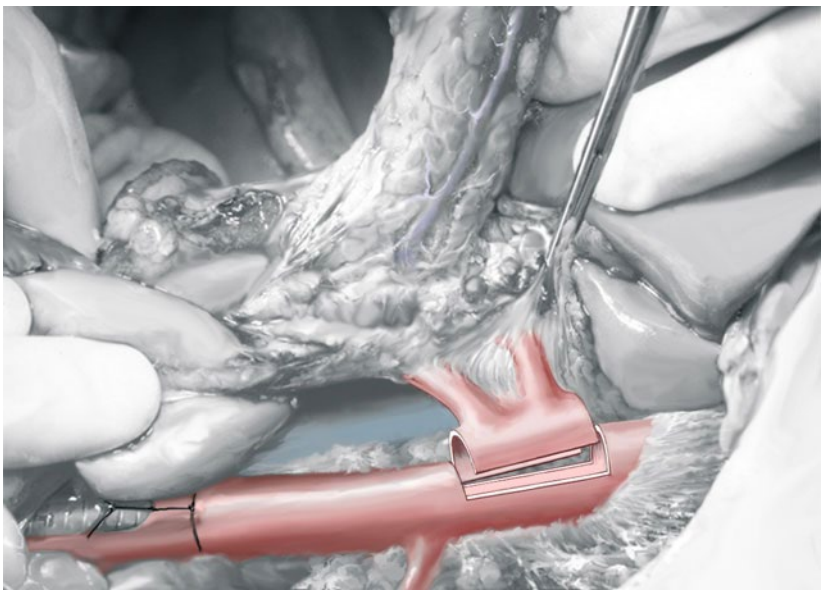
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Step 5

Preparation and procurement of the arterial axis

Once the abdominal organs are discolored and the thoracic procurement is completed, the en bloc liver-pancreas procurement can start. The dissection of the superior mesenteric artery trunk is completed at the anterior side of the abdominal aorta. Retroperitoneal tissue and solar plexus located between the IVC and aorta are transected from the left renal vein towards Winslow's foramen in order to fully expose the right side of the aorta and the superior mesenteric artery. Next, the anterior side of the aorta is incised just distal to the origin of the superior mesenteric artery. After visualization of the orifices of the renal arteries, an arterial aortic Carrel patch encompassing the origin of both the superior mesenteric artery and the celiac trunk is created. The simultaneous excision of the vascular roots of the tissue bloc is an important step of the en bloc liver-pancreas procurement.

Afterwards, the colon and intestine are repositioned in the abdomen. All branches of the left gastric artery are transected closed to the stomach, allowing the preservation of a possible left hepatic artery originating from the left gastric artery (◘ Fig. 59.5).



◘ Fig. 59.5

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Step 6

Preparation of the duodenum and the pancreas

After instillation of a betadine solution through a gastric tube, the duodenum and the jejunum are stapled distal to the pylorus and the ligament of Treitz, respectively. The mesenteric root is transected distal to the pancreas using the GIA stapling device. The splenocolic ligament is taken down and the spleen and the pancreas are freed retroperitoneally. Finally, the IVC is transected at the level of the right adrenal gland, the liver is mobilized by transection of the falciform ligament, and the liver-pancreas bloc is removed, containing a large diaphragmatic patch (Fig. 59.6).

The ex vivo separation of liver and pancreas is done on the back table after identification of the vascular anatomy. (See back-table work.)

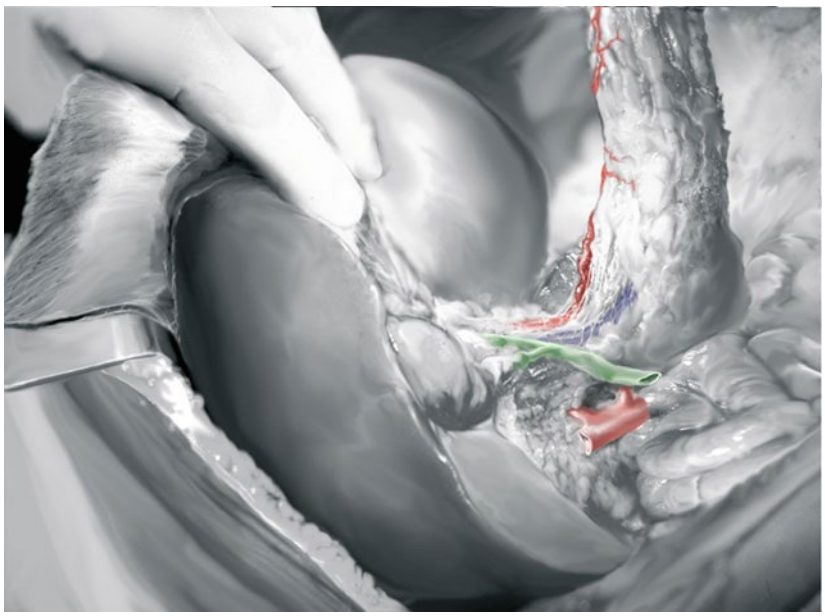


Fig. 59.6

Modifications of en bloc liver-pancreas procurement

Pancreas removal for islet transplantation

For islet procurement, the pancreas is removed together with the liver, and the duodenum is simply removed from the pancreatic head.

Procurement of intestine for transplantation

After initial preparation of the superior mesenteric artery and the celiac trunk, the intestine is repositioned adequately in the abdominal cavity. The first jejunal loop is transected about 10 cm distal to the ligament of Treitz using a GIA stapler (Fig. 59.7). The transected jejunal loop is pulled up by the assistant in order to better individualize the mesenteric root. A second assistant maintains the intestine in place to avoid traction on the superior and inferior mesenteric veins, as malpositioning causes reduced splanchnic perfusion.

Several small branches of the jejunal mesentery are transected close to the serosa (as is usually done in a duodenopancreatectomy). The proximal part of the mesenteric vessels are freed for about 2 cm, so the small pancreatic veins joining the right part of the superior mesenteric vein (SMV) are ligated, as well as those branches of the SMV draining the pancreatic isthmus. Once the SMV is freed, the abdominal organ perfusion can be started.

As soon as the perfusion is completed, the liver-pancreas-small bowel bloc can be retrieved. In case of an isolated intestinal transplant, it can be necessary to extend the superior mesenteric vein and artery using free iliac venous and arterial grafts.

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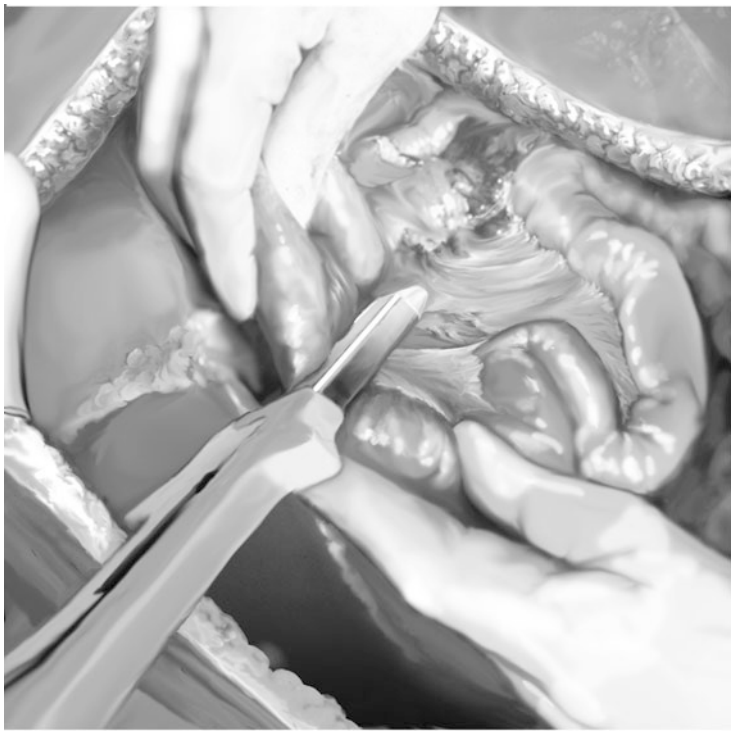


Fig. 59.7

Surgical Technique of Donation After Circulatory Death (DCD)

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Step-by-step procedure for controlled (Maastricht categories 3 and 4) DCD donors

With the agreement of the physician responsible for management of the donor, 20,000 IU of heparin are given before switch-off in order to optimize the procurement conditions. The operation field is prepared before the start of the therapy switch-off. After confirmation of circulatory death by three physicians who are independent from the procurement team, the donor surgical team enters the operation room. A 5-min "no touch" period is respected before the skin incision is done.

After a fast sterno-laparotomy, the distal abdominal aorta is cannulated just above the level of the aorto-iliac bifurcation. To avoid venous congestion of the liver, the aortic perfusion is started immediately after a right atriotomy is done and after clamping of the aorta just beneath or above the diaphragm. Abundant topical irrigation using cold saline and sludged ice is started simultaneously. If the liver is suitable for transplantation, the inferior mesenteric vein is cannulated and simultaneous portal and aortic perfusion is started. The aortic perfusion is done under pressure, using 1 L of normothermic Hartmann's solution, containing 1,500,000 IE streptokinase, followed by cold perfusion of 5 L of histidine-tryptophan-ketoglutarate solution (Custodiol HTK) and 2 L of UW solution. Portal perfusion consists of 3 L of UW solution. During organ perfusion, incision of the gallbladder fundus and of the common bile duct just above the duodenal arch is done in order to allow abundant flushing of the biliary tract with saline.

The liver-pancreas bloc is removed as described in the section on donation after brain death. The left colon and sigmoid are mobilized to facilitate en bloc procurement of the kidneys. Both organ blocks will be separated on the back table.

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Step-by-step procedure for uncontrolled (Maastricht categories 1 and 2) DCD donors

The procedure usually starts in the emergency department following unsuccessful resuscitation. Heparin is administered intravenously or intracardiac in order to optimize the quality of organ procurement.

A vertical inguinal incision is made over the axis of the femoral vessels, followed by isolation of the femoral vein and artery. Ligation of the saphenous venous cross is not necessary.

A double-balloon triple-lumen (DBTL) catheter is introduced via the femoral artery. First, the abdominal balloon is filled with 10 cc of saline solution (eventually mixed with contrast product). Gentle downwards traction on the catheter will allow positioning of the abdominal balloon just above the level of the aorto-iliac bifurcation. Second, the proximal thoracic balloon is filled with 15 mL saline (eventually mixed with contrast medium). The femoral vein is cannulated to allow venous outflow. Thereafter, cold perfusion of the abdominal organs using Custodiol/HTK or IGL1 solution is most commonly done via the DBTL catheter. The correct position of the catheter can eventually be controlled radioscopically.

After informed consent of the family, the patient should be transferred to the operating theater. Both kidneys are procured as described for controlled DCD donors. The cold perfusion via the DBTL catheter is continued until bilateral nephrectomy is done.

Procurement of Arterial and Venous Vessel Grafts

The use of free vessel grafts becomes more and more important in the fields of liver transplantation as well as oncology. Extensive venous splanchnic thrombosis, damage to the arterial tree from local or regional oncologic treatments, and living-donor and domino liver transplantation are all conditions in which the availability of vessel grafts can be life-saving. The use of these vessels, especially the larger caval and aortic grafts, can also be very useful in the armamentarium of the oncologic surgeon, especially when dealing with invasive retroperitoneal or renal tumors.

Every organ harvesting should therefore include the removal of the carotid arteries, jugular veins, and pulmonary veins (in the absence of lung procurement); the aorta-iliac and cavo-iliac bifurcation should be taken from the level beneath the renal veins and arteries up to the inguinal ligaments. This procurement does not require supplementary skin incisions. One should be aware that the diameter of the iliac vessels at the level of the inguinal ligament is exactly the same as the diameter of the celiac trunk of the liver allograft. The procured vessels can be safely kept in a preservation solution mixed with antibiotics up to14 days, or they can be cryopreserved for later use.

Back-Table Work

As biliary problems of the ischemic type account for 15 to 20 % of all surgical complications in liver transplantation, standardization of bile duct handling should be adhered to. First, the gallbladder and bile ducts must be flushed again at the back table to avoid mucosal necrosis from precipitating cold bile salts. Ex vivo arterial flush under pressure is advocated in order to adequately rinse the peribiliary arterial plexus. A cone-shaped cannula should be prudently introduced in the celiac trunk and/or the superior mesenteric artery in order to avoid endothelial wall damage. Some studies indicate that high-pressure back-table flushing of the artery has some advantages. Next, ex vivo portal flushing is done through a cannula introduced in the SMV. The tip of the portal-vein catheter is positioned with slight finger compression.

The liver-pancreas bloc is positioned as in the abdominal cavity; the aorta patch, containing the celiac trunk and the superior mesenteric artery, is dissected free. The splenic, celiac, hepatic, and left gastric arteries should all be individualized; one should look as well for the right and left hepatic arteries. The bile duct, the portal vein, and the splenomesenteric venous confluence

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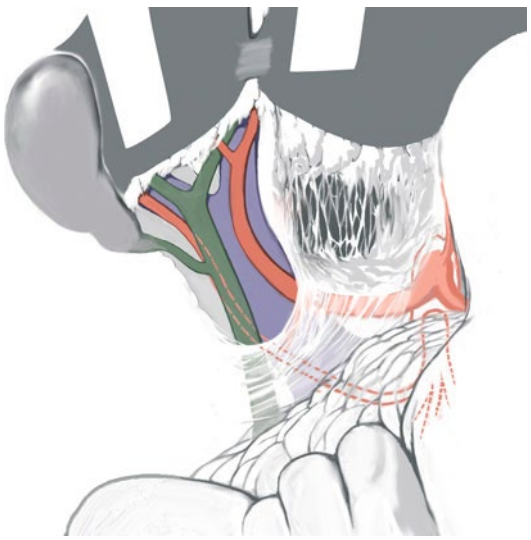
also need to be dissected. The final repartition of all vascular axes is dictated by their anatomical variability:

In the presence of *standard arterial anatomy*, the celiac trunk should be kept with the whole pancreas transplant. By doing so, a reconstruction with a Y-graft can be avoided, as the superior mesenteric artery can be directly connected to the ostium of the common hepatic artery. (For an illustration, see ▶ Chap. 60, "Orthotopic Liver Transplantation.") The repartition of the venous vessels is seldom problematic if the recipient portal vein is transected close to the liver parenchyma.

If the liver-pancreas bloc contains a *left hepatic artery originating from the left gastric artery*, the celiac trunk should go to the liver graft. In this case, a vascular reconstruction between splenic artery and superior mesenteric artery is necessary, using a free iliac arterial graft. (See ▶ Chap. 96, "Pancreas Transplantation.")

In the presence of an *aberrant right hepatic artery with a complete extrapancreatic course*, one can decide to divide the superior mesenteric artery between the head of the pancreas and the origin of the aberrant right hepatic artery (see ◘ Fig. 59.8). This allows for three different types of reconstruction, as illustrated in ▶ Chap. 60, "Orthotopic Liver Transplantation":

- Anastomosing the stump of the superior mesenteric artery on the ostium of the splenic artery
- Anastomosing the celiac trunk or the common hepatic artery on the proximal ostium of the superior mesenteric artery
- Anastomosing the aberrant right hepatic artery to the gastroduodenal artery



◘ Fig. 59.8

Division of an *intrapancreatic right hepatic artery* should be performed only after discussion with the pancreas and liver teams. If this artery is transected proximal to the pancreatic head, it must be possible for the liver surgeon to implant the artery into the ostium of the gastroduodenal or splenic artery. Both recipient teams must finally decide whether the technical difficulties will allow both organs to be implanted.

The only anatomical absolute contraindication to simultaneous transplantation of the whole pancreas and liver is the presence of an important pancreaticoduodenal artery originating from an aberrant right hepatic artery. In this case, vascularization of the pancreatic head can be compromised, as the gastroduodenal artery and thus the superior pancreaticoduodenal artery are kept to retain the common hepatic artery for the liver allograft.

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Tricks of the Senior Surgeon

- The correct procurement of the iliac, superior mesenteric, carotid, and jugular vessels is crucial, as complex vascular reconstructions may be required during the implantation. Therefore, the whole iliac axis down to the inguinal ligament must be taken.
- The bile duct should be routinely rinsed by means of a small feeding tube through the cut end, as remaining bile salts precipitate and may damage the biliary epithelium. Flushing the biliary tree through the gallbladder cleans only the distal bile duct and thus is not enough!
- Correct back-table bath temperature must be guaranteed. Warming up of the solution and direct contact with the ice can both be harmful and can easily be avoided by separating the allograft from the crushed ice through a cold saline buffer.

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Orthotopic Liver Transplantation

Jan Lerut, Robert J. Porte, Philipp Dutkowski

Since its introduction into clinical practice in 1963 by Starzl *et al.*, the technique of orthotopic liver transplantation has been refined progressively. The original technique included resection of the recipient inferior vena cava (IVC) and the use of extracorporeal venovenous bypass. More confidence with the technique and the more frequent use of technical variants in pediatric liver transplantation have led to the development of hepatectomy techniques that preserve the recipient cava, without the use of venovenous bypass and with or without the use of a temporary portocaval shunt, independently of the anatomical and general status of the recipient. Regardless of the exact technique, orthotopic liver transplantation is characterized by three stages: preanhepatic, anhepatic, and post-anhepatic. The technique of orthotopic liver transplantation, either with or without preservation of the recipient IVC, is described in this chapter, using these three stages.

Indications and Contraindications

Indications

- **Chronic liver failure (cirrhosis) due to:**
  - Chronic hepatitis B, BD co-infection, and C
  - Alcoholic liver disease
  - Non-alcoholic fatty liver disease
  - Cryptogenic cirrhosis
  - Autoimmune diseases
  - Primary and secondary biliary cirrhosis
  - Primary and secondary sclerosing cholangitis
  - Autoimmune hepatitis/cirrhosis
  - Extrahepatic biliary atresia
  - Congenital liver fibrosis
  - Metabolic liver diseases (see below)

- **Acute liver failure due to:**
  - Viral (hepatitis A, B, D [coinfection], E)
  - Intoxications (*e.g.*, acetaminophen, *NSAID*, a*manita phalloides*)
  - Extensive liver trauma
  - Liver resection
  - Pregnancy
  - Budd-Chiari syndrome
  - Acutely decompensated chronic liver disease ("acute on chronic")

- **Metabolic disorders**
  - Cirrhogenic disorder
    - Wilson's disease
    - Alpha1-antitrypsin deficiency
    - Hemochromatosis
    - Cystic fibrosis
    - Tyrosinemia
    - Alagille and Byler syndrome

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- Non-cirrhogenic disorder
  - Familial amyloid polyneuropathy (FAP)
  - Primary hyperoxaluria
  - Glycogen storage diseases
  - Protoporphyria
  - Hypercholesterolemia
  - Hemophilia (usually in context of viral cirrhosis)
  - Hemostatic disorders (protein C and S, Factor V, VIII deficiencies)

- **Vascular diseases**
- Hemorrhagic hereditary telangiectasia (Rendu-Osler-Weber disease)
- Epithelioid hemangioendothelioma
- Budd-Chiari syndrome
- Veno-occlusive disease

- **Liver tumors**
- Primary malignant
  - Hepatocellular carcinoma
    - Milan criteria IN: single tumors < 5 cm, or up to three tumors < 3 cm
    - Milan criteria OUT or extended criteria (center-dependent)
  - Hilar cholangiocarcinoma (respecting Mayo protocol)
  - Hepatoblastoma
- Secondary malignant
  - Metastases of neuroendocrine tumors
  - Metastases of colorectal metastases (Oslo Seca-protocol)
- Benign
- Polycystic liver disease
- Echinococcosis (alveolar and granular)
- Biliary cystic disease (Caroli's disease/syndrome)
- Adenomatosis
- Giant hemangioma

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Contraindications

- Systemic infections or sepsis
- Extrahepatic malignant disease
- Irreversible multiorgan failure

Preoperative Investigation and Preparation for the Procedure

- History and physical examination
- *Laboratory tests:* Liver tests, coagulation studies, kidney function, electrolytes, hepatitis and HIV serology
- *Doppler ultrasound:* Check for patency and flow of liver vessels (portal vein, hepatic artery, and hepatic veins)
- *CT scan or MRI:* Check for tumors, vascular collaterals, aneurysms of the splenic artery, or splanchnic thrombosis
- *MRC or ERC:* May be indicated in primary sclerosing cholangitis
- *Angiography:* In case of portal vein thrombosis, planned retransplantation, or transarterial chemoembolization (TACE) in patients with hepatocellular carcinoma
- *Classification:* According to the Child-Pugh-Turcotte (CTP) criteria (bilirubin, albumin, prothrombin time/INR, ascites, encephalopathy) and/or according to the Model for End-Stage Liver Disease (MELD) score (serum creatinine, bilirubin, INR)
- *Histologic examination:* Graft biopsy in case of suspected steatosis or hepatopathy of the allograft

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Procedures

The pre-anhepatic stage

Step 1

Access, exposure, exploration, and dissection of the hepatoduodenal ligament

After a J-shaped or bi-subcostal incision, the round and falciform ligaments are divided. Care must be taken to avoid injury of large collaterals or a recanalized umbilical vein, which may be present in the umbilical ligament due to portal hypertension. A retractor (*eg*, Thompson) is installed, followed by a careful mobilization of the left. Afterwards, the hepatogastric ligament is transected by cautery or after stepwise suture ligation. A possible aberrant or accessory left hepatic artery needs to be identified and ligated. All these steps must be performed with a particularly careful technique, as portal hypertension and subsequent dilatation of the vascular bed leads to more fragile vessels, which are prone to bleeding.

Next, the hepatoduodenal ligament must be palpated and checked for aberrant arterial anatomy – that is, an aberrant or accessory right hepatic artery from the superior mesenteric artery, running behind the common bile duct. The peritoneum is opened near the liver on the ventral aspect of the ligament and the proper hepatic artery is identified. Dissect the proper hepatic artery towards the liver. Ligate and divide the left and right hepatic artery distal from the bifurcation (Fig. 60.1a). Encircle the common bile duct as high as possible above the level of the cystic duct in the porta hepatis, preserving an adequate amount of tissue surrounding it to avoid devascularization. Again, check for a possible aberrant right hepatic artery. Divide the common bile duct and ligate and divide the aberrant right hepatic artery, if present (Fig. 60.1b). Dissect the portal vein completely free from its surroundings along the length of the hepatoduodenal ligament. After complete dissection of the hepatoduodenal ligament, the right hemiliver is mobilized by division of the right triangular ligament. In patients with liver cirrhosis, this step can lead to blood loss because of multiple small vessels to the diaphragm.

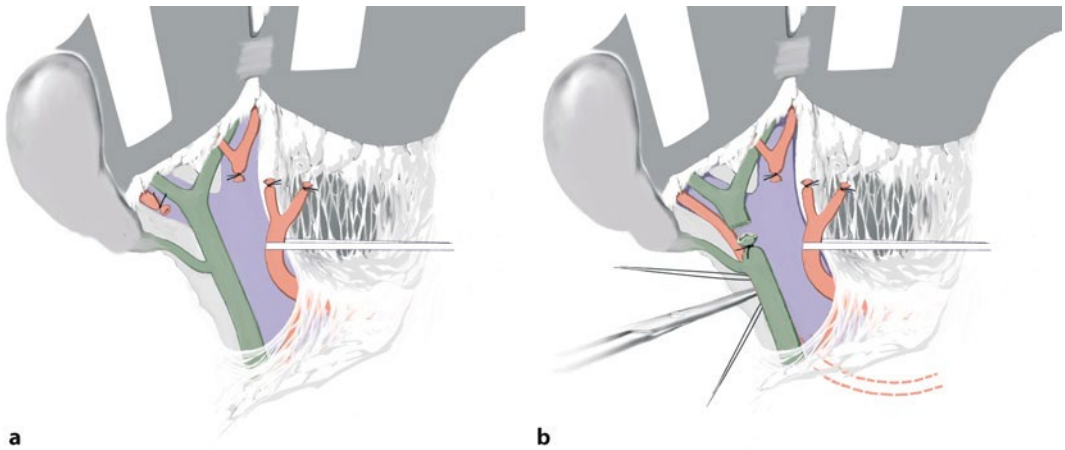


Fig. 60.1

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Step 2

Mobilization of the infrahepatic inferior vena cava

At this stage of the operation, the planes of dissection are different for the classic technique (with resection of the IVC) and the cava-sparing technique. The cava-sparing technique is more demanding but has the advantage of avoiding interruption of the caval venous return and of a shorter warm ischemia time during implantation, because only one IVC anastomosis must be performed, instead of two. The two techniques are described separately.

The Classic Technique with Resection of the IVC: The liver is turned to the left and the infrahepatic IVC is exposed and eventually encircled by an umbilical tape. The right adrenal vein is identified and ligated between ties. The IVC is then mobilized by opening the peritoneal reflection along the left side of the cava with cautery. The same technique is applied on the right side of the cava up to the right hepatic vein (Fig. 60.2).

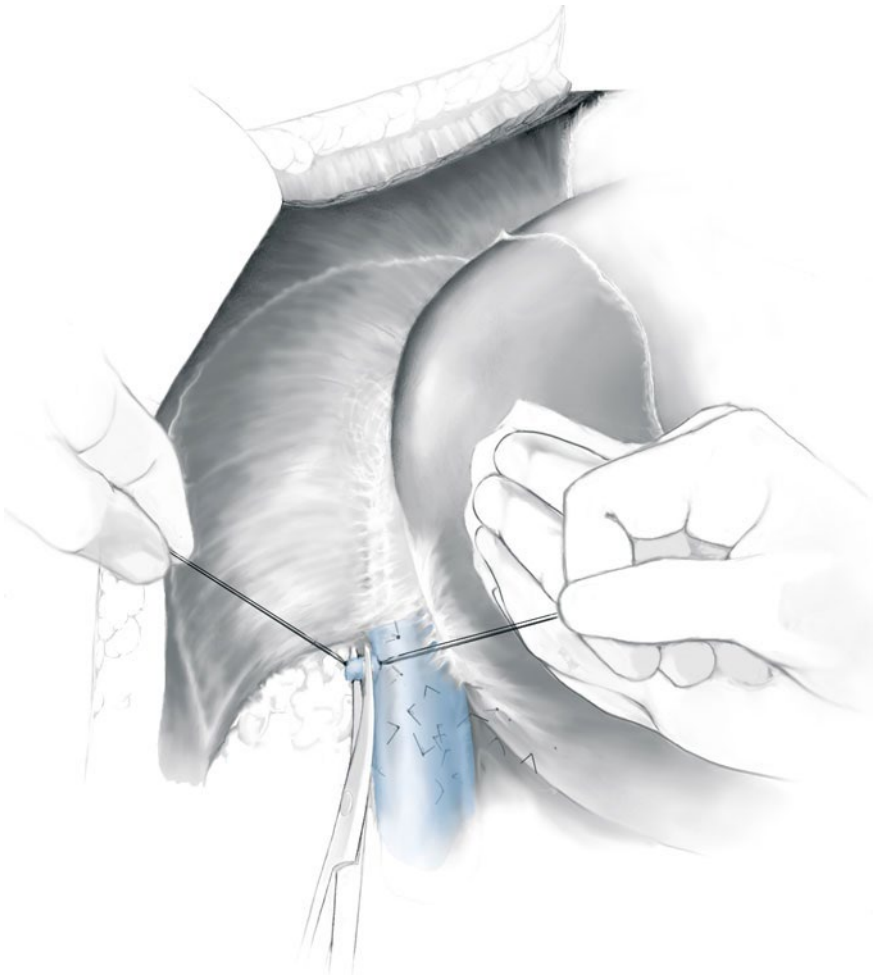


Fig. 60.2

The Cava-Sparing Technique: For this technique, the right liver is rotated towards the left upper quadrant in order to expose adequately the right and anterior sides of the retrohepatic IVC. The tissue between the retrohepatic IVC and the posterior surface of the liver is divided. All smaller and larger Spigelian veins draining the caudate lobe and the right accessory veins, when present, are selectively ligated and divided from below upwards. In this way, the hepatic veins are approached. The right hepatic vein is encircled and transected using a vascular endostapler. Precise stapler application close to the liver parenchyma permits safe and tight transsection of the right hepatic vein without narrowing the retrohepatic IVC. The transsection of the right hepatic vein

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Step 2 ***(continued)***

allows the retrohepatic IVC to be turned away from to a further extent and makes the safe isolation of the middle and left hepatic veins much easier. The cuff of left and middle hepatic veins is transected or clamped depending on the implantation method.

Some surgeons construct a temporary end-to-side portal-caval shunt (*not shown*) to reduce splanchnic pressure and bleeding and to facilitate mobilization of the liver.

In the case of retransplantation following a previous classic liver transplant with IVC replacement, the previous allograft's IVC may be preserved. In case of a piggy-back implantation, the plane between the parenchyma and the previous donor IVC will have remained intact. In case of latero-lateral implantation technique, the IVC will be clamped beneath the previous anastomosis. In retransplantation after previous cava-sparing transplantation, the graft can be removed without interfering with IVC flow (Fig. 60.3).

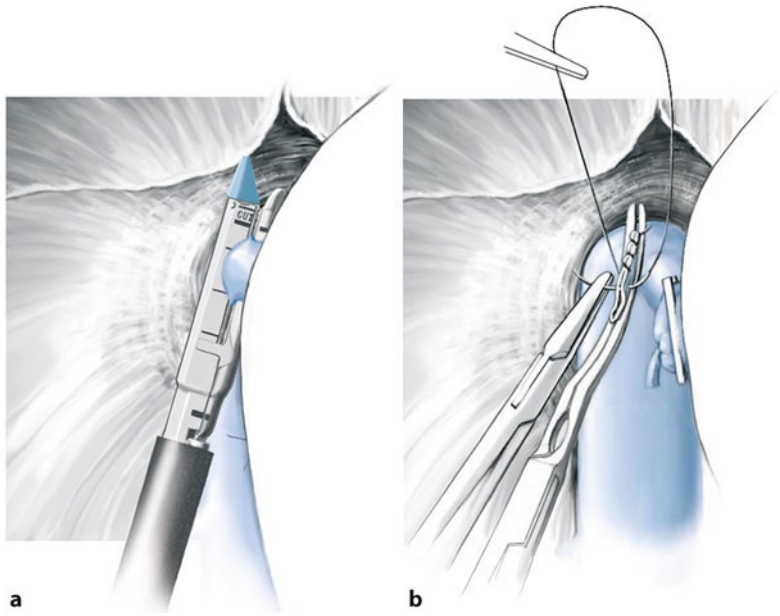


Fig. 60.3

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The anhepatic stage

Step 3

Removal of the native liver

Before completion of the recipient hepatectomy, hemostasis of the retroperitoneal bare area is performed using an argon beam coagulator. The bare areas are not routinely oversewn, in order to maximize the space available for the allograft.

The Classic Technique with Resection of the IVC: Ligate and divide the portal vein as high up into the hilum as possible (Fig. 60.4a). Place vascular clamps on the infrahepatic and suprahepatic IVC and transsect it (Fig. 60.4b).

The Cava-Sparing Technique: After clamping and division of the portal vein high up in the liver hilum, the middle and left hepatic veins are clamped and transsected, usually using also a stapling device or clamp (depending on the later implantation method), and the native liver is removed.

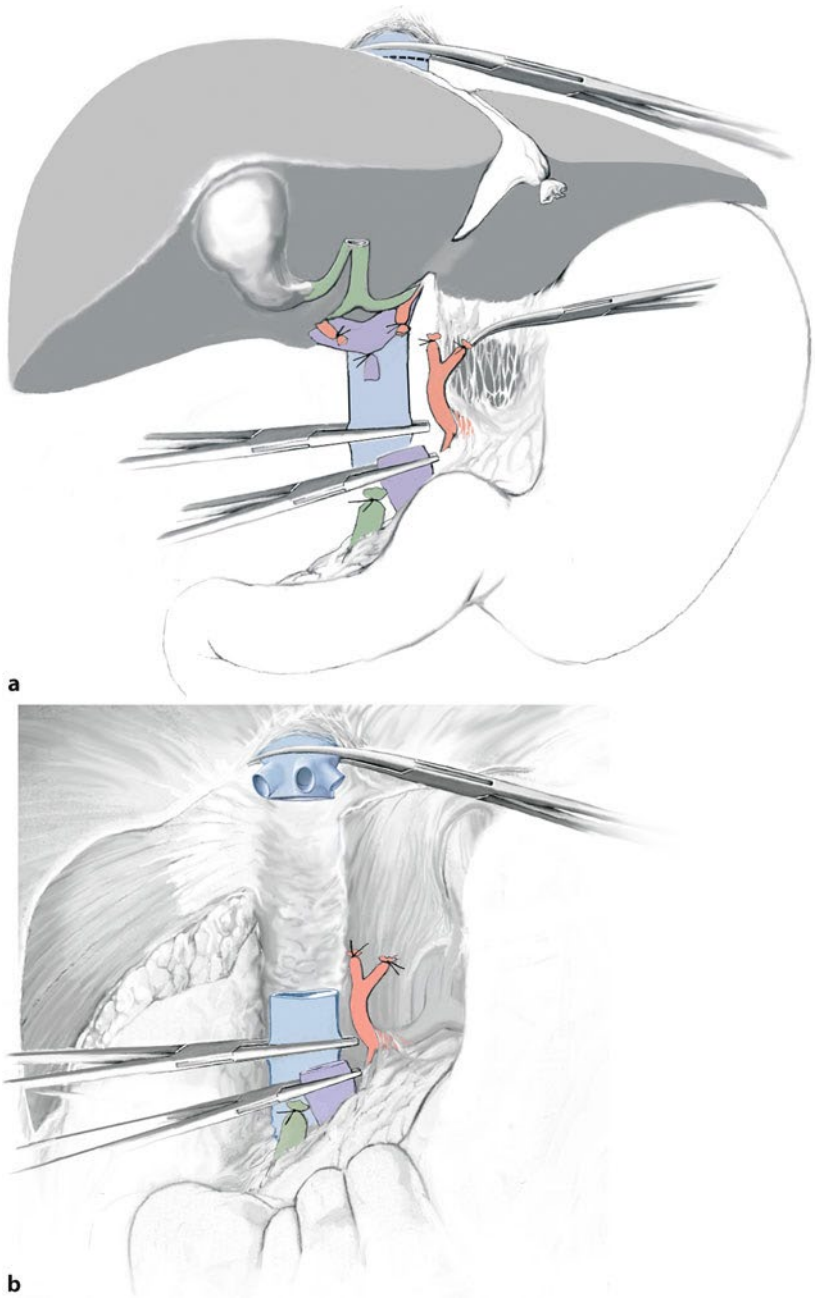


Fig. 60.4

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Step 4

Anastomosis of the IVC

The Classic Technique with Resection of the IVC: The suprahepatic vena cava of the recipient is sutured to the suprahepatic cava of the donor liver in an end-to-end fashion, using running polypropylene 4-0. During each step, the vessel wall is everted to obtain nice endothelium-to-endothelium apposition.

An identical procedure is performed for the infrahepatic vena cava. A sterile suction catheter can be positioned in the retrohepatic cava transanastomotically for venting upon. Do not tie the infrahepatic anastomosis yet (Fig. 60.5).

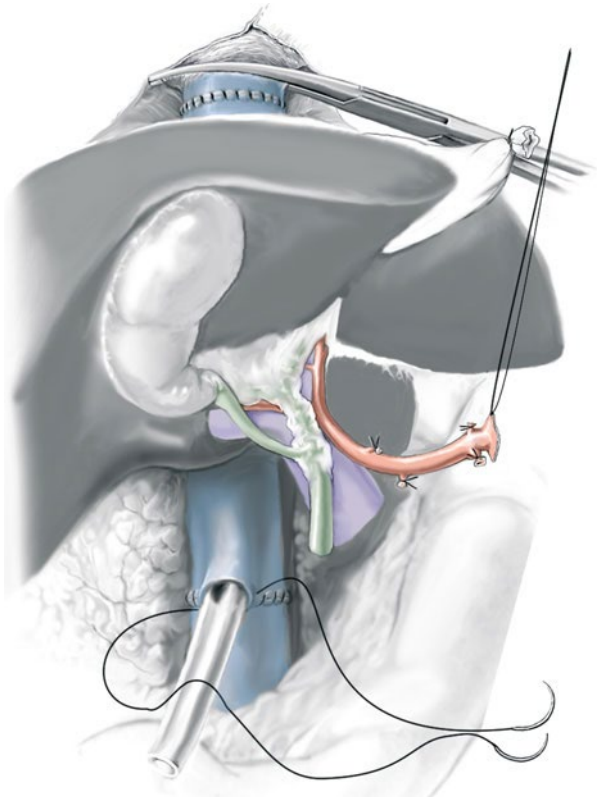


Fig. 60.5

The Cava-Sparing Technique: The retrohepatic IVC of the allograft needs careful preparation on the back table. The upper cava cuff is shortened up to the hepatic veins. The lower cava cuff of the allograft is shortened up to the level of the first major vein draining segment 1 and subsequently is oversewn with a running polypropylene 5-0 suture. A suctioning catheter can be positioned through this suture to facilitate flushing of the liver upon reperfusion (see below).

From this point on, three different methods can be used to anastomose the donor and recipient IVC:

- *End-to-end anastomosis.* The ostia of the three hepatic veins are interconnected to create a wide opening for the suprahepatic caval anastomosis (Fig. 60.6) and an end-to-end anastomosis is performed with the suprahepatic IVC of the donor liver (Fig. 60.7). This technique is becoming less popular because of the risk of (partial) venous outflow obstruction due to kinking of this relatively narrow anastomosis.

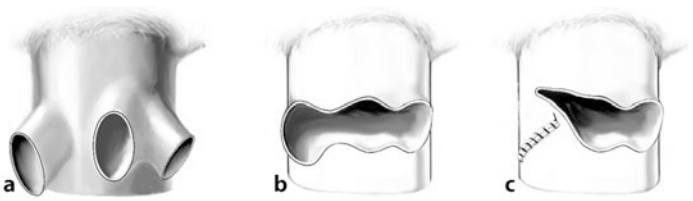


Fig. 60.6

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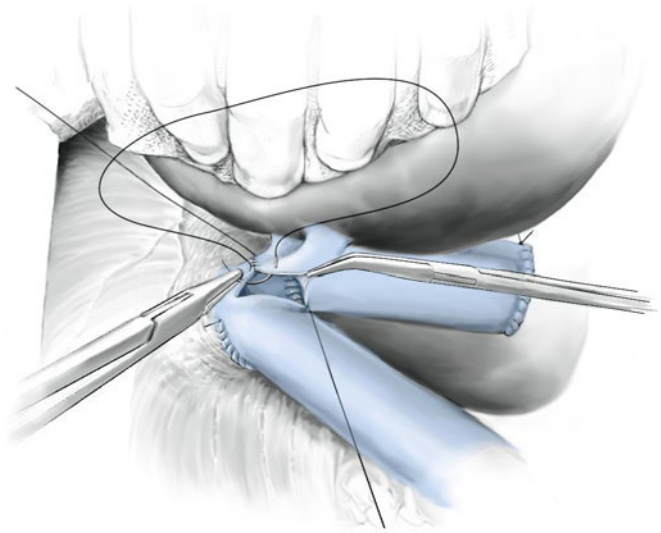


Fig. 60.7

- *Side-to-side cavo-cavostomy.* The donor suprahepatic IVC is closed as well with running polypropylene 4-0 suture, and a 6-cm-long cavotomy is made on the left posterior side of the donor IVC. This cavotomy should encompass the orifices of the major hepatic veins in order to obtain optimal venous allograft drainage and to permit later procedures such as transjugular biopsy or transjugular intrahepatic portosystemic shunt (TIPS) placement. A large anastomosis is made between both sides of the left posterior wall of the donor IVC and the anterior wall of the recipient IVC, using partial clamping of the recipient IVC (Fig. 60.8a). The anastomosis is performed from the right (or the left) side by using two running sutures of polypropylene 4-0. A long blind stump of the IVC should be avoided, to prevent clot formation. This anastomosis is rendered easier using a specially designed caval clamp (Lerut-Satinsky clamp, Ulrich CH).
- *End-to-side cavo-cavostomy.* The suprahepatic end of the donor IVC is spatulated on the dorsal side over 4 cm, allowing a wide anastomosis. The anterior wall of the recipient IVC is partially clamped as described above. A wide (> 6 cm) anastomosis is subsequently made between the spatulated suprahepatic IVC of the allograft and the recipient IVC in an oblique end-to-side fashion, using two running sutures of polypropylene 4-0 (Fig. 60.8b). An advantage of this technique is that the anastomosis can be made as wide as possible and that the blood flow from the hepatic veins follows a more direct course into the IVC than with the side-to-side technique.

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Step 4 ***(continued)***

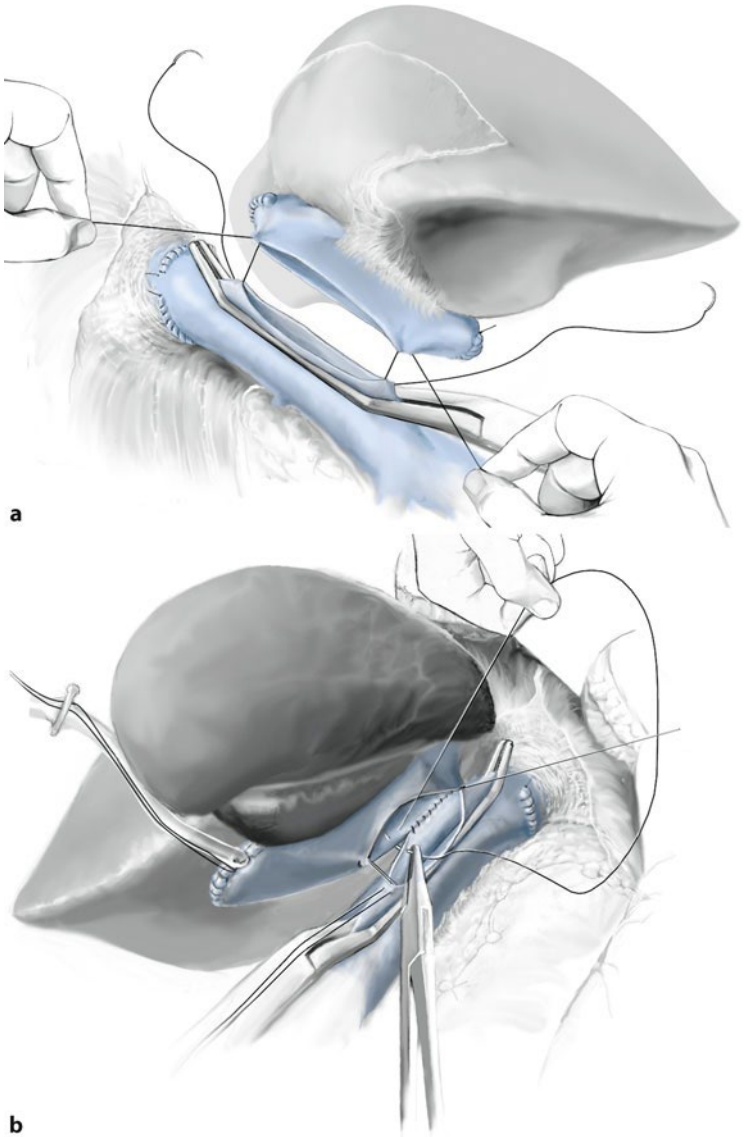


Fig. 60.8

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Step 5

Anastomosis of the portal vein

From this point on, the procedure is essentially the same for both the classic and the IVC-sparing techniques.

After cutting the donor portal vein to adequate length, the portal vein is anastomosed end-to-end, using running polypropylene 5-0 or 6-0. Avoid kinking or rotation, and flush the recipient portal vein briefly to remove any clots. Ensure an adequate growth factor of about three-fourths the diameter of the vessel (Fig. 60.9a). A growth factor is not necessary if maximal expansion of the portal suture line is allowed by temporarily clamping the portal vein just above the anastomosis at the moment of the opening of the vascular clamp. This manoeuver allows a maximal expansion of the suture line.

When the recipient portal vein is not suitable for anastomosis (after longstanding thrombosis), or when the two portal vein stumps are too short, a segment of iliac vein from the donor can be used to extend the donor portal vein or as a jump graft to the superior mesenteric vein (Fig. 60.9b,c). In cases of portal vein thrombosis, recanalization can mostly be obtained using the eversion thrombectomy technique. If thrombectomy is not possible or unsuccessful, a free iliac venous graft will be interposed between the recipient superior mesenteric and donor portal veins.

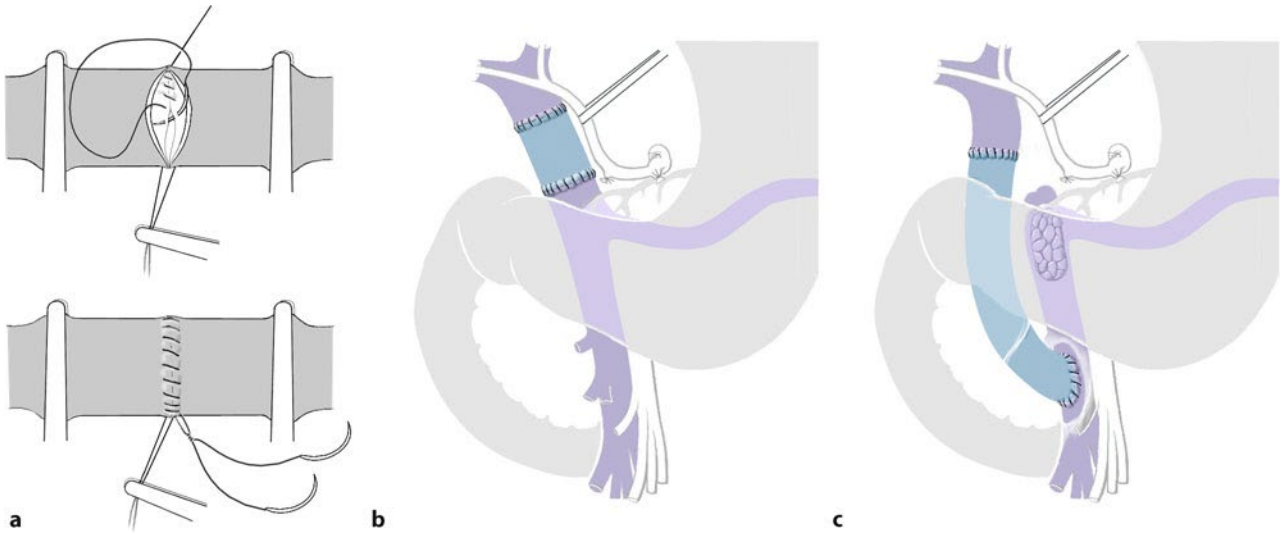


Fig. 60.9

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The post-anhepatic stage

Step 6

Reperfusion of the donor liver

Reperfusion can be done in different ways:

- Remove the vascular clamp from the portal vein and reperfuse the liver, flushing 200 to 300 mL of blood via the catheter in the infrahepatic IVC to remove air, preservation solution, and potassium from the graft. Remove the catheter in the IVC and tie the suture at the infrahepatic cava. Subsequently, slowly remove the vascular clamp at the suprahepatic and infrahepatic vena cava (for the classic procedure) or the clamp at the anterior aspect of the IVC (for the cava-sparing technique).
- When anastomosing the portal vein, the allograft can also be flushed retrogradely via the IVC. An advantage of this technique is complete restoration of the caval venous return to the heart before reperfusion of the graft.
- Once the liver is reperfused, topical irrigation of the liver with warm saline facilitates rewarming.
- Some centers flush the liver with cold albumin solution prior to reperfusion (Fig. 60.10).

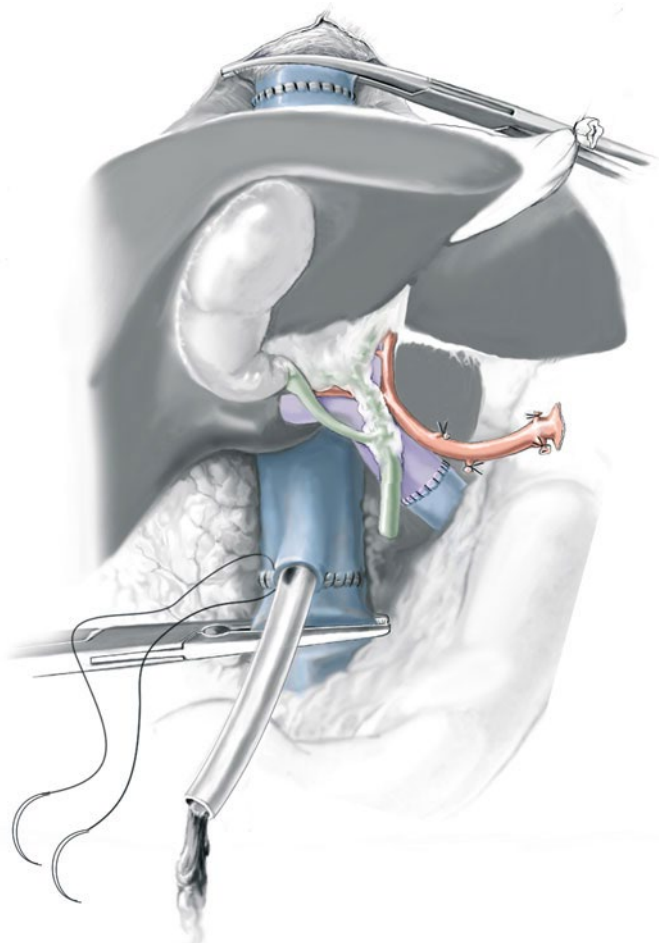


Fig. 60.10

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Step 7

Arterial anastomosis

There are several options for the arterial anastomosis. In most cases, an end-to-end anastomosis is made between the common hepatic artery or celiac trunk of the donor and the common hepatic artery or the bifurcation of the left and right hepatic arteries of the recipient, using running or interrupted polypropylene 7-0 or 8-0 (Fig. 60.11). Depending on the length and diameter of the vessels, alternative sites for anastomosis are possible. The recipient artery should be adequately flushed to remove clots before the anastomosis is completed.

Accessory or aberrant donor arteries should be revascularized either by making a direct anastomosis to the recipient artery or by anastomosing it to the stump of the gastroduodenal or splenic arteries of the graft (Fig. 60.12).

When the recipient artery is not suitable for grafting (hepatic artery thrombosis or severe stenosis of the celiac trunk), a segment of iliac artery from the donor should be used as a conduit to make a direct anastomosis with the infrarenal abdominal aorta. In some cases, the donor artery is long enough to make a direct anastomosis between the donor celiac trunk and the recipient supratruncal aorta (Fig. 60.13a). When an iliac conduit is used, it can be anastomosed in an end-to-side fashion either to the supratruncal aorta after removal of the native liver (Fig. 60.13b), or to the infrarenal aorta above the origin of the inferior mesenteric artery. These anastomoses should be performed before implantation of the allograft (Fig. 60.14).



Fig. 60.11

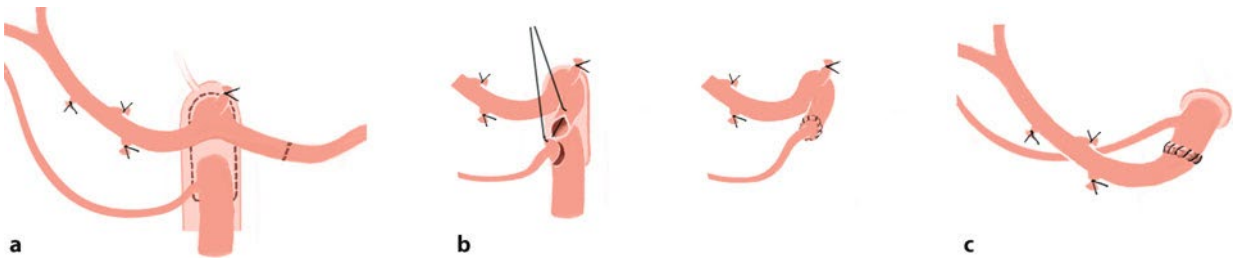


Fig. 60.12

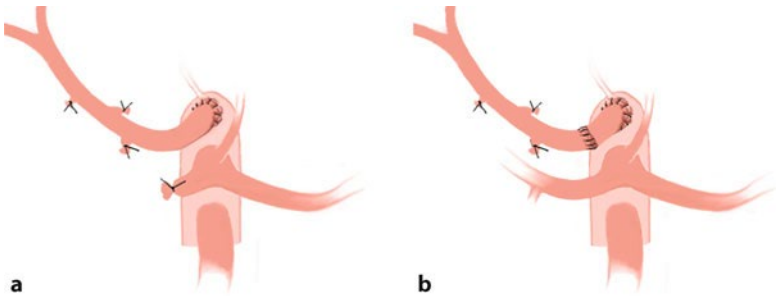


Fig. 60.13

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Step 7 ***(continued)***

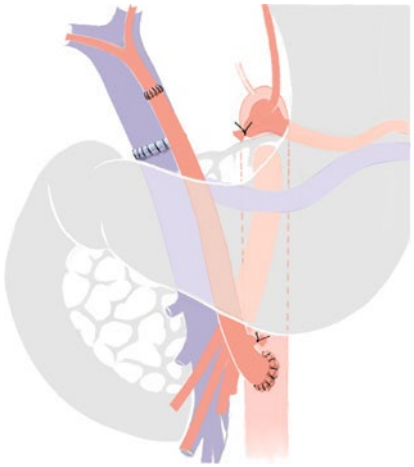


Fig. 60.14

Step 8

Bile duct reconstruction

The bile duct is shortened on both the donor and the recipient side until adequate bleeding is obtained from both ends. The bile duct anastomosis can be made in an end-to-end fashion, using interrupted PDS or prolene 5-0 to 7-0. An alternative is a side-to-side anastomosis (as shown in the chapter on biliary anastomoses). A biliary catheter can be introduced via the recipient common bile duct and placed transanastomotically using a T-tube. In patients with primary disease of the bile ducts, such as primary sclerosing cholangitis, the bile duct usually should be reconstructed by a Roux-en-Y hepaticojejunostomy. In some compromised recipients, however, in order to avoid supplementary intestinal sutures, it can be very useful to perform a direct duct-to-duct anastomosis when extrahepatic strictures and inflammation have been excluded, or even to perform a direct anastomosis with the duodenum.

The procedure can be ended without abdominal drainage if the operative field is dry. With important ascites formation or major intraoperative fluid administration, however, it is advisable to place one right upper quadrant abdominal drain to ease the postoperative care of the recipient (Fig. 60.15).



Fig. 60.15

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Venovenous bypass (optional)

Depending on the center, a venovenous bypass will be used systematically, occasionally, or never. When venovenous bypass is used during the anhepatic stage, this usually includes drainage of the portal vein and the lower part of the body via the left greater saphenous vein into the left axillary, brachial, or internal jugular vein. An alternative for direct cannulation of the portal vein stump is cannulation of the inferior mesenteric vein. The centripetal Biopump with heparin-coated, armed cannulas is the most widely used device. Before use, the cannulas are primed with normal saline or an equivalent solution.

A 6-cm longitudinal incision is made in the left groin, just below Poupart's ligament, and the proximal end of the greater saphenous vein is isolated and encircled with sutures. After ligation of the distal side, the cannula of the venovenous bypass is inserted via a small venotomy in the proximal side of the greater saphenous vein and is advanced into the femoral vein. The portal vein can be cannulated either directly by inserting and securing the cannula into the stump of the recipient portal vein or by cannulation of the inferior mesenteric vein. The axillary vein is cannulated following an identical procedure as for the saphenous vein, via a small longitudinal incision in the left axilla. It is also possible to insert a large-bore catheter transcutaneously into the internal jugular vein.

Some centers perform a temporary portosystemic shunt; this procedure is not covered in this chapter (Fig. 60.16).

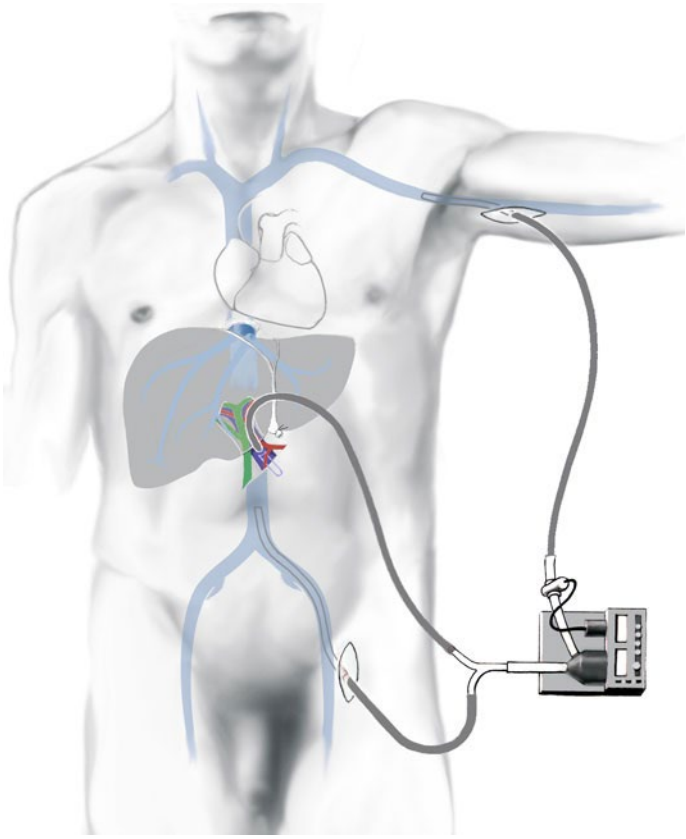


Fig. 60.16

Postoperative Tests

- *Laboratory tests:* liver tests (lactate, INR, AST, ALT), coagulation studies (INR and factor V), kidney function, monitoring of levels of immunosuppressive drugs
- *Doppler ultrasound:* check for patency of the liver vessels (daily up to day 5)
- *Liver biopsy* when rejection is clinically suspected

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Postoperative Complications

Early (< 14 days)

- Bleeding
- Hepatic artery thrombosis or stenosis
- Hepatic artery steal syndrome
- Primary nonfunction (death of patient without retransplantation)
- Initial poor function (center-dependent definition)
- Acute rejection
- Massive ascites
- Portal vein thrombosis
- Budd-Chiari syndrome
- Biliary leakage

Intermediate/late (> 14 days)

- Acute or chronic rejection
- Abdominal infections: intra-abdominal abscess, infected ascites
- Systemic infections
- Bacterial
- Viral (*eg*, cytomegalovirus [CMV] or Epstein-Barr virus [EBV])
- Fungal
- Vascular complications
- Hepatic artery thrombosis or stenosis
- Portal vein thrombosis
- Ascites
- Venous outflow tract obstruction
- Biliary complications
- Intrahepatic and/or extrahepatic stenosis and/or sludge formation
- Extrahepatic biliary stenosis
- Intrahepatic ischemia-type biliary lesions (ITBLs)
- Recurrent disease
- Malignancies
  - De novo tumors
- Posttransplant lymphoproliferative disorders
- Skin cancer

Management of the Most Common Complications

- Primary nonfunction (1–2 %): Early retransplantation
- *Rejection:* Increased or adapted immunosuppression
- *Hepatic artery thrombosis* (1–5 %)*:* Immediate surgical thrombectomy with or without intrahepatic thrombolysis. If severe ischemic biliary strictures or hepatic necrosis develops, retransplantation should be considered
- Hepatic artery stenosis or steal: Interventional radiology
- *Infectious complications:* Treat as usual (*eg*, appropriate anti-infectious chemotherapy; surgical or percutaneous drainage)
- *Ascites/edema:* Avoid fluid overload in the first week after transplantation; administer diuretics if necessary

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Tricks of the Senior Surgeon

- For both the classic approach and the cava-sparing technique, the central venous pressure should be kept as low as possible. Otherwise, the dissection of the liver from the retrohepatic IVC and the dissection of the Spigelian veins is rendered more difficult, which leads to increased blood loss.
- A short period of hypotension is usually seen upon reperfusion of the graft. This can be due to bleeding or to metabolic changes (i.e., "post-reperfusion syndrome"). When venous bleeding occurs from the (retrohepatic) IVC or the dorsal side of the liver, provide temporary packing for the retrohepatic space until hemodynamic stabilization occurs, before attempting to place any sutures.
- In case of preexisting portal vein thrombosis or previous right upper quadrant surgery and retransplantation, prepare and adapt donor and recipient operations to reduce ischemic time.
- Before starting the allograft implantation, be assured of the method of portal revascularization.

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Partial Cadaveric Liver Transplantation: Donor Procedure and Implantation

Massimo Del Gaudio, Xavier Rogiers, Daniel Azoulay

In 1989, Pichlmayr *et al.* were the first to report a case of splitting a cadaveric liver for two recipients, an adult and a child. In the same year, Bismuth *et al.* performed the first transplantation of a single liver into two adult recipients with fulminant hepatitis. Today, donor livers are split for an adult and a pediatric recipient or, less frequently, for two adults.

Indications and Contraindications

General donor criteria

- Age < 55 years
- Weight > 70 kg
- Hemodynamic stability
- Normal liver function tests
- No macroscopic aspect of liver steatosis
- Graft-to-recipient body weight ratio > 1 %

Donor Procedures

Ex situ versus in situ splitting

In general, the liver graft can be split either during the procurement procedure (i. e., in situ) or on the back table after a conventional donor procedure (ex situ).

For ex situ splitting of the liver, the whole organ is retrieved as described in ▶ Chap. 59, "Technique of Multi-Organ Procurement." Grafts are then prepared in the recipient transplant center. An alternative is the in situ splitting technique, which is closely related to the techniques established for procurement from living related donors.

The ex situ split is the most widely used method to obtain transplants for two patients with one liver, but the extended cold ischemic time and some rewarming due to the longer back-table procedure, as compared with conventional liver transplantation, increase the risk of graft dysfunction in the recipient. In situ splitting potentially eliminates this problem, but its application is limited by its more time-consuming and technically more demanding explantation procedure.

Back-table procedure for ex situ splitting

During back-table splitting, attention should be paid to keeping the liver cold. After standard procurement of the liver graft, the presence of a portal bifurcation is checked by inserting a blunt metallic probe into the portal trunk. The anatomy of the hepatic artery and the bile duct is identified by dissection, probing, or back-table X-ray with contrast medium. The ultimate dissection of the portal vein, the hepatic artery, the biliary tree, and the suprahepatic veins is performed on the back table.

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
DOI 10.1007/978-3-662-46546-2_61, © Springer-Verlag Berlin Heidelberg 2016

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In situ split-liver donor procedure for an adult and a pediatric recipient

The goal of this procedure is to obtain the following grafts:
- Graft for adult recipient: Segments IV through VIII
- Graft for pediatric recipient: Segments II and III

Step 1

Mobilization and transection of the left lateral segments

Segments II and III are mobilized and prepared in an identical manner as for a living-donor procedure. The left hepatic artery and the left portal vein are isolated. Particular attention is paid to preserving the arterial branch to segment IV whenever possible. The left hepatic vein is identified and controlled by placing a vessel loop around it to allow vessel-loop guided parenchymal transection (Fig. 61.1a). (See ▶ Chap. 42, "Hanging Maneuver for Anatomic Hepatectomy.")

Optionally, a cholangiography can be performed, as shown in the chapters on living-donor procedures.

Parenchymal transection is performed along the falciform ligament (Fig. 61.1b, resection line 1). The hepatic veins are separated. The left hepatic vein remains with the left graft, whereas the right and the middle hepatic veins remain with the right graft in continuity with the inferior vena cava (IVC).

Once the division of the parenchyma reaches the hilar plate, it is cut straight with a scalpel slightly toward the left side, thus cutting the left hepatic duct blindly. This avoids unnecessary dissection of the bile duct, which would compromise the biliary arterial blood supply.

In case of a too-large right graft, or when the perfusion of segment IV is not optimal, segment IV can be resected after implantation (Fig. 61.1b, resection line 2). (Usually segment IV is somewhat discolored. This is normal and should not lead to resection of the segment.)

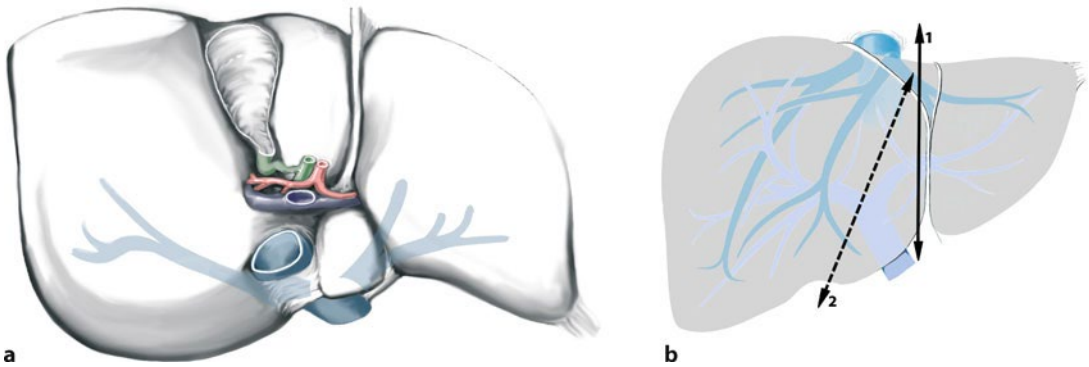


Fig. 61.1

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Step 2

Procurement of the grafts

Now the graft is prepared for procurement. Flushing of the organs is performed as in a standard multiorgan procurement. The left or right portal vein is cut at its origin and the orifice is closed with a 7-0 monofilament running suture. If the portal vein is to be cut at the origin of the left branch, the branches from the first centimeters of the left branch of the portal vein to segment I are secured between ligatures and divided in order to gain length and to allow for coaxial anastomosis to the recipient's portal vein.

In a standard situation, the artery is divided at the origin of the right hepatic artery, leaving the celiac trunk with the left graft. The left hepatic vein is divided and the left graft is removed and stored. Then the right graft is removed (Fig. 61.2).

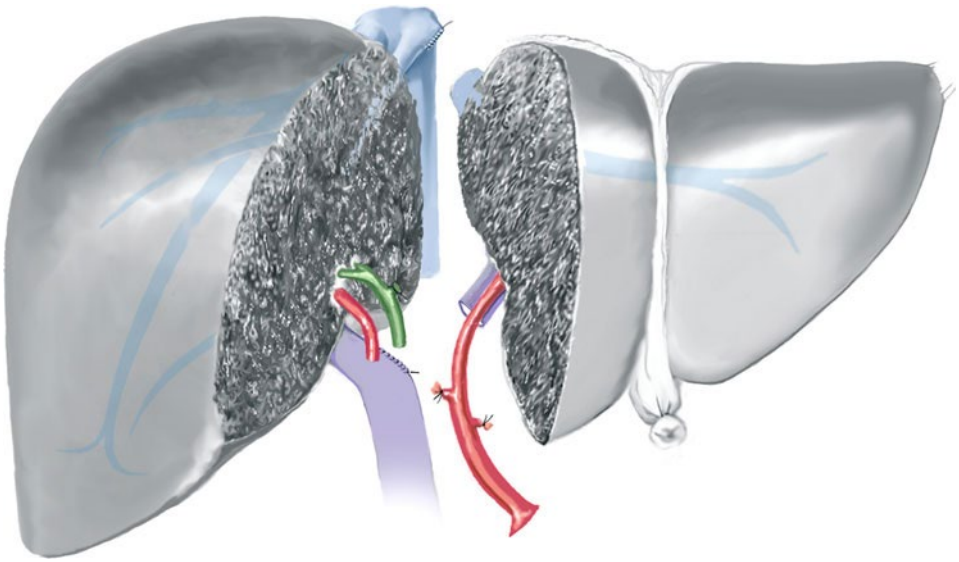


Fig. 61.2

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In situ splitting for two adult recipients

The goal of this procedure is to obtain the following grafts:
- Right graft: Segments 5 through 8
- Left graft: Segments 2 through 4

The hepatic dissection starts with complete mobilization of the right liver, including isolation of the right hepatic vein, which is prepared for vessel loop–guided parenchymal transection. Short accessory hepatic veins draining the right liver are preserved if they are larger than 5 mm, as they need to be anastomosed during implantation of the right graft.

The portal vein and the hepatic artery are prepared as described in the section on adult and pediatric split-liver procedure. In a standard situation, the celiac axis remains with the left graft. Regarding portal bifurcation, the portal vein trunk is kept in continuity with the left graft. In case of portal trifurcation, the portal trunk is kept with the right graft. The plane of transection is to the right of the middle hepatic vein, so the whole of segment 4 is included in the left graft. This procedure yields two grafts as shown in Fig. 61.3. In contrast to the split-liver procedure for an adult and a pediatric recipient, in this situation the cava remains with the left graft.

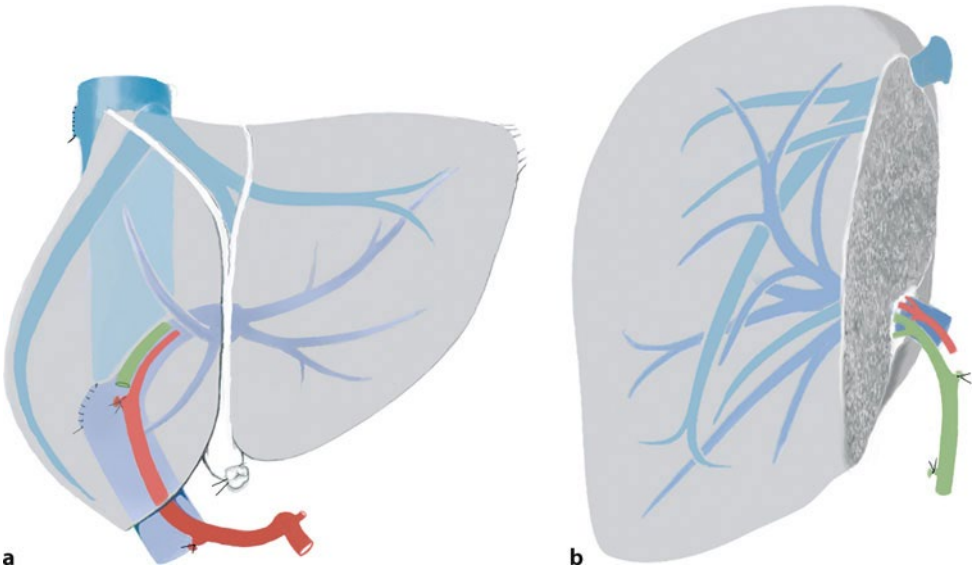


Fig. 61.3

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Implantation Procedures

Implantation of the right graft when the liver is split for an adult and a pediatric recipient

Step 1

Preparation of the graft

The cava remains with the right graft, so a side-to-side cavocavostomy is possible and yields optimal allograft outflow. The preparation of the graft consists of resection of the upper and lower IVC cuffs at a level beneath the first major hepatic veins draining the residual part of Sg1. A 6-cm cavotomy at the right posterior side of the IVC encompasses the orifices of the major hepatic veins (Fig. 61.4).

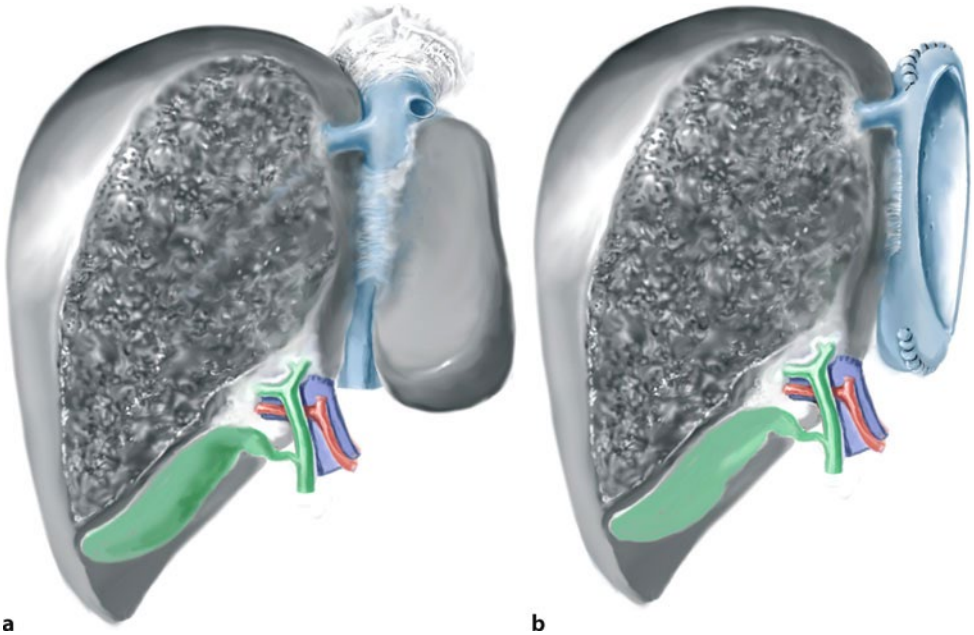


Fig. 61.4

Step 2

Side-to-side cavocavostomy

A side-to-side cavocavostomy using partial clamping of the recipient IVC is performed. (See also ▶ Chap. 60) Optional: resection of the retrocaval and left part of Sg1 during the back-table procedure improves exposure and thereby easy anastomosis between the two caval veins. The same technique can be applied for the left graft in a procedure for two adult recipients, as the cava remains with the left liver in that situation (Fig. 61.5).

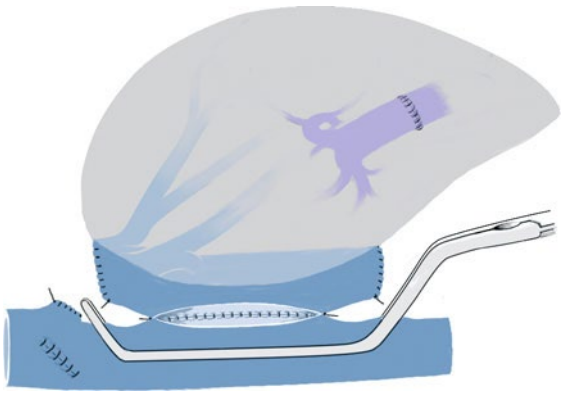


Fig. 61.5

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Step 3

Portal vein, hepatic artery, and bile duct anastomoses

An end-to-end portal vein anastomosis is performed between the right branch of the portal vein of the graft and the common trunk of the portal vein of the recipient. If long enough, the right hepatic artery is anastomosed to the hepatic artery of the recipient at the level of the bifurcation with the gastroduodenal artery. Otherwise, it is anastomosed to the right or common hepatic artery. Finally, the right hepatic duct is connected to the common bile duct of the recipient, applying the same technique as in orthotopic liver transplantation (Fig. 61.6).

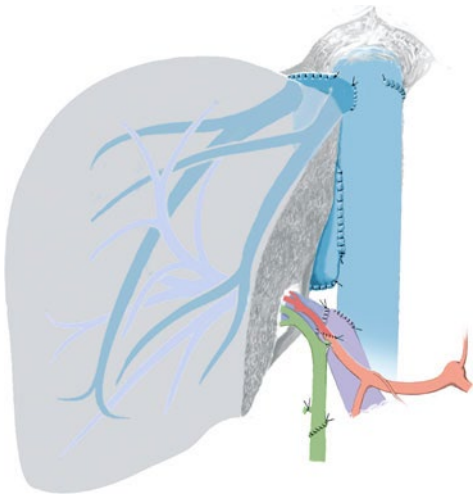


Fig. 61.6

Implantation of the right graft after splitting for two adult grafts or after right living-donor procurement

Implantation of the left graft when the liver is split for two adult recipients is described in ▶ Chap. 63.

In the situation of living-donor procurement, the cava remains in the donor, and in a split-liver procedure for two adult recipients, the cava remains with the left graft. Therefore, the venous outflow is reconstructed by anastomosing the donor's hepatic veins to the recipient's vena cava. The hepatectomy in the recipient is performed as for orthotopic liver transplantation with preservation of the IVC. The orifices of the middle and left hepatic veins are oversewn or stapled; the right hepatic vein is directly anastomosed to the stump of the right hepatic vein or to a wider orifice in the recipient's vena cava. Any inferior hepatic veins more than 5 mm in diameter are also anastomosed directly to the IVC. A significant hepatic vein from segment 5 or 8 must be drained. This can be achieved by constructing a jump graft by means of a saphenous vein or, depending on the anatomic situation, by creating a common orifice with the right hepatic vein.

Anastomoses of the portal vein and the hepatic artery are performed as for the split graft for adult and pediatric recipients. Biliary continuity can be restored by bilidigestive anastomosis, as shown in the figure, or by a direct connection between the right hepatic duct of the right graft and the common bile duct of the recipient (Fig. 61.7).

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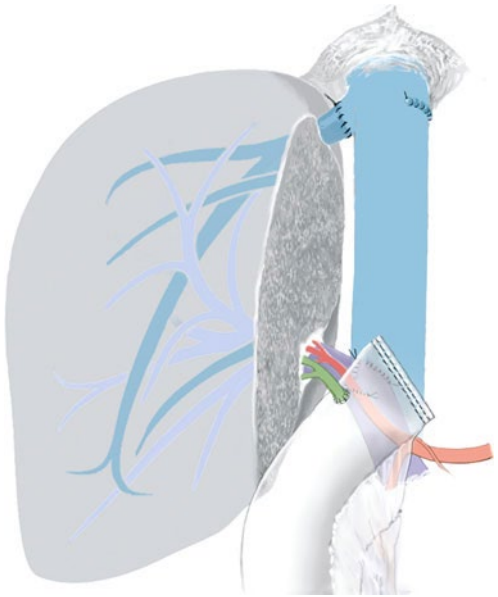


Fig. 61.7

Implantation of the left graft in a pediatric recipient (segments 2 and 3)

As in this situation the cava stays with the right graft, the left hepatic vein is anastomosed directly on the IVC of the recipient. It is fundamental to keep the hepatic vein short, as too long a vein can lead to kinking of the caval anastomosis. End-to-end anastomosis of the portal vein between the donor's left portal vein and the recipient's common trunk is performed. Finally, the celiac axis of the left graft is anastomosed to the hepatic artery of the recipient at the level of the gastroduodenal artery, and biliary continuity is reconstituted by a Roux-en-Y bilidigestive anastomosis (Fig. 61.8).

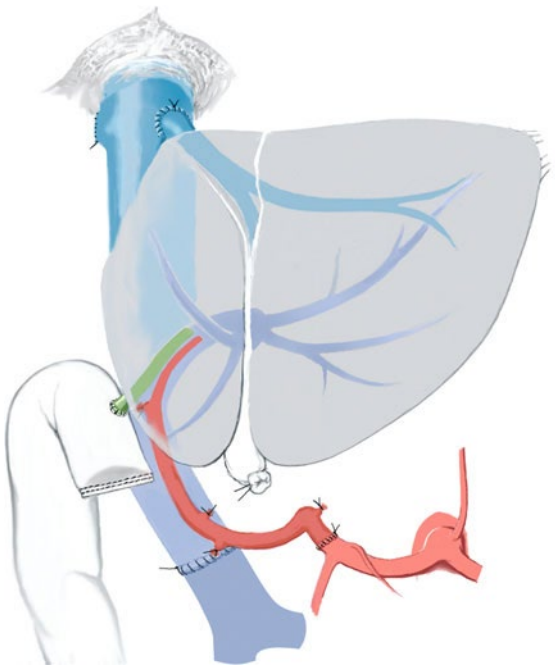


Fig. 61.8

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Alternative management of the hepatic venous outflow in split-liver transplantation for two adults

In split-liver transplantation for two adults, the maintenance of an optimal venous outflow is of great importance for maximal parenchymal integrity. In principle, the same venous reconstructions and anastomoses are made as in right liver donation, including reanastomosis of segment 6 veins and reconstruction of larger segment 5 or 8 veins, as shown. Two additional techniques that are not usable in living donation can be applied to make the implantation easier while maintaining optimal venous outflow:

- *Splitting of the inferior vena cava:* This technique can be used in both the in situ and ex situ technique. The front wall and back wall of the vena cava are cut longitudinally, thus obtaining a caval patch on both grafts containing the respective hepatic veins as well as a possible segment 6 vein on the right side and segment 1 veins on the left side. At implantation, the caval patches are sewn into the front wall of the preserved recipient vena cava (Fig. 61.9).

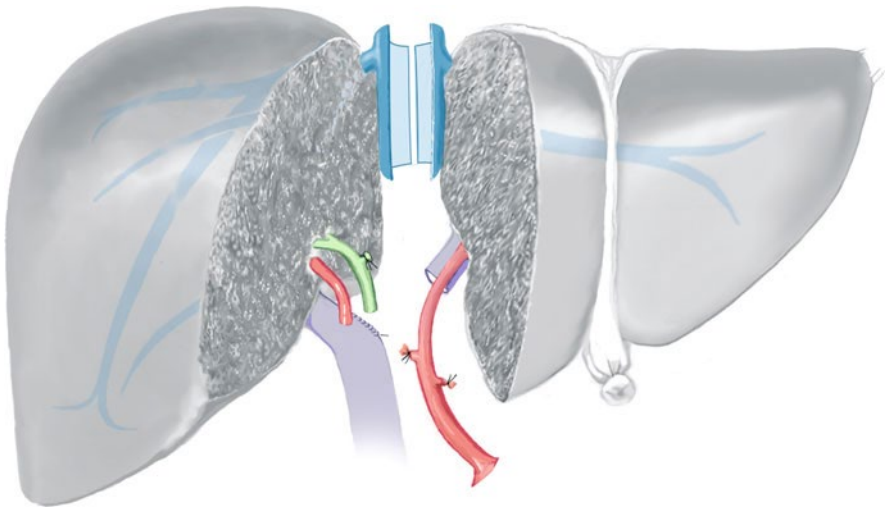


Fig. 61.9

61

- *Splitting of the middle hepatic vein:* This technique can be performed only in ex situ splitting. During parenchymal transection, the middle hepatic vein is cut through the middle, in continuity with its orifice in the vena cava (Fig. 61.10a). On both sides, it is reconstructed using donor iliac vein patches. In this way, larger segment 5 or 8 veins are drained without the need for any further reconstructions or anastomoses (Fig. 61.10b,c).

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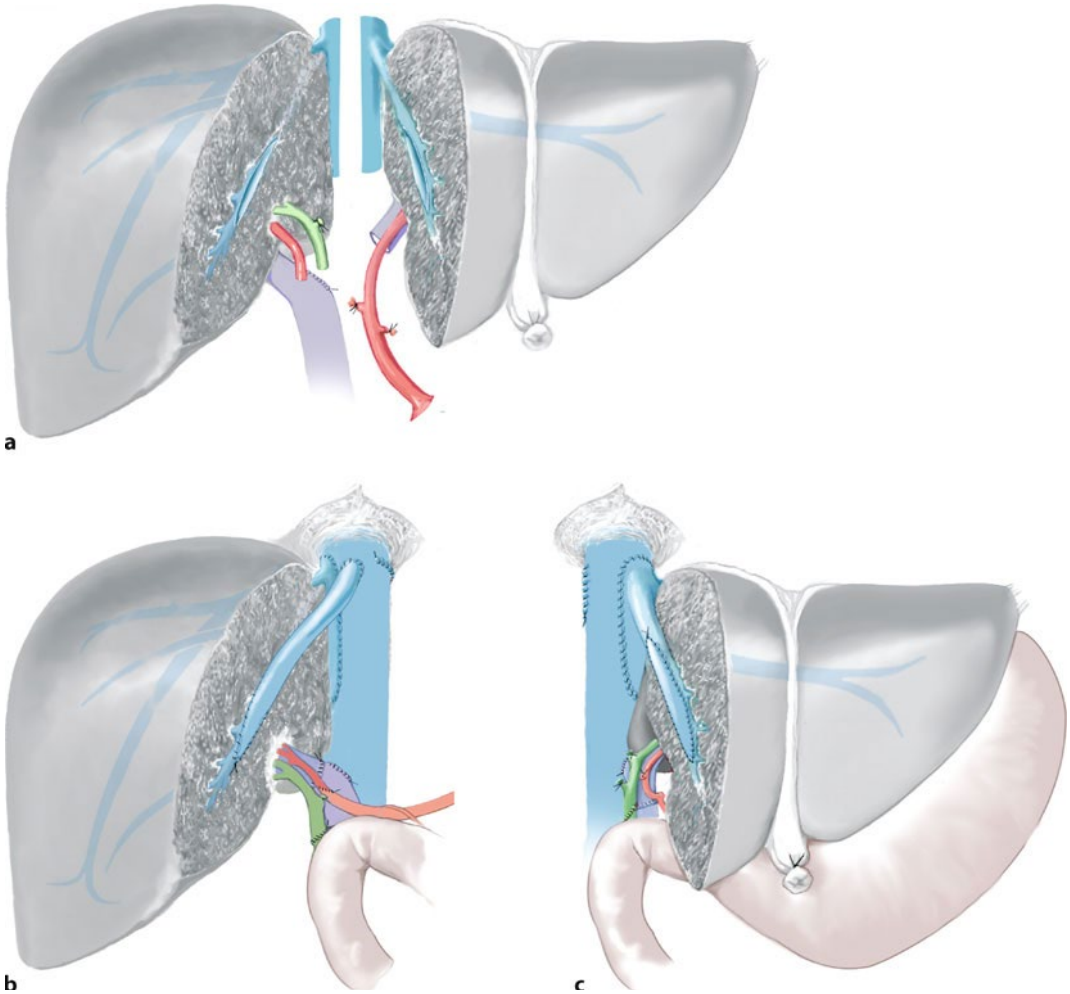


Fig. 61.10

Routine Postoperative Tests

- Doppler ultrasound examination daily in the intensive care unit, then weekly until discharge
- Laboratory parameters as for orthotopic liver transplantation

Postoperative Complications

- Biliary leaks from the raw surface, which usually resolve with percutaneous drainage.
- Other complications are the same as for orthotopic liver transplantation or living-donor transplantations and should be treated accordingly.

Tricks of the Senior Surgeon

- Sharp transection of the parenchyma is preferred, as it leaves a flat surface allowing for most efficient hemostasis.
- Clips have a propensity to drop off during the implantation procedure. Therefore, every individual vessel seen on the cut surface is closed with stitches. During this step, care is taken to avoid liver rewarming by applying cold towels, leaving only the cut surface exposed.

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Right Living-Donor Hepatectomy

Gregory Sergeant, Pierre-Alain Clavien

Indications and Contraindications

General donor criteria

- Age between 18 and 60 years
- ABO compatibility between donor and recipient
- No major medical problems
- Significant long-term emotional relationship to the potential recipient
- Donor competent to give informed consent

Donor contraindications

- Donor age less than 18 years or older than 60 years
- ABO blood group incompatibility
- Significant comorbid condition (e. g., morbid obesity, coronary artery disease)
- Multiple previous upper abdominal operations
- Hepatic steatosis greater than 30 % (center-dependent cutoff)
- Donor remnant liver volume less than 25 % of the total liver volume
- Significant celiac artery stenosis
- Anatomic variations (center-dependent)
- Body mass index greater than 28 (if a liver biopsy is not performed)

Right Lobe Living-Donor Workup

- Psychological evaluation and clinical examination
- Laboratory tests for undiagnosed liver disease, including AST, ALT, total bilirubin, alkaline phosphatase, INR-PT
- Noninvasive tests for the assessment of liver volume and anatomy:
  - CT scan or MRI for volumetry and vascular reconstruction
  - Magnetic resonance cholangiopancreatography (MRCP) or CT cholangiography for biliary anatomy (center-dependent)
- Invasive tests:
  - Liver biopsy (center-dependent)
  - Endoscopic retrograde cholangiopancreatography (ERCP) (center-dependent)

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Procedure

Step 1

Access and intraoperative evaluation

After a bilateral subcostal incision, an appropriate retractor (e.g., Thompson retractor) is placed as for a conventional right hemihepatectomy. The division of the round and falciform ligaments is followed by a careful exploration of the abdominal cavity. The falciform ligament should be cut at a distance from the liver, as it will be sutured to the diaphragm at the end of the procedure. The left triangular ligament is preserved to fixate the remnant left liver. Guided by intraoperative ultrasound (Fig. 62.1a), the position of the middle hepatic vein is marked by electrocautery on the liver surface (Fig. 62.1b) and any intrahepatic lesions missed on the preoperative workup are excluded.

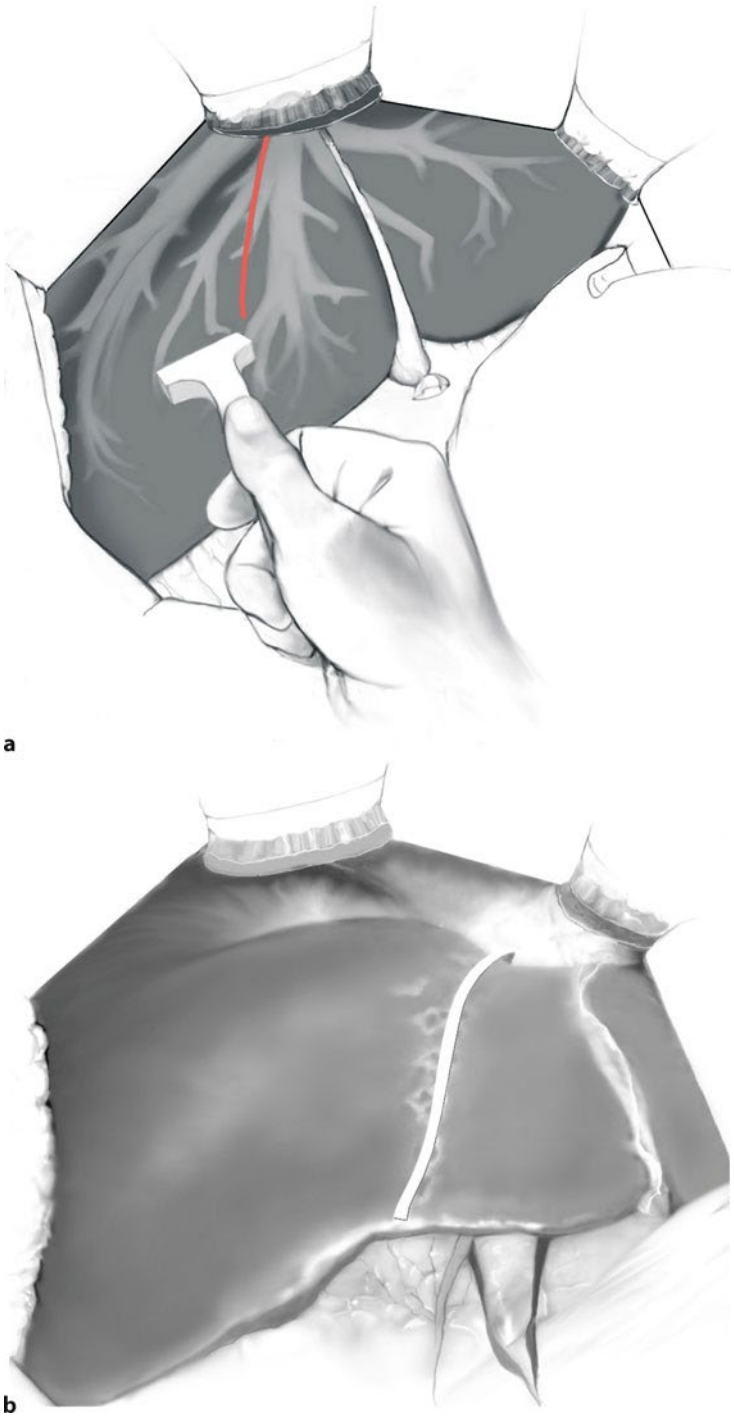


Fig. 62.1

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Step 2

Hilar dissection

A cholecystectomy is performed and an intraoperative cholangiogram is performed via a transcystic catheter (Fig. 62.2) after placement of a radiopaque marker such as a large metallic clip or a small metal bulldog clamp trans-cystic near the point where the right hepatic duct is thought to lie. We like to leave the cystic duct stump long for a bile leakage test at the end of the procedure. At completion of the cholangiogram, and once no contraindications to living donation are identified on exploration, the recipient is brought to the operating room. Next, the hepatic hilum is exposed and the posterior right aspect is palpated to check for a replaced right hepatic artery arising from the superior mesenteric artery. The peritoneum and lymphatic tissue are divided on the right lateral aspect of the hepatic hilum, avoiding skeletonization of the common bile duct, which could lead to strictures. After the right hepatic artery on the posterior aspect of the bile duct is identified, it is followed both to its bifurcation to the anterior and posterior segments distally and to its origin proximally without traction.

The proximal point may occasionally be just distal to the point of origin of the segment 4 branch (which should be preserved to avoid vascular compromise of segment 4), the gastroduodenal artery, or the origin of the left hepatic artery. An adequate length of right hepatic artery is required, and the point of proximal transection varies depending on the donor anatomy. The right portal vein branch is identified posterior to the bile duct in the right hilum. When isolating the right portal vein, care must be taken to identify clearly the confluence of the right and left portal veins as well as the main portal vein trunk. The posterior branch arising from the right portal to the caudate process should be identified and divided between ligatures to avoid accidental tearing and hemorrhage. A vessel loop can be placed around the right portal vein.

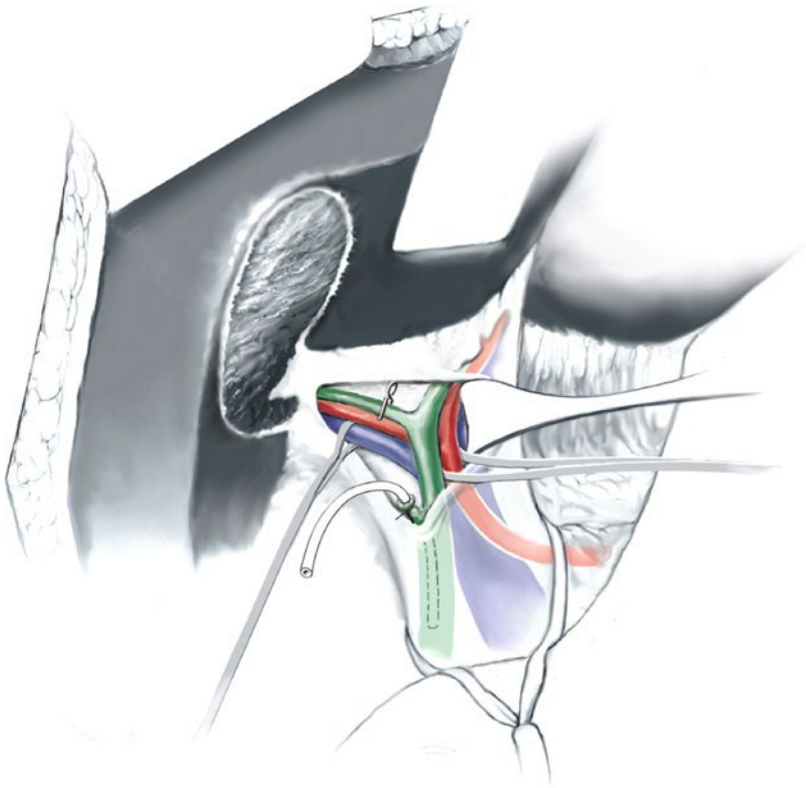


Fig. 62.2

If a portal vein trifurcation is present, the anterior and posterior branches should be individually identified and separately encircled.

After cholangiographic confirmation of the position of the radiopaque marker, the division of the right hepatic duct is started on its anterior wall 2 to 3 mm from the confluence with the left hepatic duct. Then the posterior wall of the right hepatic duct is divided, leaving an adequate

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Step 2 ***(continued)***

cuff to close the remaining donor side at a later stage, using a continuous suture of 5-0 or 6-0 resorbable PDS or Maxon without causing a stricture of either the common or left hepatic ducts (Fig. 62.3). One could also divide the right bile duct at the end of parenchymal dissection if one prefers using a true hanging maneuver after excluding the hilar plate. If there are additional bile ducts draining segments of the right liver into the left hepatic duct, they are identified and divided during the parenchymal dissection.

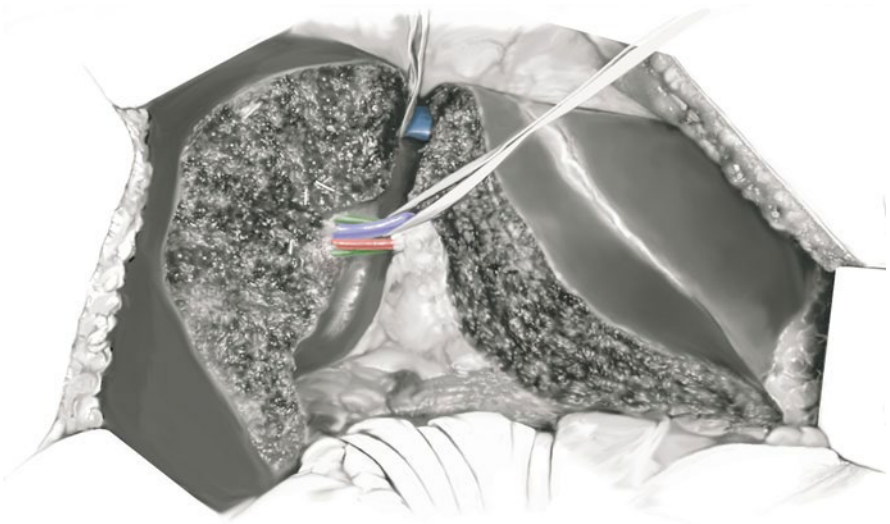


Fig. 62.3

Step 3

Mobilization of the right lobe and preparation of the right hepatic vein

The right liver is mobilized as for a conventional right hemihepatectomy, with the important difference that short, accessory hepatic veins more than 5 mm in diameter should be preserved for venous reconstruction in the recipient (Fig. 62.4).

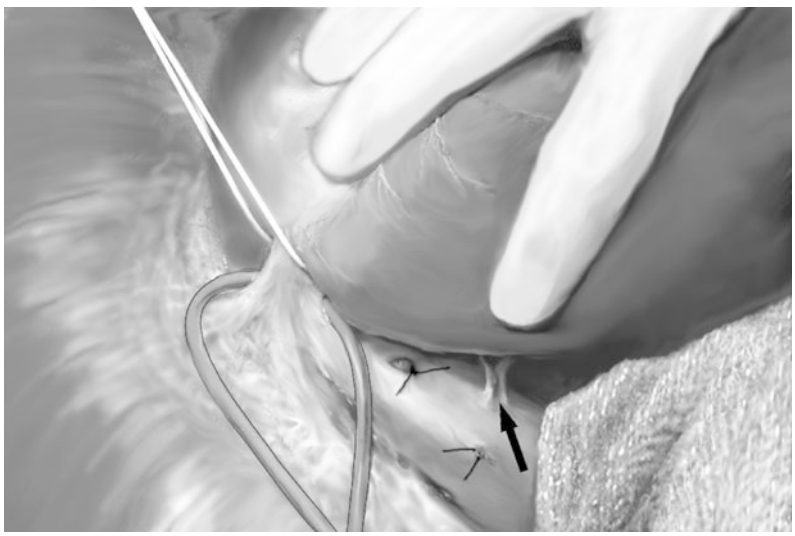


Fig. 62.4

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Step 4

Hepatic parenchymal transection

The line of hepatic transection should be approximately 1 cm to the right of the middle hepatic vein, identified and demarcated at the start of the procedure by intraoperative ultrasound. The line of demarcation can also be checked by placing a vascular or bulldog clamp on the right hepatic artery and right portal vein.

Alternatively, a partial Pringle maneuver involving the left hemiliver by temporarily occluding the left hepatic artery and portal vein using an umbilical tape is also possible. This allows demarcation of the line of transection, which can be marked using electrocautery. Depending on the technique used, the demarcation line may differ a little. Next, two stay sutures (2-0 silk) are placed on either side of the line of demarcation on the inferior border of the liver, as for a conventional right hemihepatectomy.

The anesthesiologist is asked to maintain a low central venous pressure, below 3 mmHg. In case a hanging maneuver is used (see ► Chap. 42, "Hanging Maneuver for Anatomic Hemihepatectomy"), it is prepared at this stage and should be between the middle and right hepatic vein. Although different techniques for liver dissection can be used, Hydrojet or CUSA without inflow occlusion is preferred in most centers. In a standard right donor hepatectomy, the middle hepatic vein is conserved and remains with the donor left liver. When the V5 and/or V8 veins are significant and must be preserved, they are carefully identified during the dissection and divided between a vascular metal clip on the right side and a ligature of 2-0 silk on the left side, close to the middle hepatic vein. This preserves the V5 and V8 veins for venous drainage reconstruction in the recipient. On completion of the parenchymal transection, time is taken to recheck for hemostasis and any potential bile leakage on both the graft and donor sides.

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Step 5

Right graft explantation

When the parenchymal transection is complete, the right graft is separated and remains attached to the donor only by the right hepatic artery, right portal vein, right hepatic vein, and possibly accessory veins to the cava. The right hepatic duct is usually divided either just prior to or at the end of the parenchymal division.

There are two methods of right liver graft removal: either an "in situ" perfusion with cold preservation solution, or graft removal after placement of vascular clamps and "ex situ" back-table perfusion. In some centers, an intravenous bolus of heparin is administered to the donor 5 min prior to graft explantation.

Ex situ perfusion technique: The right hepatic artery is proximally tied and divided. A vascular clamp is placed on the right portal and hepatic veins, which are also divided. The graft is removed and flushed on the back table with a cold preservation solution. As for cadaveric liver transplantation, the bile duct needs to be flushed separately.

In situ perfusion technique: Cannulation of the right portal is started by placing a vascular clamp close to the portal vein bifurcation without obstructing the left portal vein. A catheter (14–20 French) is introduced into the right portal vein and is fixed with a 2-0 ligature just distal to the clamp. The right hepatic vein is divided, followed by the right hepatic artery, while the perfusion of the right hemiliver through the catheter is started. The right graft is then removed and subsequently further perfused with cold preservation solution on the back table (Fig. 62.5).

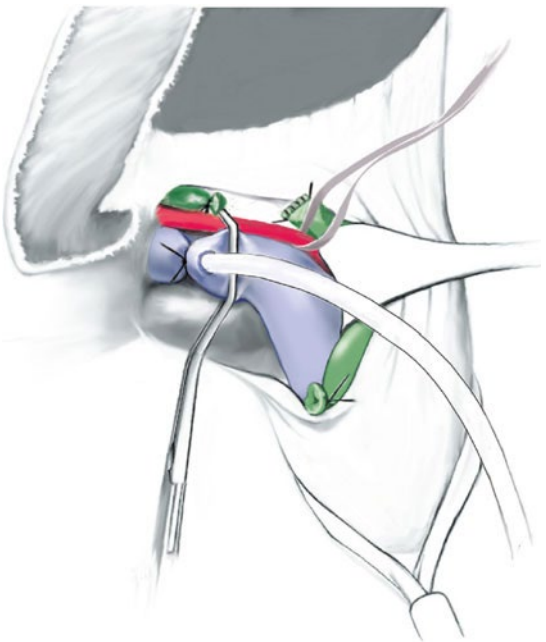


Fig. 62.5

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Step 6

Closure of donor vessels and biliostasis

Both the right portal vein and right hepatic vein should be cut at the time of graft explantation, with an adequate cuff on the remaining donor vessel. This is especially important in the case of the portal vein, where iatrogenic stricture and twisting should be avoided at all costs. In the case of a portal vein trifurcation, the right anterior and right posterior portal vein branches should be divided separately without attempting to obtain a common cuff, to avoid causing a stricture of the remaining donor portal vein. The hepatic vein stump is closed with a continuous 4-0 Prolene suture, and the portal vein stump is oversewn with a continuous 5-0 or 6-0 Prolene suture.

The transected border of the left liver is again checked for hemostasis. Potential bile leaks may be identified by placing a wet gauze sponge on the cut surface for 5 to 10 min or by performing a formal bile leakage test via the cystic duct stump.

Any areas of bile leakage are oversewn with a 5-0 PDS suture or clipped and rechecked. The remnant liver is fixed by suturing the falciform ligament to the diaphragm to prevent rotation of the left liver and an iatrogenic Budd-Chiari syndrome in the postoperative period. The abdomen is closed without placement of a drain.

Complications

Complications are the same as for right hemihepatectomy, the most common being:

- Biliary fistula
- Sustained hepatic dysfunction
- Biliary strictures
- Postoperative bleeding

Tricks of the Senior Surgeon

- Unusual portal vein anatomy should alert the surgeon for abnormal biliary anatomy.
- In performing the hilar dissection, start on the right lateral aspect when identifying the right portal vein and hepatic artery. This avoids excessive dissection and skeletonization of the right hepatic duct and bile duct.
- Identification of the biliary anatomy by intraoperative cholangiography should be performed early in the operation. A radiopaque metal clip or small bulldog clamp should be used to mark the area of the right hepatic duct during the cholangiogram. An atraumatic bulldog clamp can be placed on the distal bile duct to avoid passage of contrast into the lower bile duct.
- Marking the pathway of the middle hepatic vein by intraoperative ultrasound helps to decide the parenchymal transection line.
- Central venous pressure should be maintained low by anesthesia, as it helps to reduce blood loss.
- The hanging maneuver makes the parenchymal dissection easier, particularly in the last part.

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Living-Donor Transplantation: Left Hemiliver Donor Procedure and Implantation

Hiroto Egawa, Masakazu Yamamoto

A key issue in partial liver transplantation is size matching. A left lateral-segment graft is usually used for a pediatric recipient. The most common indication for pediatric liver transplantation is biliary atresia. Children with biliary atresia often have problems with a large-for-size graft, sclerotic stenosis of the portal vein, and a relatively large hepatic artery. The problem of a large-for-size graft can be solved by using a monosegment or hyperreduced monosegment graft, and size mismatch of the portal vein and the hepatic artery can be solved by size adjustment during performing the anastomosis.

A full left hemiliver graft for an adult patient is often too small. However, strategies for preventing the small-for-size syndrome have been developed, and living-donor liver transplantation using left lobe grafts is increasing recently. The volume of a full left hemiliver graft can be increased by procurement of a full left hemiliver graft including the caudate lobe; a cavoplasty and portal modulation are effective in preventing the small-for-size syndrome.

These techniques developed in living-donor liver transplantation can be applied for split-liver transplantation. For laparoscopic left hemiliver donor procedure, see ► Chap. 50, “Laparoscopic Liver Resection.”

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Open Donor Procedure for Left Living-Donor Liver Grafts

Step 1

Access and mobilization

Access is gained through a bilateral subcostal incision with cranial extension. The falciform ligament is divided, leaving enough length on the liver side to fix it in the recipient. Finally, a retractor (*eg*, Takasago retractor) is installed (Fig. 63.1a).

The lateral segment is lifted up and a towel is placed in front of the spleen for its protection. A sponge is placed behind the left triangular ligament and the lateral segment is placed back. The left liver is pulled downward and the left coronary ligament and the left triangular ligament are divided by a cautery knife (Fig. 63.1b).

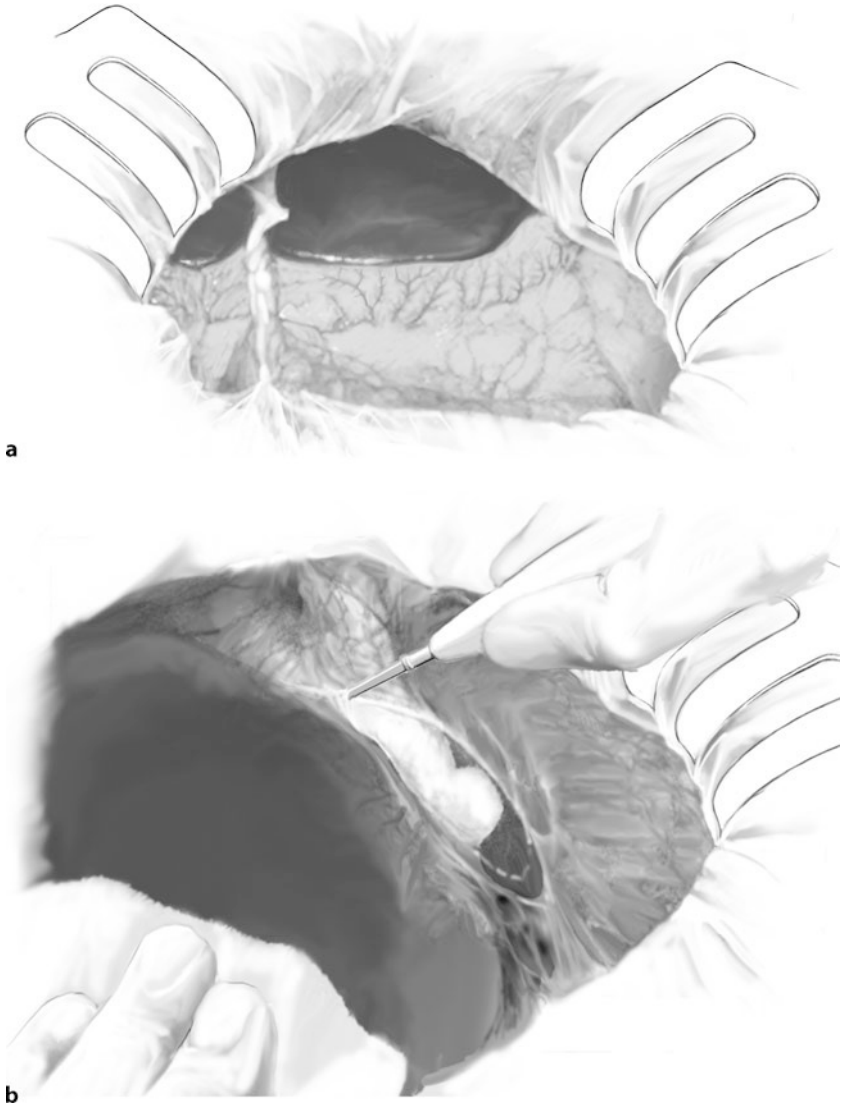


Fig. 63.1

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Step 2

Approach to the left hepatic vein and the left side of the cava

The lateral segment is rotated to the right, and the ligamentum venosum is encircled, ligated, and divided near the inferior vena cava (IVC) (Fig. 63.2a). The connective tissue is detached from the superior aspect of the Spigelius lobe to expose the left side of the IVC as well as the posterior surface of the left hepatic vein (Fig. 63.2b).

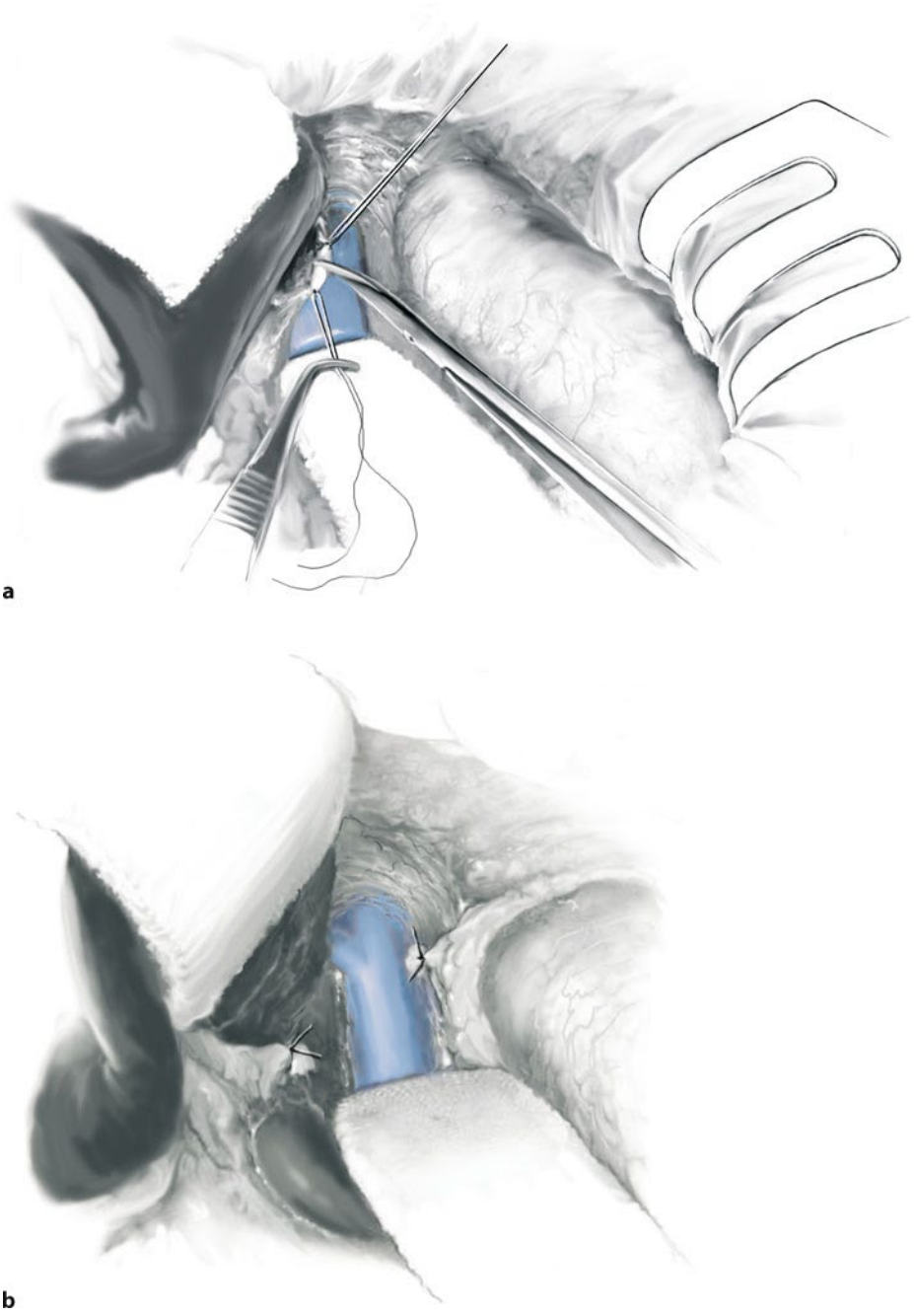


Fig. 63.2

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Step 3

Dissection of the hepatoduodenal ligament

The serous membrane on the ventral aspect of the hepatoduodenal ligament is detached at the level of the cystic duct and the hepatic arteries are identified. The left and middle hepatic arteries are dissected out at the hepatic hilum up to the bifurcation of the right and left hepatic artery (Fig. 63.3a). The middle hepatic artery can be cut off when it is clearly smaller than the left hepatic artery.

For a left lateral segment graft, cholangiography is performed in a puncture fashion, because the gallbladder is preserved. When the anterior aspect of the hepatoduodenal ligament is separated, the common bile duct can be identified. After the left hepatic duct is identified, a small vascular clip is placed to the predetermined cut line on the bile duct. A 24-G puncture needle with a trocar is inserted into the common bile duct and cholangiography is obtained (Fig. 63.3b). In some cases, the left hepatic duct may be located inside the hepatic parenchyma and is difficult to identify. In such cases, it can be identified during the dissection of the parenchyma.

In a full left hemiliver graft, the gallbladder is removed and the cholangiography is performed through a catheter inserted into the cystic duct. The cholangiography provides information on the biliary anatomy and helps to determine the dissection line of the left hepatic duct (Fig. 63.3c). After the cholangiography, the catheter is removed and the puncture site is closed by a 6-0 Prolene stitch. The left hepatic duct can now be encircled at the point of the predetermined cut line (Fig. 63.3d).

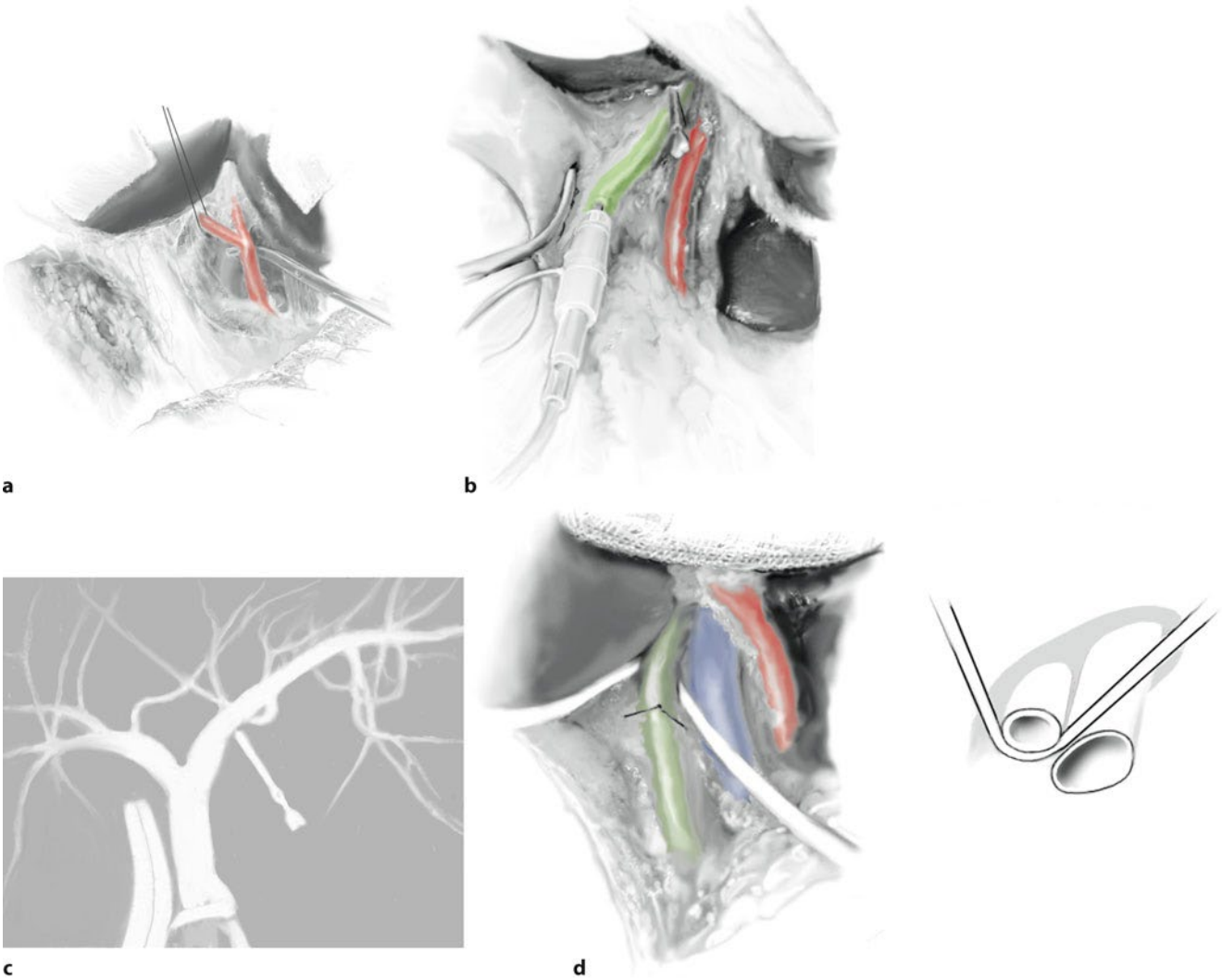


Fig. 63.3

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Step 4

Parenchymal dissection

For a Left Lateral Segment Graft (Sg2 and 3): A cutting line is marked on the surface with a cautery knife approximately 1 cm to the right of the falciform ligament (Fig. 63.4). Without any vascular obstruction during parenchymal dissection, the liver surface is incised with a cautery knife and the parenchyma is dissected with a Cavitron Ultrasonic Surgical Aspirator (CUSA) in combination with a bipolar cautery with irrigation system for hemostasis.

Small vessels are dissected with the cautery knife, whereas thicker vessels (diameter > 3 mm) are ligated or clipped. Large vessels are clamped, dissected, and suture-ligated by 5-0 or 6-0 Prolene stitches.

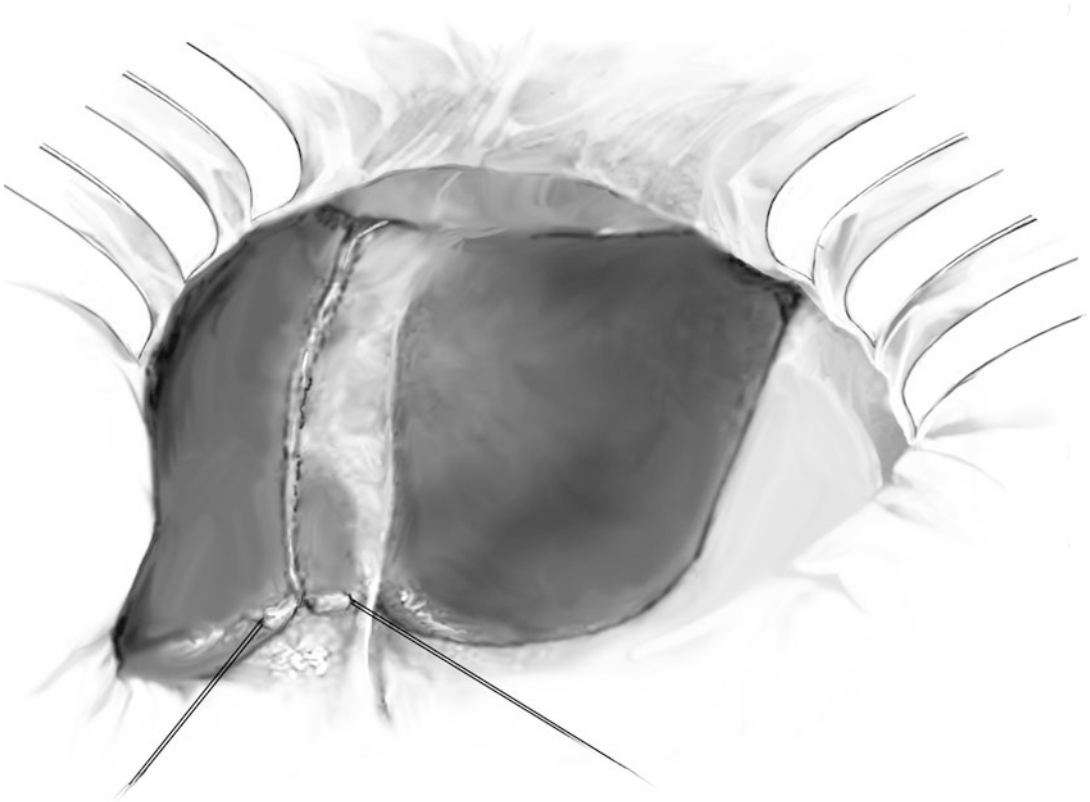


Fig. 63.4

The left hepatic duct can be found where the parenchymal dissection line meets the hepatic hilus region (right side of the left portal branch) (Fig. 63.5a). The left hepatic duct is cut at the previously determined site. The hilar plate and the stiff fibrous tissue are dissected with a cautery knife. The left hepatic duct is closed with 6-0 Prolene suture on the donor side.

In the left lateral segment graft, reconstruction of the Sg4 hepatic duct is not necessary, and it can be closed after confirming the direction. The Sg4 duct also can be closed on the donor side. It is crucial to free the left portal vein branch completely through ligation and isolation of the caudate branches. They extend from the horizontal part of the origin of the branch.

For the parenchymal dissection, curved DeBakey forceps are used as a guide. The tip of the forceps is inserted between the caudate lobe and the lateral segment from the head direction of the portal vein. The forceps are lifted and fixed. The cutting line of the parenchyma is made between the marked incision of the surface and the tip of the forceps (Fig. 63.5b).

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Step 4 *(continued)*

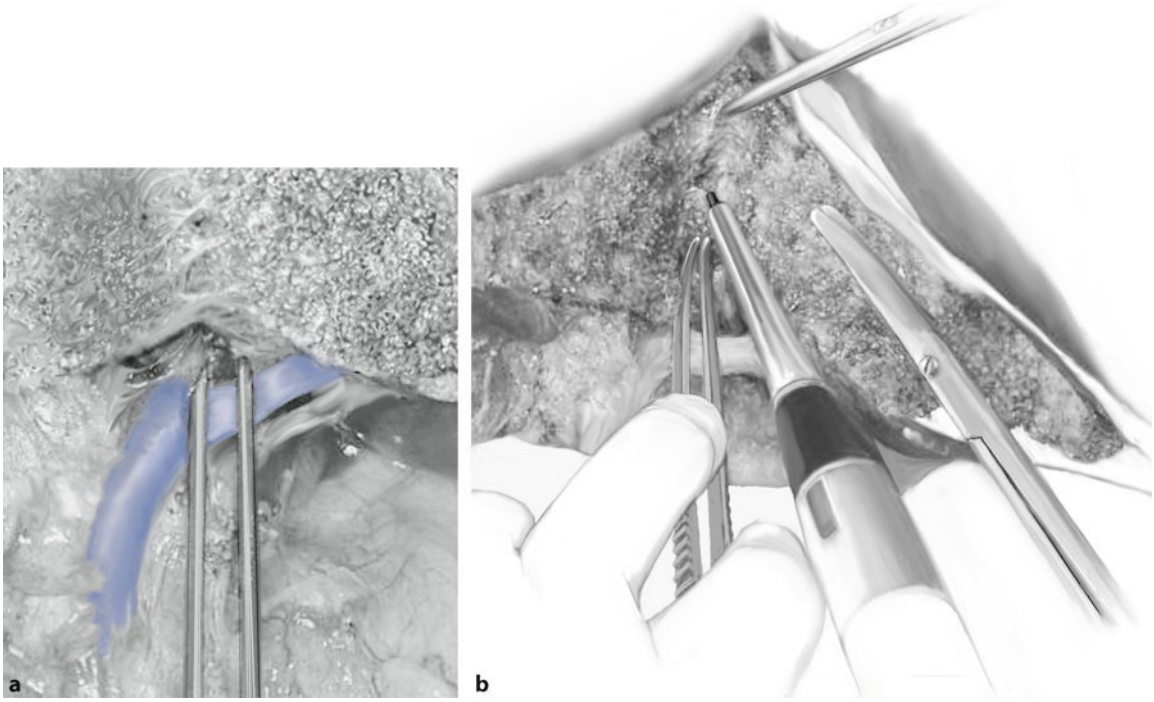


Fig. 63.5

For a Full Left Hemiliver Graft With Caudate Lobe: The plane of parenchymal dissection for a hemiliver graft with caudate lobe is straight to the anterior surface of the IVC. A hanging maneuver is useful.

For a Full Left Hemiliver Graft Without Caudate Lobe (Sg2–4): The cutting line is marked on the surface with electrocautery, starting from the right side of the middle hepatic vein to the liver bed of the gallbladder. The location of the middle hepatic vein is confirmed with ultrasonography before parenchymal dissection. The cutting line on the posterior side starts from the liver bed and reaches to the right side of the predetermined cutting point of the left hepatic duct (Fig. 63.6).

The parenchymal dissection follows the sagittal plane from the top surface to the level of the middle hepatic vein (*line 1*). When the entire middle hepatic vein is included in the graft side, the direction of the dissection is changed in an oblique plane (*line 2*). To prevent injury of the middle hepatic vein and its small venous branches, some parenchymal tissue should be left on the middle hepatic vein. After dissection of the left hepatic duct, the direction is changed toward the space between the lateral segment and the caudate lobe (*line 3*). The curved DeBakey forceps are useful as a guide, as in left lateral segmentectomy.

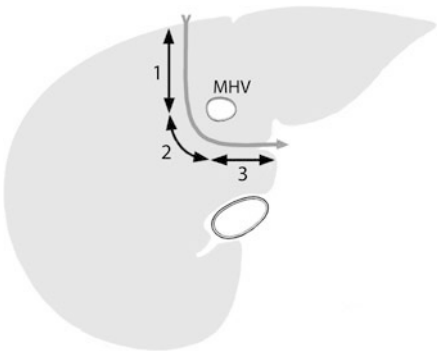


Fig. 63.6

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Step 5

Preparation of the hepatic veins

The tissue around the hepatic veins is separated, and the confluence of the left hepatic vein and the middle hepatic vein is exposed using the CUSA. Small branches around the confluence should be stitched with 6-0 Prolene suture and divided. Do not use hemostatic clips, as they may interfere with the vascular clamp. The tissue around the IVC cranial to the root of the left hepatic vein is separated to extend the neck of the hepatic vein (Fig. 63.7).

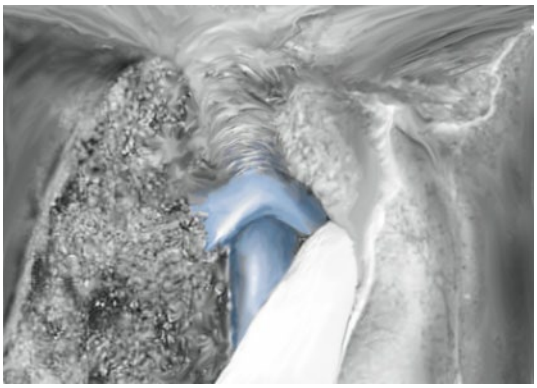


Fig. 63.7

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Step 6

Perfusion and removal of the graft

After accomplishing the parenchymal dissection, the donor is systemically administered 1000 units of heparin. The left hepatic artery is clamped with two clips and divided. The anterior wall of the left portal vein is opened and the tip of the catheter for perfusion is inserted into the lumen. Subsequently the left portal vein is divided (Fig. 63.8a). The left hepatic vein is clamped with a spoon clamp and divided. Immediately after dividing the left hepatic vein (Fig. 63.8b), the graft is perfused with preservation solution (histidine-tryptophan-ketoglutarate [HTK] or University of Wisconsin [UW] solution) (Fig. 63.8c). The artery is not rinsed. The hepatic duct is washed with the solution.

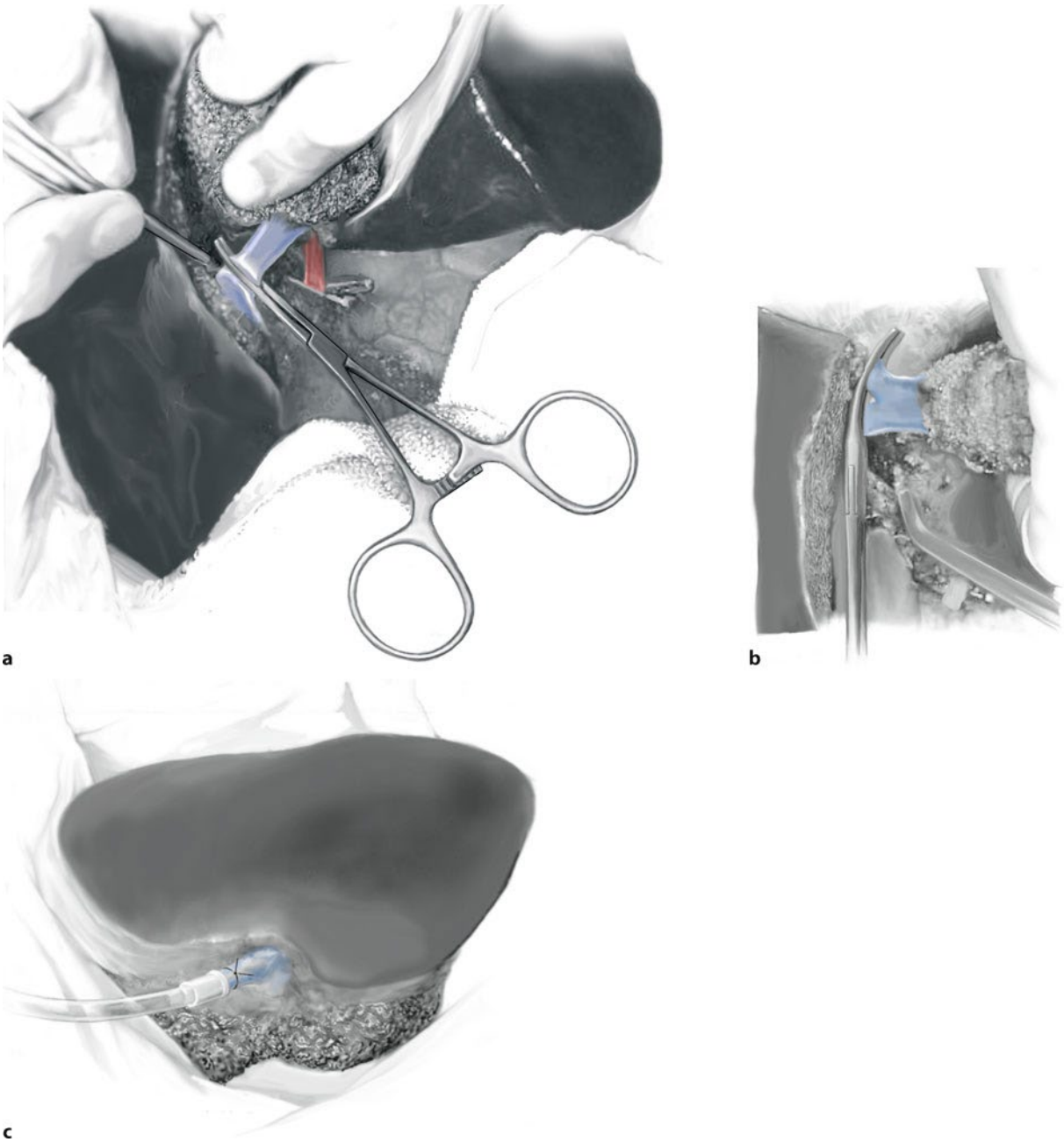


Fig. 63.8

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Step 6 ***(continued)***

The donor hepatic vein is closed with 5-0 Prolene, the donor portal vein with 6-0 Prolene, and the donor hepatic artery with 6-0 Prolene suture or 3-0 silk double ligation. If the left hepatic vein has a septum close to the orifice, it is cut sharply with scissors and sutured to make a single orifice with a long enough cuff (Fig. 63.9).

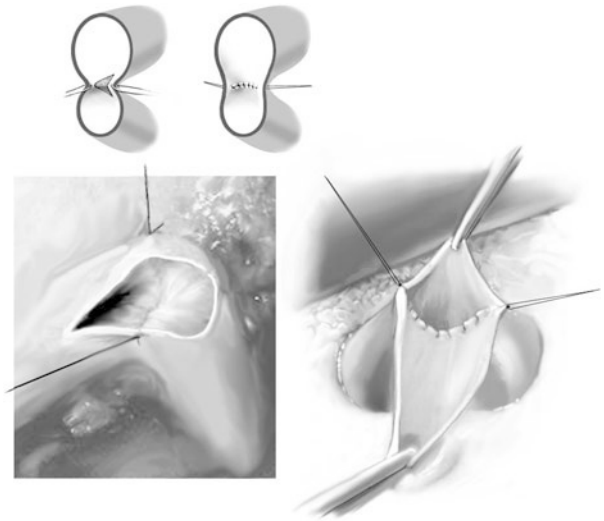


Fig. 63.9

Venous Patch for the Hepatic Vein: To make a hepatic vein anastomosis with a large orifice and a flexible wall, a piece of venous patch, which is usually made from the portal bifurcation or the hepatic vein of a recipient, is sewn to the anterior wall of the hepatic vein. The patch is trimmed in a cashew-nut shape.

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Implantation of Left Living-Donor Liver Grafts

Step 1

Access and hilar dissection

A bilateral subcostal incision with an upper midline extension to the xiphoid is the preferred access. The most important point to consider during the hilar dissection in living-donor liver transplantation is to leave the pedicle of the vessels and bile duct with the greatest possible length, because they are much shorter than those in a cadaveric liver graft. The hepatic arteries are dissected carefully and transected close to the liver to provide adequate length and enough options for arterial reconstruction. In children suffering from biliary atresia, the hepatic artery frequently is larger than expected. In this situation, dissection of the hepatic artery inside the liver of the recipient is required to adjust the size of the hepatic artery between the graft and the recipient. Double ties on the proximal side of the hepatic arteries are recommended to prevent injury to the intima. The first ligation is done loosely, just to occlude the lumen, with 4-0 silk. The second tie is placed tightly just distal to the first.

The portal pedicle is elongated by dissecting the tissue around the portal vein up to the confluence of the superior mesenteric and splenic veins. Removal of the lymph nodes around the portal vein is helpful, as it provides the desired smooth curve of the portal vein. The portal flow should be confirmed by unclamping the portal vein. The left gastric vein is divided routinely to increase portal flow (Fig. 63.10).

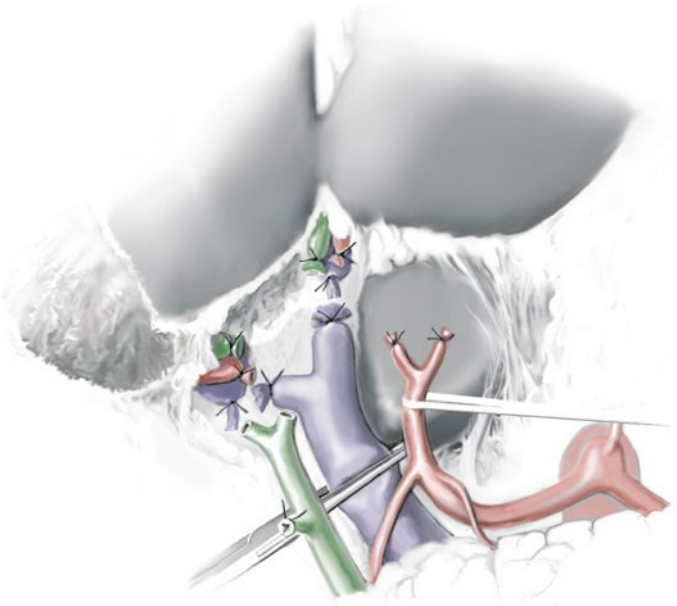


Fig. 63.10

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Step 2

Reconstruction of the hepatic vein

We have three standard procedures for hepatic vein reconstruction in left-sided graft implantation (Fig. 63.11): one orifice using all of the hepatic veins; the left and middle hepatic vein orifices and an additional incision of the IVC; and the right hepatic vein and an additional incision of the IVC.

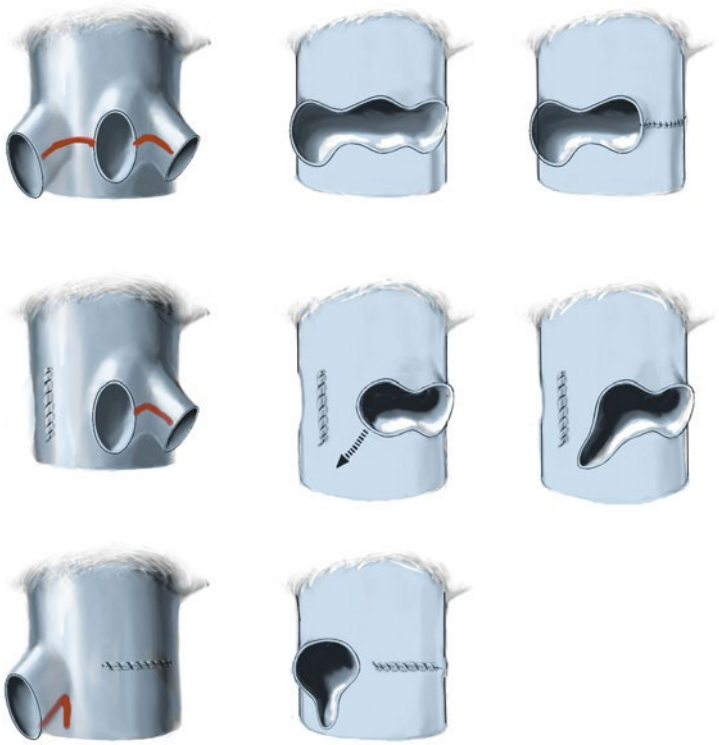


Fig. 63.11

Preparation of a single orifice by using all of the hepatic veins is shown in the following figures: The IVC is entirely clamped to include all hepatic venous stumps (Fig. 63.12a). All septa are opened to create a single hole (Fig. 63.12b), and the size is measured (Fig. 63.12c). If the hole is too large for the hepatic vein of the graft, the diameter is adjusted by 5-0 Prolene suture at the left corner of the hole. Stitches with double-armed 5-0 Prolene or PDS are placed on the right and left corners (Fig. 63.12d). The posterior anastomosis is made by the intraluminal method. After accomplishing the anastomosis, another small vascular clamp is placed just proximal to the anastomosis and the large one is removed to resume blood flow of the IVC.

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Step 2 *(continued)*

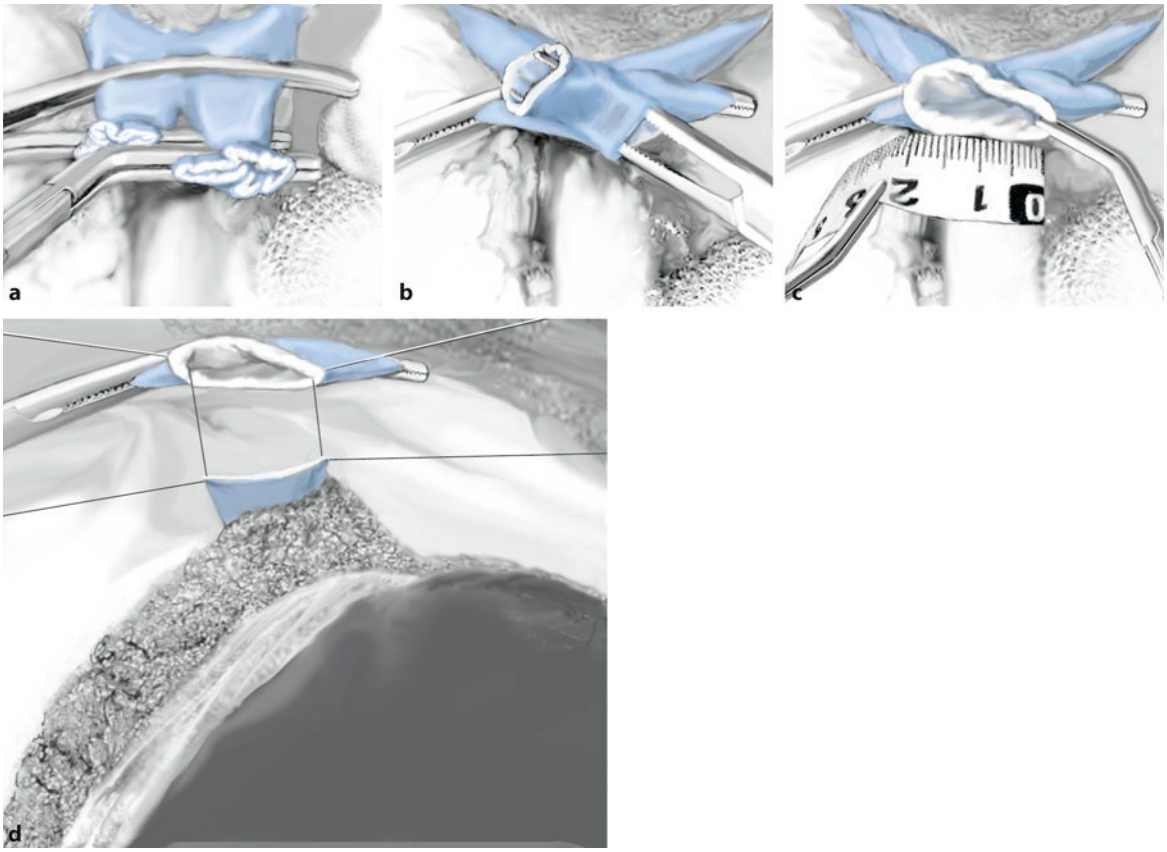


Fig. 63.12

Step 3

Portal vein anastomosis

Children with biliary atresia often have sclerotic stenosis of the portal vein. Size matching and adjustment of angle are important for sufficient portal flow. Different techniques can be used for portal vein preparation (Fig. 63.13), including: with a branch patch, with an oblique incision, by graft interposition, and by a patch graft. The first two are the simplest and most frequently used techniques to adjust the graft size of the portal vein. If the portal vein wall is damaged or narrow, it should be changed with a venous graft. When the available venous graft is too small for interposition, the patch graft technique (using a patch made from a small venous graft that is longitudinally opened) is recommended.

Before the portal anastomosis is started, the portal vein should be briefly unclamped and washed with heparinized saline to check the flow and to remove possible coagula. The anastomosis is started by placing two double-armed 6-0 Prolene or PDS sutures at the right and left corners of the graft portal vein. Anastomosis of the posterior wall is first carried out from the inside, in a running suture fashion. During the anastomosis, the suturing stitch should be kept loose to prevent anastomotic stricture (Fig. 63.14). When this technique is used, creation of a growth factor is not required.

This continuous suture is our standard technique in most cases. However, in cases of a size mismatch or a small diameter, interrupted sutures are used for the anterior wall subsequent to a running suture for the posterior wall, using 7-0 Prolene or PDS sutures.

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Step 3 *(continued)*



Fig. 63.13

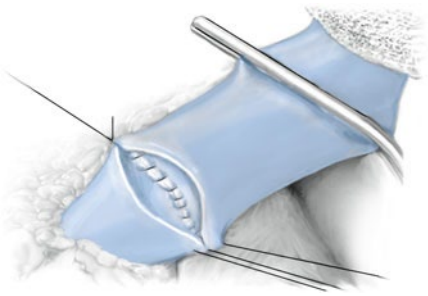


Fig. 63.14

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Step 4

Arterial anastomosis

A surgical microscope and magnifying glasses should be used to perform the arterial anastomosis. First, excellent front flow of the recipient artery must be confirmed. Both arteries are clamped with fine vascular clips and are freed from the surrounding connective tissue with microscissors until the smooth adventitial surface is reached. The anastomosis is carried out with an interrupted 8-0 Prolene suture.

Size mismatch between the graft and recipient artery is frequently encountered. In most cases it can be managed by simple mechanical dilation of the smaller artery using fine forceps. When the mismatch is significant, several techniques for adaptation can be used. In cases of multiple arteries, a larger one is chosen for the first anastomosis. When excellent arterial backflow is observed from the second artery after the first anastomosis, the second artery can be ligated (Fig. 63.15).

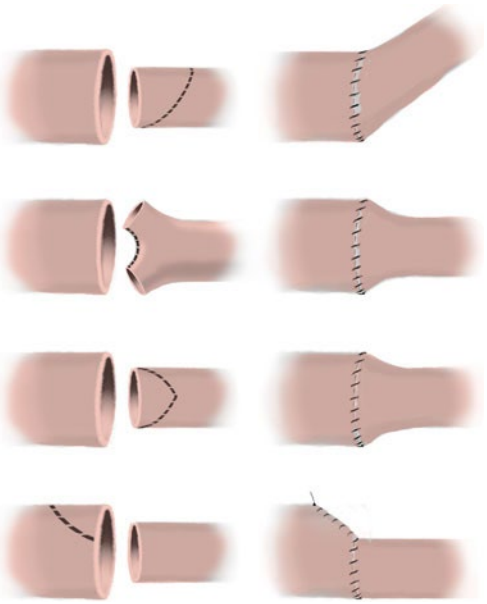


Fig. 63.15

Step 5

Biliary anastomosis

In patients with biliary atresia, in pediatric patients with small-diameter bile ducts, or in patients with primary sclerosing cholangitis and a sclerotic common bile duct, a hepaticojejunostomy should be performed. In other patients, a duct-to-duct anastomosis can be performed in a similar way as for orthotopic or right living-donor liver transplantation.

A small hole is made in the Roux-en-Y limb close to the proximal end. A 4-Fr polyvinyl alcohol tube is inserted through the hole into the intestinal lumen as an external stent and is led out of the intestinal wall again. Two double-armed 6-0 PDS sutures are placed on the right and left corners of the graft hepatic duct. The stitch of the right corner is pulled with a small clamp to open the hepatic duct. Anastomosis of the posterior wall is made first with a running suture using the stitch of the left corner (Fig. 63.16a). After completion of the posterior wall, the inside needle of the stitch of the right corner of the graft is passed through the corner of the jejunum from inside to outside. After insertion of the tip of the stent into the duct lumen, anastomosis of the anterior wall is made using another needle of the left corner in running fashion or in intermittent fashion (Fig. 63.16b). When the diameter of the hepatic duct is small, an incision on the anterior wall along the axis can be used to enlarge it.

In a full left-liver graft for an adult patient, a duct-to-duct anastomosis in intermittent fashion is preferred. Three double-armed 6-0 PDS sutures are placed at 12, 5:30, and 6:30 o'clock. First, several 6-0 PDS sutures are placed between the sutures at 12 and 6:30 o'clock. A 4-Fr polyvinyl alcohol tube is inserted through the anastomosis and is led out of the common bile duct. Then the

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Step 5 ***(continued)***

hepatic duct between the sutures at 12 o'clock and 5:30 o'clock is sutured in intermittent fashion. All knots are placed outside.

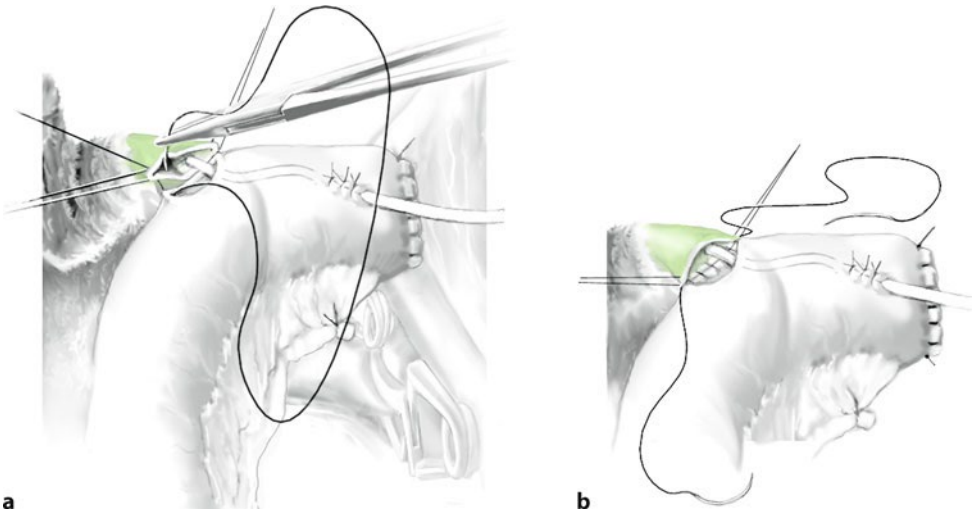


Fig. 63.16

Tricks of the Senior Surgeon

- Preparation of the hepatic artery for a left lateral segment liver graft: If a small middle hepatic artery disturbs the hilar dissection, it can be cut after confirmation of a sufficiently large left hepatic artery. By contrast, the left hepatic artery should be kept until the anatomy of the left and middle hepatic artery is clarified, even if it seems too small for anastomosis.
- Preparation of the hepatic duct for a left lateral segment liver graft: When the left hepatic duct is cut above the B4 bifurcation to preserve it for the donor, the result is likely to be two separate bile ducts (B2 and B3), which would complicate the biliary anastomosis. Therefore, we recommend the preparation of a single biliary orifice even if B4 needs to be sacrificed for this purpose. Because the inflow to Sg4 is usually limited, it usually shrinks, which leads to a compensatory enlargement of the remnant liver. Hence, the occlusion of B4 will not be a problem for the recipient.
- "Monosegment grafts": If the lateral segment is too large, the graft can be reduced by cutting the lateral half or two thirds. If this reduced graft is still too large, the caudal one third can be removed.
- To prevent twisting of the hepatic vein secondary to dislocation of the graft into the right subphrenic space, the falciform ligament should be reattached before the abdomen is closed.

Acknowledgments

We would like to acknowledge Koichi Tanaka, who co-authored this chapter in the first edition of this Atlas.

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Auxiliary Liver Transplantation

Karim Boudjema, Laurent Sulpice

The principle of auxiliary liver transplantation is the implantation of a right or left hemiliver into the abdominal cavity to restore normal liver function temporarily, while the native liver recuperates. Once the native liver has recovered, the graft can be removed, or it can be left in place without immunosuppression, leading to atrophy.

Indications and Contraindications

Indications

- Fulminant and subfulminant liver failure (approximately 5 % of all liver transplant indications) as defined by the King's College or the Clichy criteria
- Fulminant rather than subfulminant form of acute liver failure (interval jaundice/encephalopathy < 2 weeks)
- Preferentially acute liver failure due to viral hepatitis (A and B), mushroom intoxication, or drugs that are known to induce reversible acute liver failure (e. g., paracetamol)

Exclusion Criteria

- General contraindications to transplantation
- Presence of fibrosis (or cirrhosis) on a frozen section biopsy performed during the procedure

Special Considerations

- Because there is not enough space in the abdominal cavity to harbor two entire livers, the graft must be reduced.
- The reduced liver graft can be implanted heterotopically (i. e., below the native liver), but this technique may lead to a portal steal syndrome and may compromise graft vascularization.
- Orthotopic implantation of the graft is more physiologic and is widely accepted as the standard technique. It implies resection of a native hemiliver. Consequently, two types of auxiliary partial orthotopic liver transplantation (APOLT) can be performed, depending on the type of graft that is used:
  - Right APOLT (Fig. 64.1a): right hemihepatectomy of the native liver and implantation of a right liver graft (Sg5, 6, 7, and 8 and right part of the dorsal sector).
  - Left APOLT (Fig. 64.1b): left hemihepatectomy of the native liver and implantation of either a left lateral section (Sg2 and 3) or a left hemiliver (Sg2, 3, and 4).
- The liver graft can be harvested from a living donor or a cadaveric donor. When harvested from a cadaveric donor, the liver can be split in situ or ex situ.
- Two teams are mandatory and work simultaneously: a donor team, which procures and splits the graft, and a recipient team, which fits up the recipient abdominal cavity and performs the transplantation.

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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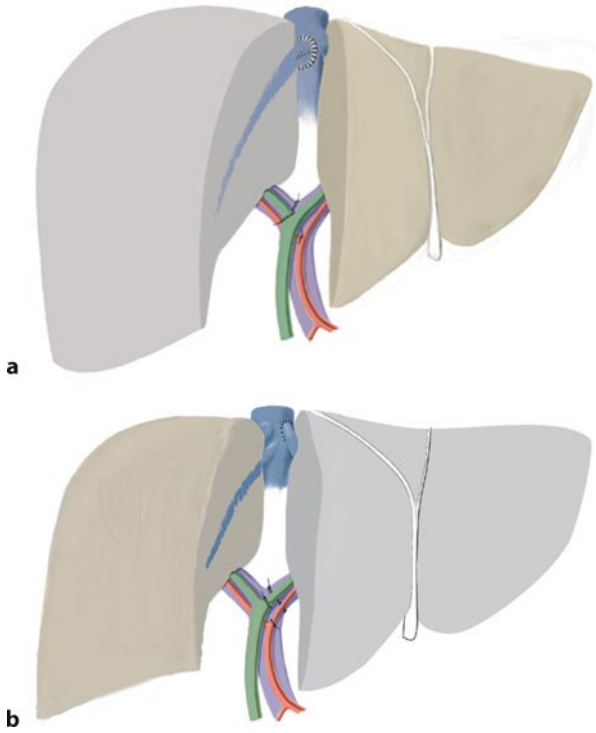


Fig. 64.1

Procedure: Right Auxiliary Partial Orthotopic Liver Transplantation

Right APOLT is recommended for adult patients in order to raise the graft weight/patient weight ratio above 1 %. This part of the procedure mimics the removal of a right living-donor graft except that it can be performed under selective occlusion of the right portal triad.

Step 1

Exploration, mobilization, and resection of the native right hemiliver

After visual and manual exploration of the liver and the entire abdominal cavity, the vascular structures (median hepatic vein and its branches from segments V and VIII) are evaluated by ultrasound with a special emphasis on anatomical variations that may complicate the procedure, such as the absence of a right portal trunk. Next, a wedge biopsy is performed for the evaluation of fibrosis, as the presence of fibrosis or cirrhosis is a contraindication for auxiliary liver transplantation. Parenchymal necrosis is common, and its intensity does not necessarily predict the likelihood of recovery.

After cholecystectomy, the right hemiliver is mobilized. Of note, the distal end of the right hepatic vein can be encircled from below using a lace, but it should not be transected at this stage.

The lateroposterior peritoneal sheath of the right part of the hepatoduodenal ligament is opened and the right hepatic artery is gently dissected from behind the common hepatic duct up to its bifurcation and marked with a vessel loop. The right branch of the portal vein is cautiously freed from the hilar plate. This maneuver cannot be performed safely without having controlled and cut one or two small branches to the caudate process. The vein is also marked with a vessel loop.

The right hepatic artery and the right portal vein are temporarily occluded with vascular clamps in order to reveal the demarcation line between the left and right hemiliver. Then both vessels are divided between ligatures, as distally as possible.

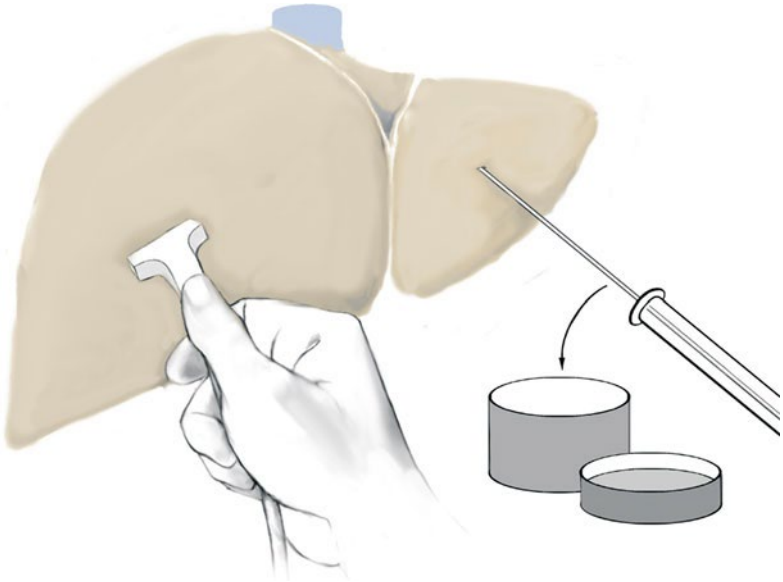
The right hepatic duct should not be isolated extrahepatically. It can easily be transected during the parenchymal dissection.

The liver parenchyma is transected 1 cm to the right of the main portal fissure, preserving the median hepatic vein. Transection is conducted posterior to the retrohepatic vena cava, and the

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Step 1 ***(continued)***

right hepatic duct is divided through the liver parenchyma at the confluence of its anterior and posterior branches. The bile duct from segment 1 is carefully preserved. Then, the right hepatic vein is transected by means of a vascular stapler (or another technique; see ▶ Chap. 71, "Right Hepatectomy with Bile Duct Resection"). At the end, the retrohepatic segment of the inferior vena cava (IVC) is widely exposed, ready to receive the right hepatic graft (◘ Fig. 64.2).



◘ Fig. 64.2

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Step 2

Preparation of the right liver graft

A right cadaveric graft is ideally split in situ. If it is split ex situ, the median hepatic vein should be preserved on the graft side in order to avoid congestion and bleeding of the graft cut surface at the time of revascularization. As shown in Fig. 64.3a, the graft includes:

- Segments 5–8.
- The right branch of the hepatic artery.
- The right branch of the portal vein.
- The right hepatic duct(s) along with the confluence and the common hepatic duct.
- The right and median hepatic vein both attached to the retrohepatic IVC. Because the left hepatic vein has been divided by retaining a narrow patch from the common trunk, the defect must be closed by transverse suture.

In a right living-donor graft (see also ▶ Chap. 62 and 63 on living donor liver transplantation), the retrohepatic vena cava, median hepatic vein, and extrahepatic biliary tract must stay on the donor side. Consequently, as shown in Fig. 64.3b, the graft includes:

- Segments 5–8
- The right branch(es) of the hepatic artery
- The right branch(es) of the portal vein
- The right hepatic duct(s)
- The right hepatic vein

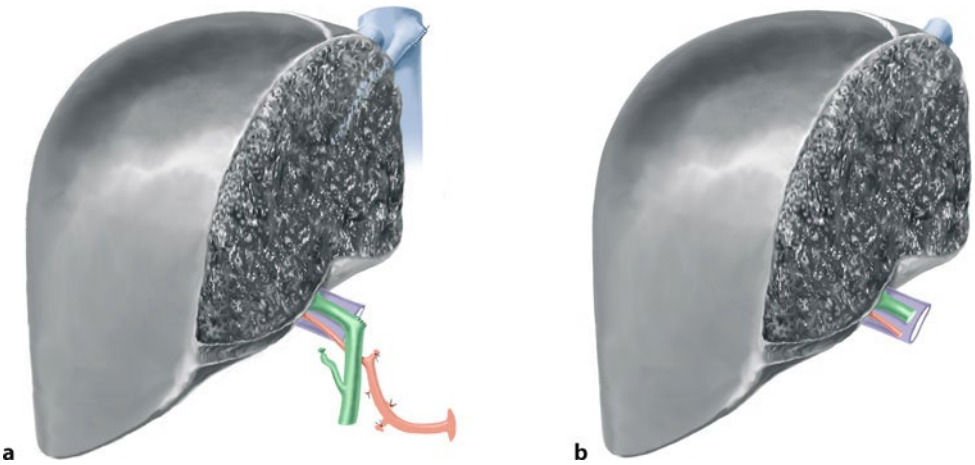


Fig. 64.3

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Step 3

Implantation of a right liver graft: caval anastomosis

With a cadaveric graft, a caval implantation is performed. The native IVC is clamped laterally and opened for about 5 cm, including the ostium of the right hepatic vein. The left side of the graft IVC is widely opened and a side-to-side cavocavostomy is performed with continuous 4-0 Prolene suture. While the posterior layer is stitched, the graft is flushed with Ringer's or 4 % albumin solution.

Implantation of a right liver graft from a living donor differs from cadaveric graft implantation at this step only. Because the IVC has been left to the donor, the graft's right hepatic vein is implanted in an end-to-side fashion to the recipient IVC (Fig. 64.4).

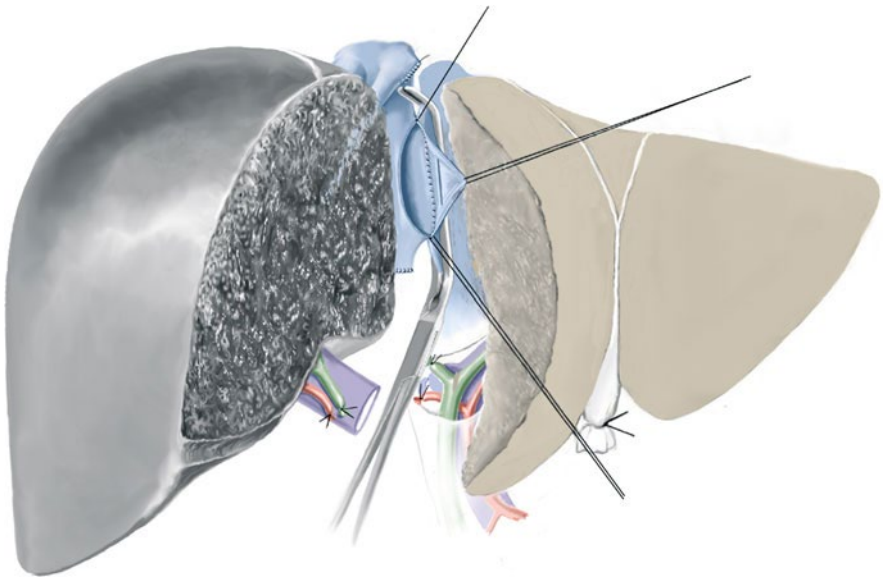


Fig. 64.4

Step 4

Portal vein and arterial anastomosis in implantation

The native right portal branch stump is clamped at its origin, and it is widely opened. The length of the graft portal vein is accurately adjusted in order to avoid tearing or kinking. An end-to-end anastomosis is performed between the donor and recipient right portal branch with a 5-0 or 6-0 Prolene running suture, leaving a growth factor of about 5 mm. The graft is then revascularized and careful hemostasis is performed.

The standard artery reconstruction is an end-to-end anastomosis between the donor and recipient right hepatic artery, using separate stitches of 8-0 Prolene. Donor saphenous vein interposition may be necessary to implant the graft artery more proximally on the recipient celiac axis (Fig. 64.5).

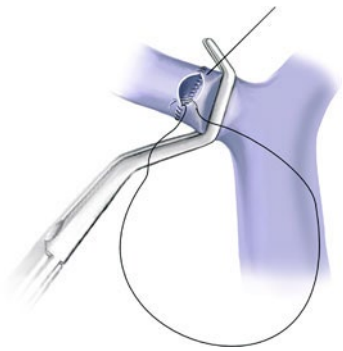


Fig. 64.5

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Step 5

Reconstruction of the biliary tract

After careful hemostasis, a standard, direct duct-to-duct anastomosis with separate PDS 6-0 stitches is performed and a T-drain is inserted. If a standard choledochocholedochostomy cannot be performed, a Roux-en-Y hepaticojejunostomy would be performed (Fig. 64.6).

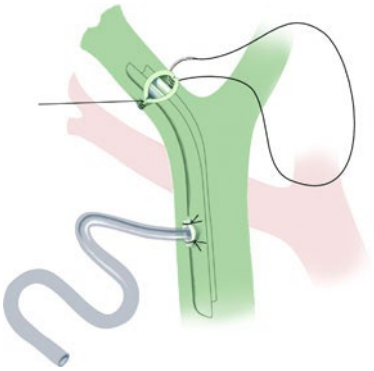


Fig. 64.6

Procedure: Left Auxiliary Partial Orthotopic Liver Transplantation

Left APOLT is recommended for children because an adult right liver graft may be too large. An adult left lobe or left hemiliver graft is sufficient to provide a graft weight/patient weight ratio above 1 %.

Step 1

Removal of the native left hemiliver and preparation of the graft

The resection of the native left hemiliver can be performed under selective occlusion of the left portal triad (see ▶ Chap. 49, "Segmentectomies, Sectionectomies, and Wedge Resections") and includes resection of segment 1 with preservation of the median hepatic vein in the right hemiliver. The left side of the retrohepatic segment of the IVC is widely exposed to facilitate the left hepatic graft implantation.

For the preparation of the graft, resection of segment 1 is recommended, regardless of the type of graft (Sg2 and 3 or left hemiliver) or the type of donor (cadaveric or living). Left grafts include the left branch of the hepatic artery (living donor) or the entire hepatic artery including the celiac trunk (cadaveric donor); the left branch of the portal vein; the left hepatic duct; and either segments 2 and 3, drained through the left hepatic vein (left lateral section), or segments 2, 3 and 4, drained through the left and the median hepatic vein (left hemiliver graft) (Fig. 64.7). The retrohepatic IVC is never left attached to the left graft.

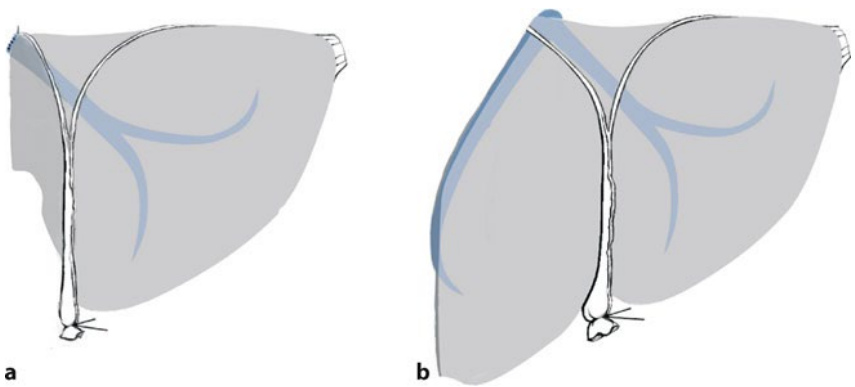


Fig. 64.7

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Step 2

Implantation of left liver grafts

The native IVC is clamped anterolaterally, using the remaining stump of the left hepatic vein to expose the vessel. Then the native IVC is opened vertically for 2 cm, beginning at the ostium of the left hepatic vein. An end-to-side anastomosis is performed using a continuous 4-0 Prolene suture between the recipient vena cava and the graft left hepatic vein or common median-left stem. The portal vein is adjusted and implanted with a growth factor as for the right side. The standard artery reconstruction is an end-to-side anastomosis between the graft celiac axis and the recipient common hepatic artery or splenic artery. End-to-end anastomosis between the donor and recipient left hepatic artery is used in case of a living-donor graft.

The standard technique for biliary tract reconstruction is a direct, duct-to-duct anastomosis, with separate PDS 6-0 or 7-0 stitches, and with insertion of a T-drain. A Roux-en-Y hepaticojejunostomy is performed if a direct anastomosis cannot be performed (Fig. 64.8).

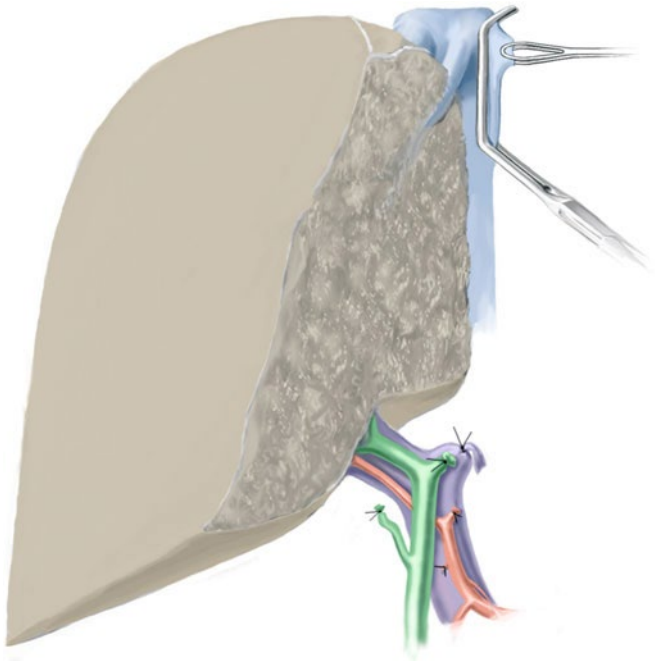


Fig. 64.8

Specific Postoperative Complications

- Primary nonfunction of the liver graft
- Bleeding from the cut surfaces of both native and auxiliary livers
- Stricture of the portal vein anastomosis and subsequent portal steal syndrome and graft nonfunction
- Hepatic artery thrombosis and subsequent biliary tract necrosis of an atrophic graft

Tricks of the Senior Surgeon

- Never start the recipient procedure before the split procedure has been shown to be anatomically feasible.
- Two teams need to work simultaneously, headed by two experienced liver surgeons.
- Never start before a biopsy of the recipient liver has been performed. Fibrosis or cirrhosis would lead to performance of orthotopic rather than auxiliary liver transplantation.

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■ Acknowledgments

We would like to acknowledge Philippe Compagnon and Jean-Pierre Campion, who co-authored this chapter in the first edition of this Atlas.

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Double Transplantation

Sung-Gyu Lee, Jung-Man Namgoong

The shortage of cadaveric donor livers has stimulated the development of advanced surgical approaches such as living-donor liver transplantation (LDLT), which produces the same results as cadaveric organ replacement. However, insufficient graft size has been a major obstacle to expanding the use of adult-to-adult LDLT when the donor graft is taken only from the left lobe. To successfully expand LDLT to adult recipients, right lobe grafts have been used, but the risk to the donor is still unknown. The safety of right lobectomy varies, depending mainly on the volume of the remaining left lobe. Although a donor has a relatively large right lobe that is suitable as a graft for a larger recipient, the remaining left lobe may be too small to maintain the donor's life in many instances. In this particular circumstance, the donor cannot be accepted to donate the left or right liver for a larger recipient. As an alternative, dual left-lobe grafts from two living donors into one recipient can make up for graft size insufficiency and secure the donors' safety.

Procedure

Step 1

Post-total hepatectomy

In the recipient operation, both the right and left branch of the portal vein and the hepatic artery are dissected free from the surrounding tissue as peripherally as possible to obtain maximal length for future bilateral vascular anastomosis (Fig. 65.1a).

After the total hepatectomy, enlarging orifice plasty of the right hepatic vein (RHV) and augmentation of the middle and left hepatic vein (MHV, LHV) trunk is performed (Fig. 65.1b).

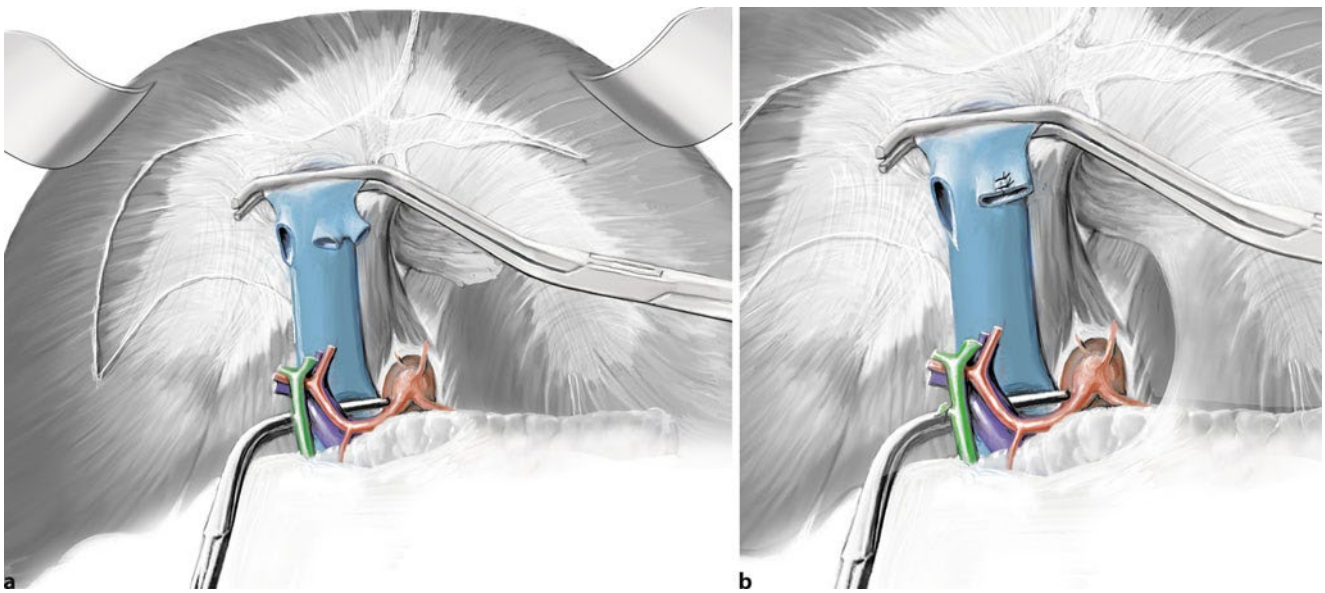


Fig. 65.1

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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Step 2

Implantation of the first graft

The first graft is orthotopically implanted at the original left position (Fig. 65.2a).

5-0 prolene is used for hepatic vein anastomosis. 6-0 prolene is used for portal vein anastomosis.

Hepatic vein anastomosis of the orthotopic liver graft is completed (Fig. 65.2b).

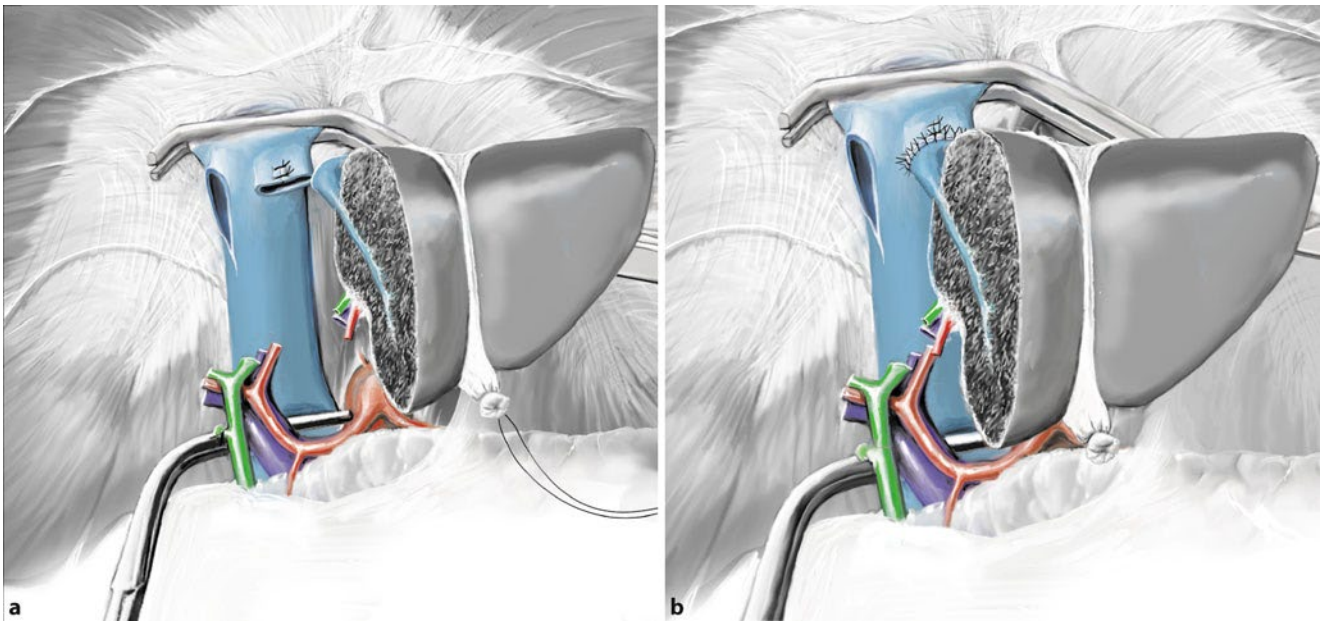


Fig. 65.2

Step 3

Positioning of the second graft

The second graft is heterotopically positioned to the right upper fossa and rotated 180°. The rotation of the heterotopic second liver graft through 180° of sagittal orientation brings the hilar structures into a reversed location. That is, the bile duct comes to lie behind the portal vein and the hepatic artery (Fig. 65.3).

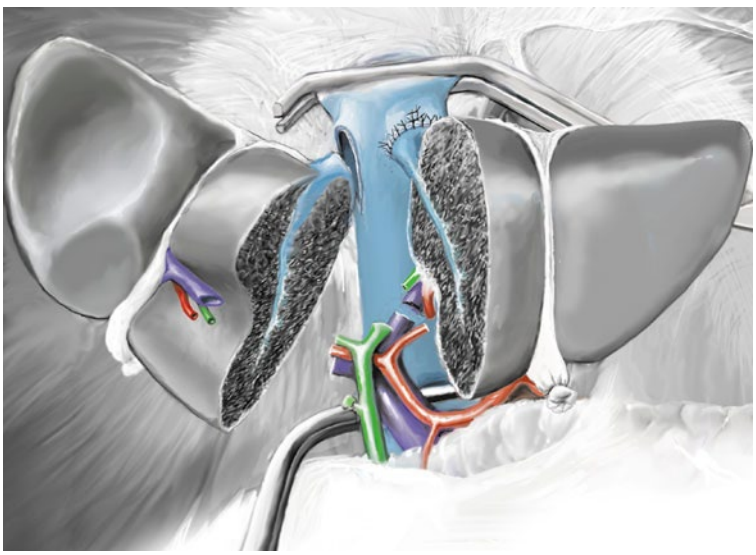


Fig. 65.3

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Step 4

Vein anastomoses

Hepatic vein anastomosis of the heterotopic left-lobe graft is performed (Fig. 65.4).

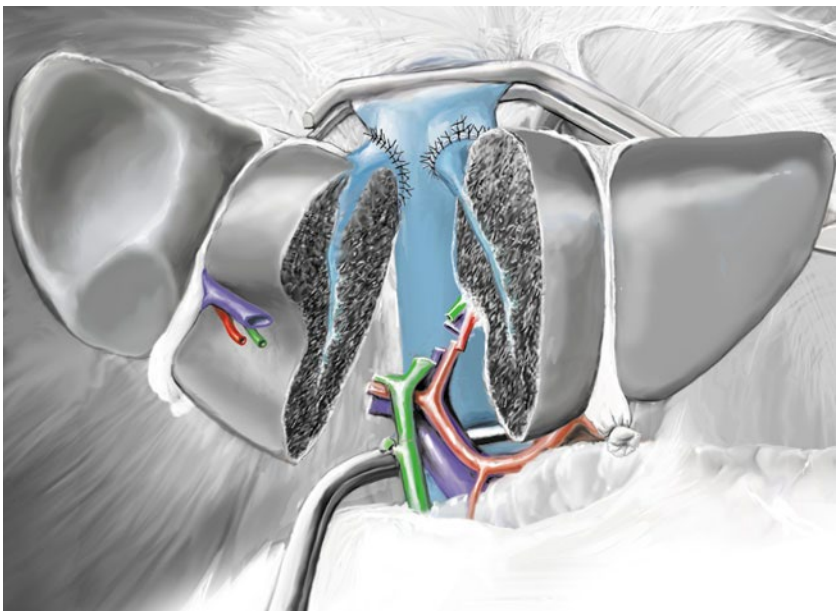


Fig. 65.4

After completion of hepatic vein anastomoses of both left-lobe grafts, the left portal vein anastomosis is made. The portal cannula for venovenous bypass is removed and followed by anastomosis between the left-sided liver graft and the left branch of the recipient's portal vein (Fig. 65.5).

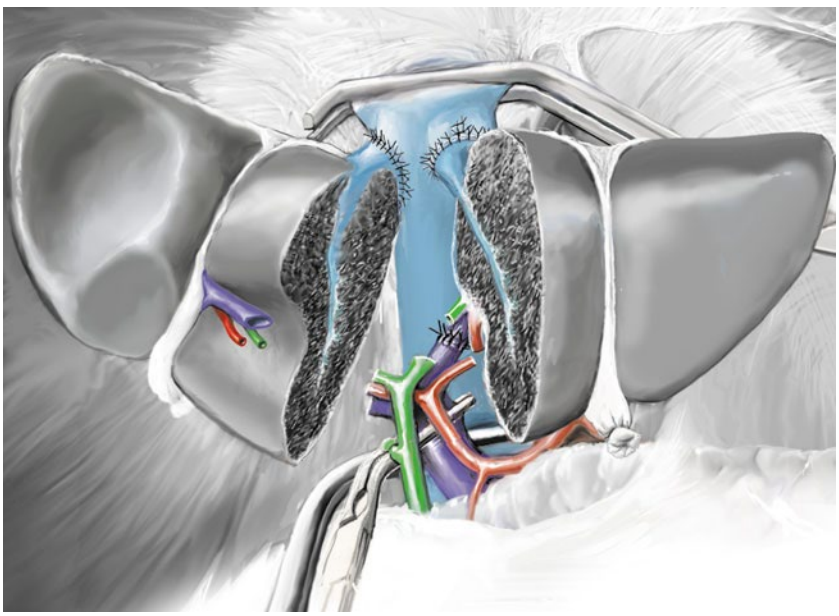


Fig. 65.5

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Step 5

Reperfusion of the orthotopic liver graft

First, the RHV clamp is applied before releasing caval clamps to prevent reflux entry of venocaval flow to the right-sided liver graft. Then, the portal vascular clamp is reapplied to the right branch of the recipient's portal vein. The vena caval vascular clamps are removed, and reperfusion of the liver graft is allowed by releasing the vascular clamp on the main trunk of portal vein. Finally, post-LPV anastomosis and reperfusion of the orthotopic left-sided liver graft is shown (Fig. 65.6).

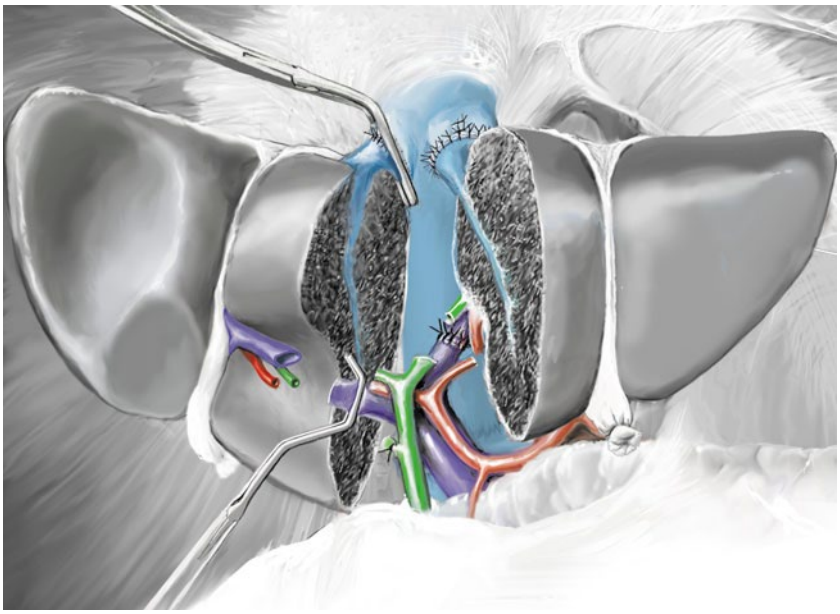


Fig. 65.6

Step 6

Reperfusion of the heterotopic liver graft

The rotation of the graft would make the future hepaticojejunostomy of the heterotopic liver graft difficult in a limited area after portal vein anastomosis is established. Therefore, the first technical modification is that the bile duct is reconstructed by duct-to-duct anastomosis, followed by the ventrally lying portal vein anastomosis (Fig. 65.7a).

The portal vein of the liver graft is anastomosed to the right branch of the recipient's portal vein (Fig. 65.7b).

Reperfusion of the heterotopic liver graft (Fig. 65.7c).

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Step 6 ***(continued)***

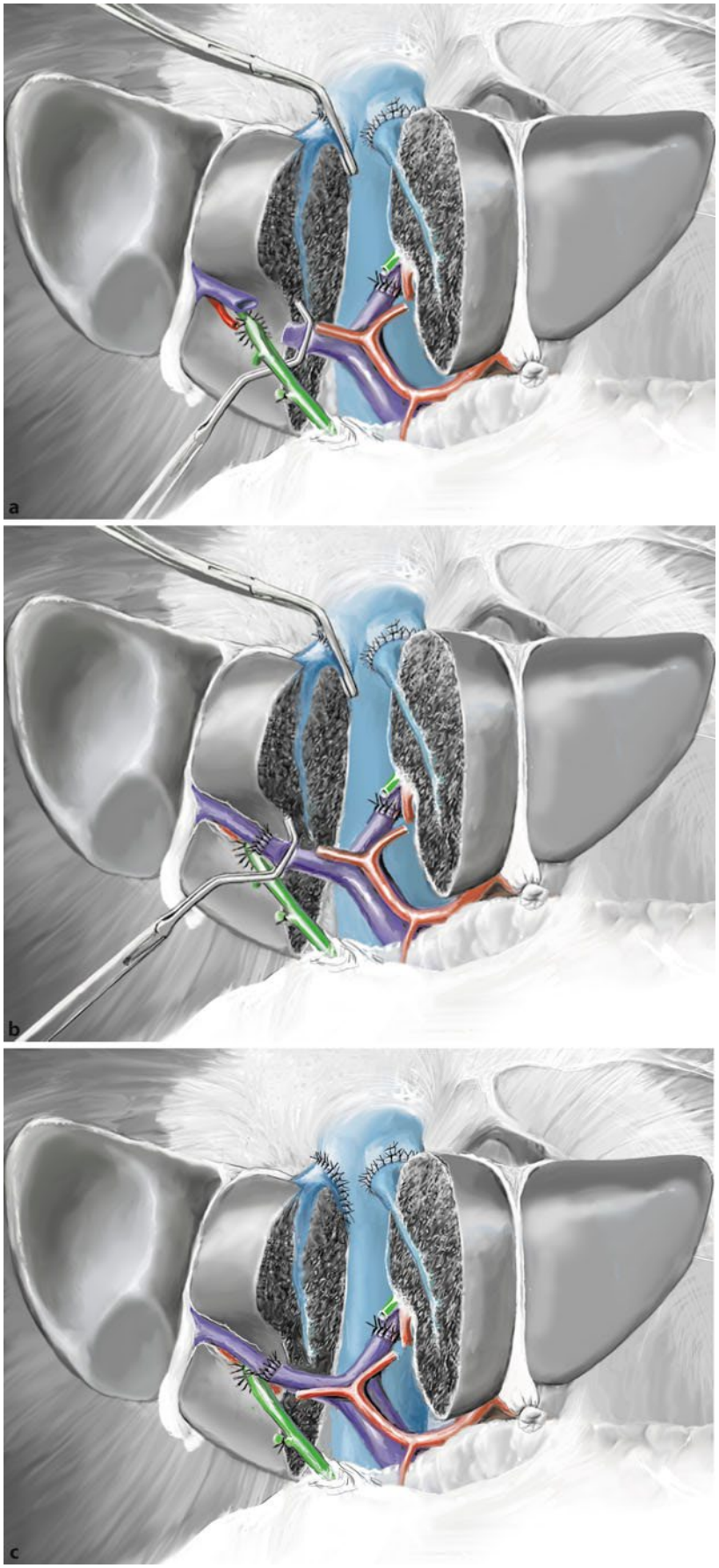


Fig. 65.7

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Step 7

Hepatic artery anastomoses

Hepatic artery anastomoses of both liver grafts are performed under microscopy (Fig. 65.8).

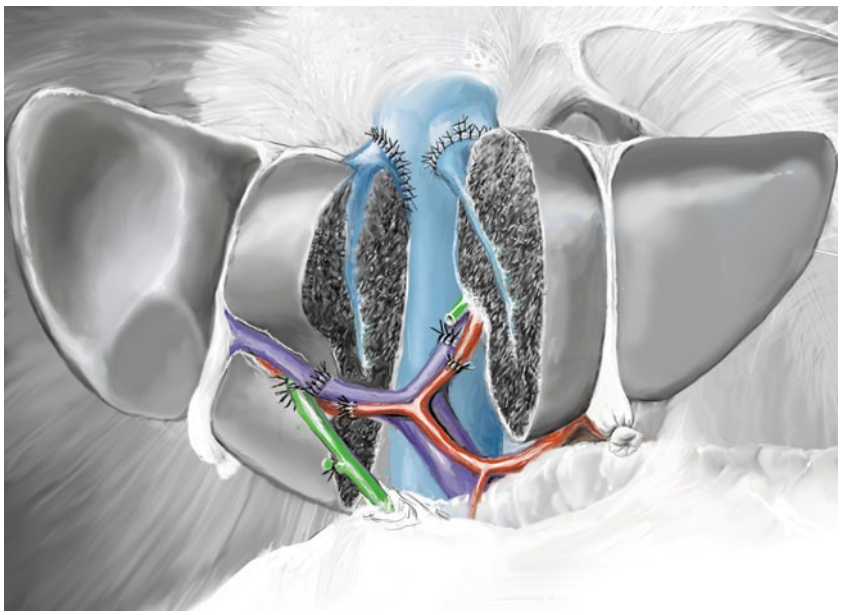


Fig. 65.8

Step 8

Insertion of a tissue expander

A tissue expander filled with saline solution (200–500 mL) is inserted underneath the second liver graft to relieve undue tension on the hilar anastomosis. The tissue expander is gradually deflated after 5 days and removed 2 weeks after transplantation. Lastly, hepatico-jejunostomy of the orthotopic liver graft is followed (Fig. 65.9).

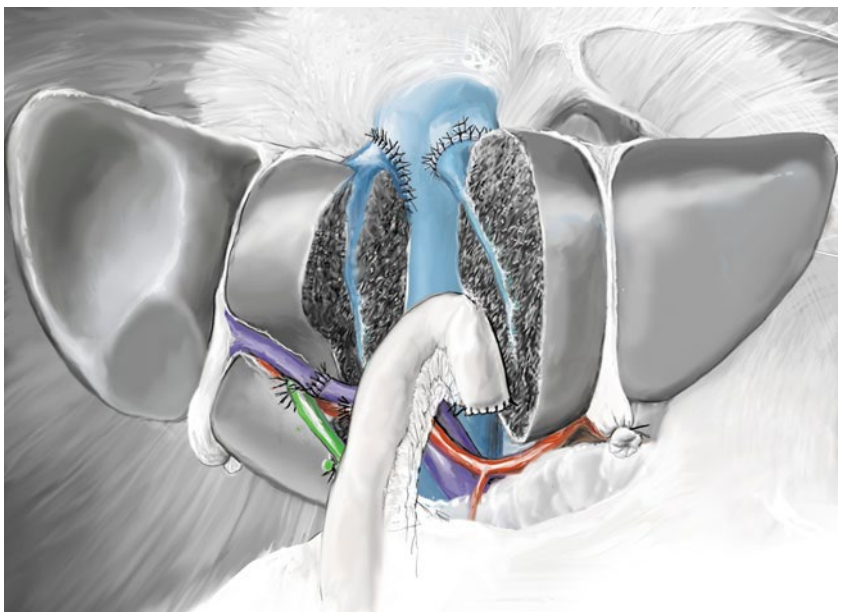


Fig. 65.9

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Tricks of the Senior Surgeon

- The 108° sagittal rotation of the heterotopic second liver graft brings the hilar structure into the reversed location. The bile duct comes behind the portal vein and the hepatitic artery.
- The bile duct has to be reconstructed first by a duct-to-duct anastomosis followed by the portal vein anastomosis lying venterally.

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Biliary Tract and Gallbladder

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Introduction: Biliary Tract and Gall Bladder

Yuman Fong, Masaru Miyazaki

Diseases of the biliary tract represent some of the most challenging problems for the surgeon. Gallstone disease is a common ailment, for which surgical treatment has been recorded since ancient times. In the following chapters, authorities in the field will describe the often-performed procedures of cholecystectomy and common bile duct exploration. Versions of these procedures performed as open surgery will be presented, as well as the laparoscopic versions, which arguably represent one of the major advances in general surgery in the past two decades. Surgery to fix bile duct injury, the most feared complication from treatment of gallstone disease, will also be presented.

Next come discussions of treatments for diseases that are much rarer: congenital malformations of the biliary tree and malignancies of the proximal/mid bile duct and gallbladder. Resections of these conditions are extremely challenging from a technical perspective. The principles, operative conduct, and "tricks of the senior surgeon" are presented by accepted masters of this trade. Distal bile duct problems are presented in the chapters on pancreatic resection. Finally, palliative bypasses for obstructions of the biliary tree are presented. These chapters describe the general approach to performing a facile biliary-enteric anastomosis, as well as methods of specific bypass procedures such as a choledochoduodenostomy or a hepaticojejunostomy. Even though biliary stent placement by endoscopic or percutaneous routes is widely used for patients who have clearly unresectable malignancies, for patients with benign disease or with disease found unresectable at surgery, such bypasses offer durable palliation with little added morbidity over the surgical exploration.

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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Laparoscopic Cholecystectomy, Open Cholecystectomy, and Cholecystostomy

George A. Fielding

Laparoscopic Cholecystectomy

Mouret performed the first laparoscopic cholecystectomy in Lyon in 1988, and the first written report was by Dubois in 1989. Reddick popularized the procedure in the United States in 1990.

Indications and contraindications

Indications

- Same as for open procedure
- One of the most important indications is that the surgeon must be adequately trained to perform the procedure
- All manifestations of symptomatic gallstones: biliary colic, history of jaundice, chronic cholecystitis, and acute cholecystitis
- Gallstone pancreatitis
- Acalculous cholecystitis
- Large gallbladder polyps

Contraindications

- There are no absolute contraindications to laparoscopic cholecystectomy
- Relative contraindications include cirrhosis and portal hypertension, bleeding diathesis, and pregnancy, but technical modifications can be made to suit these three problems

Preoperative investigation and preparation for the procedure

Preoperative investigations include liver function tests and typically an ultrasound examination. If the laparoscopic cholecystectomy is being performed for acalculous cholecystitis, patients may have had nuclear studies to assess gallbladder function.

If gallbladder cancer or big polyps are suspected, a CT scan is required.

There is no place in laparoscopic cholecystectomy for routine preoperative endoscopic retrograde cholangiopancreatography (ERCP).

The patient should have prophylactic antibiotics on induction and appropriate antithromboembolic measures.

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery*,
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Procedure

Step 1

Access

The procedure should be performed on a table allowing operative cholangiography. There is no routine need for a nasogastric tube or Foley catheter. Typically, invasive anesthetic monitoring is not required. Patients are placed supine, legs together, with a slight reverse Trendelenburg position. There is little to gain by using a steep reverse Trendelenburg position.

Safe access is attained by open insertion of a Hasson cannula through a transumbilical incision. Eversion of the umbilicus creates access via the gap in the linea alba at the base of the umbilicus. The Hasson cannula can be sat directly in the peritoneal cavity. There is no need for stay sutures or for suturing the port in place. A 30° telescope is used; insufflation pressures are set at 15 mm Hg. Placement of other access ports is as shown in Fig. 67.1.

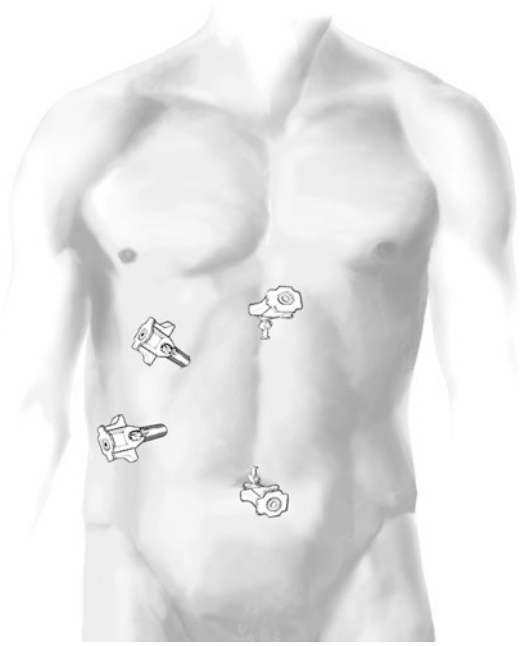


Fig. 67.1

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Step 2

Retraction and dissection of Calot's triangle

Once caudad retraction of the fundus is established, the crucial maneuver is lateral retraction of Hartmann's pouch by the upper lateral 5-mm port. This places Calot's triangle on the stretch and will greatly reduce the chance of injury of the common bile duct (Fig. 67.2).

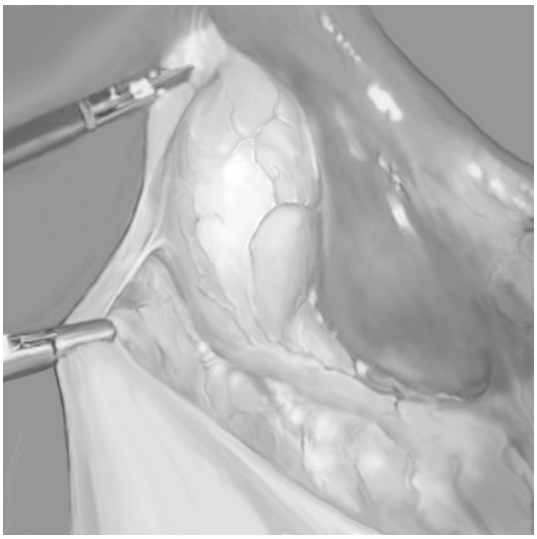


Fig. 67.2

Step 3

Then incise the posterior peritoneal attachment behind Hartmann's pouch to separate Hartmann's pouch from the liver and further stretch out Calot's triangle (Fig. 67.3).

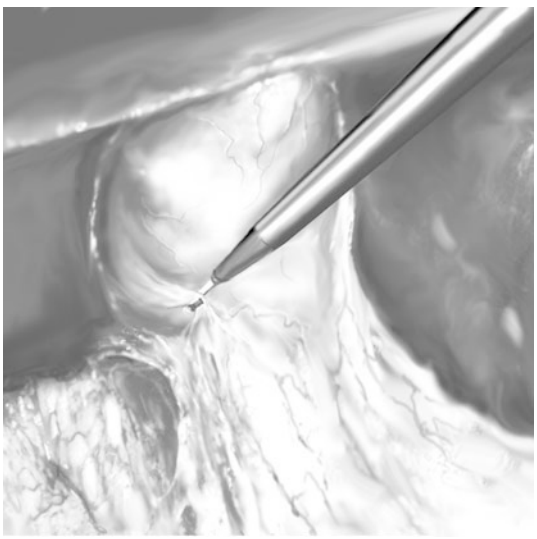


Fig. 67.3

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Step 4

Once these two maneuvers are instituted, hook dissection can be performed, staying close to the gallbladder to incise the anterior sheet of peritoneum over Calot's triangle. This will expose one or two cystic arteries and the cystic duct. Windows should be developed between all these structures before anything is divided.

Once the anatomy is determined (see sections below on Anatomical variations and Tricks), the cystic arteries are divided between clips, and a clip is placed below Hartmann's pouch to the proximal end of the cystic duct (Fig. 67.4).

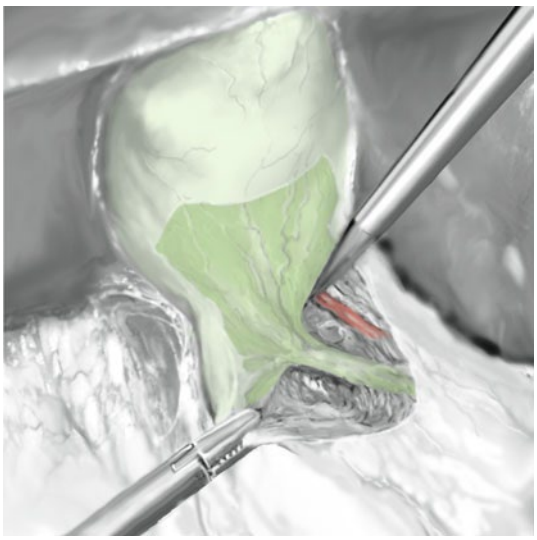


Fig. 67.4

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Step 5

Cholangiography

Lateral retraction of Hartmann's pouch is maintained by a grasper, this time coming from the subxiphoid port. The cystic duct is incised through the right (Fig. 67.5a). The cystic valve can occasionally make this difficult. A No. 4 ureteric catheter with an end hole is inserted through the Olsen-Reddick cholangiogram clamp into the cystic duct and the clamp closed around the duct (Fig. 67.5b).

Operative cholangiography is then performed with aid of C-arm fluoroscopy. Cholangiography confirms the biliary anatomy and reveals the common duct stones, allowing laparoscopic duct exploration.

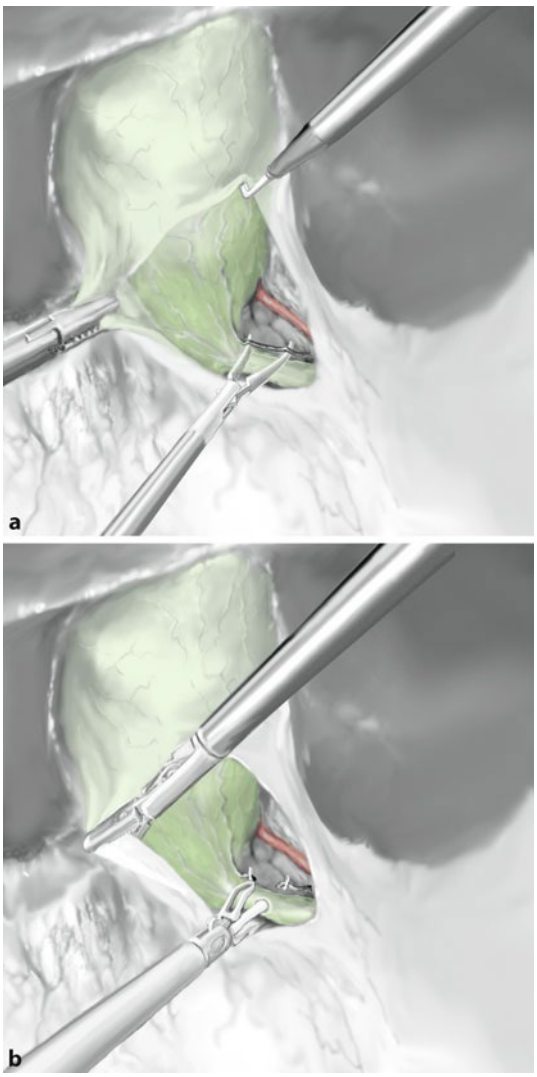


Fig. 67.5

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Step 6

Removal of gallbladder

Once cholangiography is completed, the ureteric catheter is removed and the cystic duct is clamped. The gallbladder is then removed from the liver bed using hook diathermy. This is done through a combination of elevating the peritoneum, burning with the hook, and pushing so that the gallbladder is removed toward the fundus and finally separated from the liver at the fundus. There is very little place for fundus-first laparoscopic cholecystectomy (Fig. 67.6).

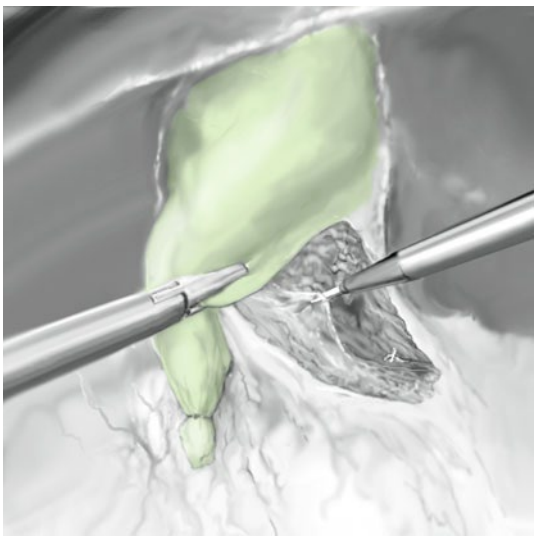


Fig. 67.6

Anatomical variations

- The major anatomical variations are involved with the common bile duct and the right hepatic artery.
- A very small common bile duct can be mistaken for the cystic duct and completely excised. Even more worrisome is the variant of a low junction of the left and right hepatic ducts (Fig. 67.7a) or a low junction of the right anterior and right posterior hepatic ducts (Fig. 67.7b). In these situations, the cystic duct can enter the right hepatic duct or the right posterior hepatic duct. The right or right posterior ducts can therefore be mistaken for the cystic duct and divided.
- More rarely (but even more difficult, particularly in the setting of acute cholecystitis), there is no cystic duct, and Hartmann's pouch opens directly underneath the right hepatic duct or the common duct.

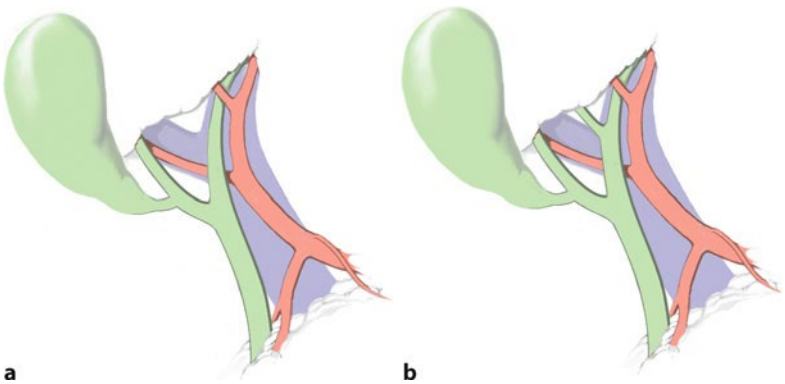


Fig. 67.7

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Intraoperative complications

- *Bleeding:* The major intraoperative complication is bleeding, typically from a very short cystic artery or from the right hepatic artery itself. Bleeding from the portal vein is very rare, but in contrast to hepatic and cystic artery bleeding, it is always torrential, and the patient must be opened.
- *Failure to progress:* The second major complication is failure to progress. If the surgeon is not making any progress, the procedure should be converted to an open cholecystectomy.
- *Bile duct injury:* Proper retraction, careful dissection, steady control of hemorrhage, and recognition of an appropriate time to convert to open cholecystectomy should minimize the chance of the most feared intraoperative complication: bile duct injury or bile duct resection. If a duct injury is recognized, the surgeon should just stop, collect his or her thoughts, and ring a hepatobiliary colleague immediately.

Postoperative complications

- Most bile leaks are low-volume and will settle spontaneously.
- A high-volume bile leak suggests that the clip has come off the cystic duct or there is a major unrecognized duct injury. ERCP will determine this, allowing appropriate management.
- Subphrenic collection may require percutaneous drainage.
- Pneumonia is best treated with physiotherapy and antibiotics.
- Jaundice suggests major duct obstruction or excision and requires ERCP or referral to a hepatobiliary specialist.

Tricks of the Senior Surgeon

- Patients with portal hypertension and cirrhosis should be considered for a partial cholecystectomy, in which the back wall of the gallbladder is left on the liver bed. Failure to do so can result in life-threatening hemorrhage. Furthermore, with laparoscopic surgery, you simply will not be able to see the operative field because of the blood.
- In severe acute cholecystitis, the first step is to decompress the gallbladder by inserting the trocar directly into the gallbladder and aspirating the contents. This will convert a tense, unmanageable gallbladder to a collapsed, thick-walled gallbladder that can be grasped and maneuvered.
- If there is a stone impacted in Hartmann's pouch, it should be pushed back into the gallbladder to allow safe manipulation of Calot's triangle.

Open Cholecystectomy

Until 1989, open cholecystectomy was the procedure of choice for all complications of symptomatic gallstones. It has largely been supplanted by laparoscopic cholecystectomy as a freestanding elective procedure. The principle of open cholecystectomy is removal of the gallbladder and its contents with preservation of the biliary tree.

Open cholecystectomy is now performed most frequently as part of other major procedures. If it is in the setting of a failed laparoscopic procedure, it is often a very difficult cholecystectomy, and it is vital in this situation to make an adequate incision.

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Indications and contraindications

Indications

- Failed laparoscopic cholecystectomy
- Whipple resection or bile duct resection as part of hepatectomy
- Patient choice
- Suspected malignant gallbladder polyp

Contraindications

- No absolute contraindications
- For a severely ill patient, a cholecystostomy may be the best option

Preoperative investigation and preparation for the procedure

- Liver function tests
- Ultrasound
- Planning of associated major procedure
- Clinical preparation and prophylactic antibiotics
- Anti-deep vein thrombosis therapy of choice

Procedure

Step 1

Operative table allowing C-arm fluoroscopy should be used. If the procedure is done for patient choice and there are no other contraindications, a 5-cm transverse incision is centered over the lateral border of the rectus sheath.

Step 2

After conversion from laparoscopic cholecystectomy, it is essential to make an adequate incision, as the main reason for conversion is an anatomical difficulty, usually in the setting of an inflamed gallbladder. A long, right subcostal incision is made a finger's width below the costal margin. The rectus sheath is divided in the line of the incision and this is taken down to the peritoneum using diathermy coagulation (Fig. 67.8).

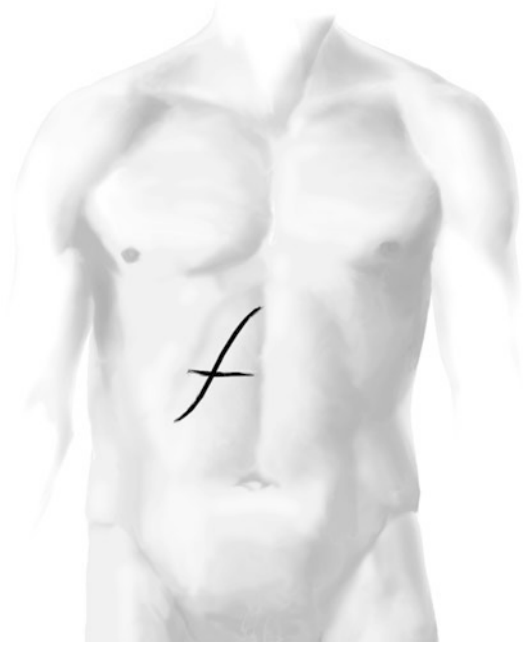


Fig. 67.8

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Step 3

The peritoneal cavity is elevated with the fingers and the wound is incised along its full length. Three packs are inserted: one behind the liver, one on the colon, and one over the gastroduodenal area. Retractors are placed over the gastroduodenal area and one over the liver, to place Calot's triangle on the stretch (Fig. 67.9).

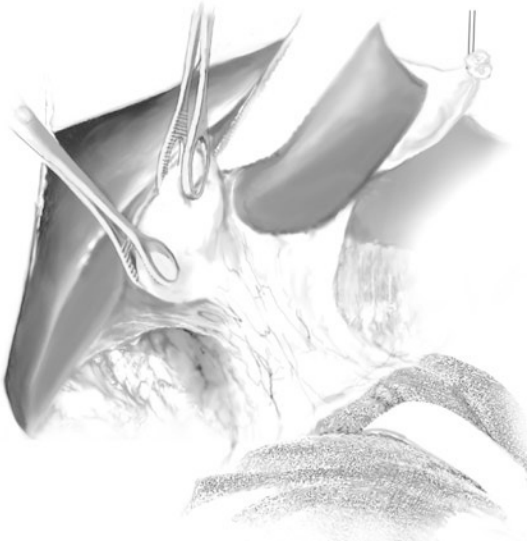


Fig. 67.9

Step 4

The key step in open cholecystectomy is division of the cystic artery, which allows Hartmann's pouch to swing out and permit clear definition of the biliary anatomy. The cystic duct is clipped and the gallbladder is retracted inferiorly and dissected free of the liver.

Cholangiography is typically performed through the cystic duct, using the same equipment as for laparoscopic cholecystectomy. Once the anatomy has been determined and cleared, the gallbladder is removed. This is typically done starting from Hartmann's pouch, but in the case of severe inflammation it may be better done with fundus-first dissection, carefully dividing in the plane between the liver and the gallbladder (Fig. 67.10).

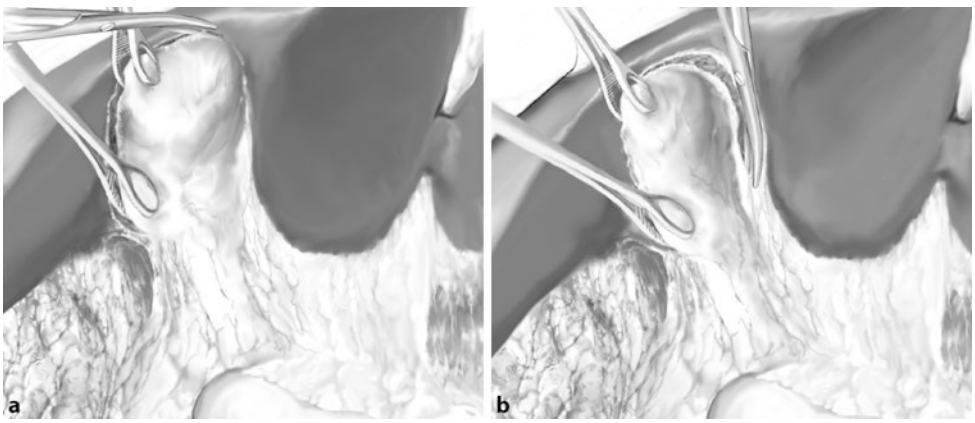


Fig. 67.10

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Complications

Complications are the same as those for laparoscopic cholecystectomy.

Cholecystostomy

Indications

- Percutaneous cholecystostomy is used most commonly in the setting of a severely ill patient with underlying gallbladder sepsis.
- Operative severe inflammation of Calot's triangle at surgery, where the safest option is to decompress the gallbladder.

Procedure

Cholecystostomy may be performed open but is much more typically found at laparoscopic cholecystectomy.

Step 1

The 5-mm lateral trocar is inserted directly into the gallbladder and the gallbladder is aspirated. The gallbladder will collapse, typically showing a large stone in Hartmann's pouch; if this stone can be milked back and removed, it should be done.

Step 2

A Foley catheter is inserted via the lateral port directly into the gallbladder. If indicated, cholangiography can be completed via this catheter.

Step 3

The trocar is removed from the gallbladder, leaving the Foley catheter in place, which is then insufflated. The gallbladder is sutured around the Foley catheter. The Foley catheter is then left on free drainage and should be left in place for at least 6 weeks, to allow the gallbladder to settle prior to completion of the laparoscopic cholecystectomy.

The Foley catheter should be irrigated twice daily with 20 mL of saline.

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Resection of Gallbladder Cancer, Including Surgical Staging

Guillaume Martel, Rebecca Auer

Gallbladder cancer is the most common malignancy of the biliary tract. Its incidence increases significantly with age, and it is two to three times more common in women. It is particularly more frequent in geographic locations such as Chile and India. The most prevalent risk factor for gallbladder cancer is cholelithiasis-associated chronic inflammation, with cancer developing in 0.3 to 3.0 % of those with gallstones. Other risk factors include cigarette smoking, chemical and drug exposures, gallbladder polyps, *Salmonella* bacterial infections, choledochal cysts and anomalous junctions of the pancreatobiliary ducts, and primary sclerosing cholangitis. Gallbladder calcification (porcelain gallbladder) has been associated with carcinoma in 15 % of patients. It is estimated that 1 % of patients undergoing cholecystectomy for gallstones are found to have cancer.

Natural History

- Patients with incompletely resected gallbladder cancer have a 5-year survival rate of less than 5 %
- Patients with complete resections have a 5-year survival rate that is dependent on the stage of disease: T2N0, 61 to 100 %; T3 and/or N1, 16 to 69 %

Indications and Contraindications for Resectional Procedures

Indications

- Gallbladder cancer with T1–4, N0/1, and M0

Relative Contraindications

- Lymph node metastases to N2 compartment
- T4 gallbladder cancer

Contraindications

- Peritoneal carcinomatosis or other distant metastases (M1)

Presentation

- Pathologic finding after cholecystectomy (0.3–1 %, commonest modern presentation)
- During surgery for presumed cholelithiasis
- Mass in segment 4/5 associated with gallbladder (can sometimes be interpreted as an abscess)
- Pain (chronic cholecystitis-like, more often constant)
- Jaundice in one third of patients

Preoperative Investigations and Preparation for the Procedure

- *History:* Biliary colic, pain, pruritus, weight loss, anorexia, previous gallbladder or biliary surgery
- *Physical examination:* Right upper quadrant mass, jaundice

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
DOI 10.1007/978-3-662-46546-2_68, © Springer-Verlag Berlin Heidelberg 2016

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- *Imaging:*
  - Ultrasound
  - Contrast-enhanced CT scan (CT angiogram is preferred)
  - Magnetic resonance cholangiopancreatography (MRCP)
  - Cholangiography (if invasive cholangiography is necessary, percutaneous cholangiography [PTC] is preferred over endoscopic retrograde cholangiopancreatography [ERCP])
  - Direct arteriography (rarely needed)
  - Important anatomic details: porcelain gallbladder, mass, enlarged/necrotic lymph nodes, arterial involvement, portal venous involvement, adjacent organ (colon, duodenum) involvement, peritoneal metastasis
  - Gallbladder polyp: solitary, sessile, large polyps (> 1 cm) are worrisome for cancer
  - Look at anomalous pancreaticobiliary duct junction, choledochal cyst, and hepatic arteries

Extent of Resection According to Stage

- Patients presenting with gallbladder mass on imaging or operative exploration:
  - *T2/3, N0/1, M0:* radical cholecystectomy and lymph node dissection
  - *Unilateral vascular involvement:* extended lobectomy and lymph node dissection
  - *T4, N0/1, M0:* extended lobectomy and lymph node dissection, possible vascular resection/reconstruction, possible adjacent organ resection
  - *N2 or M1:* no curative surgery, possible palliation by biliary or gastric bypass
- Patients with cancer discovered as an incidental finding after cholecystectomy for presumed cholelithiasis:
  - *T1a with negative liver and cystic duct margin, negative Lund's lymph node (if present):* no further therapy
  - *T1b with negative liver and cystic duct margin:* gallbladder bed resection (segments 4b and 5), lymph node dissection
  - *Any T1 with positive cystic duct margin:* gallbladder bed resection (segments 4b and 5) re-resection of cystic duct or common bile duct to negative margins, lymph node dissection
  - *T2/3/4, M0:* gallbladder bed resection (segments 4b and 5) or extended lobectomy to achieve R0, common bile duct resection, lymph node dissection, and resection of laparoscopic port sites
  - *N2 or M1:* no curative surgery (palliation)

Procedure

A radical cholecystectomy (including segments 4b and 5) resection is described. If an extended lobectomy is necessary because of the bulk of the tumor or because of vascular invasion, the dissection of the porta hepatis and hilar areas is performed as described below. With gallbladder cancer, when an extended resection is necessary, it is usually an extended right lobectomy. The liver resection is then performed as described in Part III, "Liver," after the vasculature to the left side is dissected free and protected and the left hepatic duct has been divided.

Step 1

Incision and surgical exploration

In patients with no previous surgery, a low right subcostal (hockey stick) incision is favored. (See Part I, ▶ Chap. 2 "Positioning and Accesses" for descriptions of incisions and division of falciform ligament.)

In patients with previous cholecystectomy, a subcostal incision is used to incorporate excision of previous open or laparoscopic port incisions, plus separate excision of the umbilical port.

Exposure and exploration include installation of the retractor (see Part I, ▶ Chap. 3 "Retractors and Principles of Exposure") and inspection of possible port-site and peritoneal metastasis. Ultrasound is used to evaluate the location of the primary tumor in relation to vascular structures (portal vein, hepatic artery, hepatic vein) and to rule out discontiguous liver metastases. Careful inspection of vascular variation is performed.

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Step 2

Radical cholecystectomy and regional lymph node and connective tissue dissection

The two segments (4b and 5) contiguous with the gallbladder bed are resected.

N1 lymph nodes (*blue*): those in the hepatoduodenal ligament (No. 12) and common hepatic (No. 8) and celiac arteries (No. 9) are resected. Positive N2 nodes (*red*), retropancreatic nodes (No. 13), perigastric nodes, or aortocaval nodes indicate incurable disease.

Nerve plexuses around the hepatic artery should be dissected.

Full kocherization allows inspection of these nodal stations and facilitates subsequent dissection (Fig. 68.1).

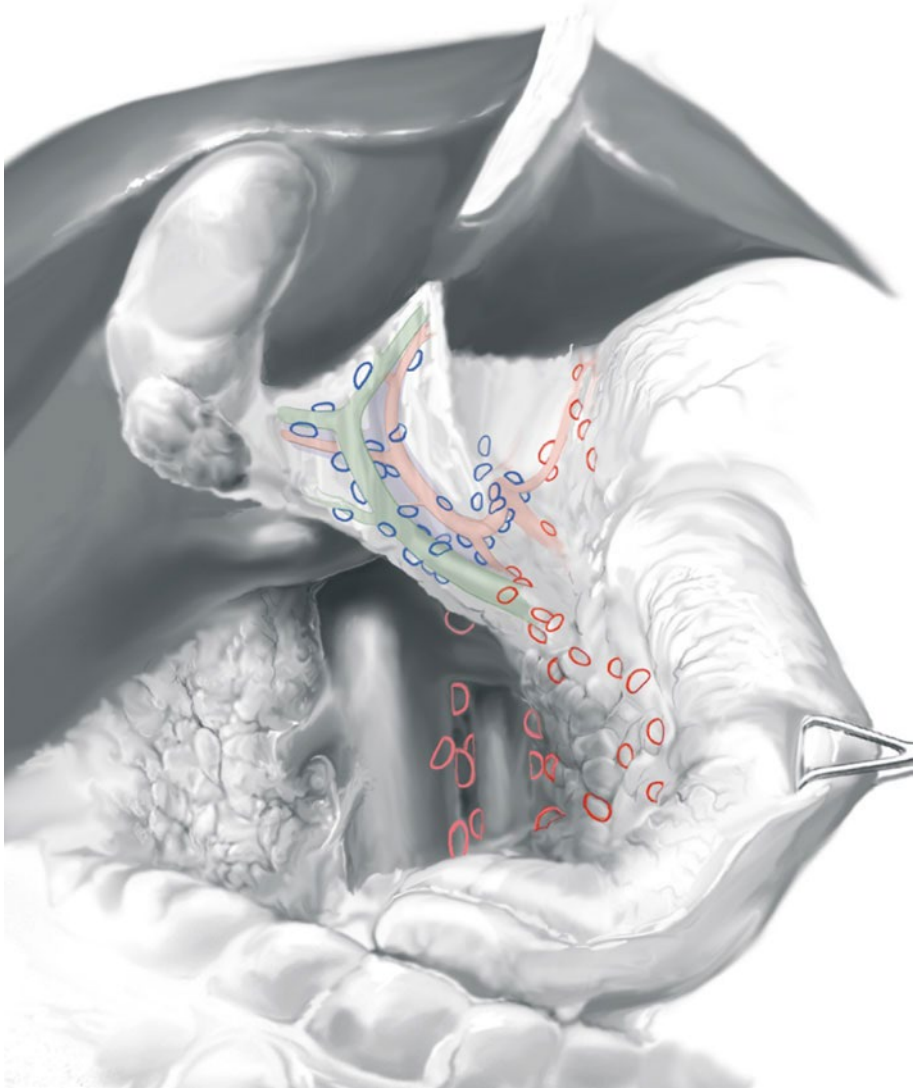


Fig. 68.1

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Step 3

Excision of the highest peripancreatic lymph node

After kocherization, the highest peripancreatic lymph node is excised. This node is sent for frozen section histologic analysis. After excision of this node, retraction of the bile duct anteriorly allows visualization of the portal vein and facilitates safe dissection of nodal and connective tissues. Frozen section staging using this node also guides the operative procedure. If this node is positive and the patient is at high medical risk, then the radical resection is usually abandoned. A radical resection performed in the setting of a positive node should include a retropancreatic nodal dissection and aortocaval nodal dissection, with or without a pancreaticoduodenectomy (Fig. 68.2).

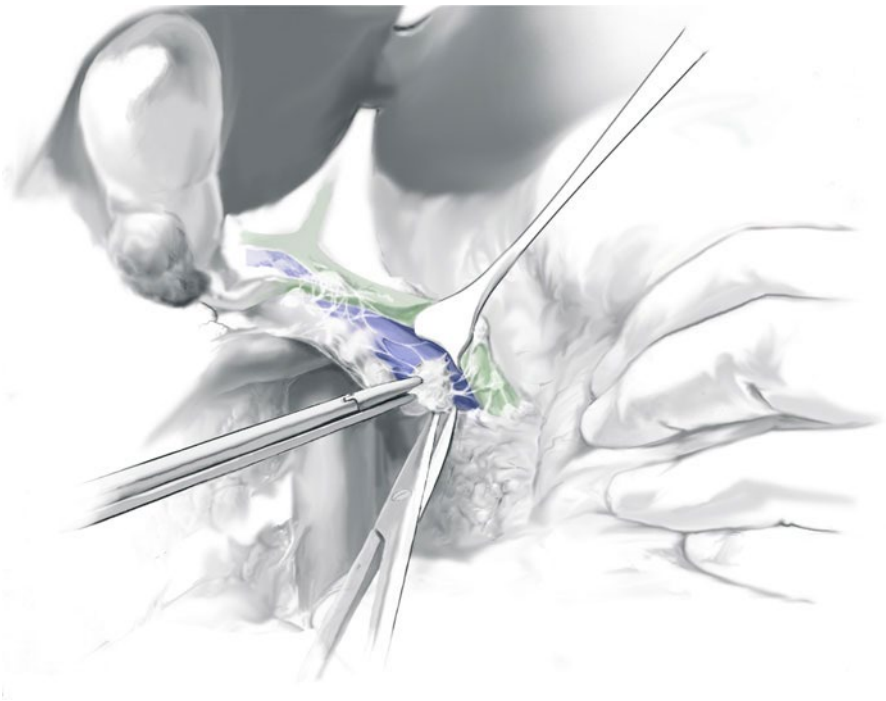


Fig. 68.2

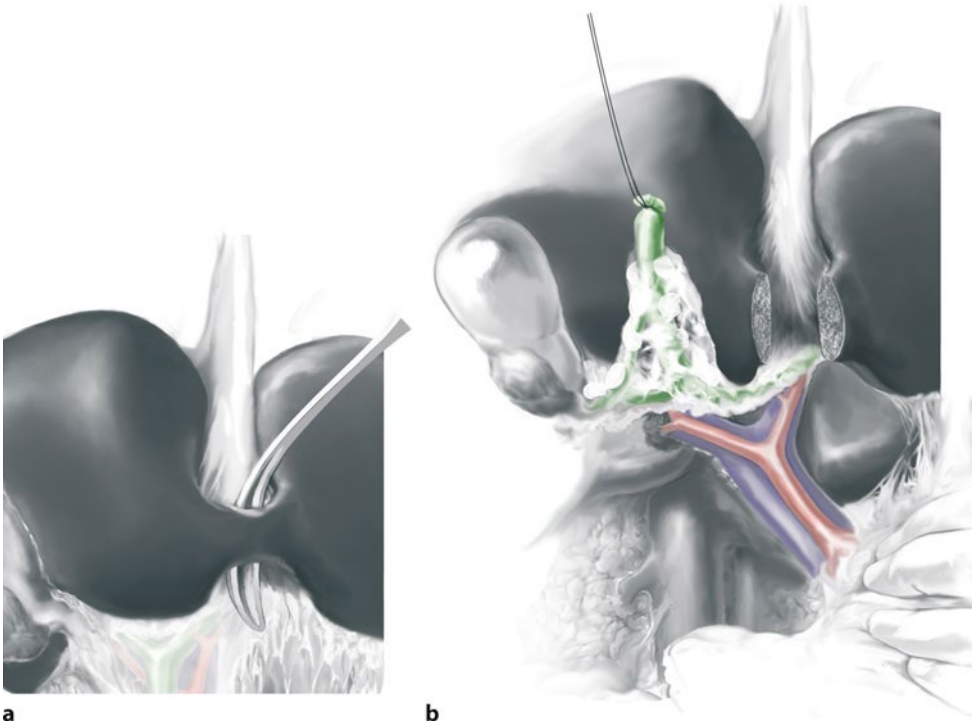
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Step 4

Common bile duct resection

Except in the very thin patient, it is very difficult to adequately excise the nodal tissue in the porta hepatis without resecting the common bile duct. This is particularly true if the patient has recently had a cholecystectomy, as the scars from such surgery further complicate identification of nodal tissue and tumor. Resecting the common bile duct also allows the most certainty of resection of the cystic duct-common duct junction. Furthermore, resecting the common duct allows the safest dissection and inspection of the portal vein and hepatic arteries behind the tumor and in the hilar area.

The bridge of liver tissue between segments 4b and 3, overlying the base of the falciform, is divided (Fig. 68.3a) to allow access to the left portal pedicle. The common bile duct is divided immediately above the pancreas and reflected upward (Fig. 68.3b). The resection margin must be examined by frozen section. All nodal and connective tissues, including the celiac, hepatoduodenal, and portal-caval nodes, are dissected with the common duct, leaving behind only the skeletonized portal vein and hepatic artery.



a b

Fig. 68.3

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Step 5

Assessment of the portal vein and hepatic artery

With the common duct and portal nodal tissue reflected upward, the main, left, and right portal veins and arteries are dissected. If the main portal vein is involved, a portal vein resection and reconstruction may be necessary (see below). If the right hepatic artery and/or right portal vein are involved, an extended right liver resection is warranted. Once the arterial anatomy and possible arterial variations are clearly identified, the right or left hepatic artery is skeletonized distally to the right and left extremes of the hilar plate. In doing so, the left and right hepatic ducts are dissected free.

Step 6

Transection of the left and right hepatic ducts

The left hepatic duct is then identified and transected at the base of the umbilical fissure. Unlike the dissection for a hilar cholangiocarcinoma, the junction of the left and right hepatic ducts can usually be freed from the liver. Retraction of the left hepatic duct stump upward then allows a good look at the right hepatic duct from the posterior-inferior aspects. A stay suture is then placed on this duct before transection (Fig. 68.4).

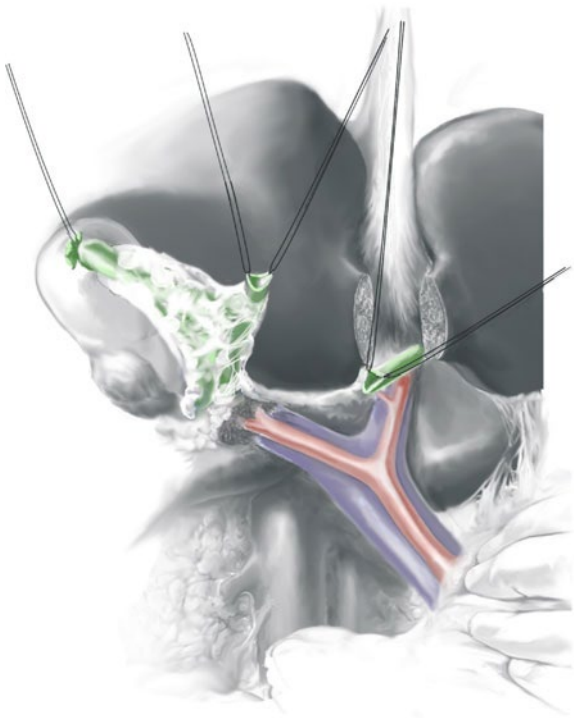


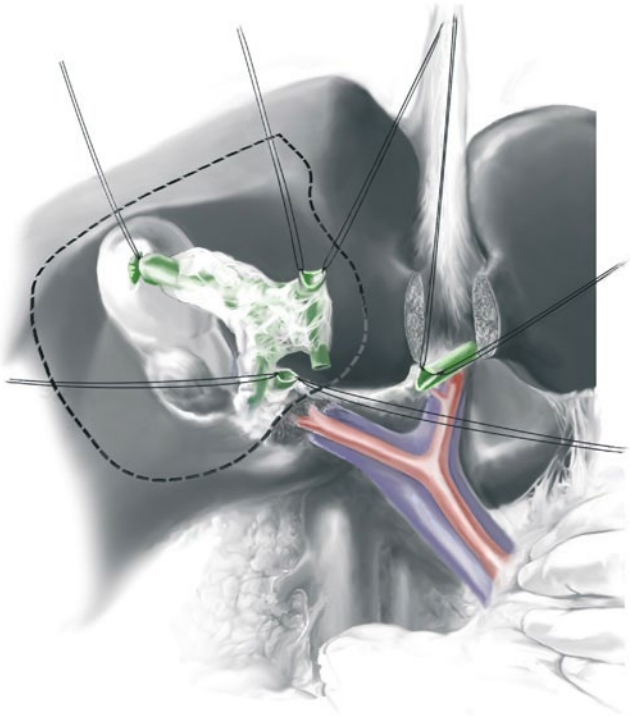
Fig. 68.4

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Step 7

Liver resection

After transection of the right hepatic duct, tissue from both the left and right ductal margins is sent for frozen section analysis. The entire gallbladder bed, including segments 4b and 5, is then resected along the dotted lines shown. The portal veins and hepatic arteries are protected under direct vision. Liver parenchymal transection is as described in Part III, ▶ Chaps. 45 "Liver Resections" and 47 "Left Hemihepatectomy," usually with the option of inflow occlusion by the Pringle maneuver, and with central venous pressure (CVP) maintained below 5 cm H_2O (see Part III, ▶ Chap. 48 "Extended Hemihepatectomies") (◘ Fig. 68.5).



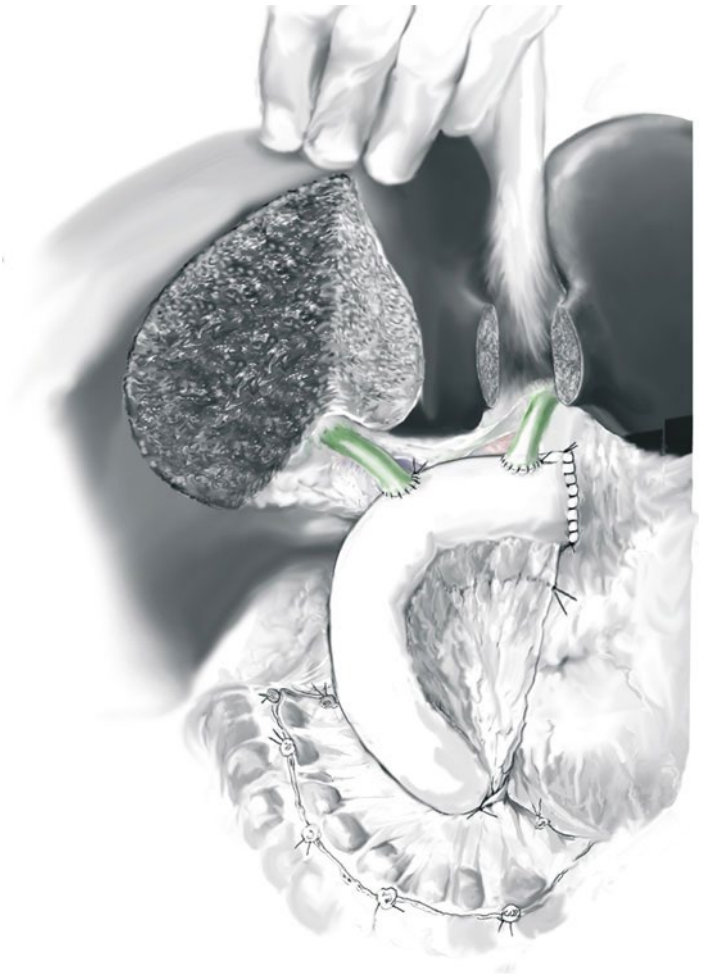
◘ Fig. 68.5

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Step 8

Biliary reconstructions

Before bilioenteric anastomosis, the left and right hepatic ducts can be joined by interrupted, absorbable sutures (4-0 to 6-0 PDS) to minimize the number of anastomoses. Alternatively, the two ducts can be anastomosed separately. A 70-cm Roux-en-Y jejunal loop is lifted through the shortest route that allows for no tension on the anastomosis: retrocolic or retrogastric. For details on the biliary anastomosis, please see this section, ▶ Chaps. 73 "Intrahepatic Bilioenteric Anastomosis" and 77 "Reconstruction of Bile Duct Injuries." If a plastic biliary stent has been placed before surgery, it is removed and not replaced. If a metal stent has been placed, it is usually safest to cut across the metal stent at a site believed to be free of cancer. The jejunal loop is then sewn to the duct and the stent (◘ Fig. 68.6).



◘ Fig. 68.6

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Step 9

Portal vein reconstruction

Tumors that occupy the neck of the gallbladder or the cystic duct often invade into the right portal vein or the main portal vein. Patients presenting with jaundice are at particularly high risk for portal invasion. If the left portal vein and artery are free of tumor, these vascularly invasive tumors often may be resectable by combined extended lobectomy, portal lymphadenectomy, and portal vein resection and reconstruction.

Splitting the liver along the umbilical fissure, on the line of the extended lobectomy, provides access to the hilar area and allows for easier control of the portal vein and safer reconstruction. After cutting the left hepatic duct, this duct is reflected to the patient's left. The right hepatic artery is then transected to allow for unobstructed access to the portal vein. Vascular clamps are then placed on the main portal vein and the left portal vein (Fig. 68.7a). After transection, anastomosis of the main and left portal vein is accomplished with a running, nonabsorbable suture (e.g., 5-0 or 6-0 Prolene) (Fig. 68.7b).

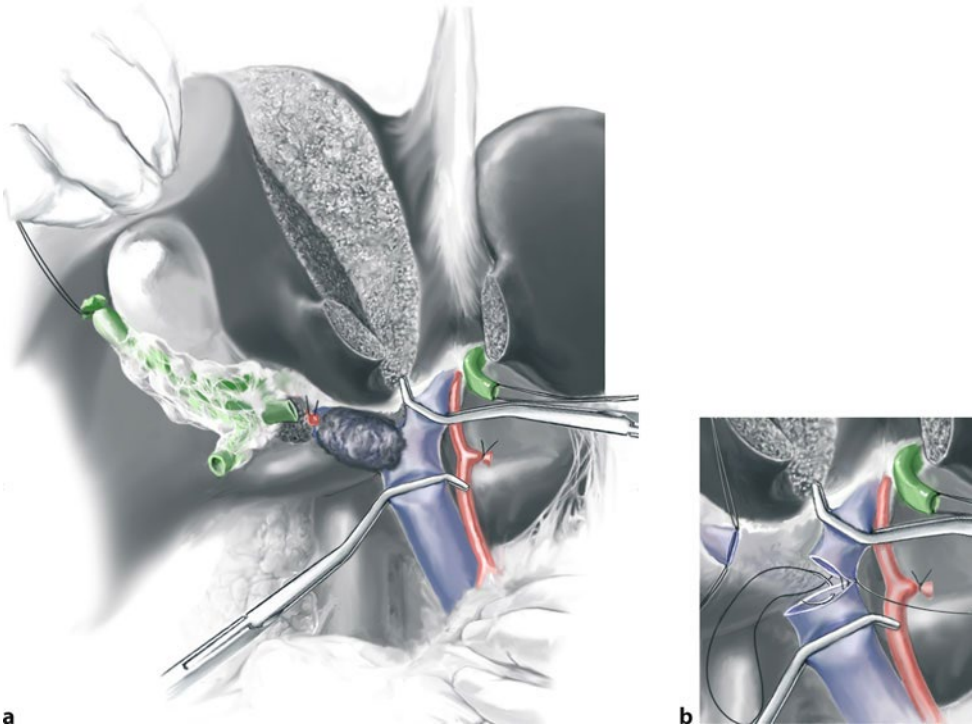


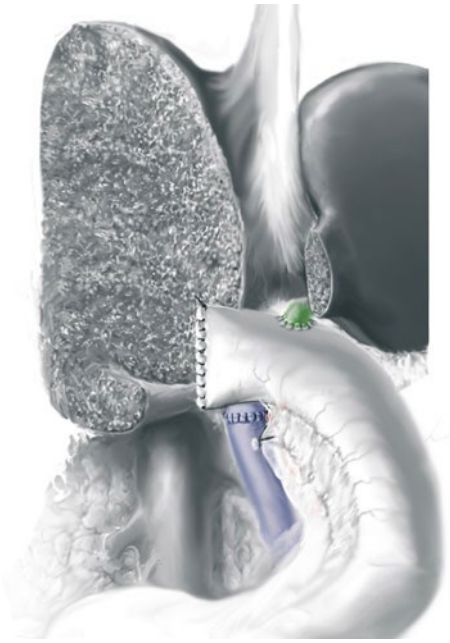
Fig. 68.7

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Step 10

Liver resection and biliary reconstruction

An extended right hepatic resection is then performed, as described in Part III, ▶ Chap. 48 "Extended Hemihepatectomies." The figure illustrates the subsequent reconstruction utilizing a retrocolic Roux-en-Y hepaticojejunostomy (◘ Fig. 68.8).



◘ Fig. 68.8

Step 11

Drainage after reconstruction

After completing hemostasis in the surgical field, closed drains are placed in the right upper quadrant near the biliary anastomosis. If a percutaneous transhepatic stent has been removed, a drain should also be placed near the site of the stent entry site on the liver surface. We do not usually use stents for the anastomosis.

Nasogastric tube decompression of the gastrointestinal tract is usually continued until bowel function returns. This is particularly important if the bile duct used for anastomosis is small. Nasogastric decompression prevents swelling of the Roux-en-Y limb and possible disruption of the anastomosis.

Postoperative Tests

- Postoperative surveillance in an intensive or intermediate care unit (for extended procedures)
- Coagulation parameters and hemoglobin for at least 72 hours
- Liver function test and electrolytes (including phosphorus) for at least 72 hours
- Bilirubin level measurement on the closed suction drain fluid if a bile leak is suspected

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Postoperative Complications

- **General:**
  - Pleural effusion
  - Pneumonia
  - Deep vein thrombosis
  - Pulmonary embolism

- **Abdominal:**
  - Intra-abdominal bleeding
  - Infected collection/abscess
  - Liver failure (extended procedures)
  - Bile leak with biloma formation
  - Leakage of biliodigestive anastomosis (procedures with common bile duct resection)
  - Portal vein thrombosis

Tricks of the Senior Surgeon

- If the patient presents with a radiologic T3 or T4 gallbladder cancer, laparoscopic staging is warranted because of the high incidence of peritoneal metastases.
- For surgical planning, any patient with a tumor in the neck of the gallbladder or in the cystic duct or any patient presenting with jaundice should be scrutinized on preoperative scans for signs of right hepatic arterial involvement. If the right artery is encased, a minimum of an extended lobectomy is necessary for resection.
- Accessory or replaced left hepatic arteries do not reside in the porta hepatis, but rather pass across the lesser omentum and enter the base of the umbilical fissure. Resections therefore are often possible in patients with these anomalous vessels even when the porta hepatis is extensively involved.
- Stay sutures should be placed before dividing the intrahepatic bile duct; otherwise, the small segmental duct can slip away and retract within the liver parenchyma.
- The lymphatic vessels throughout this dissection should be tied to prevent postoperative lymphorrhea.

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Standard Radical Cholecystectomy for T1 and T2 Gallbladder Cancer

Masaru Miyazaki, Yuman Fong, Anil K. Agarwal, Raja Kalayarasan

Gallbladder cancer (GBC) is the most common malignancy of the biliary tract. Though traditionally considered to be an aggressive disease with rapid progression and dismal outcome, several recent reports have suggested that aggressive surgical resection improves survival. Adenocarcinoma is the most common histological type; squamous cell carcinoma, adenosquamous carcinoma, neuroendocrine carcinoma, and carcinosarcoma are the rare histological variants. According to the recent AJCC/UICC TNM staging system, T1 and T2 GBC includes patients with carcinoma limited to the mucosa (T1a) or muscularis proper (T1b) or invading the perimuscular connective tissue (T2) without liver infiltration. T1a tumors are difficult to diagnose preoperatively and are usually diagnosed after histopathology of the cholecystectomy specimen. Simple cholecystectomy is sufficient for cure in these patients, provided that the cystic duct margin is free of tumor and there is no intraoperative bile spillage. According to the National Comprehensive Cancer Network (NCCN) guidelines, a radical cholecystectomy is recommended for patients with a lesion T1b and beyond.

Radical cholecystectomy includes partial hepatectomy around the gallbladder bed and dissection of regional lymph nodes. Partial hepatectomy could be either en bloc resection of the gallbladder along with a 2–3 cm nonanatomical wedge of liver around the gallbladder bed or anatomical bisegmentectomy involving resection of segments IVb and V. Whether a nonanatomic wedge resection or resection of segments IVb and V should be performed in T1 and T2 GBC remains a matter of debate, and no randomized controlled trials have compared these two procedures. Limited wedge resection of the liver is aimed at achieving a tumor-free resection margin; segment IVb and V resection theoretically has some additional oncological benefits. Anatomical studies have demonstrated that veins and lymphatics from the gallbladder drain predominantly to segments IVb and V. Thus anatomical segment IVb and V resection could eradicate occult intrahepatic metastases in addition to achieving a negative resection margin.

Standard lymphadenectomy includes clearance of regional nodes from the hepatoduodenal ligament (including pericholedochal and periportal nodes), nodes anterior and posterior to the head of the pancreas, and the hepatic artery to its origin from the celiac axis (Fig. 69.1). Dissection of peripancreatic nodes is a matter of debate, as they are now classified as N2 nodes (considered to be metastatic disease) in the recent TNM staging system. However, many studies have reported long-term survivors among patients with involved peripancreatic lymph nodes, so most centers (including ours) include them as part of locoregional lymphadenectomy.

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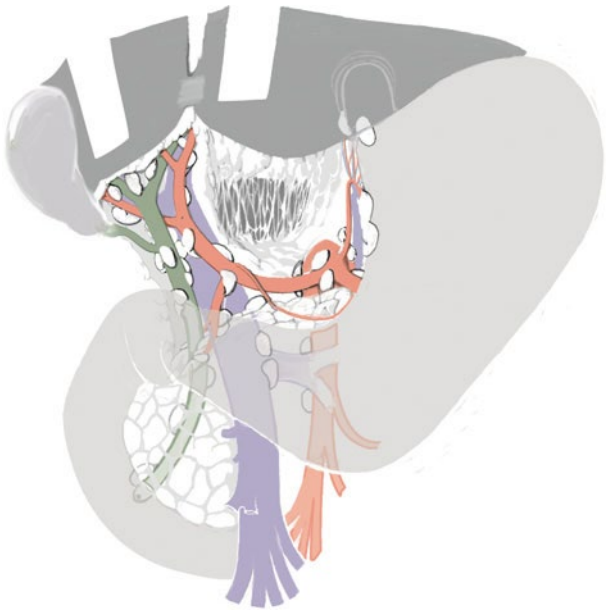


Fig. 69.1

A few surgeons have recommended routine excision of the extrahepatic bile duct (EBD) in all patients with T2–4 GBC, however EBD resection is not included as a part of radical cholecystectomy, since there is no evidence that this procedure offers a survival advantage. In selected cases with extensive hepatoduodenal adenopathy, however, it may aid complete clearance of lymph nodes and occult cancer cells in the connective tissue and the perineural space in the hepatoduodenal ligament, even in the absence of obvious cancer invasion in the bile duct. There are several current indications for EBD excision in patients with T1 and T2 GBC:

- Gross lymph node enlargement close to or involving the EBD (to facilitate lymphadenectomy)
- Inflamed or fatty hepatoduodenal ligament (often in incidentally detected GBC), rendering nodal dissection difficult
- Positive cystic duct margin on intraoperative frozen section
- Associated anomalous pancreatobiliary ductal junction (APBDJ) abnormality or choledochal cyst
- Papillary tumor of gallbladder

This chapter describes a standard radical cholecystectomy, which includes resection of segments IVb and V and regional lymphadenectomy without routine EBD excision.

Preoperative Evaluation

The aim of the preoperative evaluation is to accurately diagnose and stage the disease:

- Ultrasonography of the abdomen is generally the initial investigation performed in patients who present with symptoms suggestive of gallbladder pathology. The presence of suspicious findings on ultrasonography is an indication for cross-sectional imaging in the form of contrast-enhanced CT scans or MRI.
- Contrast-enhanced CT scan in addition to diagnosis, provides additional information for tumor staging and resectability, including the extent of liver infiltration, lymph node metastasis, and adjacent organ and vascular involvement (Fig. 69.2)
- MRI with MR cholangiopancreatography (preferred in patients with biliary obstruction)
- Doppler ultrasonography in patients with suspected vascular involvement; T1–T2 stage does not involve adjacent vasculature or the bile duct
- Tumor marker CA 19-9
- Endoscopic ultrasonography is useful for local staging of GBC and the assessment and biopsy of interaortocaval lymph nodes (16b1) when visible
- Other investigations including a PET-CT may be required for advanced lesions

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In addition to the staging of the disease, a patient fitness assessment is performed to ascertain the patient's suitability to undergo the planned surgical procedure. The fitness of the patient in the light of any comorbidities is considered, and an informed consent is obtained.

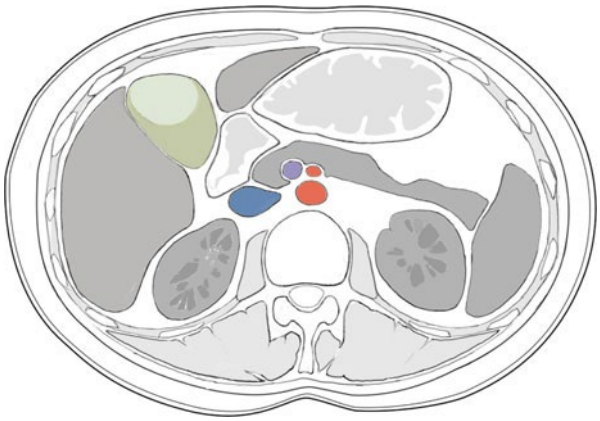


Fig. 69.2

Preparation for Surgery

In patients with T1 and T2 tumors with a normal liver, there is no risk of liver failure. In patients with advanced and cholestatic liver disease, preparation is required to optimize the timing and results of surgery. Availability of the equipment required for surgery (in particular, aids for liver transection) based on the surgeon's preference is ensured. Thromboprophylaxis is done, based on the patient's risk stratification, and antibiotics are administered just prior to surgery.

Staging laparoscopy

Standard radical cholecystectomy can be performed by the conventional open approach, which is currently the standard of care and is described in detail in this chapter. A laparoscopic approach can also be adopted to perform radical cholecystectomy for T1 and T2 stage disease. For either approach, the first step is to perform a staging laparoscopy aimed at excluding metastatic disease.

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Significant numbers of GBC patients have radiologically occult metastatic disease (typically small peritoneal deposits and liver metastasis), which is detected at the time of surgical exploration despite extensive preoperative workup (Fig. 69.3). Therefore a staging laparoscopy is performed in all cases to detect these occult metastases and avoid a nontherapeutic laparotomy. The yield of staging laparoscopy is high in locally advanced GBC, but a significant number (11 %) of patients with early GBC (T1 and T2) can have radiologically occult metastatic disease. Traditionally, staging laparoscopy is performed using one port, but recently we have tended to use two ports. The second port helps in taking the biopsy (for frozen section analysis) when metastases are present and help in visualizing hidden areas such as the undersurface of the liver prior to proceeding for radical cholecystectomy.

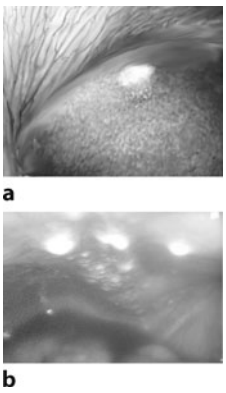


Fig. 69.3

Procedure: Conventional Open Standard Radical Cholecystectomy

Step 1 Positioning, incision, and exploration

With the patient in a supine position, a right subcostal incision is performed (Fig. 69.4a). Staging laparoscopy findings are confirmed by performing a thorough evaluation for evidence of occult liver and peritoneal metastases. Any metastases detected should be confirmed by a frozen section histopathological examination.

The locoregional extent of disease is assessed. The ligamentum teres is divided, leaving a suture on the cephalad stump to serve as a retractor.

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Step 2

Interaortocaval lymph node biopsy

Para-aortic lymph node involvement is considered distant metastatic disease in the AJCC/UICC TNM staging system. Positive interaortocaval (IAC) lymph nodes and lymph nodes to the left of the celiac axis on frozen section analysis are considered as metastatic disease, and the resection is abandoned. Therefore, before proceeding with radical resection, a routine biopsy of the IAC lymph node (16b1) is recommended. Duodenal kocherization is performed to adequately expose the area, and lymph nodes in the IAC region below the level of the left renal vein are excised and sent for frozen section examination (Fig. 69.4b). Positive IAC lymph node on frozen section analysis is considered as metastatic disease and the planned surgical resection is abandoned.

In patients with no evidence of IAC lymph node metastases, the right subcostal incision is extended to left with a gentle curve in the middle and a standard radical cholecystectomy is performed.

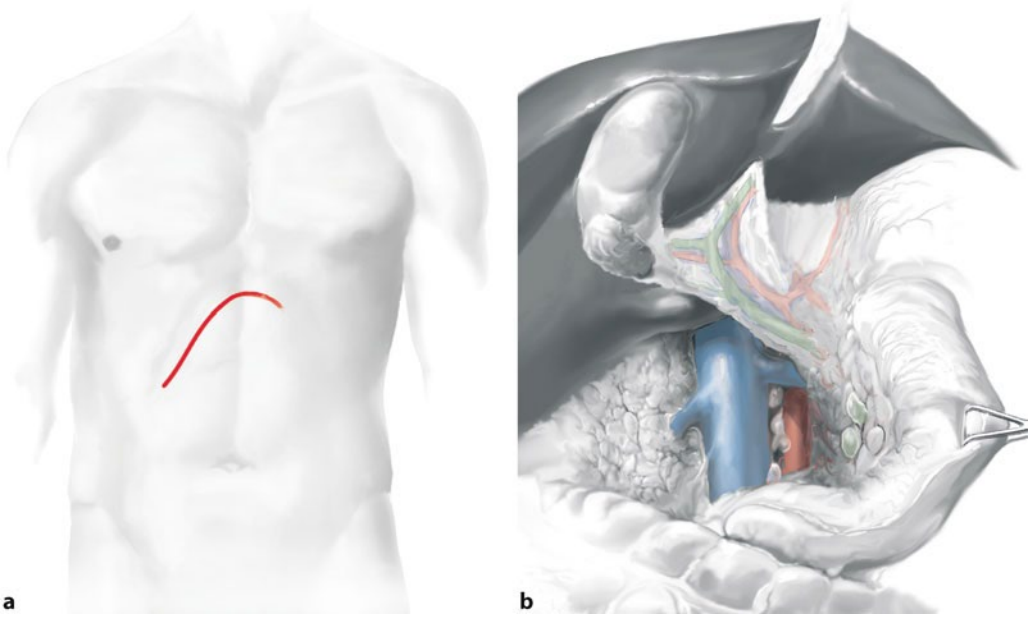


Fig. 69.4

Step 3

Radical cholecystectomy

The extent of resection and the surgical procedure for GBC is guided by the locoregional extent of the tumor. A standard radical cholecystectomy, including limited liver resection (up to segment IVb and V) with regional lymphadenectomy is sufficient for limited disease, but more extensive resection is required for locoregionally advanced disease. In advanced disease the procedure may include more extensive liver resection, extrahepatic bile duct excision, adjacent viscera resection, pancreatoduodenectomy, and vascular resection and reconstruction to achieve an R0 resection.

Standard radical cholecystectomy is used to manage locoregionally limited T1 and T2 malignancy of the gallbladder. In patients with T1 and T2 GBC, dissection in Calot's triangle is done. The cystic artery is ligated and divided. The cystic duct is looped, ligated, and divided, and the cystic duct margin is sent for frozen section analysis.

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Step 4

Regional lymphadenectomy

Regional lymphadenectomy can start from the retropancreatic region. Retropancreatic lymph nodes are dissected from the posterior aspect of the head of the pancreas, with care taken not to enter the pancreatic parenchyma (Fig. 69.5a). The dissection is extended posteriorly to the retroportal area. Anterior dissection at the upper border of the duodenum extends along the gastroduodenal artery to its origin from the common hepatic artery. The right gastric artery, which usually arises from the proper hepatic artery, may be ligated and divided. The dissection then proceeds along the common hepatic artery to its origin from the celiac axis. The common hepatic artery may be looped to facilitate lymph node dissection. As the dissection proceeds towards the celiac axis, the left gastric vein is encountered which may be ligated and divided. The en bloc lymph node dissection then proceeds along the left of the hepatoduodenal ligament. The proper hepatic artery is looped to facilitate lymph node dissection in this region. At the end of this dissection, the left side of the portal vein is exposed completely. The en bloc lymphatic tissue is then swept posterior to the portal vein and the dissection proceeds along the right side of the hepatoduodenal ligament. The portal vein may be looped at this stage to facilitate complete clearance of retroportal lymph nodes. If not done earlier, once the dissection reaches close to Calot's triangle, the cystic duct is divided at the confluence with the common bile duct and the cystic duct margin is sent for frozen section examination. The cystic artery is divided close to its origin from the right hepatic artery. Lymphadenectomy in the hepatoduodenal ligament is completed by the skeletonization of the hepatoduodenal ligament. During the skeletonization of the hepatoduodenal ligament, dissection and isolation of hepatic artery and portal vein are performed up to the level of hilum. When EBD resection is not performed, the EBD is skeletonized, along with the hepatic arterial system and portal trunk. However, care is taken to avoid excessive dissection of the connective tissue around the bile duct, to prevent injury to the peribiliary vascular plexus, which can result in bile duct ischemia and stricture in the long term. Complete clearance of lymph node stations 8, 9, 12, and 13 is achieved as in Fig. 69.5b.

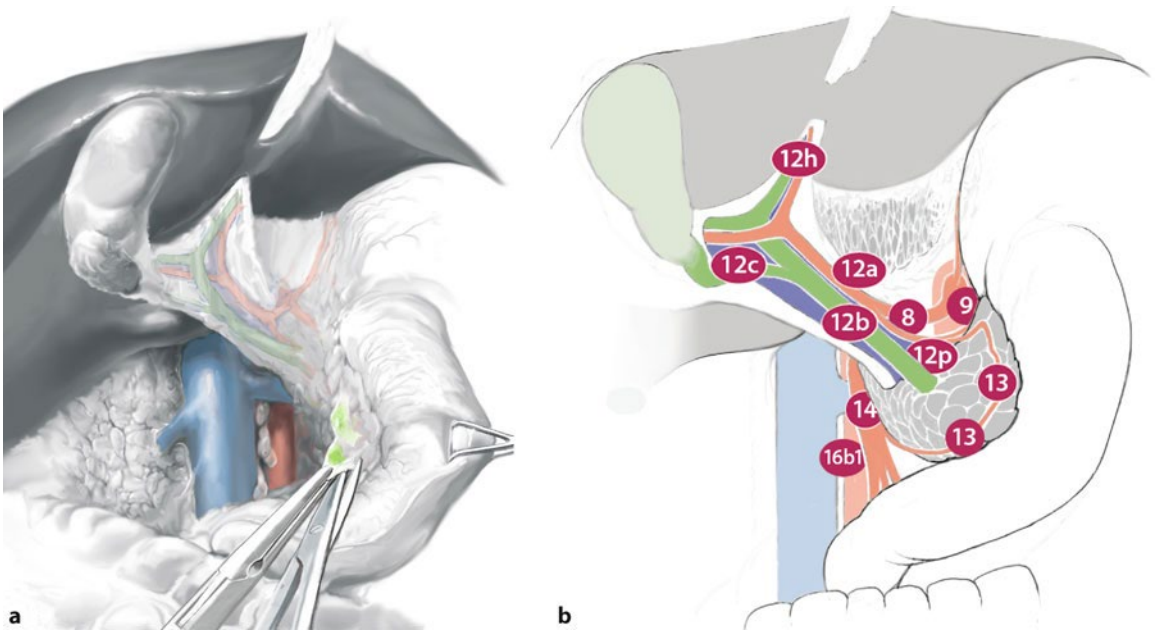


Fig. 69.5

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Step 5

Hepatectomy: Identification of transection lines

Resection of anatomic segments IVb (anterior) and V involves two critical steps:

- Identification of the transection line between segments V and VI
- Identification of the transection line between segment IVa and segment IVb

Identification of transection line between segments V and VI: The parenchymal transection line between segments V and VI can be identified by using any of three methods: the Glissonean pedicle approach, the use of intraoperative ultrasound, or the use of a surface landmark.

- The Glissonean pedicle approach involves selective ligation of segment IVb and segment V pedicles (from inside after transecting segment IVb). Alternatively to determine the lateral extent of segment V, dissection of anterior or posterior Glissonean pedicles and temporary clamping can be performed. Since identification and dissection of posterior Glissonean pedicle is relatively simpler, we prefer this approach. The landmark for the identification of the posterior pedicle is Rouviere's sulcus. Temporary clamping can be done either by looping the posterior Glissonean pedicle and applying a Rummel tourniquet or by simple application of bulldog vascular clamp. We prefer to apply a bulldog vascular clamp, as it does not require complete dissection and looping of the posterior Glissonean pedicle and thus can avoid potential iatrogenic biliovascular injury associated with looping of the pedicle. Temporary clamping of the posterior Glissonean pedicle results in ischemia of the posterior sector (segments VI and VII), which can facilitate identification of the parenchymal transection plane between segments V/VIII and segments VI/VII (Fig. 69.6).
- The use of intraoperative ultrasound involves identification of the right hepatic vein, which runs between the right anterior and posterior sectors. Once the right hepatic vein is identified using intraoperative ultrasonography, the transection line between segments V/VIII and segments VI/VII is marked using electrocautery to the left of the right hepatic vein (extrapolated to the inferior edge). This line can be confirmed using intraoperative ultrasound, as the markings made with electrocautery appear as a hyperechoic line on ultrasonography.
- The use of a surface landmark is technically simple: According to Ton That Tung, the right portal scissura containing the right hepatic vein follows a line parallel to the right lateral edge of the liver three fingerbreadths from the right edge of the liver. Though simple, however, this method can be a bit inaccurate.

We recommend the posterior Glissonean pedicle approach, using a bulldog vascular clamp for the identification of the transection line between segments V and VI or direct ligation of segment V pedicle as the liver transection proceeds from segment IV toward segment V.

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Step 5 ***(continued)***

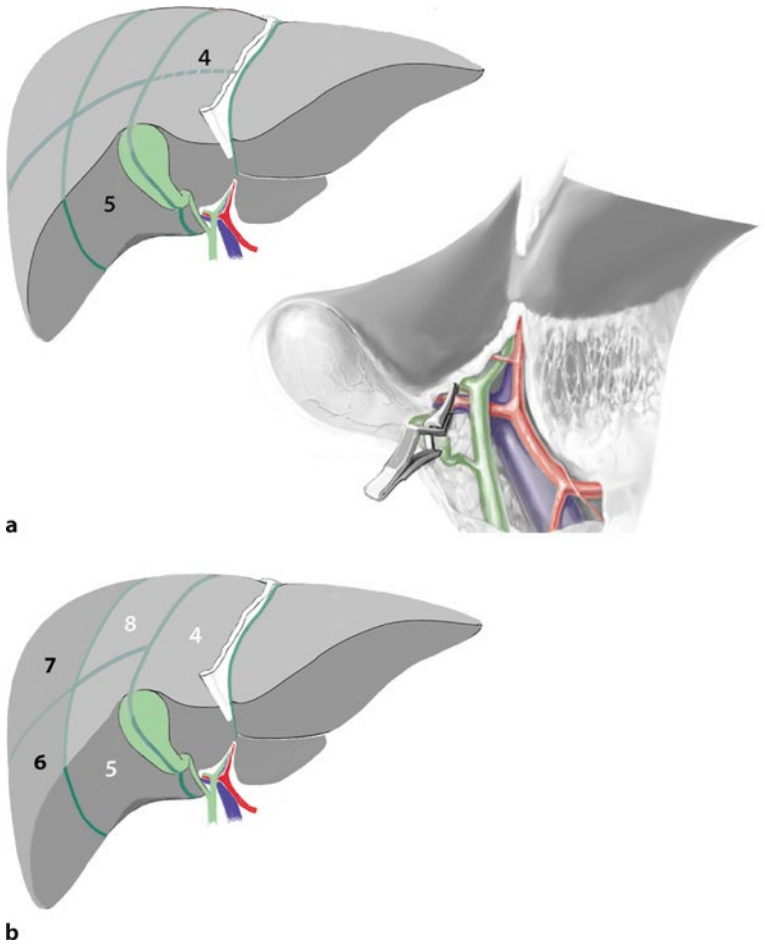


Fig. 69.6

Identification of transection line between segments IVa and IVb: (In Japanese terminology, the anterior portion of segment IV is labeled as IVa). Identification of this line involves dissection and isolation of the horizontal and umbilical portion of the left portal vein. The portal vein branches to segments IVa and IVb originate from the right side of the umbilical portion of the left portal vein. Usually the origins of these branches are extrahepatic, but they sometimes can be intrahepatic. When there is extrahepatic origin of these branches, it is imperative to distinguish between the segment IVa and IVb branches, which can be done by one of two methods: 1) Temporary clamping of the portal vein branch and looking for the area of ischemic demarcation; or 2) Injection of indigo carmine dye into a portal vein branch and looking for the area of blue staining on the liver surface.

Using either of these two methods, the horizontal line of demarcation between segments IVa and IVb can be identified; it is then extended to the right to meet the line of demarcation between segments V and VI (Fig. 69.7). When the division of the segment IVa and IVb branches is intrahepatic, parenchymal transection is begun to the right of the falciform ligament to identify these branches intrahepatically, and either of the two methods is used to identify the line of demarcation between segments IVa and IVb.

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Step 5 ***(continued)***

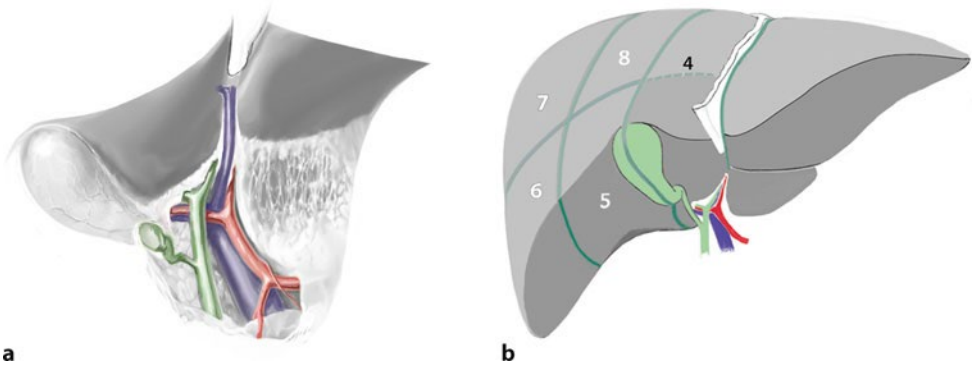


Fig. 69.7

Step 6

Hepatic parenchymal transection

Parenchymal transection is performed along the marked transection lines, using a Kelly clamp method or any of the energy devices, according to the surgeon's preference (the superiority of any one method has not been shown in randomized controlled trials). Central venous pressure (CVP) is lowered before starting the parenchymal transection. Usually the parenchymal transection is started from the left anterior side of segment IVb and then proceeds to the right side and down to the hilar plate. Use of intermittent Pringles maneuver (15 min occlusion plus 5–7 min of reperfusion) is optional. We do not routinely adopt Pringles maneuver in segment IVb–V resection but rather reserve it for cases in which the CVP cannot be lowered, the liver resection is more extensive, or when bleeding is anticipated (cholestatic or cirrhotic livers).

The middle hepatic vein is encountered as the parenchymal transection is deepened; it is double ligated or clipped and divided. As the dissection approaches the hilar plate, pedicle branches to segment V along the right anterior Glisson sheath are identified and divided. Resection of the remaining portion of segment V completes the anatomic segment IVb and V resection (Fig. 69.8).

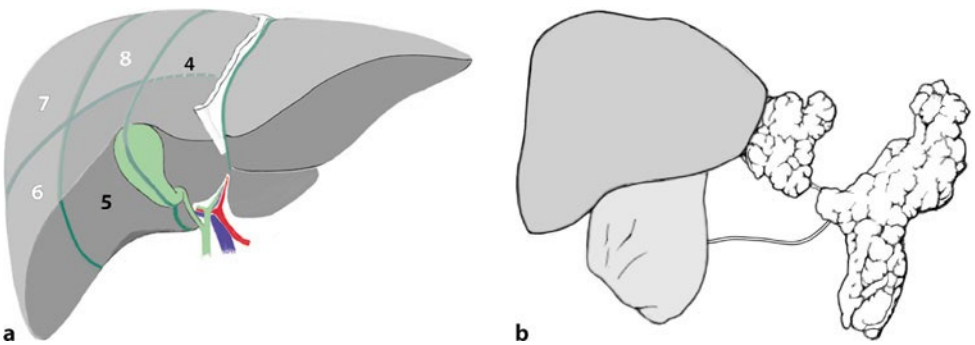


Fig. 69.8

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Step 7

Hemostasis and closure

Hemostasis of the cut surface of the liver is secured using argon plasma coagulation or electrocautery in spray mode. Bile leak from the cut surface can be checked by cannulating the cystic duct and injecting saline and air. We do not routinely cannulate the cystic duct, but do so only in cases with evidence of bile leakage from the cut surface. Once hemostasis is secured, the peritoneal cavity is irrigated, a single tube drain is placed in the subhepatic region, and the subcostal incision is closed in layers.

Additional steps

Common bile duct excision: As already mentioned, bile duct excision is not performed routinely, but only in selected situations.

Adjacent viscera resection: Adjacent viscera resection is not required in primary T1 and T2 GBC, but in some cases of incidental GBC taken up for completion radical cholecystectomy, resection of adjacent viscera (a segment of the gastroduodenum or colon) may be required when it is adherent to the gallbladder fossa and residual tumor is suspected. In some of these patients, bile duct excision also may be required.

Port-site excision in incidental GBC: All port sites should be excised in cases of incidentally detected GBC taken up for completion radical cholecystectomy. A full-thickness excision of all the ports should be performed. It is reported that half of the port-site metastasis occurs in the port of gallbladder extraction, but other port sites are involved in 50 % of cases. Some recent papers have questioned the practice of port-site excision, but there is no convincing evidence to give up the practice. We have seen several cases of port-site metastasis (without any other site of spread) to justify the addition of port site excision to the procedure.

In addition, the scar of open cholecystectomy is excised in cases of GBC incidentally detected following open classical cholecystectomy.

Postoperative care

- Postoperatively, the patient is kept in the ICU or postoperative recovery for the first 24 hours, with adequate analgesia.
- DVT prophylaxis is continued, using graduated stockings or pneumatic compression pump.
- The nasogastric tube is kept until 6–12 hours after surgery.
- After a standard radical cholecystectomy, early postoperative ambulation is encouraged.
- Chest physiotherapy is started from postoperative day 1 to prevent lung atelectasis, particularly in elderly patients.
- The drain can be removed once the volume is less than 50 mL and its nature is serous, between the 2nd and 5th day.
- Most patients of Radical cholecystectomy for T1 and T2 GBC can be discharged between 2nd and 5th postoperative day.

Complications

The commonest complication is a bile leak that resolves with conservative management, or an intra-abdominal collection, which may necessitate percutaneous ultrasound-guided aspiration. Procedure-related mortality is extremely rare, being virtually nonexistent for a standard radical cholecystectomy in a reasonably fit patient (with little or no comorbidity), but it may sometimes occur in more extensive resections.

- General complications:
  - Respiratory: atelectasis, pneumonia, pleural effusion
  - Deep vein thrombosis

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- Abdominal complications:
  - Bleeding
  - Bile leak and bilioma formation
  - Intra-abdominal collection and abscess formation
  - Chyle leak

Procedure: Hepatic Wedge Resection Around the Gallbladder Bed

In this procedure, aimed at removing the gallbladder without dissecting into the plane between the gallbladder and the liver bed, only a small part of the liver – the gallbladder bed in the liver – is removed, ensuring no breach in the plane between the gallbladder and the liver. There is no guideline regarding how much of the hepatic parenchyma to resect. The planned extent of resection is marked by electrocautery, usually 2 to 3 cm away from the gallbladder bed or from the invasive front of the gallbladder carcinoma, ensuring a negative margin of resection and removal of the gallbladder bed in the liver without entering the plane between the gallbladder and the liver. The transection proceeds from the right and left margin down towards the hepatic hilum. Approaching the hepatic hilum, the anterior surface of the right anterior Glisson's sheath is exposed. Only peripheral vascular branches and bile ducts are usually encountered while transecting the parenchyma. Finally, the cystic plate is transected at the confluence of the hilar plate, and the surgical specimen is taken out.

Procedure: Laparoscopic Radical Cholecystectomy

Traditionally, laparoscopic surgery has been contraindicated in patients with suspected GBC, but a few recent studies have advocated the use of a minimally invasive approach in GBC. We have performed laparoscopic radical cholecystectomy in selected cases of GBC that are limited to the gallbladder (that is, T1, T2, and some T3 stage tumors). The procedure is performed using a five-port technique with the patient in a French (low lithotomy) position. To date, we have performed 41 laparoscopic radical cholecystectomies.

The patient is placed in the reverse Trendelenburg position with a left lateral tilt. A staging laparoscopy is performed using two ports. Before proceeding with radical resection, a routine sampling biopsy of IAC lymph nodes with frozen section histopathological examination is done, and surgical resection is abandoned in patients with IAC lymph node metastases. In patients with no evidence of disseminated disease on staging laparoscopy, additional ports are placed: a 5-mm right pararectal port below the right subcostal region, an 11-mm left pararectal port above the level of the umbilicus, a 5-mm left midclavicular port below the left subcostal region, and a 5-mm epigastric port. The cystic artery is clipped and divided. The cystic duct is double clipped using Weck Hem-o-lok® clips (Teleflex Medical, Research Triangle Park, NC, USA) and divided, and the cystic duct margin is sent for the frozen section examination. Resection of liver segments IVb and V and a locoregional lymphadenectomy are performed, as described above for the open technique. The specimen is then extracted in a bag and removed through an enlarged umbilical incision or a Pfannenstiel incision.

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Tricks of the Senior Surgeon

- We perform two port laparoscopy, in which the second port is sited on the proposed incision site. The second port was introduced after we detected some occult metastases in certain hidden areas of the liver/peritoneum (when using a single port).
- IAC lymph node biopsy can also be performed laparoscopically as part of staging laparoscopy, which has the benefit of avoiding laparotomy in patients with IAC lymph node metastases. Adopting EUS assessment & biopsy has further decreased the incidence of nontherapeutic laparotomy.
- Lymph nodes to the left of the celiac artery are considered metastatic.
- Dissection of the cystic duct with cystic duct margin frozen section histopathological examination can be done during the initial stage of the procedure as it helps to decide the need for bile duct excision before completing lymphadenectomy.
- During dissection for lymphadenectomy, we prefer to extend the retropancreatic lymph node dissection toward the right and anterior part of hepatoduodenal ligament and the dissected lymph node and connective tissue is then delivered from behind the portal vein to the left to complete dissection along the left border of the HDL and along the hepatic artery towards the celiac trunk. This helps in removing the lymph nodes as a single chain and ensures adequate lymph nodal clearance (same can also be done from left to right).
- Avoid/resist the temptation to completely bare the bile duct as it may affect the vascularity of the duct.
- The pedicle of segment V is looked for behind and below the middle hepatic vein while transecting the liver.
- During liver transaction, ensure a uniform thickness to avoid coning of the specimen which may lead to compromise of the surgical resection margin.
- Monopolar cautery in spray mode is as effective as argon plasma coagulation for hemostasis of liver cut surface. We in fact use it to perform a major part of the parenchymatous transaction.
- During laparoscopic radical cholecystectomy, the cystic duct is double clipped to ensure that there is no bile spillage.
  - Minimal handling of the GB with no tumor manipulation
  - The specimen is retrieved in a bag

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Bile Duct Resection

Yuji Nimura

Resection of tumors at the confluence of the left and right hepatic duct requires one of the most difficult operations. The surgical procedure requires not only a portal lymphadenectomy and bile duct resection, but also almost always a liver resection. This operation has three goals: 1) resection of the primary tumor, 2) resection of the lymphatic drainage of the liver, and 3) reestablishment of biliary continuity.

Indications and Contraindications

Indications

- Primary malignancies (e. g., intrahepatic cholangiocarcinoma involving the hepatic hilus, hilar cholangiocarcinoma, gallbladder carcinoma involving the hepatic hilus, diffuse carcinoma of the extrahepatic bile duct)
- Benign diseases (e. g., primary sclerosing cholangitis, inflammatory pseudotumor)
- Traumatic lesion at the hepatic hilus

Absolute Contraindications

- Biliary carcinoma with distant organ metastasis (liver, lung, bone, peritoneum)
- Uncontrollable severe cholangitis with or without sepsis
- Poor liver reserve with prolonged cholestasis
- Severe coagulopathy despite vitamin K administration

Relative Contraindications

- Cholangiocarcinoma with para-aortic lymph node metastasis

Preoperative Investigation and Preparation for the Procedure

Preoperative investigation

- *History:* Biliary surgery
- *Clinical evaluation:* Jaundice, cholangitis, nutritional status
- *Laboratory tests:* Bilirubin, alkaline phosphatase, ALT, AST, albumin, coagulation parameters (prothrombin time, platelets), indocyanin green test, tumor markers carbohydrate antigen 19–9 (CA 19–9) and carcinoembryonic antigen (CEA)
- *Radiology:* Ultrasonography, MRCP, MDCT cholangiography, PTC, ERCP, 3D angiography, CT volumetry
- *Endoscopy:* Peroral cholangioscopy, percutaneous transhepatic cholangioscopy.

The above procedures should be performed to make a differential diagnosis or to define the intraductal spread of cancer by taking a biopsy.

What not to do

- A metallic stent should not be used in resectable biliary carcinoma.

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Preparation prior to surgery

- Antibiotics sensitive to bile culture
- Endoscopic nasobiliary drainage (ENBD) (endoscopic biliary drainage is not advisable)
- Percutaneous transhepatic biliary drainage
- Internal biliary drainage or bile replacement through a nasogastric tube for patients with external biliary drainage
- Portal vein embolization for major hepatectomy

Procedure

Access

Incision, division of round and falciform ligament (see Part I, ▶ Chaps. 2 "Positioning and Accesses" and 3 "Retractors and Principles of Exposure").

Step 1

Exposure and exploration

The retractor is installed (see Part I, ▶ Chap. 3 "Retractors and Principles of Exposure") and inspection is performed to look for possible peritoneal metastases.

Percutaneous transhepatic biliary drainage (PTBD) catheters are moved to the operative field to maintain intraoperative biliary drainage.

Ultrasound is used to evaluate the location of the tumor in relation to vascular structures (portal vein, hepatic artery, hepatic vein). Careful inspection of vascular variation is performed.

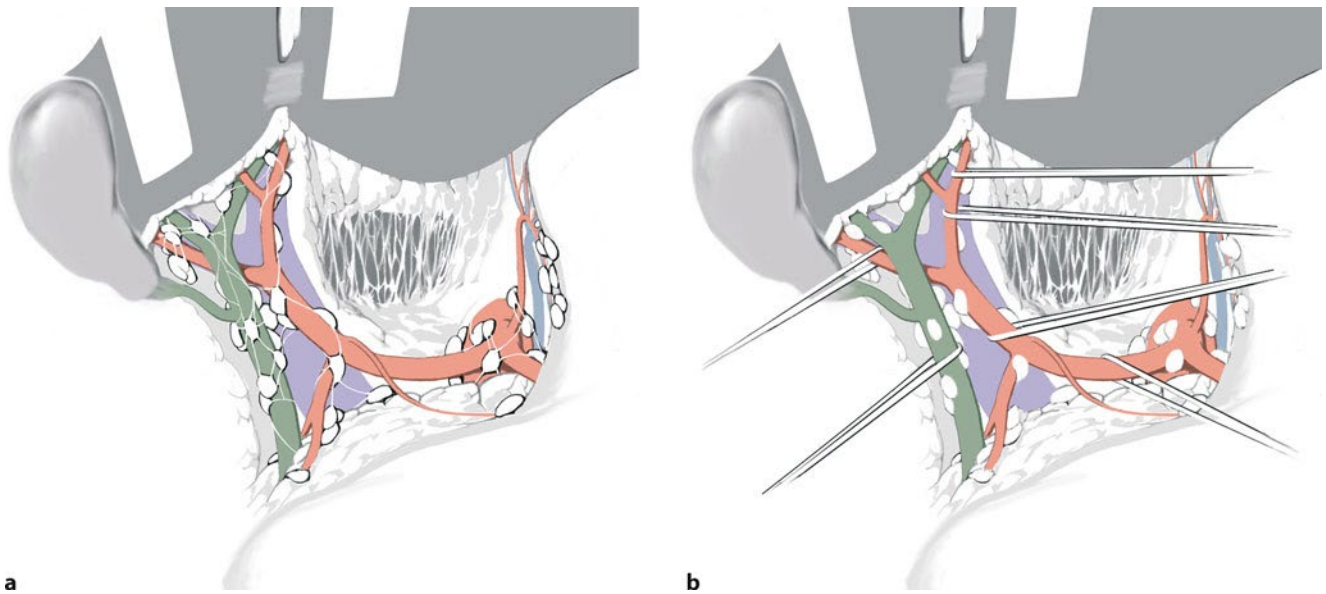
Step 2

Regional lymph node and connective tissue dissection

Lymph nodes in the hepatoduodenal ligament (No. 12), along the common hepatic (No. 8) and celiac arteries (No. 9) and retropancreatic nodes (No. 13), should be dissected (◘ Fig. 70.1a) while placing a vessel loop around the common, proper, right, middle, and left hepatic arteries and common bile duct (◘ Fig. 70.1b).

Nerve plexuses around the hepatic artery should be dissected.

Vascular variation is confirmed.



◘ Fig. 70.1

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Step 3

Distal bile duct resection

The Kocher maneuver is performed to mobilize the duodenum and allow dissection of the distal bile duct. The distal bile duct is dissected down to the head of the pancreas and divided above the pancreas (Fig. 70.2). The resection margin must be examined by frozen section.

In some cases, this procedure should be advanced more distally to detach the bile duct from the pancreatic tissue and resect the duct in the pancreas with a free margin.

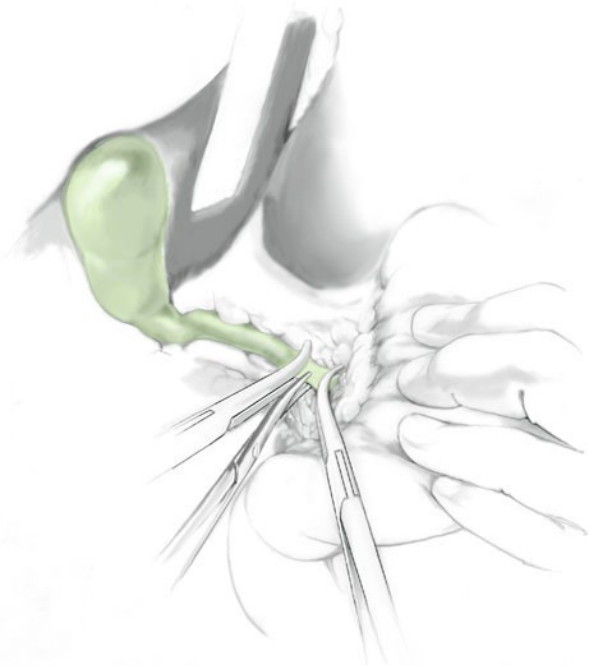


Fig. 70.2

Step 4

Skeletonization of the upper part of the hepatoduodenal ligament

The transected distal bile duct is pulled up and the distal portion of the hepatic artery and portal bifurcation are exposed (Fig. 70.3a). After dividing the caudate lobe branches of the portal vein (Fig. 70.3a), the right and left portal veins are encircled by a vessel loop (Fig. 70.3b).

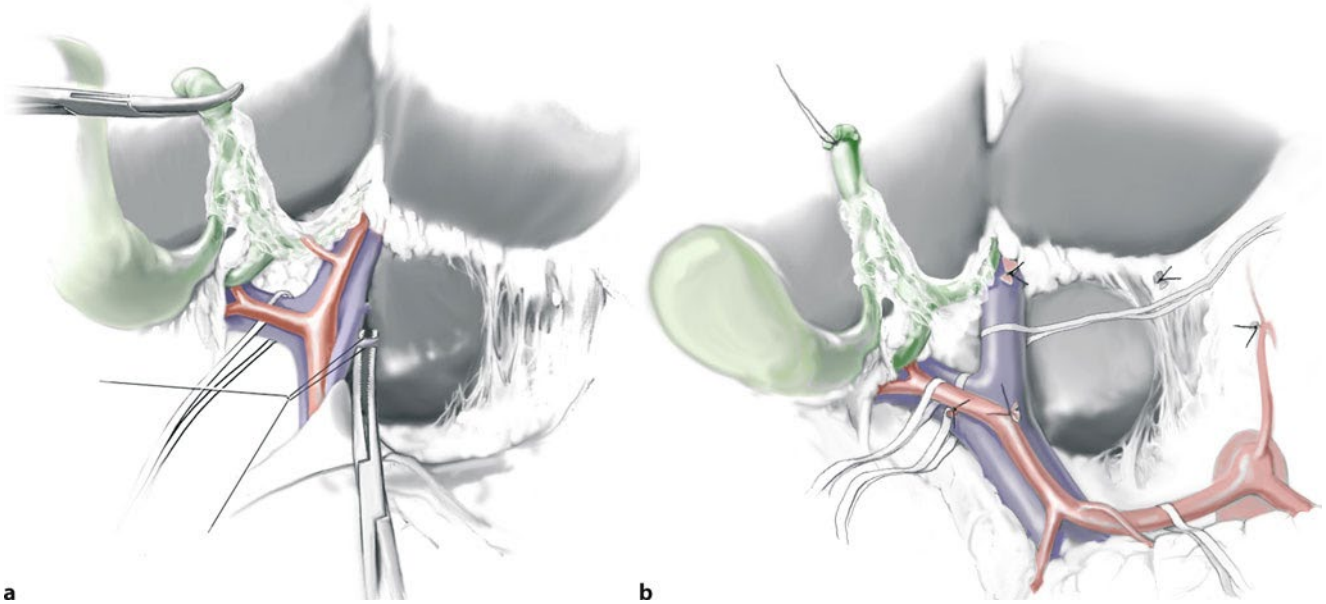


Fig. 70.3

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Left Hepatic Resection

This procedure is indicated for a case of hilar cholangiocarcinoma predominantly involving the left intrahepatic bile ducts. Right hepatic resection is covered separately later.

Step 5

Dividing the hepatic artery

Once the arterial anatomy and possible arterial variation are clearly identified, the left and middle hepatic arteries (and cystic artery) are divided at the origin (see Fig. 70.3b in STEP 4). The remaining right hepatic artery is skeletonized more distally to encircle the right anterior and posterior branches at the right extremity of the hilar plate.

Step 6

Transection of the left portal vein

The left portal vein is ligated and divided distally to the bifurcation. An alternative is to use a vascular clamp on the proximal side and oversew the venous stump with a running suture of 5-0 Prolene (Fig. 70.4).

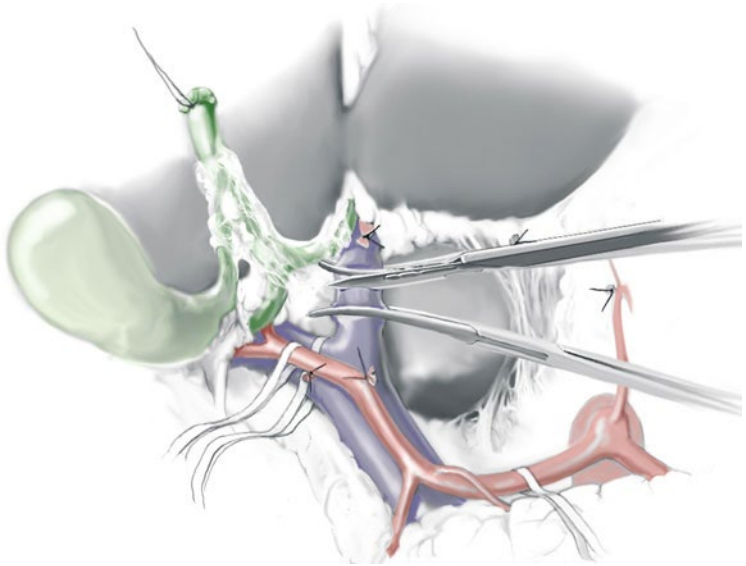


Fig. 70.4

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Step 7

Mobilization of the caudate lobe with division of the short hepatic veins

For a left-sided hepatectomy, the short hepatic veins are divided in the same manner from the left caudal side to the right cranial side. Finally, the distal end of the Arantius canal is ligated and divided at the confluence of the left hepatic vein or the vena cava (Fig. 70.5).

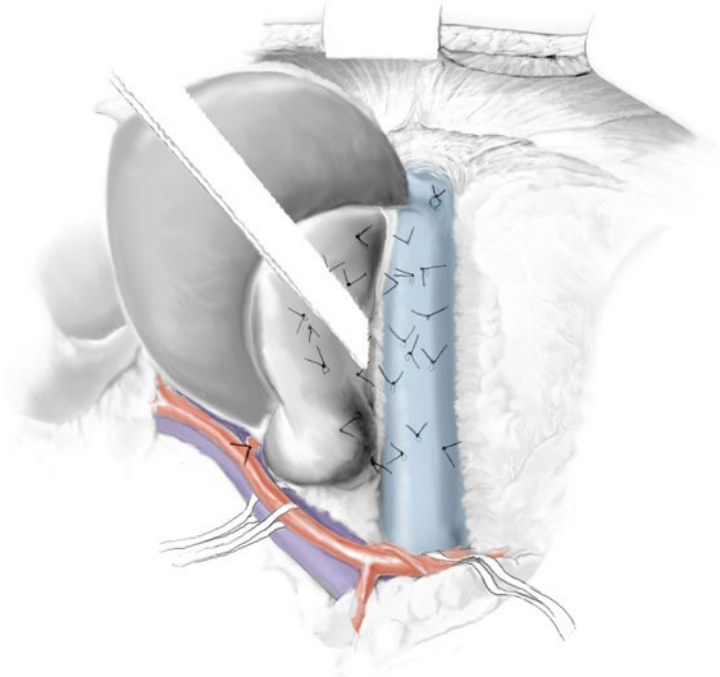


Fig. 70.5

Step 8

Exposure and transection of the left hepatic vein

For a left hepatectomy, the left hepatic vein is not transected before liver dissection. A vessel loop is placed around the common trunk of the left and middle hepatic vein. For a left trisectionectomy, the common trunk of the left and middle hepatic veins is transected before liver dissection.

Step 9

Demarcation and incision of the liver capsule

For a left hepatectomy with caudate lobe resection, dorsal demarcation appears between the caudate process and segment 7 after complete devascularization of the caudate lobe (Fig. 70.6).

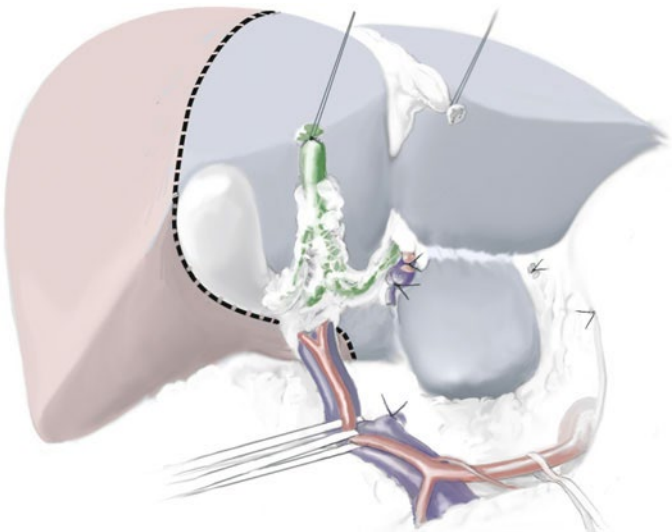


Fig. 70.6

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Step 10

Division of the draining veins of the paracaval segment

For a total caudate lobe resection, draining veins of the paracaval segment (segment 9) are identified behind the middle hepatic vein and carefully divided. Liver transection is continued until the left hepatic vein is reached, divided, and closed at its confluence of the middle hepatic vein. The right intrahepatic bile duct is identified behind the middle hepatic vein, and the posterior wall is carefully detached from the right anterior branch of the hepatic artery, which runs in the connective tissues between the bile duct and the portal vein. Two stay sutures are placed caudally and cranially, and the bile duct is incised from the caudal edge where the anterior branch or the bile duct of segment 5 is opened (Fig. 70.7).

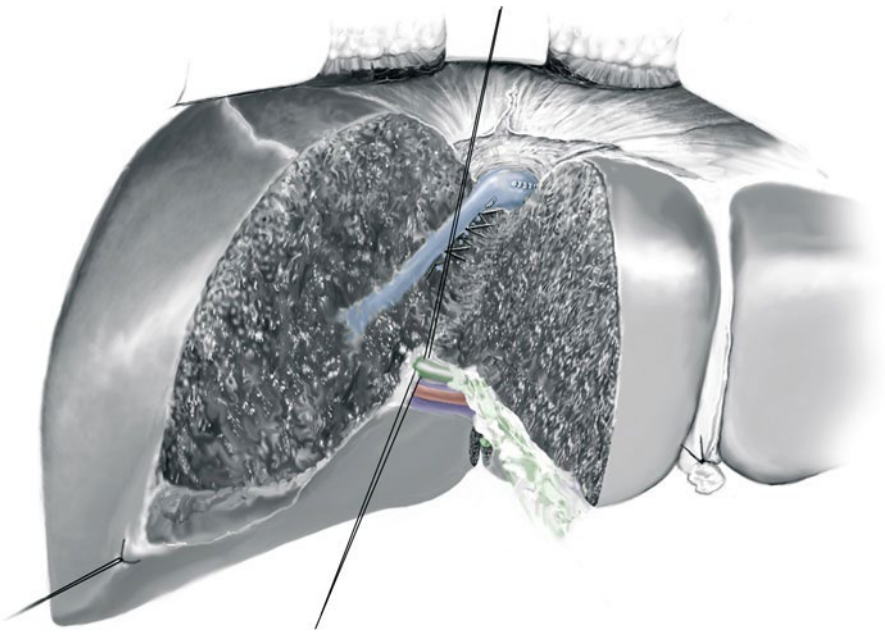


Fig. 70.7

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Step 11

Intrahepatic bile duct resection

Further extension of the incision opens the segmental or subsegmental bile ducts of segment 8 (B8, B8a, B8bc) and the right posterior duct. The surgical field after removal of the left lobe and caudate lobe is shown (Fig. 70.8).

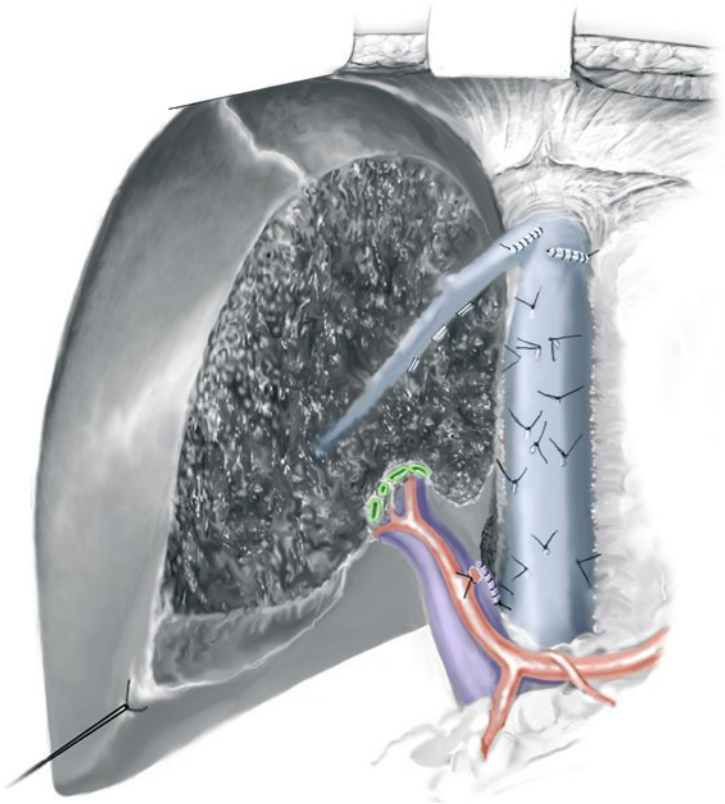


Fig. 70.8

Step 12

Extended lymph node dissection

After removing the hemiliver and the caudate lobe, para-aortic node dissection is carried out from the level of the ligamentum crus to the origin of the inferior mesenteric artery. The lymph nodes behind the left renal vein are carefully dissected by taping the left renal vein and the right renal artery. Right celiac ganglionectomy is also performed during this procedure (Fig. 70.9).

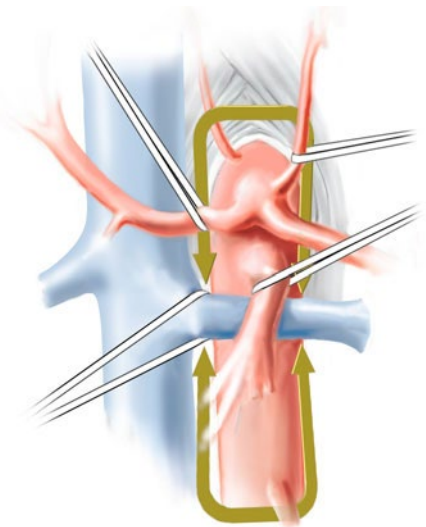


Fig. 70.9

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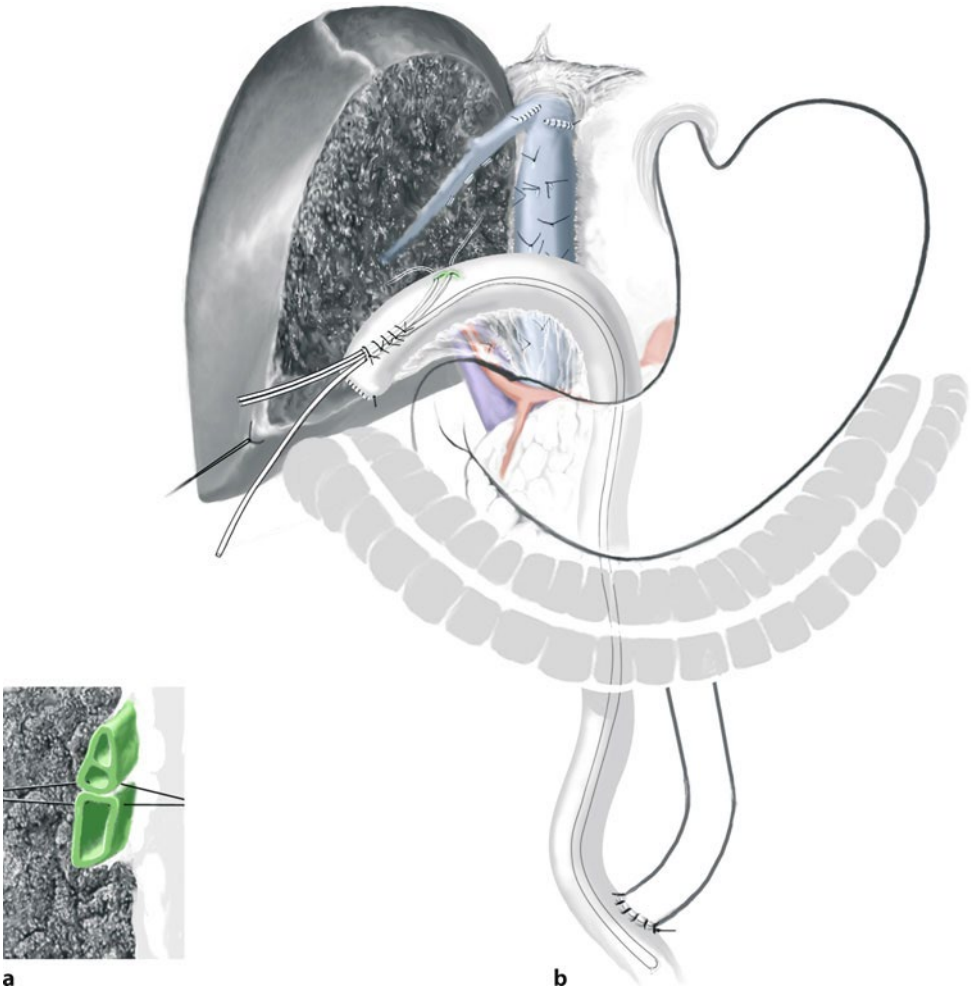
Step 13

Biliary reconstructions

Before bilioenteric anastomosis, hepaticoplasty should be performed with 5-0 PDS sutures to minimize the number of anastomoses (Fig. 70.10a).

A Roux-en-Y jejunal loop is lifted through the shortest route: the retrocolic and retrogastric route. A jejunostomy tube is also introduced from the proximal edge of the jejunal limb before hepaticojejunostomy (Fig. 70.10b).

The posterior wall is first anastomosed with 4-0 PDS sutures and a biliary drainage tube is placed in each anastomosis. Finally, the anterior wall is anastomosed. See ▶ Chap. 73 on biliary anastomosis.



a b

Fig. 70.10

Step 14

Drainage after reconstruction

After completing hemostasis in the surgical field, closed drains are placed in the foramen of Winslow, in the paracaval space along the aorta, and along the cut surface of the liver. Biliary drainage catheters and a jejunostomy tube are fixed on the skin, and the abdomen is closed. Although some groups do not use biliary stents, externally drained bile is mixed with elemental diet and ingested through the jejunostomy tube from the second postoperative day.

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Right Hepatic Resection

Contrary to left hepatic resection which is covered in the previous pages, this procedure is indicated for a case of hilar cholangiocarcinoma predominantly involving the right intrahepatic bile ducts.

Step 5

Dividing the hepatic artery and portal vein

Once the arterial anatomy and possible arterial variations are clearly identified, the right hepatic artery is divided at its origin. The remaining left and middle hepatic arteries are skeletonized more distally at the left extremity of the hilar plate or the middle and left hepatic artery at the Rex recess. Figure 70.11 demonstrates a right predominant lesion and ligation of the right portal vein. Also illustrated is the ligated right hepatic artery.

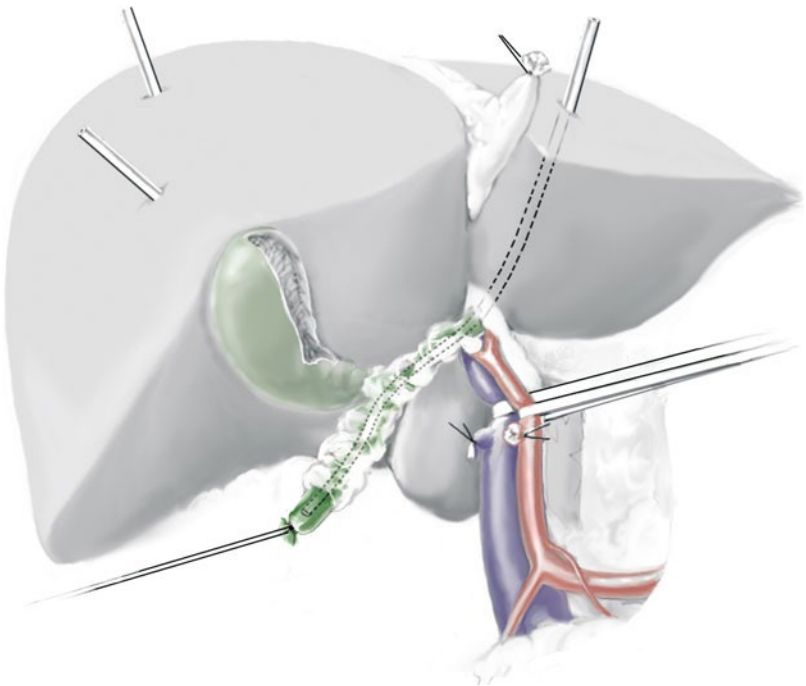


Fig. 70.11

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Step 6

Mobilization of the right hepatic lobe and caudate lobe with division of the short hepatic veins

The right liver is mobilized and the entire short hepatic veins are divided between ties on the caval side and clips on the liver side from the right caudal side to the left cranial side (Fig. 70.12).

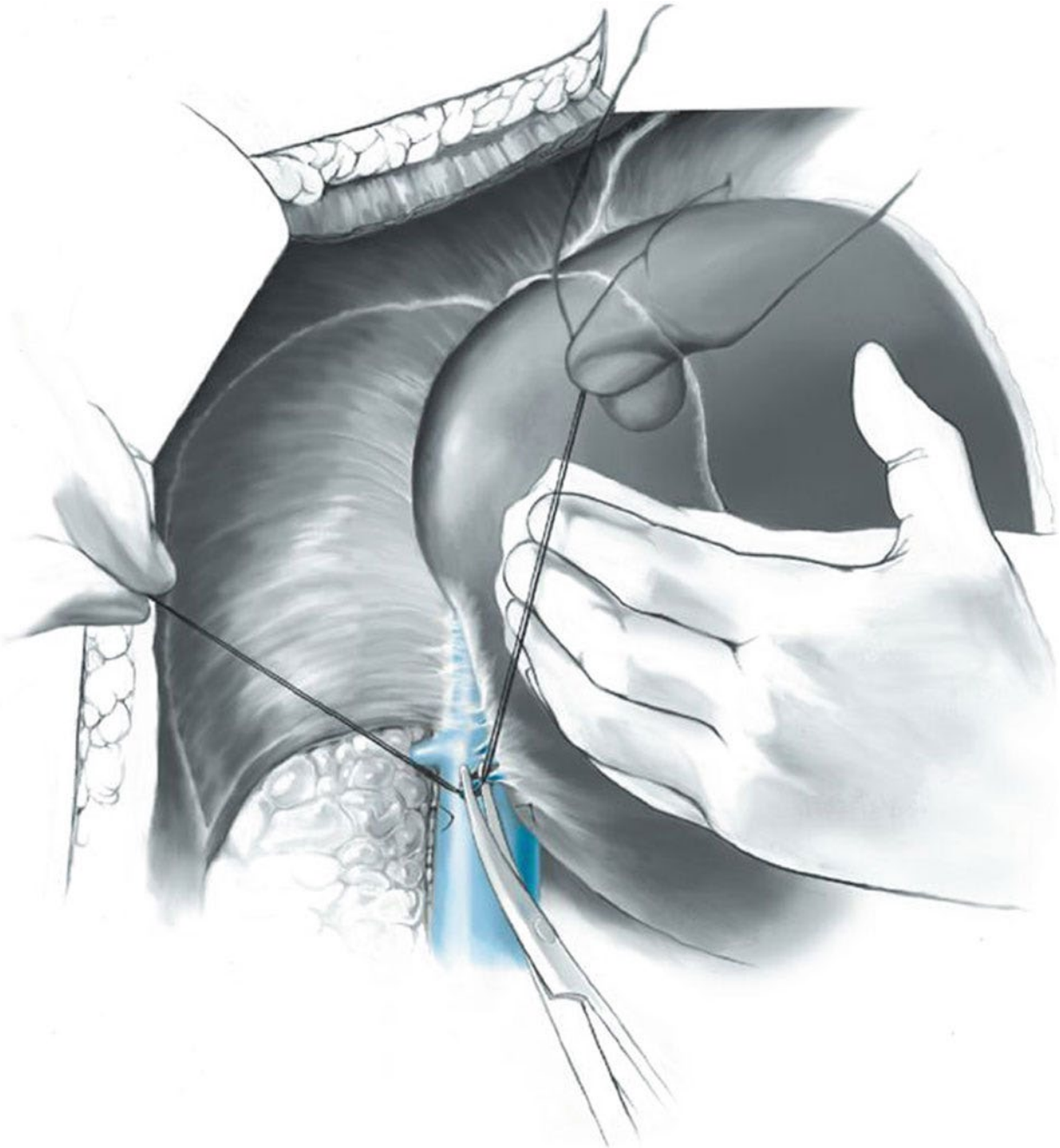


Fig. 70.12

Step 7

Exposure and transection of the right hepatic vein

A vessel loop is placed around the right hepatic vein, and vascular clamps are placed on the caval side and the liver side. The transection can be performed between the clamps. The caval side is secured by a running 4-0 Prolene suture and the other side with a 3-0 silk suture. An alternative technique is to transect the right hepatic vein with a vascular stapler (see ▶ Chap. 46 "Right Hemihepatectomy").

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Step 8

Demarcation and marking of the liver capsule

A stay suture is placed at the inferior margin of the ischemic side of the liver, and the liver capsule is incised with monopolar diathermy or bipolar scissors along the demarcation. At this point, central venous pressure (CVP) should be maintained below 3 cm H_2O.

For a right hepatectomy with caudate lobectomy, a transection line on the visceral surface of the liver is turned transversely from the Cantlie line about 1 cm above the hilar plate to maintain a surgical margin and reach to the right edge of the Rex recess (Fig. 70.13).

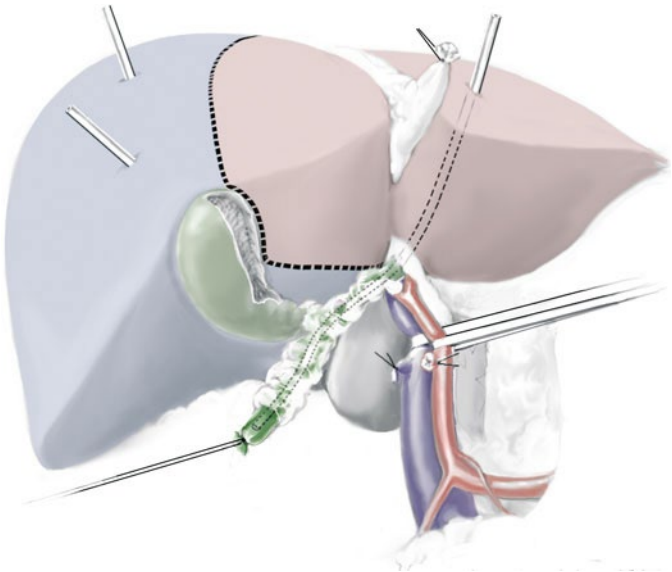


Fig. 70.13

Step 9

Transection of the liver

The liver dissection is started from the inferior margin under intermittent occlusion of the hepatic artery and the portal vein. The dissection is continued cranially and posteriorly, exposing the middle hepatic vein on the raw surface of the liver (Fig. 70.14).

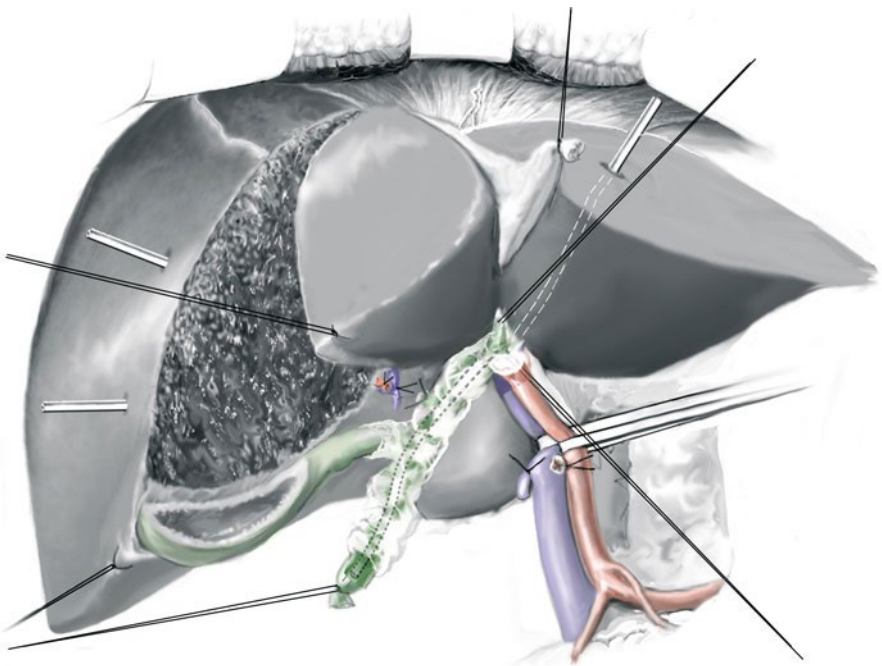


Fig. 70.14

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Step 10

Intrahepatic bile duct resection

The left intrahepatic bile duct is identified at the right edge of the Rex recess. Two stay sutures are placed ventrally and dorsally (Fig. 70.15a), the left hepatic duct is transected perpendicularly, and the right liver, caudate lobe, and extrahepatic bile duct are removed (Fig. 70.15b). At the ventral edge of the resected margin of the left hepatic duct, the bile duct of segment 4 is opened, followed by segments 3 and 2 dorsally.

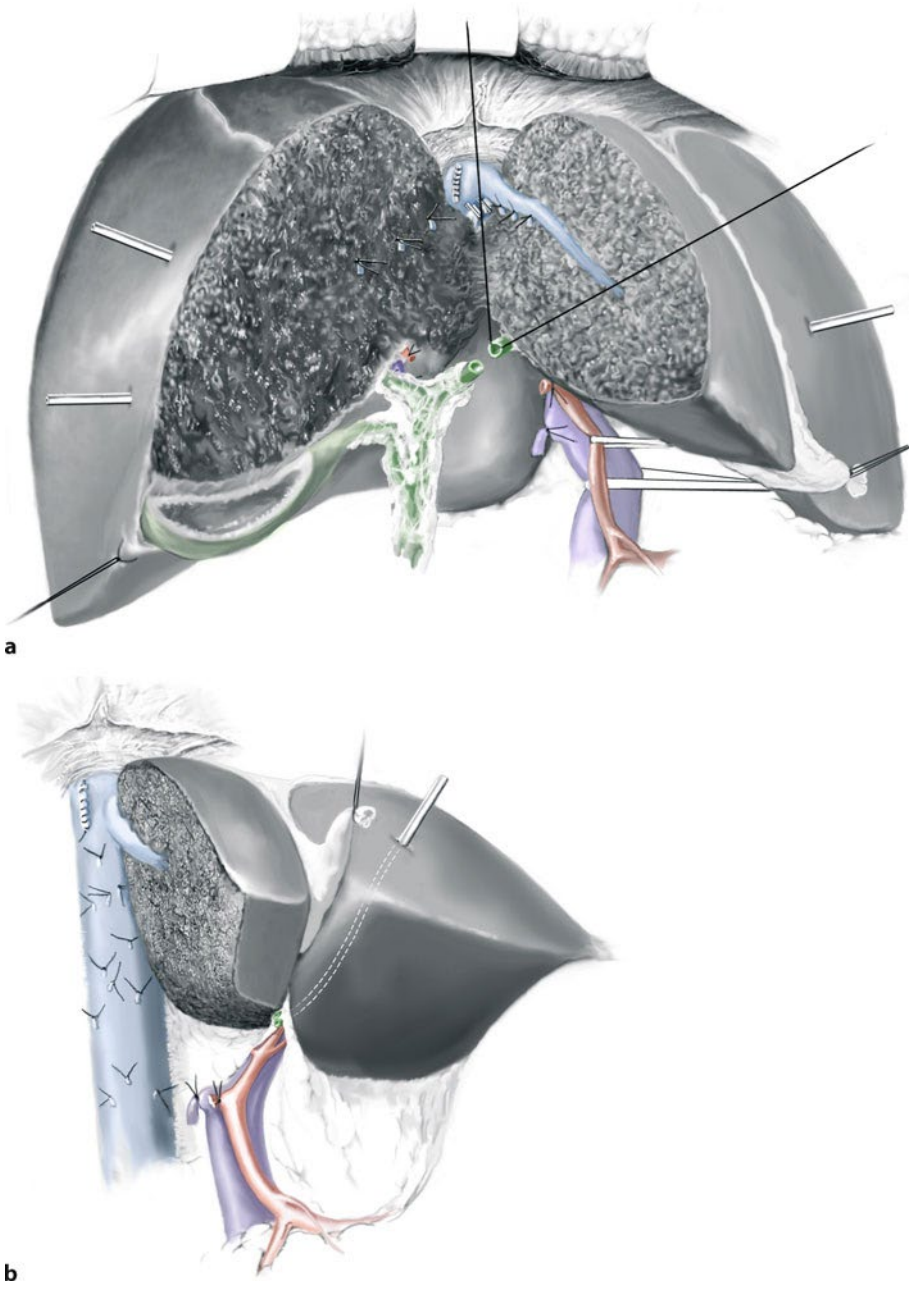


Fig. 70.15

Step 11

Extended lymph node dissection

Extended lymph node dissection is performed as above.

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Step 12

Biliary reconstructions

A Roux-en-Y jejunal loop is lifted through the shortest route: the retrocolic and retrogastric route. A jejunostomy tube is also introduced from the proximal edge of the jejunal limb before hepaticojejunostomy (Fig. 70.16).

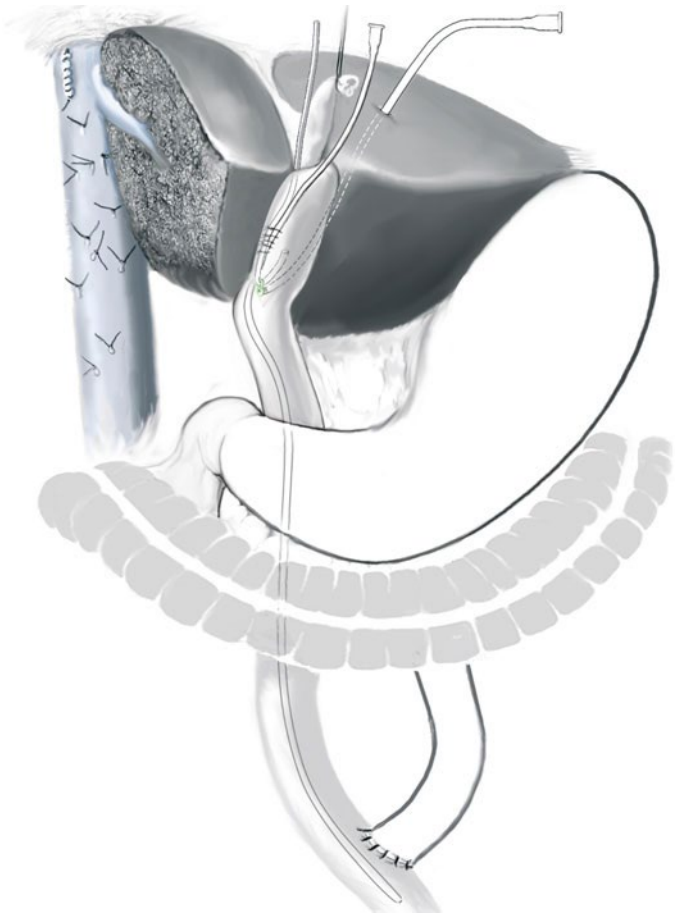


Fig. 70.16

Postoperative Tests

- Postoperative surveillance in an intensive or intermediate care unit
- Liver function tests (bilirubin, ALT, AST, albumin), coagulation parameters, hemoglobin, red blood cell (RBC), white blood cell (WBC), CRP
- Color Doppler ultrasound to estimate the blood flow of the portal vein and hepatic artery

Local Postoperative Complications

- **Short-term**
  - (Pleural effusion)
  - Wound infection
  - Bile leak from hepaticojejunostomy or raw surface of the liver
  - Subphrenic or subhepatic abscess
  - Intra-abdominal bleeding
  - Liver failure
  - Portal vein thrombosis

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- **Long-term:**
  - Cholangitis
  - Anastomotic stricture
  - Chronic liver failure

Tricks of the Senior Surgeon

- Check the intraoperative external biliary drainage to prevent unexpected biliary congestion from which septic complications may develop.
- Overview Stop
- Suture the large short hepatic veins or caudate lobe veins in detaching the caudate lobe from the vena cava.
- Check the CVP in the monitor before liver transection. If the CVP is higher than 3 cm H_2O, do not start to transect the liver.
- The hepatic vein on the liver side should be closed by a running suture to prevent bleeding during the handling of the liver.
- Stay sutures should be placed before dividing the intrahepatic bile duct; otherwise the small segmental duct will slip away and be hidden by the liver parenchyma.
- The lymphatic vessels should be tied in a para-aortic lymph node dissection to prevent postoperative massive lymphorrhea, although the indication of para-aortic node dissection has been controversial.

Editor's Comments

- Tissue diagnosis is not a prerequisite for surgical resection of suspected cholangiocarcinoma; clinical presentation and radiographic appearance are enough.
- ERCP and peroral cholangioscopy are avoided for high bile duct obstruction, as these are unlikely to define the problems or palliate obstruction, and they can lead to cholangitis.
- Percutaneous drainage is not always necessary prior to surgery. The patients who will benefit from preoperative drainage are those who 1) have cholangitis, 2) have renal dysfunction, 3) have possible vascular invasion on the side that will be the remnant liver after resection, or 4) should undergo portal vein embolization.

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Right Hepatectomy (Resection of Segments 5, 6, 7, 8, and 1) with Bile Duct Resection

Tomoki Ebata, Masato Nagino

Perihilar cholangiocarcinomas often invade the right hepatic artery, the adjacent liver parenchyma, and the bile ducts of the caudate lobe. Therefore, right-sided hepatectomy plus total caudate lobectomy combined with bile duct resection is commonly employed for this type of tumor. This procedure involves lymphadenectomy, major hepatectomy, and bilioenteric anastomosis, representing a complex and difficult hepatectomy. The oncologic goal is to remove the primary tumor with a sufficient tumor-free margin (R0 resection), because a positive surgical margin is a major factor that can impede postoperative survival.

Indications and Contraindications

Indications

- Perihilar cholangiocarcinoma, Bismuth type I, II, IIIa, or a subset of IV
- Intrahepatic cholangiocarcinoma involving the hilar duct
- Gallbladder cancer involving the common hepatic duct
- Complex bile duct injury/stricture after cholecystectomy

Controversial Indications

- Lymph node metastasis at the celiac axis and the aorta (N2)
- Involvement of the left hepatic artery (bilateral hepatic artery invasion)

Contraindications

- Distant metastatic disease (liver, lung, bone, or peritoneum)
- Poor liver functional reserve and general condition, or severe comorbidity

Specific Preoperative Preparations

- Assessment of biliovascular anatomy based on multidetector computed tomography (MDCT) and cholangiography
- Liver function assessment based on the indocyanine green test and CT volumetry
- Portal vein embolization using a percutaneous ipsilateral approach
- Endoscopic nasobiliary drainage (ENBD) of the future liver remnant
- Bile replacement in cases with external biliary drainage
- Autologous blood donation, when possible, to avoid homologous blood transfusion
- Surveillance of bile cultures for the selection of sensitive antibiotics

Notes

- A self-expandable metallic stent should not be placed in potentially resectable tumors.
- Percutaneous transhepatic biliary drainage carries a risk of seeding metastasis of at least 5 %.
- Never perform operations in patients with active cholangitis, because of the potential for major complications or mortality.

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DOI 10.1007/978-3-662-46546-2_71, © Springer-Verlag Berlin Heidelberg 2016

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Procedure

Step 1

Exposure and exploration

An upper midline incision with right lateral extension towards the inferior costal margin is made. A left subcostal or a right costal extension is rarely necessary. A limited upper midline incision may be made first to allow preliminary exploration in order to exclude the presence of extrahepatic spread.

The ligamentum teres is divided, and the falciform ligament is incised and separated from the abdominal wall. The lesser omentum is incised to allow manual palpation of the celiac lymph node basin; attention should be directed to the possible presence of an accessory or replaced left hepatic artery. The wound protector and the retractors are installed for optimum exposure. Nodal metastasis, ductal invasion at the level of the pancreas, and invasion of the umbilical fissure are manually inspected for final assessment of local resectability. Kocher's maneuver is performed to expose the periaortic nodes, which are routinely sampled for frozen section examination (Fig. 71.1).

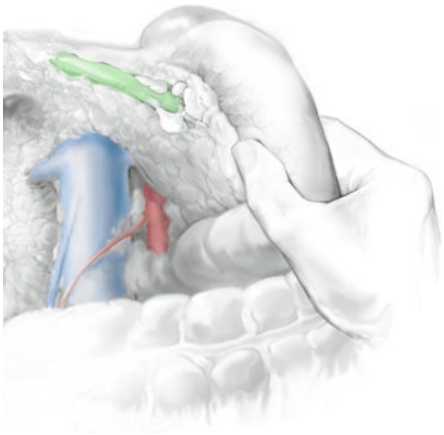


Fig. 71.1

Step 2

Regional lymph node clearance

Supraduodenal vessels and the right gastric artery are divided; the upper half of the duodenum is detached from the pancreatic head, facilitating the subsequent lymphadenectomy. After removal of the retropancreatic node, the common bile duct can be isolated at the pancreatic entry. The gastroduodenal artery, common hepatic artery, and proper hepatic artery are dissected meticulously; the lymph nodes and the nerve plexus around these arteries are dissected. The tiny vessels communicating with the lymph nodes are secured by hemostasis. Attention should be paid to avoid dissection of the pancreatic parenchyma, which can lead to a pancreatic fistula (Fig. 71.2).

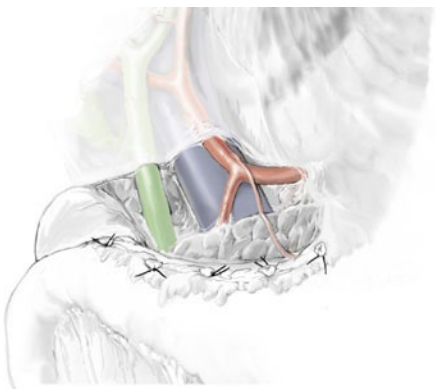


Fig. 71.2

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Step 3

Transection of the distal bile duct

After removal of the ENBD tube, the distal bile duct is cut at the level of the pancreas. A new decompression tube is inserted from the cut stump up to the liver to drain bile during surgery. The segment of the ductal margin is histologically examined by frozen section. In some patients whose tumors have advanced more distally, the cut level is set at the intrapancreatic portion to obtain a tumor-free margin. The right wall of the main portal trunk is exposed at the level of the pancreas. The posterior superior pancreatoduodenal vein is divided at the confluence to avoid tearing during the manipulation (Fig. 71.3).

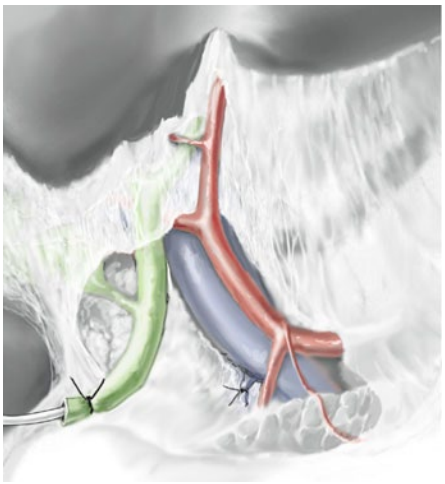


Fig. 71.3

Step 4

Division of the right hepatic artery and portal vein

The transected distal bile duct is retracted ventrally to allow good exposure of the porta hepatis. The proper hepatic artery is dissected upwards, followed by exposure of the bifurcation of the right and the left hepatic artery. The right hepatic artery is divided by double suture ligation of the proximal end. The main portal trunk is dissected distally to the portal bifurcation. An approximately 1-cm segment of the right portal vein is exposed, and the entire length of the left portal vein is isolated by the division of several portal branches of the caudate lobe. The right portal vein is divided after the vascular clamps are placed. The proximal open end is carefully inspected, as thrombus induced by portal vein embolism may be found. The proximal stump is closed with a continuous 5-0 nonabsorbable suture (Fig. 71.4).

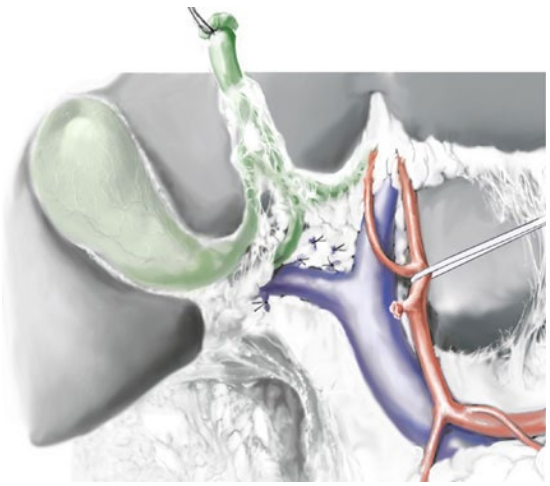


Fig. 71.4

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Step 5

Dissection of the umbilical fissure

The left hepatic artery is further dissected towards the umbilical fissure, ramifying the left medial branch (A4) and the lateral branch (A2 + 3). Usually, the A4 runs anterior to the left portal vein and encroaches on the right side of the fissure, whereas A2 + 3 approaches toward the left side of the umbilical fissure and intersects the canal of Arantius. Excluding A4 and A2 + 3, the other small arteries feeding the caudate lobe or the hilar bile duct are ligated and divided. The canal of Arantius is divided at the attachment to the left portal vein, and the A2 + 3 is freed from the canal. Here, the left portal vein and the left hepatic artery are completely detached from the hilar plate (Fig. 71.5).

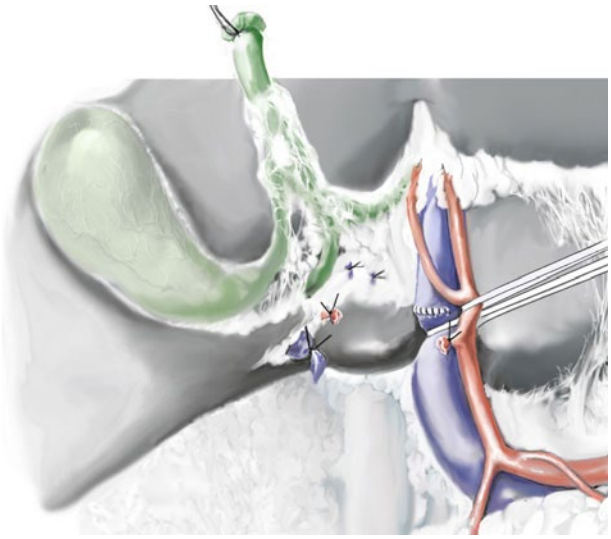


Fig. 71.5

۰۲۱-۶۶۱۹۸۵۱۴ www.myuptodate.com دریافت آخرین نسخه آپتودیت آفلاین

Step 6

Mobilization of the right liver

The falciform ligament is divided toward the right to expose the right hepatic vein. The peritoneal reflection at the edge of the right triangle is incised, and the entire bare area of the right liver is exposed. The right liver is freed up from the diaphragm and rotated medially away from the diaphragm, exposing the inferior vena cava. The vena cava ligament, a dense fibrous tissue, obscures the upper right part of the inferior vena cava to a variable extent. The ligament is carefully divided to expose the inferior border of the right hepatic vein. Rarely, this ligament encircles the inferior vena cava with a thin rim of liver tissue (annular caudate lobe).

After full exposure of the right hepatic vein, two vascular clamps are applied to the vein with a sufficient margin to obtain the open ends. The right hepatic vein is divided, and the ends are closed with an over-and-over 4-0 nonabsorbable vascular suture. Alternatively, a vascular stapling device can be used (Fig. 71.6).

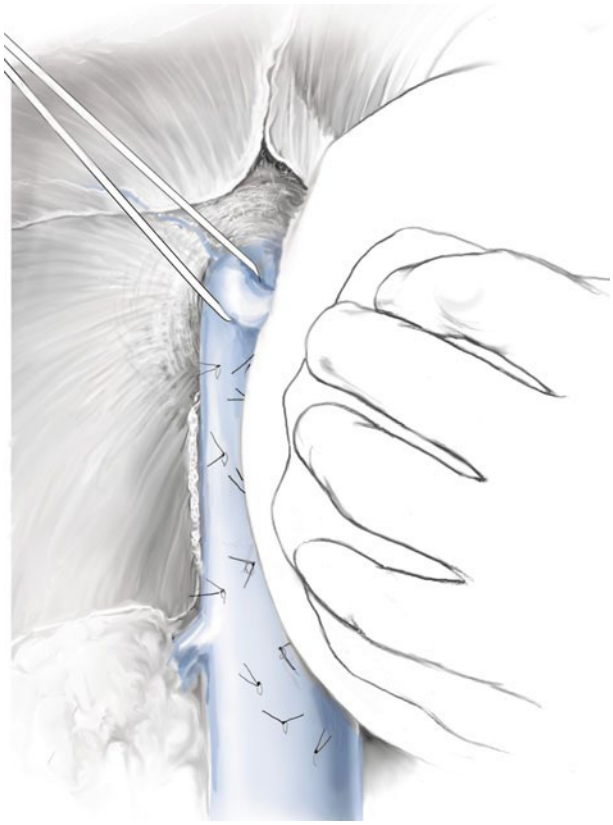


Fig. 71.6

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Step 7

Mobilization of the caudate lobe

All short hepatic veins that drain directly from the caudate lobe to the inferior vena cava are ligated/clipped and divided serially, progressing from the inferior aspect toward the cranial direction. The left border of the caudate lobe remains attached to the retroperitoneum with the left caval ligament, and to the cranial end of the canal of Arantius. Division of these structures allows the complete mobilization of the caudate lobe (Fig. 71.7).

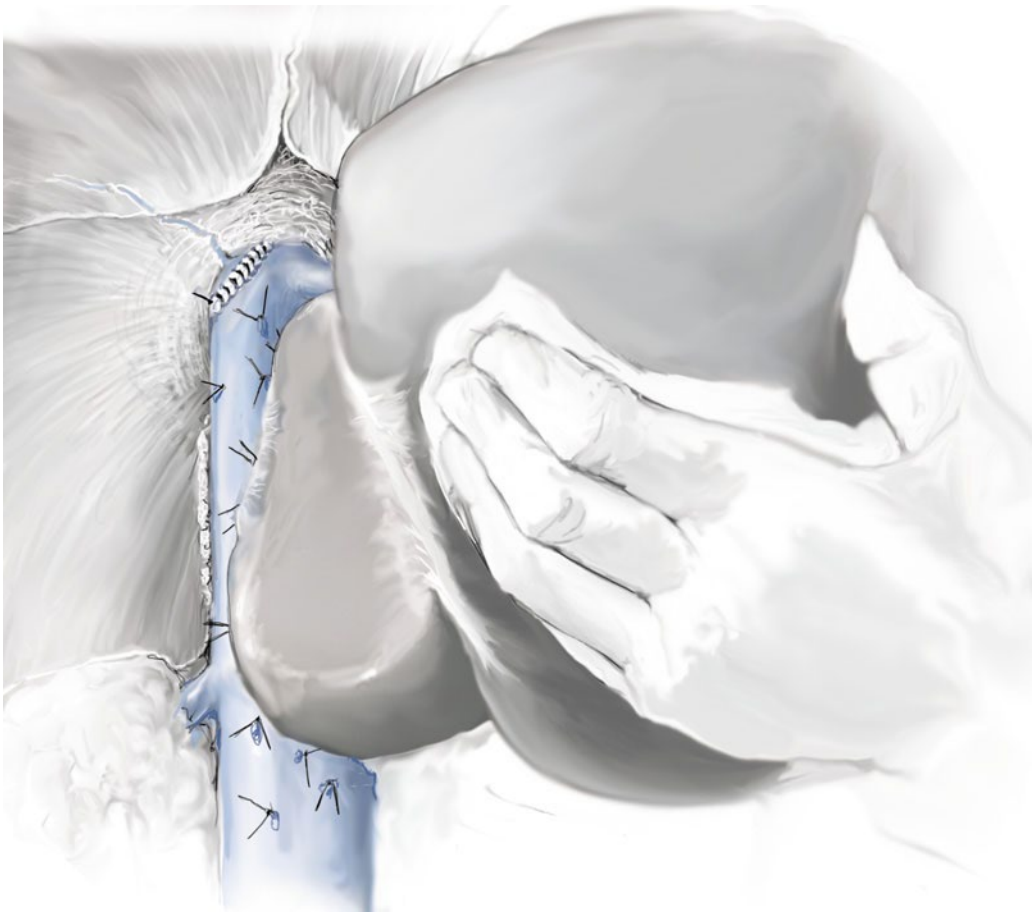


Fig. 71.7

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Step 8

Design of the liver transection line

An ischemic demarcation between the right and left liver is visualized on the liver surface. The liver capsule is incised with monopolar diathermy along the demarcation. The incision on the visceral surface of the liver is turned transversely from the Cantlie line approximately 1 cm apart from the porta hepatis to obtain a surgical margin. In case of evident liver invasion, the distance from the porta hepatis is increased, as appropriate. At this point, the central venous pressure should be maintained below 5 mm Hg to minimize backflow bleeding during the liver transection (Fig. 71.8).

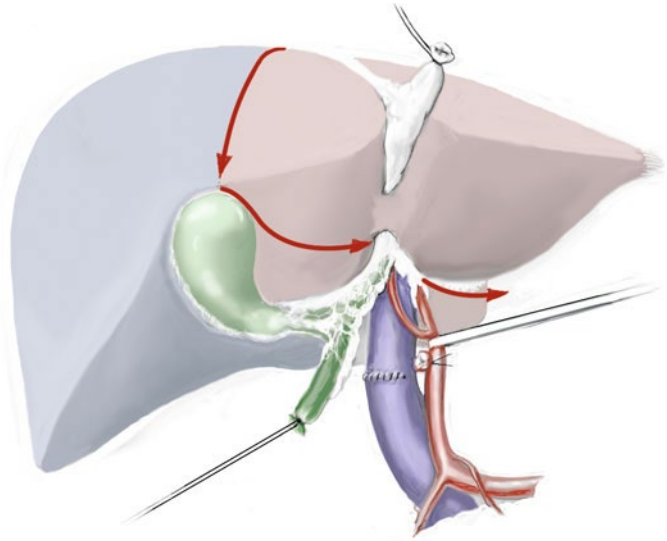


Fig. 71.8

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Step 9

Liver transection

The liver transection technique is chosen based on the surgeon's preference. Under intermittent inflow clamping for 15 to 20 min at 5-minute intervals (Pringle's maneuver), parenchymal transection is initiated from the caudal margin. The major bifurcation of the middle hepatic vein (V4 and V5), an intrahepatic landmark of the main portal fissure, is exposed as early as possible. The V5 branch is isolated, ligated, and divided, and then the transection is advanced along the middle hepatic vein. The major branch draining the right anterior sector (V8) is divided, and the entire middle hepatic vein is exposed. Then, the transection is continued to the left and rear of the middle hepatic vein. As the middle hepatic vein runs only 1 to 2 cm from the right anterior portal pedicle, exposure of the middle hepatic vein is important to obtain a sufficient parenchymal margin. The tiny vessels draining the caudate lobe are meticulously ligated and divided. Finally, the transection plane turns toward the canal of Arantius as the terminal landmark (Fig. 71.9).

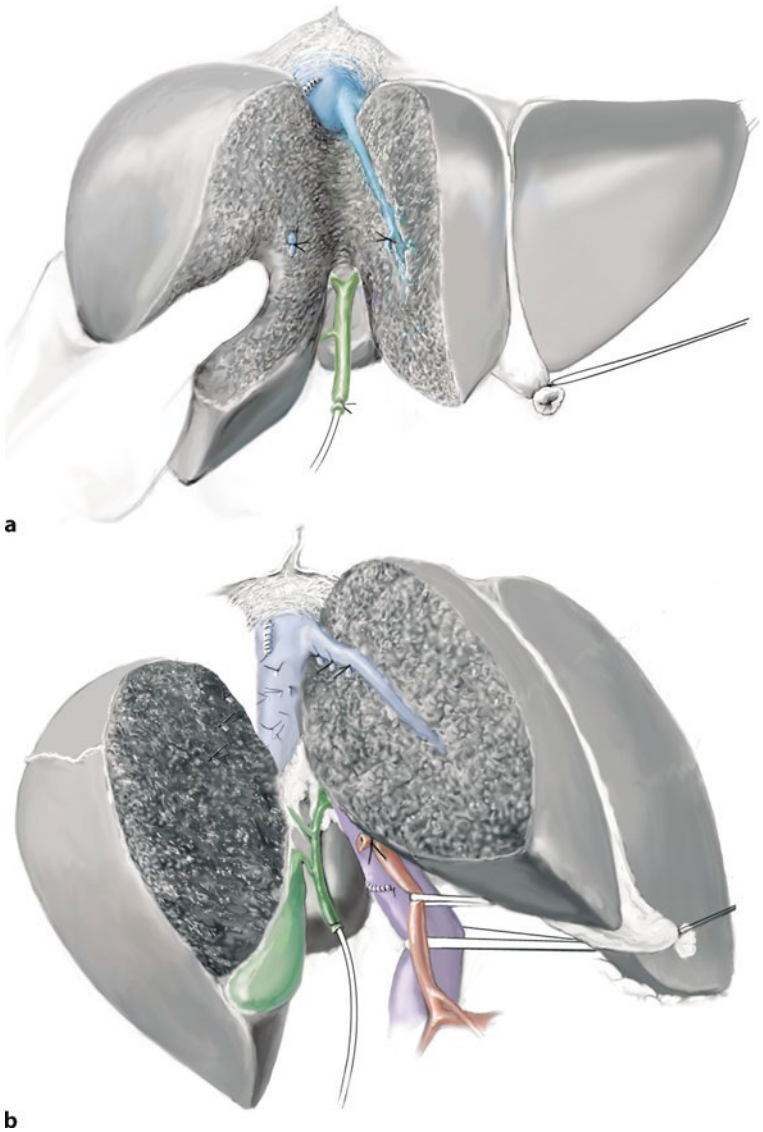


Fig. 71.9

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Step 10

Division of the intrahepatic bile duct

After completion of the liver transection, the left intrahepatic bile duct is identified at the right side of the umbilical portion of the left portal vein. The clamp is placed at the bile duct of the resection side to minimize bile spillage. The duct is transected vertically, considering an adequate margin for anastomosis. The right liver, the caudate lobe, and extrahepatic bile duct are removed en bloc. The ductal stump is histologically inspected by frozen section examination. Although the number and size of the ductal stumps differ individually, the stump of the bile duct of segment 4 is opened at the most ventral side, followed by the ductal stumps of segments 3 and 2 at the dorsal side. The adjoining walls of the multiple ducts are sutured together to make a single stump for anastomosis (hepaticoplasty) (Fig. 71.10).

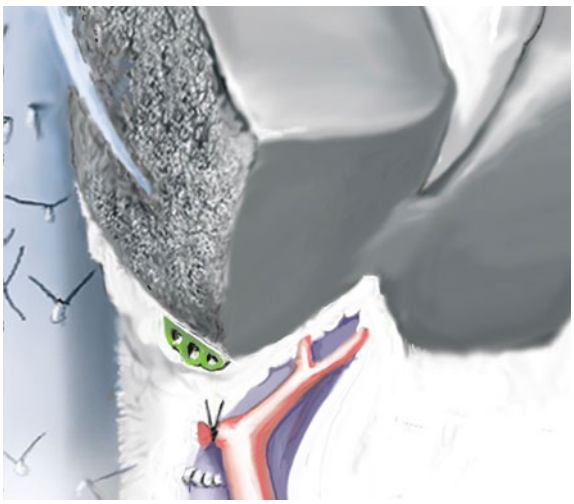


Fig. 71.10

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Step 11

Biliary reconstruction

The Roux-en-Y jejunal limb is lifted through the retrocolic and retrogastric route, which is the shortest distance and easiest for reconstruction. An 8F jejunostomy tube is introduced through the edge of the limb. A smaller corresponding opening is made on the jejunal loop because the bowel opening tends to enlarge during the procedure. A water-tight, mucosa-to-mucosa approximation is essential for good healing; therefore, sutures should pass through all of the layers with suitable bites and pitches, depending on the ductal diameter and thickness. First, two corner sutures are placed using a 5-0 absorbable monofilament material, followed by interrupted posterior sutures. Second, the posterior sutures are gently tied serially. Third, a 6F biliary stent tube is introduced through the jejunal stump. Last, the anterior wall is sewn similar to the posterior wall (Fig. 71.11).

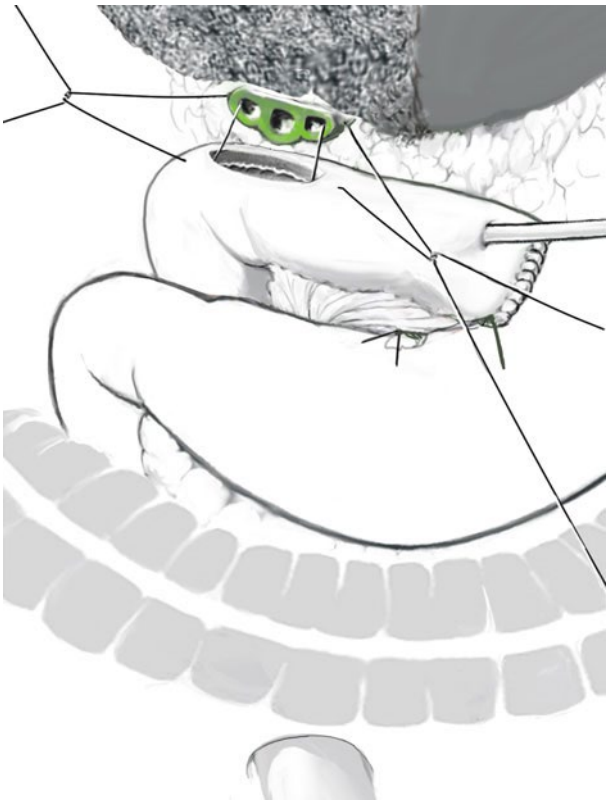


Fig. 71.11

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Step 12

Drainage and closure of the abdomen

Three surgical drains are routinely placed at the retropancreatic region, the right subphrenic space, and the liver stump. The ligamentum teres is re-fixed to the midline incision to prevent outflow blockage.

Specific Postoperative Protocols

- Early enteral nutrition and administration of symbiotic agents
- Replacement of the externally drained bile
- Biochemical measurement of the drainage fluids on days 1, 3, and 7
- Surveillance of bacterial culture of the drained fluids and the externally drained bile
- Color Doppler ultrasound on days 1, 3, and 7
- Enhanced CT scan on day 7

Local Postoperative Complications

- Infectious complications including wound sepsis, abdominal abscess, or bacteremia
- Bile leakage from the liver stump or the biliodigestive anastomosis
- Pancreatic fistula
- Refractory ascites
- Portal vein thrombus

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Left-sided Hepatectomy (Left Hemihepatectomy or Left Trisectionectomy) Extending to the Caudate Lobe with Bile Duct Resection for Perihilar Cholangiocarcinoma

Hiroaki Shimizu, Masaru Miyazaki

Left-sided hepatectomy (left hemihepatectomy or left trisectionectomy) extending to the caudate lobe with bile duct resection has been recognized as a standard treatment option for perihilar cholangiocarcinoma of the left-side predominance. From the viewpoint of anatomical factors at the hepatic hilus, left-sided hepatectomy is considered to be a more complicated procedure, requiring greater skill, than right-sided hepatectomy. As there are many anatomical variations of the sectional artery and bile duct in the right liver (remnant side), preoperatively evaluating individual 3-D hilar anatomy is essential for successful surgery.

The surgical procedures consist of 1) regional lymphadenectomy and skeletonization resection of the hepatoduodenal ligament, 2) hepatectomy combined with extrahepatic bile duct resection, and 3) biliary reconstruction.

Indications and Contraindications

Indications

- Primary malignancies (e. g., perihilar cholangiocarcinoma of the left-side predominance, intrahepatic cholangiocarcinoma in the left liver involving the hepatic hilus)
- Benign diseases (e. g., primary sclerosing cholangitis, inflammatory pseudotumor, hepatolithiasis)

Absolute Contraindications

- Biliary carcinoma with distant organ metastasis (liver, lung, bone, peritoneum)
- Uncontrollable severe cholangitis with or without sepsis
- Poor liver functional reserve (due to prolonged cholestasis, chronic hepatitis, cirrhosis)

Relative contraindications

- Distant lymph node metastasis (e. g., para-aortic lymph node)
- Locally advanced cholangiocarcinoma with bilateral arterial involvement

Preoperative Investigation and Preparation for the Procedure

Preoperative investigation

- *History:* Biliary surgery
- *Clinical evaluation:* Jaundice, cholangitis, nutritional status
- *Laboratory tests:* Bilirubin, alkaline phosphatase (ALP), aspartate aminotransferase (AST), alanine aminotransferase (ALT), albumin, coagulation parameters (prothrombin time, platelets), indocyanine green retention rate at 15 min (ICG R15), tumor markers: carcinoembryonic antigen (CEA), carbohydrate antigen 19-9 (CA 19-9)
- *Radiology:* Multidetector CT (MDCT), ultrasonography, MR cholangiopancreatography (MRCP), endoscopic retrograde cholangiography (ERC), percutaneous transhepatic cholangiography (PTC), CT volumetry

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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- *Endoscopy:* Peroral cholangioscopy (POCS), percutaneous transhepatic cholangioscopy (PTCS) (These procedures may be useful to make a differential diagnosis or to define the intraepithelial spread of papillary cancer by taking a step biopsy.)

What not to do

- For accurate evaluation of cancer extension to the bile duct, a biliary drainage catheter should not be placed before MDCT imaging.
- A metallic stent should not be used in resectable biliary carcinoma.

Preparation prior to surgery

- Determination of the optimal surgical procedure mainly by MDCT imaging, particularly before biliary drainage
- Endoscopic biliary drainage (EBD) of the future liver remnant (percutaneous transhepatic biliary drainage [PTBD] is currently the treatment of choice when EBD is unsuccessful or not feasible)
- Examination of hepatic functional reserve and future remnant liver volume
- Portal vein embolization for major hepatectomy (>60 % resection of the liver in patients with obstructive jaundice)
- Antibiotics sensitive to bile culture

Procedure

Access

Incision, division of round and falciform ligament (see Part I, ▶ Chaps. 2 "Positioning and Accesses" and 3 "Retractors and Principles of Exposure").

Step 1

Laparotomy

The retractor is installed (see Part I, ▶ Chap. 3 "Retractors and Principles of Exposure"). Upon entering the abdominal cavity, inspection of possible peritoneal metastasis and liver metastasis should be done.

If PTBD catheters have been placed, these should be cut, drawn into the abdominal cavity, and connected to the small drainage bags to maintain intraoperative drainage.

Intraoperative ultrasonography may be helpful to evaluate the location of the tumor in relation to vascular structures (portal vein, hepatic artery, hepatic vein).

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Step 2

Regional lymph node dissection

After the Kocher's mobilization, para-aortic lymph nodes are sampled for frozen section examination (Fig. 72.1). Following removal of the lymph nodes along the common and proper hepatic arteries, the nerve plexus around these arteries is dissected, the arterial adventitia is exposed, and vessel tapes are placed around these arteries. After confirmation of vascular variations, the proximal parts of the right and left hepatic arteries are also dissected and taped. Lymph nodes in the hepatoduodenal ligament are dissected. The common bile duct close to the upper margin of the pancreatic head is encircled and taped after removal of retropancreatic nodes.

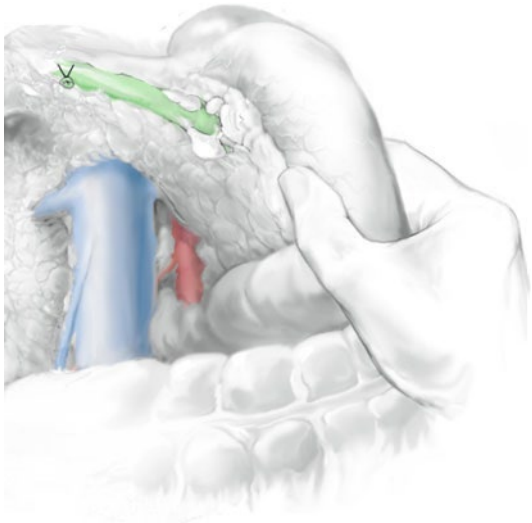


Fig. 72.1

Step 3

Dividing the lower bile duct

The distal bile duct is dissected down to the head of the pancreas and divided just above the pancreas (Fig. 72.2), but in some cases, this procedure should be advanced more distally as long as possible by detaching the bile duct from the pancreatic tissue to obtain a longer resection margin. The lower ductal resection margin should be examined by frozen section.

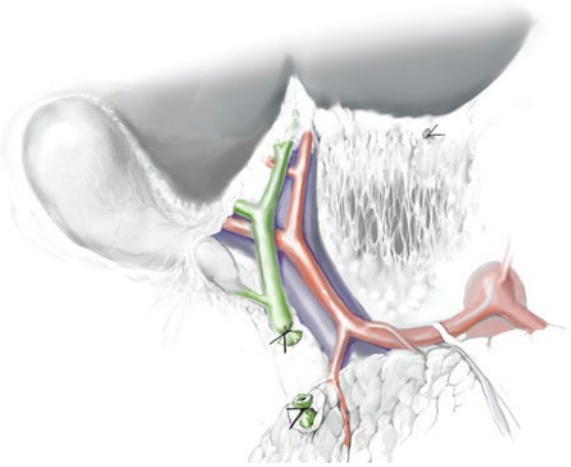


Fig. 72.2

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Step 4

Skeletonization of the upper part of the hepatoduodenal ligament

The transected distal bile duct is pulled up cranially, and the distal portion of the hepatic artery and portal bifurcation are exposed. After dividing the caudate lobe portal branches behind the confluence of the right and left portal veins (Fig. 72.3), the right and left portal veins are carefully encircled by a vessel loop.

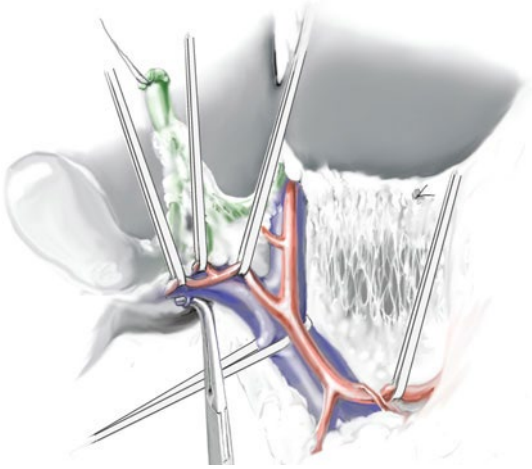


Fig. 72.3

Left Hemihepatectomy

Left hemihepatectomy extending to the caudate lobe with bile duct resection is applied mainly in patients with Bismuth type IIIb tumors (left trisectionectomy, *see* Step 13).

Step 5

Dividing the hepatic artery

Once the arterial anatomy and possible arterial variation are clearly identified, the left and middle hepatic arteries are divided at the origin (Fig. 72.4). The remaining right hepatic artery is skeletonized more distally to encircle the right anterior and posterior branches at the right extremity of the hilar plate. Then the right anterior and right posterior sectional arteries are taped.

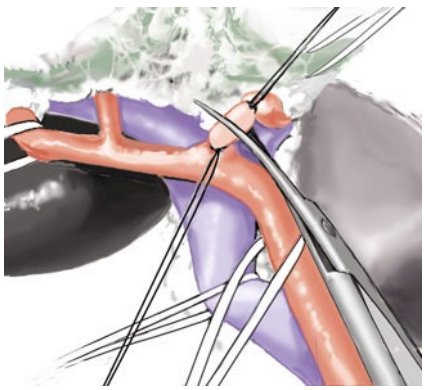


Fig. 72.4

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Step 6

Dividing the left portal vein

The left portal vein is ligated and divided distally to the bifurcation. If there is not enough length for ligation and division of the left portal vein due to the cancer invasion, the left portal vein is divided after clamping the portal trunk, right portal vein (Fig. 72.5a), and is closed with transverse continuous sutures to prevent stenosis of the portal vein (Fig. 72.5b).

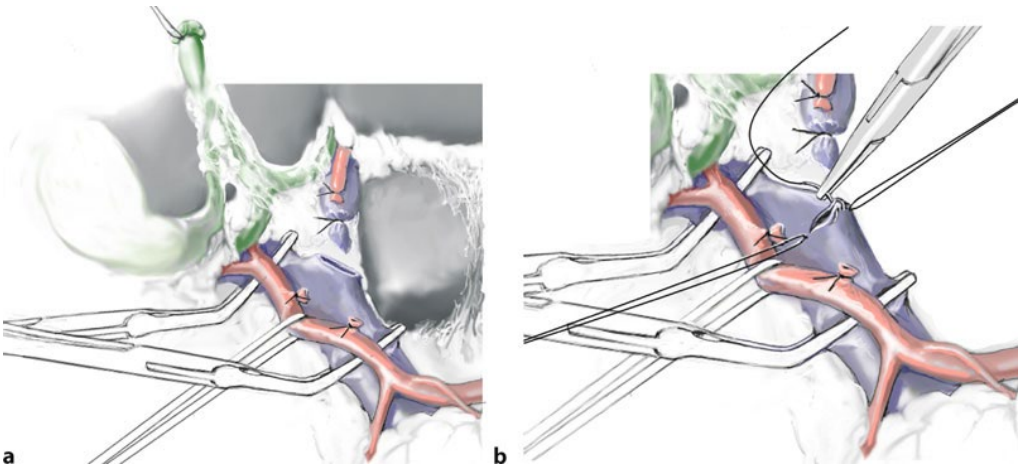


Fig. 72.5

Step 7

Mobilization of the left hemiliver

The left coronary and triangular ligaments are divided, the left hemiliver is mobilized to the right (Fig. 72.6a), and the minor omentum is opened. The middle and left hepatic veins, which usually share a common trunk, are exposed above the liver by careful dissection (Fig. 72.6b).

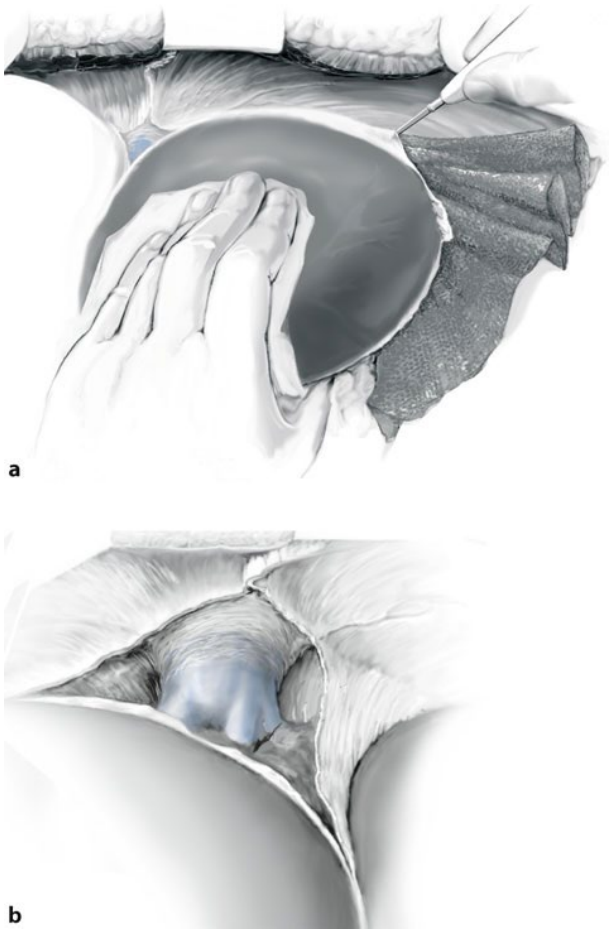


Fig. 72.6

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Step 8

Separation of the caudate lobe from the vena cava

Mobilization of the caudate lobe is performed, preferably only from the left-hand side. The entire short hepatic veins are then divided from the left caudal side to the right cranial side (Fig. 72.7). The large short hepatic veins or caudate lobe veins should be divided using a spoon clamp and secured by a running 4-0 suture at the caval side. Finally, the distal end of the canal of Arantius is ligated and divided at the confluence of the left hepatic vein or the vena cava. Although the caudate lobe must be fully separated from the inferior vena cava, the inferior or the middle right hepatic vein, if present, must be preserved to prevent deterioration of the venous drainage in the right posterior section.

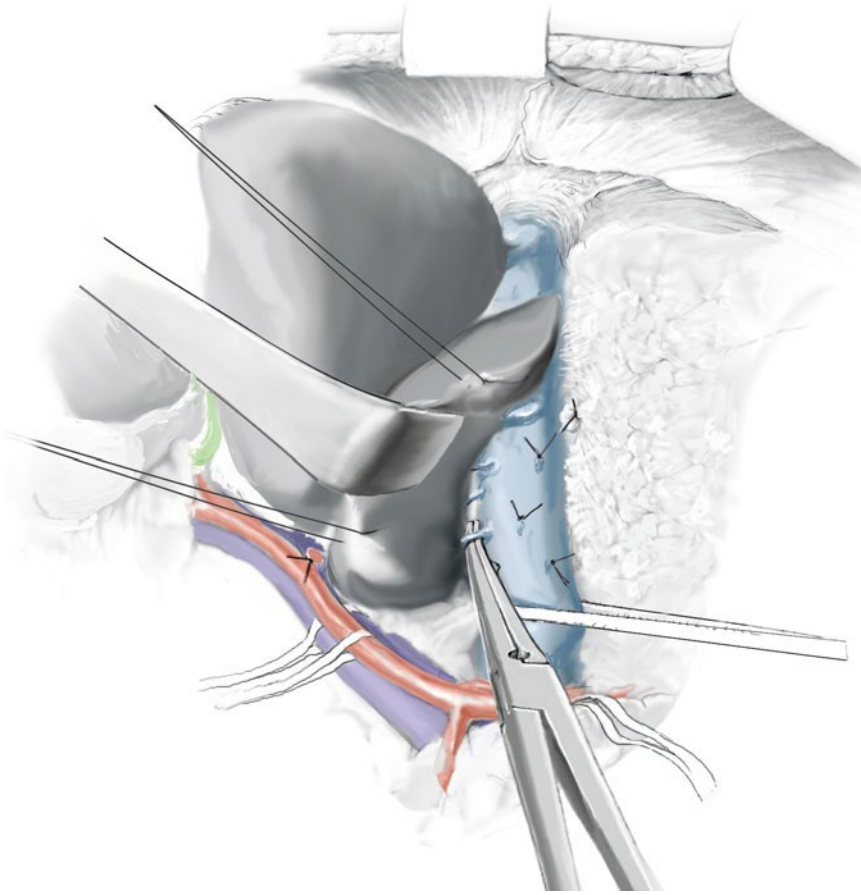


Fig. 72.7

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Step 9

Liver resection

A demarcation line is already present along the Rex-Cantlie line on the liver surface. Parenchymal transection is performed using a cavitron ultrasonic surgical aspirator (CUSA) under Pringle maneuver (inflow occlusion time, 15 min; reperfusion time, 7 min). Liver resection is usually started from the caudal edge of the demarcation line and advanced in the craniodorsal direction with preservation of the middle hepatic vein on the transection plane of the right anterior section (Fig. 72.8a). When the left-side wall of the middle hepatic vein is fully exposed up to its confluence, the left hepatic vein is encircled, divided at the origin (Fig. 72.8b), and closed with a running 4-0 suture. Then liver resection progresses posteriorly to the dorsal side of the middle hepatic vein for the total caudate resection. When the liver resection is accomplished, the left liver is connected only by hilar connective tissue containing the right hepatic duct.

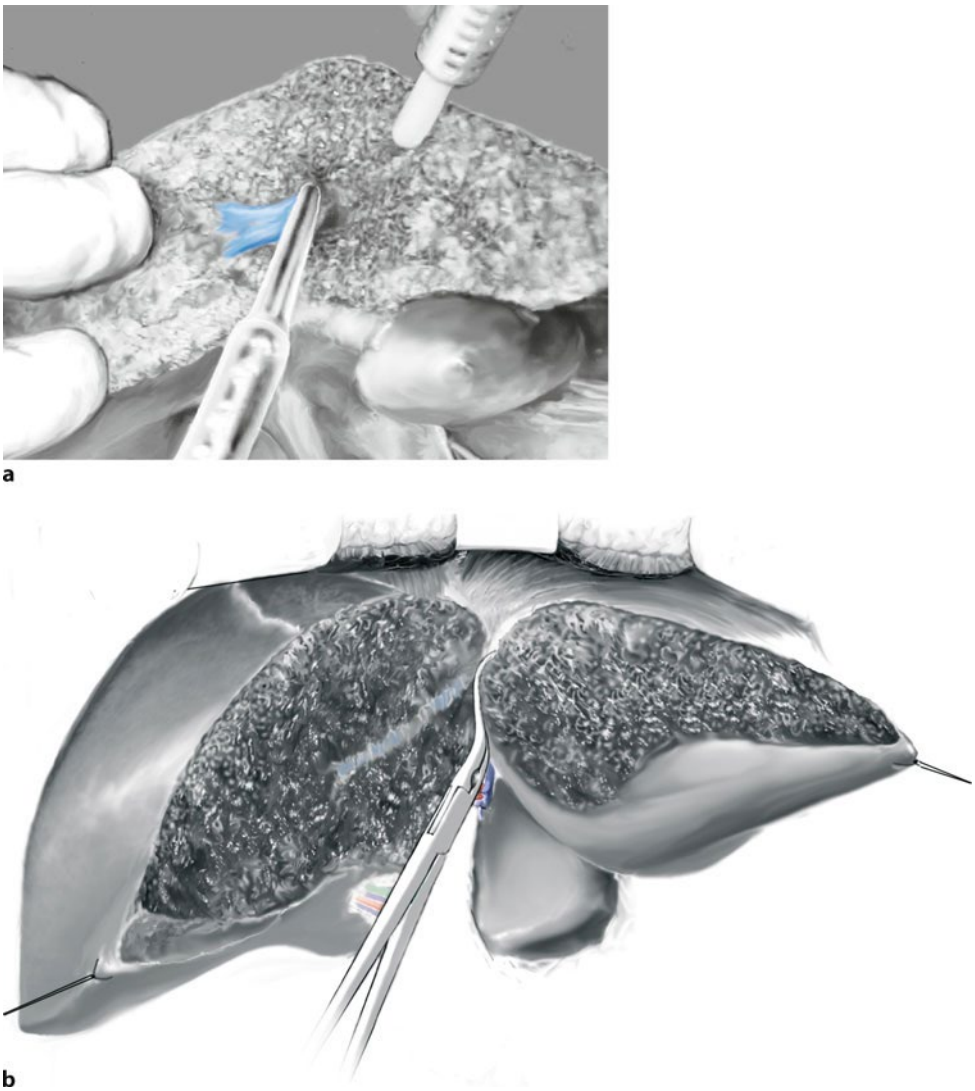


Fig. 72.8

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Step 10

Intrahepatic bile duct resection

The right intrahepatic bile duct is identified behind the middle hepatic vein, and the posterior wall is carefully detached from the right anterior branch of the hepatic artery. Two stay sutures are placed ventrally and dorsally and the bile duct is divided from the ventral edge. The right anterior sectional ducts were first divided at the ventral side of the right portal vein (Fig. 72.9a), and then the right posterior sectional duct is divided along the craniodorsal side of the right portal vein (Fig. 72.9b), and the left hemiliver, caudate lobe, and extrahepatic bile duct are removed. The resection margin of the each bile duct should be examined by frozen section.

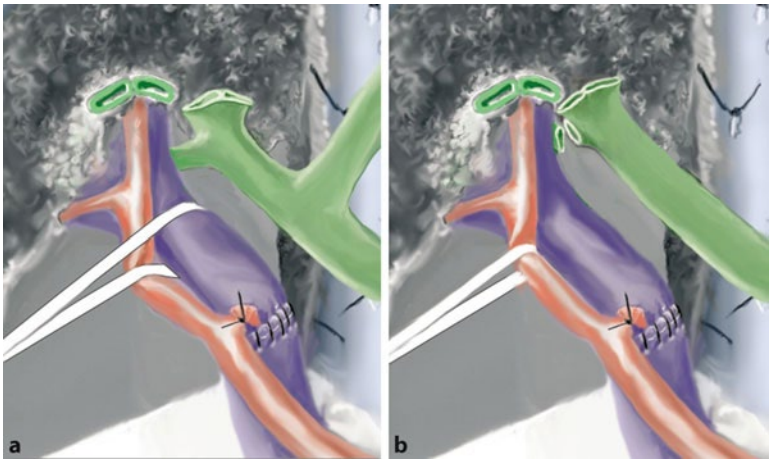


Fig. 72.9

Step 11

Biliary reconstruction

Before bilioenteric anastomosis, bile duct orifices to be reconstructed in the vicinity of the resected liver surface are grouped as much as possible to reduce the number of anastomoses (Fig. 72.10a) required.

A Roux-en-Y loop using a 40-cm-long segment of the jejunum is lifted through the retrocolic route.

The anterior layer of the suture is placed on the bile duct (outside to in) (Fig. 72.10b). The sutures are lifted upward to obtain good view of the ductal lumen. Then the posterior wall is anastomosed with interrupted fashion. A biliary stent tube is then placed at each anastomosis. Finally, previously placed sutures on the anterior wall of the bile duct are used to complete the anterior anastomosis. See the ▶ Chap. 73 on biliary anastomosis.

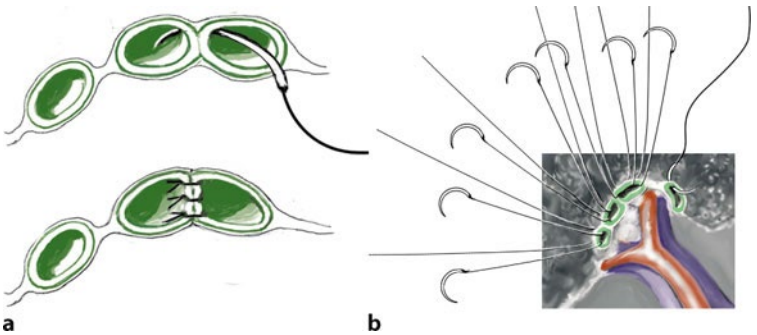


Fig. 72.10

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Step 12

Drainage after reconstruction

After completing hemostasis in the surgical field (Fig. 72.11), closed drains are placed in the right subphrenic space, the foramen of Winslow (behind the bilioenteric anastomosis), and along the resected liver surface. Then the abdomen is closed.

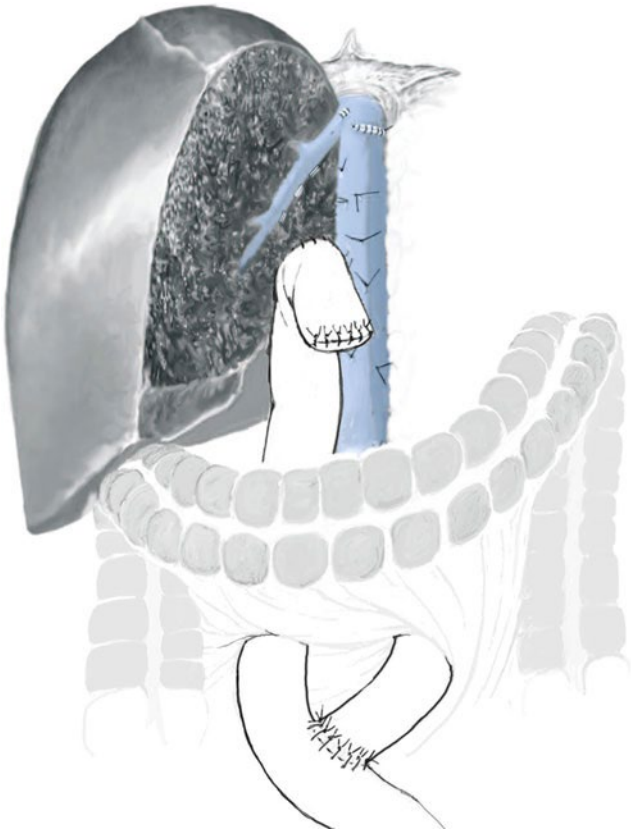


Fig. 72.11

Left Trisectionectomy

Left trisectionectomy (resection of segments 2, 3, 4, 5, and 8) extending the caudate lobe with bile duct resection is applied in patients with Bismuth type IV tumors of left-side predominance. This procedure should be performed when the liver functional reserve is sufficient. Therefore, preoperative assessment of liver function and volumetric evaluation of the future remnant liver is essential.

Steps 1 to 4 are the same as for a left hemihepatectomy.

Step 13

Dividing the hepatic artery

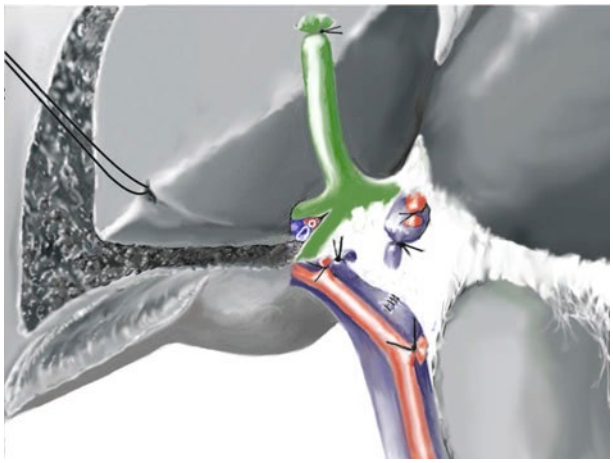
Once the arterial anatomy and possible arterial variation are clearly identified, the right anterior sectional artery is ligated and divided, with preservation of the right posterior sectional artery, which usually runs on the caudal and ventral aspect of the right portal vein.

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Step 14

Dividing the right anterior portal vein

When preoperative portal vein embolization has been performed, the left portal vein must be divided after clamping the portal trunk and right portal vein to ensure that there is no thrombus in the right portal vein. The stump of the left portal vein must be closed with transverse continuous sutures to prevent stenosis. The right anterior portal vein is then encircled, ligated, and divided. If sufficient length of the right anterior portal vein cannot be exposed, division of the right anterior portal vein should not be performed at this time. It can be dissected and divided after liver transection (◘ Fig. 72.12).



◘ Fig. 72.12

Step 15

Mobilization of the left hemiliver and separation of the caudate lobe from the vena cava

The left coronary and triangular ligaments are divided, the left hemiliver is mobilized to the right, and the minor omentum is opened. The middle and left hepatic veins, which usually share a common trunk, are exposed by careful dissection.

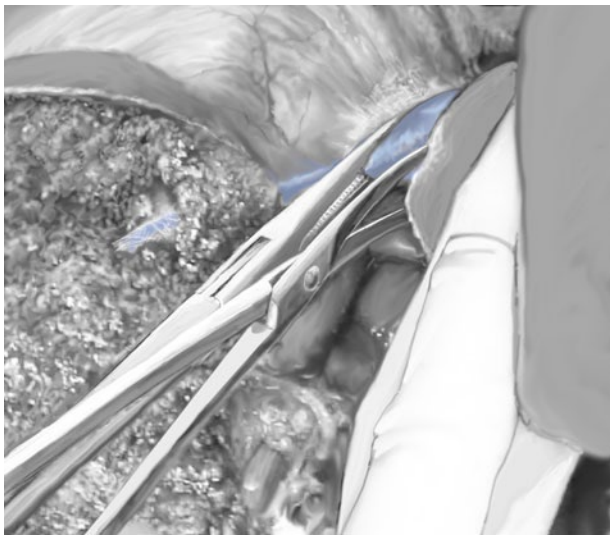
Then, to mobilize the left caudate lobe, entire short hepatic veins are divided from the left caudal side to the right cranial side. However, the inferior or the middle right hepatic vein, if present, must be preserved to prevent deterioration of the venous drainage in the right posterior section (*see* ◘ Fig. 72.7).

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Step 16

Liver resection

A demarcation line is already present between the right anterior and posterior sections on the liver surface. Liver resection is started from its caudal edge and advanced to the cranial direction, with preservation of the right hepatic vein on the transection plane of the right posterior section. When the liver resection progresses to the origin of the right hepatic vein, then the common trunk of the left and middle hepatic veins is dissected, divided using a vascular clamp ◘ Fig. 72.13), and secured by a running 4-0 suture at the caval side. An alternative technique is to transect the common trunk of the hepatic veins with a vascular stapler. After transection of the liver parenchyma between the right caudate process and the posterior section, the liver resection for the left trisectionectomy is accomplished.



◘ Fig. 72.13

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Step 17

Intrahepatic bile duct resection

After completing the liver transection for the left trisectionectomy, the right posterior section is connected only by hilar connective tissue containing the right posterior sectional bile duct. The right posterior sectional bile duct is finally dissected, with great care being taken to avoid injuring the right posterior sectional artery (Fig. 72.14). Then, the resected part of the liver and the extrahepatic bile duct are removed. The resection margin of the right posterior sectional duct should be examined by frozen section.

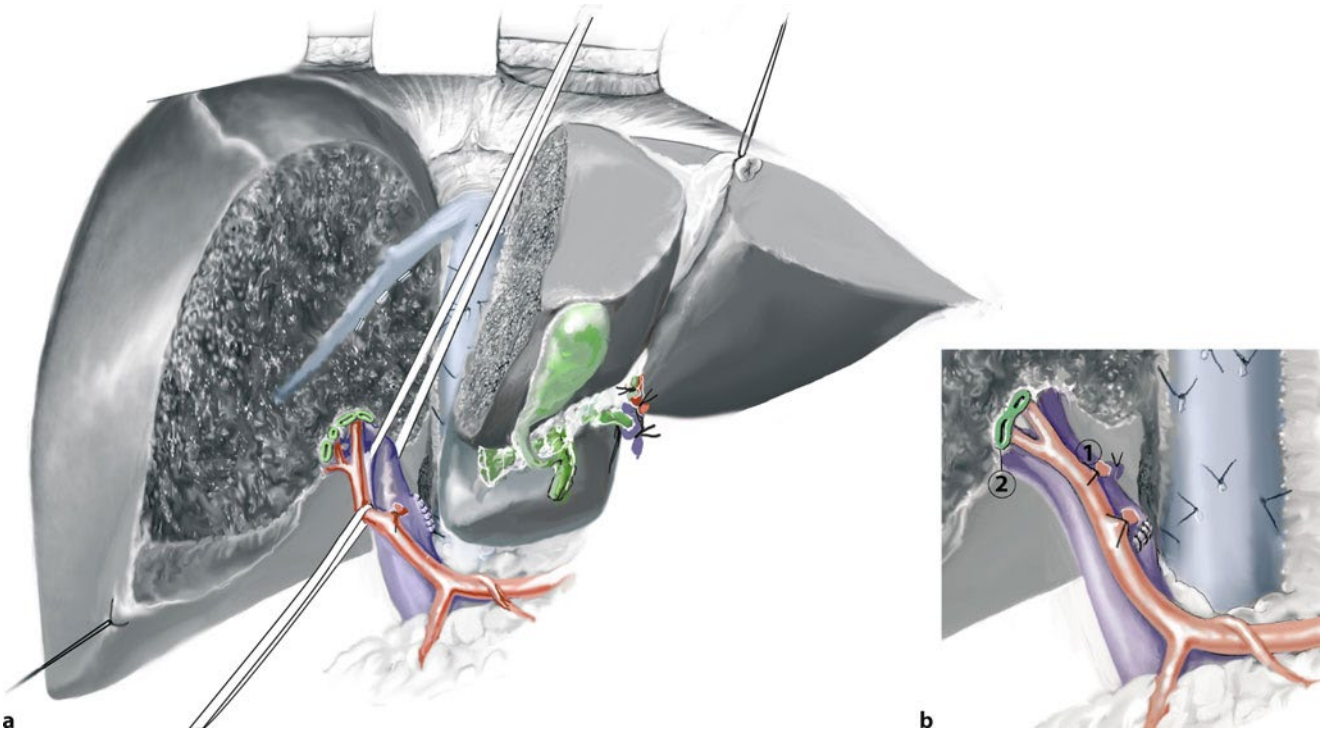


Fig. 72.14

Step 18

Biliary reconstruction

Biliary reconstruction is performed as above.

Step 19

Drainage after reconstruction

Drainage after reconstruction is performed as above.

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Postoperative Tests

- Postoperative surveillance in an intensive or high care unit.
- Color Doppler ultrasound to evaluate the blood flow of the portal vein and hepatic artery.
- Liver function tests (bilirubin, AST, ALT, albumin), coagulation parameters, hemoglobin, red blood cell (RBC), white blood cell (WBC), CRP.
- Culture of drain fluid.

Local Postoperative Complications

- **Short-term:**
  - Pleural effusion
  - Wound infection
  - Intra-abdominal bleeding
  - Portal vein thrombosis
  - Bile leak from hepaticojejunostomy or raw surface of the liver
  - Subphrenic abscess or liver abscess
  - Liver failure
- **Long-term:**
  - Anastomotic stricture
  - Cholangitis
  - Chronic liver failure

Tricks of the Senior Surgeon

- Perform careful preoperative evaluation for 3-D anatomical variation of the right posterior sectional hepatic artery and right posterior sectional bile duct in relation to the right portal vein (infra-portal type or supraportal type).
- Suture the large short hepatic veins or caudate lobe veins in continuous fashion in mobilizing the caudate lobe from the vena cava.
- Check the central venous pressure (CVP) before liver transection. The CVP should be maintained at less than 3 to 5 cm H_20.
- The inferior or the middle right hepatic vein, if present, must be preserved to prevent deterioration of the venous drainage in the right posterior section.
- Stay sutures should be placed before dividing the intrahepatic bile duct; otherwise the small segmental duct will slip away and be hidden in the transected surface of the liver.
- When dividing intrahepatic ducts, extreme attention is needed to avoid injuring the corresponding hepatic artery.
- The lymphatic vessels should be tied in a para-aortic lymph node dissection, to prevent postoperative massive lymphorrhea or chylous ascites.

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Intrahepatic Bilioenteric Anastomosis

Hiroaki Shimizu, Masaru Miyazaki

After extrahepatic bile duct resection with or without hepatectomy for biliary tract carcinomas, reestablishing continuity of the intrahepatic bile ducts to the intestinal tract must be completed. Multiple biliary orifices are often encountered on the transected surface of the liver when hemihepatectomy or central hepatectomy combined with bile duct resection is performed for perihilar cholangiocarcinoma. All orifices of transected bile ducts should be anastomosed to prevent postoperative complications such as persistent bile leak, intraabdominal abscess, or biliary fistulation.

It is worthwhile to have an established routine for bilioenteric anastomosis, although the difficulty of the anastomotic procedure may depend on the size and number of the anastomoses in each case. This chapter describes the basic technique for bilioenteric anastomosis.

Indications and Contraindications

Indications

- Hepatectomy combined with bile duct resection for malignancy involving the proximal bile duct, such as perihilar cholangiocarcinoma or gallbladder cancer involving the hepatic hilus.
- Benign stricture/injury of the proximal bile duct, often associated with laparoscopic cholecystectomy.
- Benign bilioenteric anastomotic stricture after extrahepatic bile duct resection. In such cases, after excision of the strictured anastomosis (including dense and inflamed bile ducts), more proximal hepaticojejunostomy should be carried out.

Contraindications

- In patients with unresectable malignant disease, elective, palliative intrahepatic bilioenteric bypass for hilar obstruction should be avoided. A less invasive procedure, interventional radiology (IVR), including biliary drainage and stent placement by an endoscopic or transhepatic approach, should be recommended.

Procedures: End-to-Side Anastomosis

The described technique for intrahepatic and proximal extrahepatic bilioenteric anastomoses is quite useful in all cases, particularly those with multiple small ductal orifices onto the transected surface of the liver. Several points are worth emphasizing:

- When more than one ductal orifice is present at the hepatic hilus, adjacent ductal orifices may be grouped as much as possible with a row of sutures, so that separated orifices can be treated as a single duct for anastomosis.
- The anterior layer of sutures on the bile duct is placed first (the needles being passed from the outside in), before any attempt to place the posterior layer. The row of anterior sutures is then lifted upward to obtain good view of the ductal lumen and the posterior ductal wall; then the posterior row of sutures is placed.
- This technique allows precise placement of sutures under direct vision, before apposition of the jejunum and bile duct hinders access. Absorbable suture material (4-0 or 5-0) should be used.

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Step 1

Identification of transected bile ducts

After adequate exposure of the duct has been obtained, a tension-free Roux-en-Y jejunal loop is brought through the transverse mesocolon, and end-to-side anastomosis is prepared.

It is important that the surgeon must identify all exposed ductal orifices on the transected surface of the liver (Fig. 73.1, *left*: isolated caudate lobectomy; *middle*: right hemihepatectomy; *right*: left hemihepatectomy). Failure to provide adequate drainage of all ducts often leads to serious postoperative complications, such as persistent bile leak, intraabdominal abscess, biliary fistulation, cholangitis, or hepatic abscess.

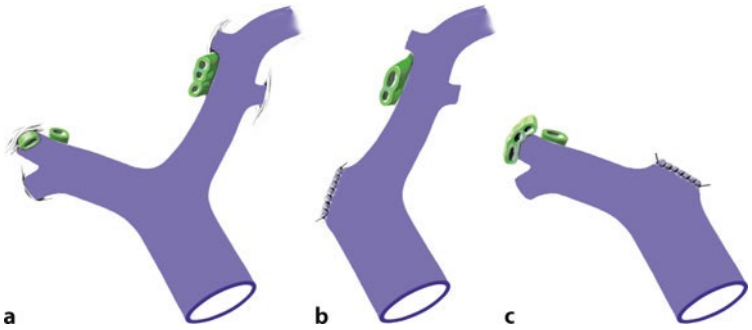


Fig. 73.1

Step 2

Grouping of separated bile ducts

All exposed bile ducts are carefully identified. When more than one ductal orifice is present, adjacent ductal orifices may be grouped as much as possible. Separated adjacent ducts that are not connected by a septum are brought into apposition by placing two or three interrupted sutures (5-0 absorbable suture) (Fig. 73.2), so that they can be treated as a single duct for anastomosis.

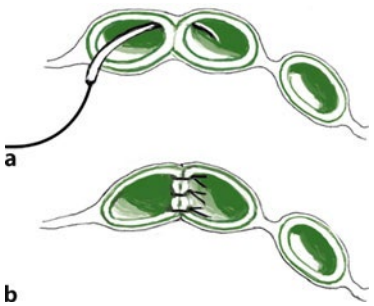


Fig. 73.2

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Step 3

Placement of anterior stitches on the bile duct

The entire anterior layer of sutures on the bile duct is placed first, the needles being passed from outside to in. The sutures are sequentially clamped and the needles of the sutures are left. It is important to keep the sutures in order for subsequent identification (Fig. 73.3).

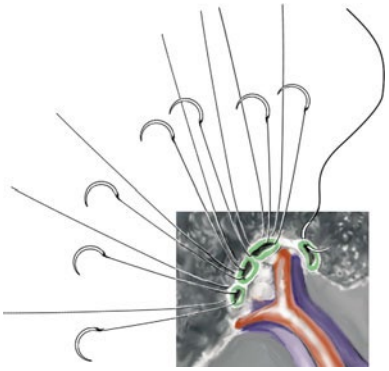


Fig. 73.3

Step 4

Placement of posterior row of sutures

Once the anterior stitches on the bile duct has been placed, the row of sutures is lifted upward to obtain good opening of the ductal orifice. The posterior row of sutures is then placed, which are now introduced from the jejunal limb (inside to outside) to the posterior wall of the bile duct (outside to inside). The sutures are not tied, but are sequentially clamped after removal of the needles, and are kept in order (Fig. 73.4).

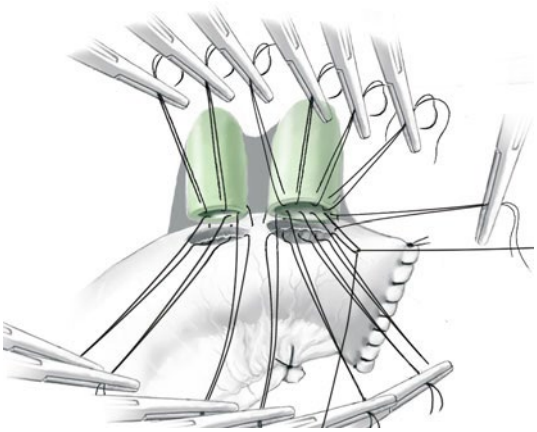


Fig. 73.4

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Tying the posterior stitches

After completion of the posterior full-thickness sutures, the jejunum loop is then brought up along the posterior row of sutures until the back wall of the jejunum and the bile ducts are apposed. It is important to make sure that jejunal openings are properly aligned to the respective ductal orifices. The posterior sutures are then tied from left to right (Fig. 73.5). Corner sutures are held, and all other sutures are cut.

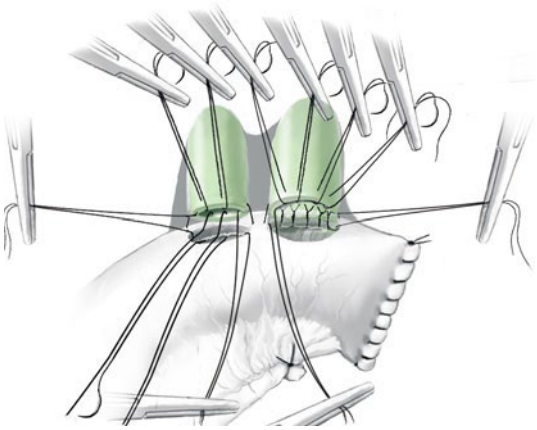


Fig. 73.5

Step 6

Completing the anterior row of sutures

The previously placed sutures on the anterior wall of the bile duct are now used to complete the anastomosis. The needles are passed sequentially through the anterior wall of the jejunum (inside to outside) (Fig. 73.6). The sutures are sequentially clamped and are left in order with the needles removed.

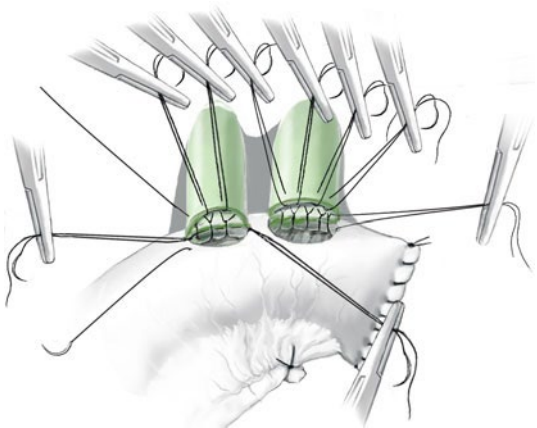


Fig. 73.6

Step 7

Tying the anterior row of sutures

The anterior anastomosis is then completed by securing the sutures, tying from left to right, making certain that the ductal sutures are correctly placed to the corresponding jejunal openings. Stenting of the bilioenteric anastomosis is not mandatory, but in patients with multiple small ductal orifices, placement of a biliary stent at the anastomosis is recommended to prevent anastomosis leakage and stenosis.

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Side-to-Side Intrahepatic Anastomosis

Side-to-side intrahepatic bilioenteric anastomosis is undertaken for palliative biliary drainage in patients with unresectable perihilar cholangiocarcinoma or gallbladder cancer involving the hepatic hilus. The most common approaches use segment III or the right anterior sectional duct.

The indications for these procedures are presently quite limited. Less invasive interventional radiology (IVR) procedures, such as placement of a biliary stent by either an endoscopic or transhepatic approach, are generally performed in patients with unresectable malignant hilar obstruction.

Tricks of the Senior Surgeon

- When dividing intrahepatic ducts, stay sutures should be placed before dividing the intrahepatic bile duct; otherwise the small segmental duct will slip away and be hidden in the transected surface of the liver.
- When multiple ductal orifices are encountered, it is particularly important to find and anastomose all orifices of the transected bile duct. If these are left without anastomoses, a chronic fistula may occur.
- When a ductal orifice is too tiny for anastomosis, ligation with a nonabsorbable suture may be possible.
- For benign hilar and more proximal bile duct strictures, which are often associated with laparoscopic cholecystectomy, hilar bile duct resection by separating the liver parenchyma along the interlobar plane ("transhepatic approach") may be a useful procedure for approaching the second or more proximal biliary ducts without hepatic resection, because of good exposure of the hilar plate. Senior surgeons should keep this procedure in mind at the time of hilar or more proximal bile duct resection and reconstruction (Fig. 73.7).

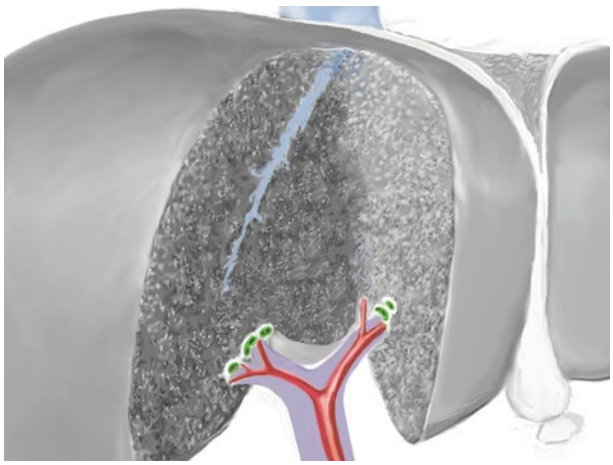


Fig. 73.7

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The Ligamentum Teres Approach and Other Approaches to the Intrahepatic Ducts for Palliative Bypass

Michael D'Angelica

When the hilus of the liver is not accessible for decompression of obstructive jaundice, use of intrahepatic ducts for surgical bypass is a safe and effective technique, as originally described by Bismuth and Corlette in 1975 and later by Blumgart and Kelly in 1984. The general principle is to identify intrahepatic healthy bile duct mucosa proximal to a point of biliary obstruction and to create a mucosa-to-mucosa anastomosis to a long Roux-en-Y loop of jejunum. Anastomosis should provide biliary drainage and relief of symptoms such as jaundice and pruritus. It should be noted that these surgical approaches to biliary decompression have largely been replaced by endoscopic and percutaneous drainage procedures. Nonetheless, they can be helpful in uncommon but important clinical scenarios.

Indications and Contraindications

Indications

- Malignant obstruction (most commonly gallbladder carcinoma and hilar cholangiocarcinoma) of the biliary confluence when access to the common hepatic duct is not possible
- Life expectancy greater than 6 months
- Extensive benign stricture involving the biliary confluence when access to the common hepatic duct is not possible

Exclusion Criteria

- Complete obliteration of the biliary confluence and consequent disconnection of the right from the left liver is not a contraindication
- Lack of safe access to healthy bile duct mucosa for an adequate anastomosis
- Bypass to a portion of liver that is atrophied or fibrotic

Preoperative Investigation and Preparation for the Procedure

- *Clinical:* Signs and symptoms of cholangitis, cirrhosis, and portal hypertension
- *Laboratory:* Liver function tests, nutritional parameters, clotting parameters, renal function
- *Radiology:* Duplex ultrasound, magnetic resonance cholangiopancreatography (MRCP); consider direct cholangiography (percutaneous transhepatic) with or without preoperative stenting
- *Preparation:* Perioperative broad-spectrum antibiotics, adequate control of cholangitis

Procedure

Access and general principles

- The incision must provide adequate access to the hilum of the liver and provide the ability to completely mobilize the liver if necessary.
- Potential incisions: right subcostal incision with a midline vertical extension (hockey stick), bilateral subcostal incision with or without midline vertical extension (chevron, rooftop).

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- In the special case of right lobe atrophy, extension of the incision to a thoracoabdominal approach from the midpoint of the right subcostal portion up through the 7th intercostal space can be helpful.
- Retraction with any upper abdominal retractor with wide blades pulling the ribs in an anterior and cephalad direction.
- Intraoperative ultrasound to determine the relationship of tumor/stricture and adequately dilated bile ducts.
- Intraperitoneal drain is placed at the site of the bilioenteric anastomosis and left for gravity drainage postoperatively (Fig. 74.1).

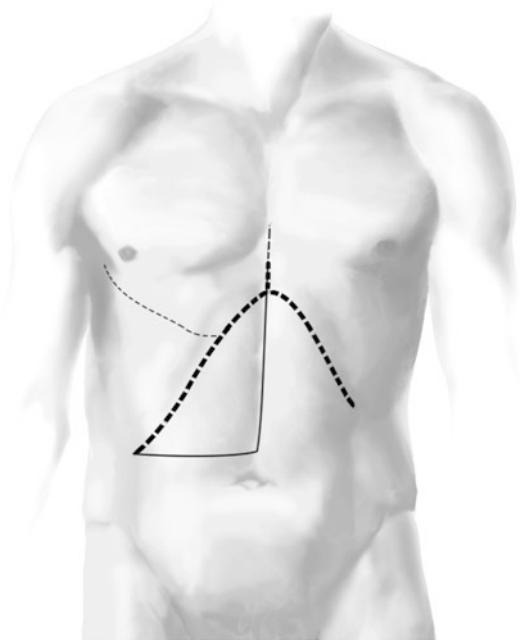


Fig. 74.1

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Approach to the left hepatic duct

Step 1

Dividing the bridge between segments 3 and 4

The ligamentum teres is divided and the falciform ligament is freed from the abdominal wall and diaphragm. A tie is left in place on the hepatic side of the ligamentum teres, to serve as a retractor to help elevate the liver. The bridge of liver tissue between segment 4 and the left lateral segment is divided. There are never major vessels in this tissue, and it can be divided with electrocautery. This maneuver exposes the umbilical fissure completely and makes dissection at the base of segment 4 easier (Fig. 74.2).

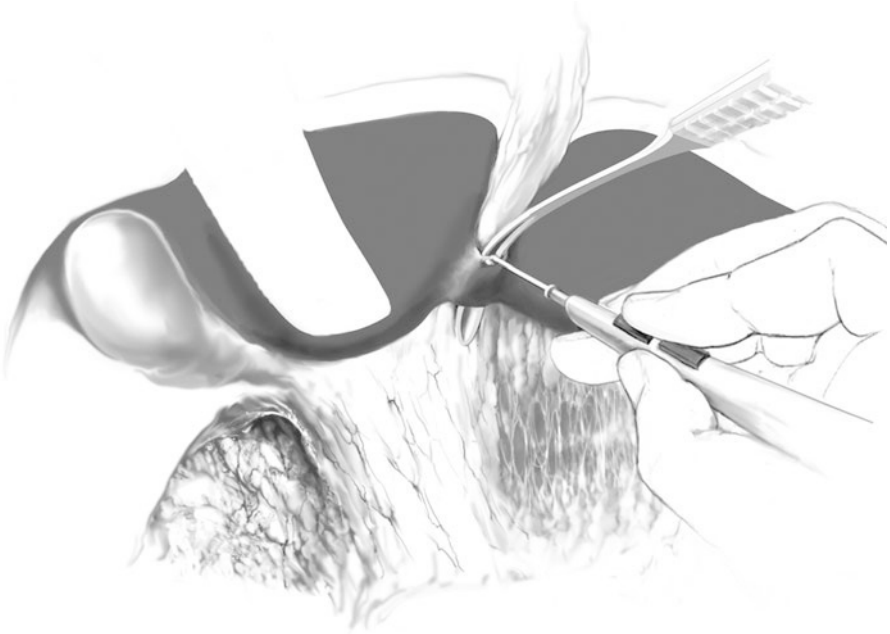


Fig. 74.2

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Step 2

Exposing the duct

Segment 4 is elevated superiorly, exposing its base. Sharp dissection is used to dissect the plane between Glisson's capsule and the left portal triad, thus lowering the hilar plate (Fig. 74.3a). The left hepatic duct is exposed and dissected throughout its transverse extrahepatic course at the base of segment 4 before it enters the umbilical fissure. Dissection to the right side can expose the biliary confluence and the right hepatic duct origin as well (Fig. 74.3b). Minor bleeding can occur in this area from small portal or arterial branches to segment 4; it is almost always controllable with light pressure or small clips. A thin, curved retractor placed at the base of segment 4 from above can help with exposure. A large tumor in this area may make exposure difficult, mandating local excision or abandonment of this approach.

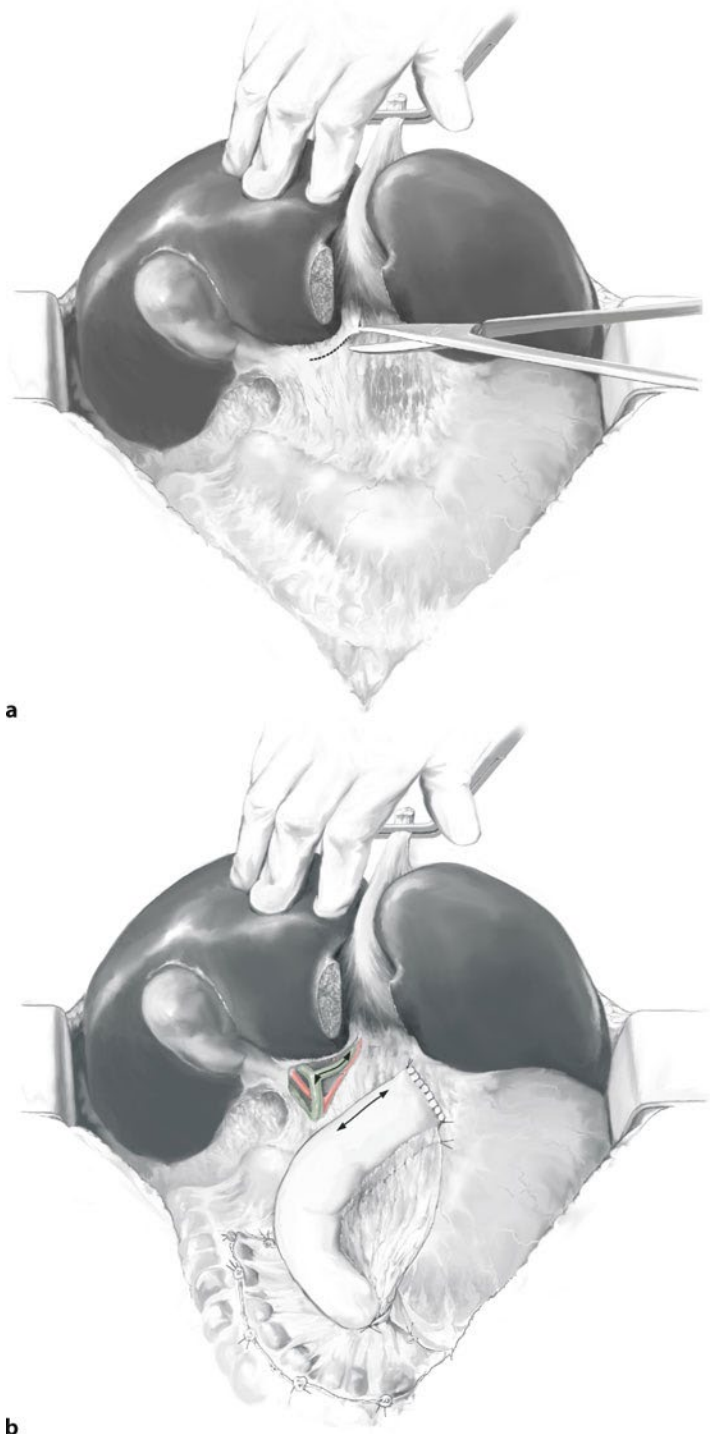


Fig. 74.3

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Step 3

Biliary-enteric anastomosis

A 70-cm Roux-en-y loop of jejunum is brought up to the hilum in a retrocolic fashion and a side-to-side anastomosis is performed (Fig. 74.4).

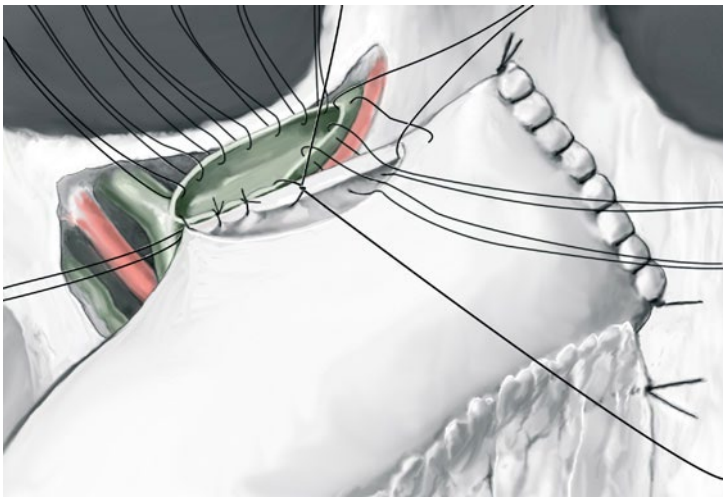


Fig. 74.4

Ligamentum teres (round ligament) approach

(See also ▶ Chap. 73 "Intrahepatic Bilioenteric Anastomosis")

Step 1

Controlling the round ligament

The ligamentum teres is divided and the falciform ligament is freed from the abdominal wall and diaphragm. The bridge of liver tissue between segment 4 and the left lateral segment is divided (Fig. 74.5).

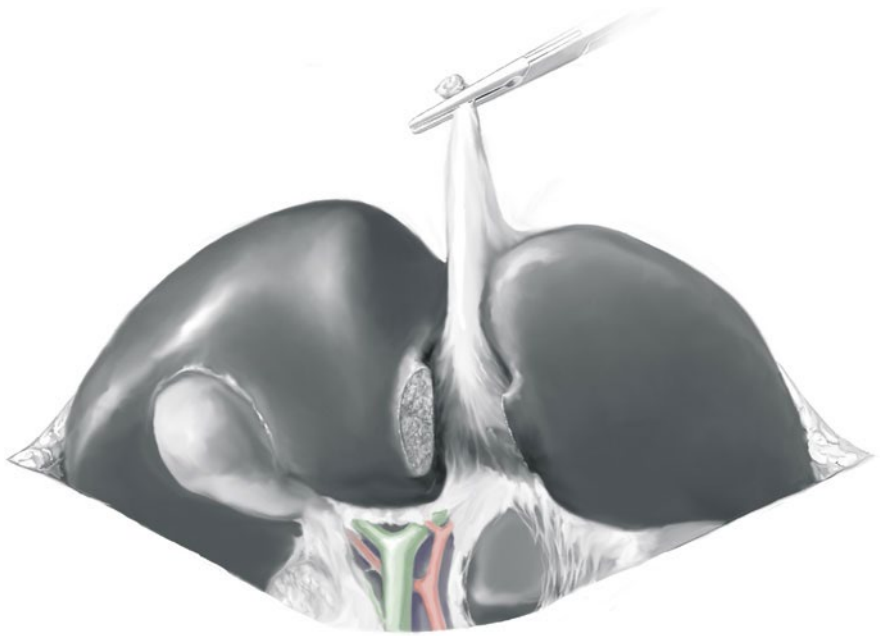


Fig. 74.5

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Step 2

Mobilizing and positioning the round ligament

While holding the liver upward, the ligamentum teres is then pulled downward and its attachments to the liver are released, exposing its base (Fig. 74.6).

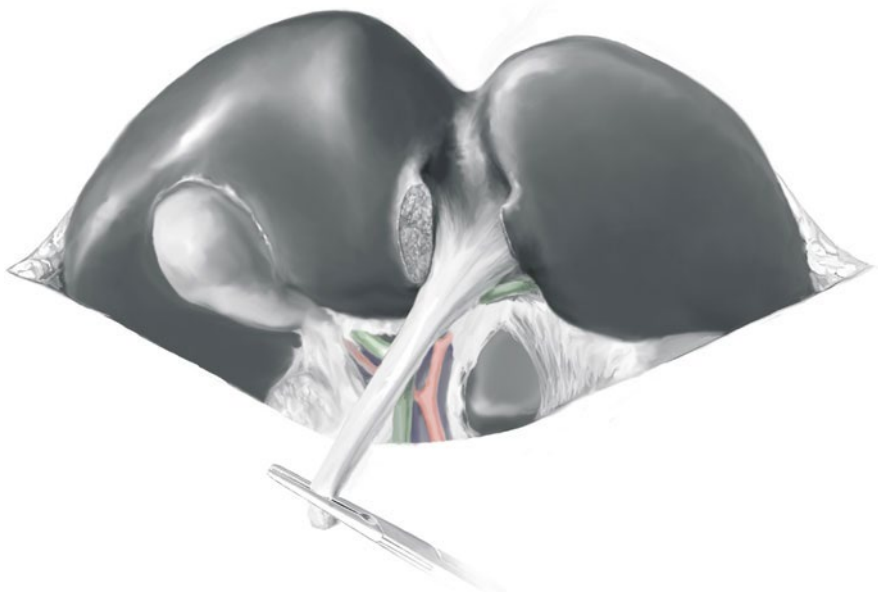


Fig. 74.6

Step 3

Dissection

Dissection is then carried out to the left of the upper surface of the base of the ligamentum teres. A number of small vascular branches to the left lateral segment will be encountered and sometimes must be ligated and divided. The main portal pedicle to segment 3 is carefully preserved. This dissection can be tedious and must be done carefully because bleeding in this area can be difficult to control.

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Step 4

Exposing the segment 3 duct

The segment 3 duct is exposed in its position above and behind the portal vein branch. The duct is opened longitudinally just beyond the branching of the segment 2 and 3 ducts. A side-to-side hepaticojejunostomy to a 70-cm retrocolic Roux-en-Y jejunal loop is carried out (Fig. 74.7).

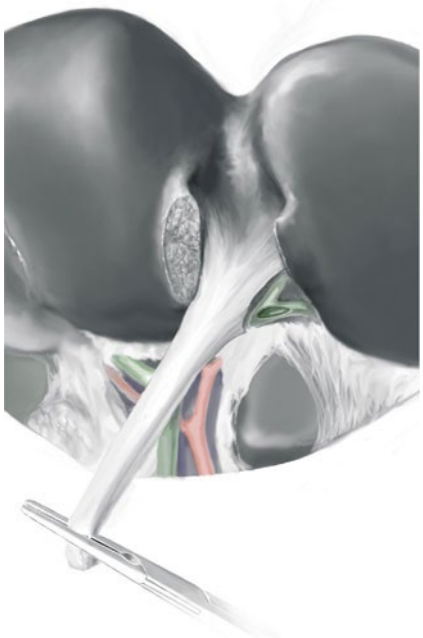


Fig. 74.7

Step 5

Partial hepatectomy to facilitate exposure

An alternative approach or a helpful adjuvant technique to expose the segment 3 duct is to split the liver just to the left of the falciform ligament superiorly (Fig. 74.8a) and to divide the tissue until the duct is reached from above (Fig. 74.8b). This approach can assist identification of the duct, or it can be the primary means of approach. The added benefit of this approach is the lack of devascularization to parts of segment 3 that can occur during the dissection in the umbilical fissure.

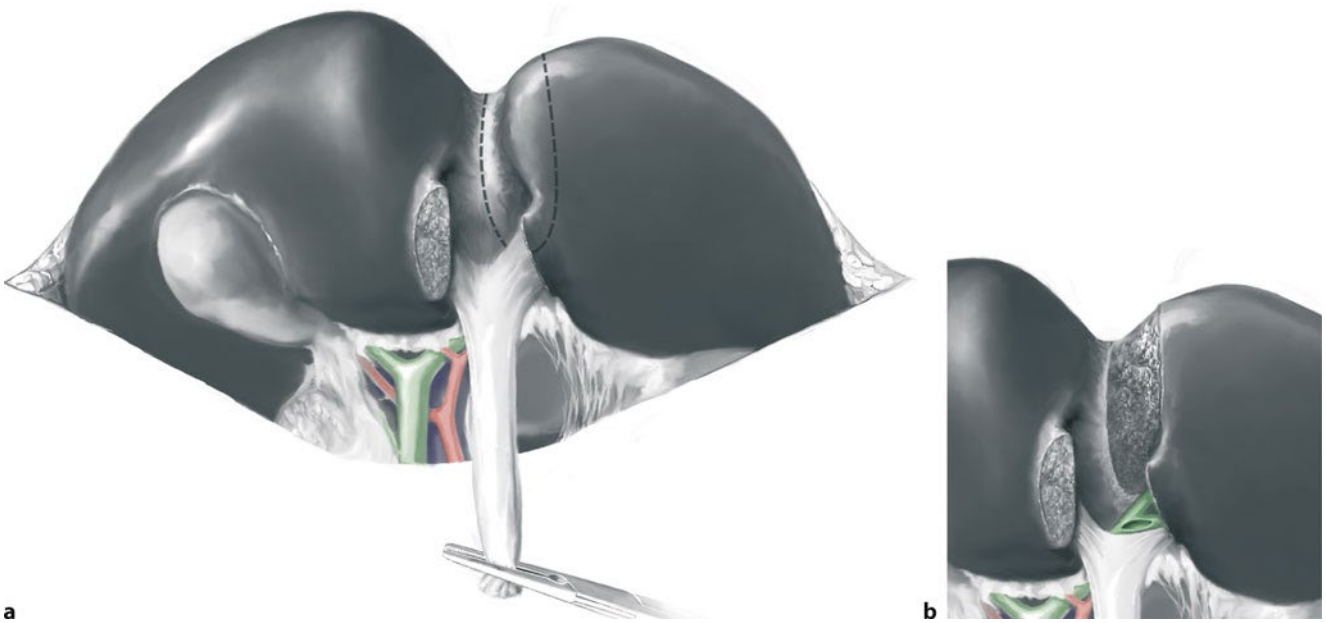


Fig. 74.8

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Approach to proximal right sectoral ducts

Step 1

Controlling the round ligament

The ligamentum teres is divided and the falciform ligament is freed from the abdominal wall and diaphragm. A tie is left in place on the hepatic side of the ligamentum teres, which serves as a retractor to help elevate the liver.

Step 2

Identification of the right portal pedicle

Hepatotomies are made at the base of the gallbladder and at the caudate process, and the main right portal pedicle is identified. The tissue in front of the main right portal pedicle is divided by blunt dissection and ligation and is excised (Fig. 74.9).

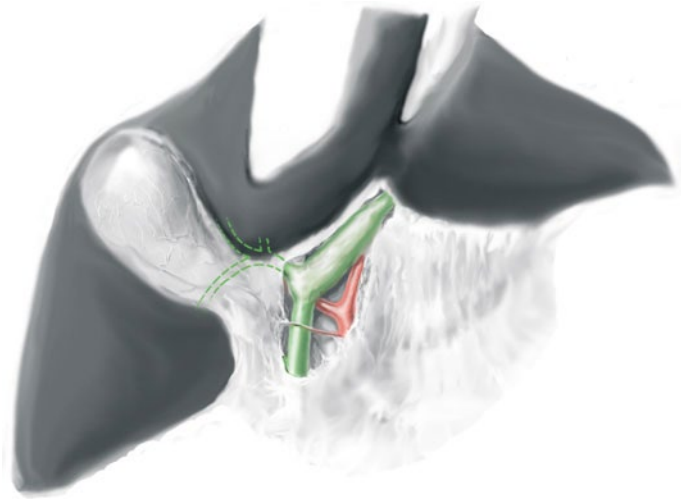


Fig. 74.9

Step 3

Exposing the right hepatic ducts

With the main right portal pedicle exposed, intrahepatic dissection is continued along either the anterior (more commonly) or the posterior pedicle until a satisfactory length is demonstrated. The bile duct is then dissected and exposed longitudinally. A longitudinal incision is then made in the bile duct (Fig. 74.10).

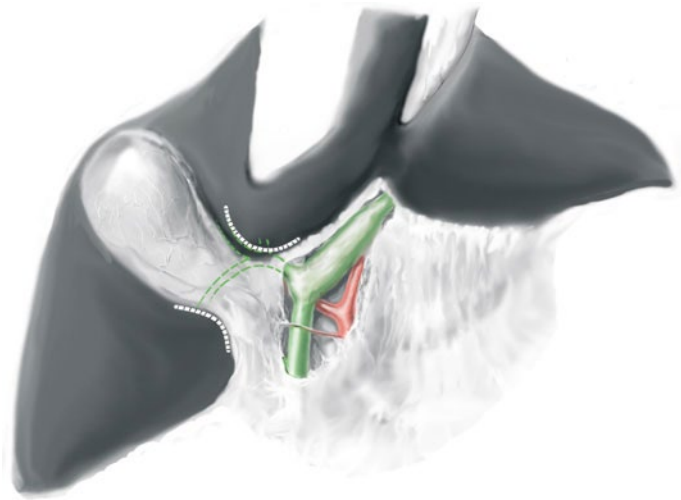


Fig. 74.10

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Step 4

Bilioenteric anastomosis

A side-to-side hepaticojejunostomy to a retrocolic 70-cm Roux-en-Y loop of jejunum is performed (Fig. 74.11).

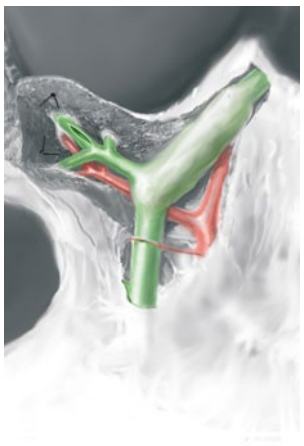


Fig. 74.11

Postoperative Tests

- Coagulation parameters and hematocrit in the first 48 hours
- Daily liver function tests
- Daily assessment of renal function
- Daily assessment of drain output for bile leakage

Postoperative Complications

- **Short-term:**
  - Bile leakage
  - Biloma
  - Abscess
  - Liver dysfunction/liver failure
  - Intra-abdominal bleeding
  - Early stricture of anastomosis
- **Long-term:**
  - Recurrent benign biliary stricture
  - Recurrent malignant biliary stricture
  - Cholangitis

Tricks of the Senior Surgeon

- In the round ligament approach, a small branch of the portal vein passing to segment 3 usually lies immediately anterior to the segment 3 duct. This branch may need to be divided for adequate ductal exposure.
- Even if the malignant obstruction has isolated the left biliary tree from the right, drainage of only the left liver most often will suffice to relieve jaundice. This is particularly true if the tumor occupies predominantly the right liver and has produced right hepatic atrophy.
- Because of technical difficulties, right-sided bypasses have largely been abandoned in favor of percutaneous drainage.
- If dissection is particularly difficult, identification of these ducts can be facilitated by aspiration of bile with a fine needle.

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Choledochojejunostomy and Cholecystojejunostomy

Peter Lodge, Michelle L. de Oliveira

These days, endoscopic and percutaneous radiological approaches to biliary dilatation and stenting can solve the majority of acute biliary emergencies, but long-term outcomes may be less than ideal, particularly because of chronic problems related to stent blockage leading to recurrent jaundice and ascending cholangitis. For any patient with a diagnosis of inoperable malignancy with a life expectancy longer than 6 months, and for patients with benign biliary structuring, surgical biliary bypass can provide durable relief of jaundice and ascending cholangitis.

The preferred surgical method for palliative treatment of biliary obstruction in some centers is a side-to-side anastomosis between the jejunum and the common hepatic duct or common bile duct, because it allows the possibility of making a large anastomosis, and of draining the intrahepatic bile duct as well as the part of the bile duct distal to the anastomosis. However, there is no clear advantage for this method, and modern practice is to create an end-to-side anastomosis whenever possible or, for high strictures, a side-to-side anastomosis between a Roux-en-Y limb of jejunum and the confluence of the right and left hepatic ducts. In some circumstances, tumor prevents access to the common bile duct, the common hepatic duct, and the confluence of the right and left hepatic ducts; in that situation, a segment 3 hepatic duct bypass may be the only surgical possibility. Longmire's procedure, in which the left lateral section of the liver is transected laterally and anastomosed to jejunum, is rarely used these days, but it can be life-saving in selected patients. Although the majority of surgery is carried out at laparotomy, increasing expertise in laparoscopic surgery means that these techniques may be carried out laparoscopically.

Indications and Contraindications

Indications

- Inoperable malignant tumors of the head of the pancreas or the papilla Vater
- Primary (inoperable) duodenal malignancy (adenocarcinoma, neuroendocrine tumors, lymphoma, sarcoma)
- Secondary (inoperable) malignancy in the porta hepatis (carcinoma, melanoma, lymphoma, leukemia, sarcoma)
- Benign biliary stricture

Absolute and relative Contraindications

In this patient group, there are no absolute contraindications to biliary bypass surgery, but the following should be taken into consideration:

- Severe coagulation disorders due to the biliary obstruction (preoperative correction through vitamin K administration)
- Local infection: cholangitis, abscesses (preoperative correction with antibiotics and, if necessary, endoscopic or percutaneous biliary drainage)
- Quality of biliary, ligamental, or intestinal surgical anatomy (*e.g.*, portal hypertension, sclerosing cholangitis, short bowel syndrome)
- Comorbidity (*e.g.*, Child-Pugh C liver cirrhosis)

Indications for cholecystojejunostomy

This procedure is rarely performed today, but it can be considered if the patient is very frail, there is a high insertion of the cystic duct into the common bile duct (CBD), and there is a low obstruction.

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
DOI 10.1007/978-3-662-46546-2_75, © Springer-Verlag Berlin Heidelberg 2016

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Investigation and Preparation

Preoperative investigations

- **Clinical**
  - Pain in the right upper abdomen
  - Weight loss/catabolic state
  - Icterus
  - Pruritus
  - Coagulopathy
  - Hepatorenal dysfunction
  - Cholangitis

- **Laboratory tests**
  - Full blood count
  - Urea and electrolytes
  - C-reactive protein
  - Liver function tests (bilirubin and liver enzymes)
  - Prothrombin time (coagulation test in case of an interrupted enterohepatic circle such that vitamin K absorption is poor; correct with intravenous vitamin K or clotting factors)

- **Radiology**
  - Ultrasound: Origin, location, and type of the obstruction; width of the intrahepatic and extrahepatic bile ducts; possibility of relieving the bile ducts by percutaneous transhepatic drainage
  - Three-phase CT scan: Extent of the obstructive lesion, local resectability, and relation to the surrounding structures (the portal vein and the common hepatic artery)
  - MRI with MRCP to further define tumor extent and biliary anatomy

What not to do

Preoperatively, one should consider whether the morbidity and mortality of the surgical procedure outweigh the life expectancy of the patient. Often, one is confronted with inoperability during exploration. In such situations, biliary bypass can be performed as a palliative measure, but postoperative stent placement is preferred if life expectancy is short. If preoperative drainage of the obstruction is required, plastic endoprostheses are the equipment of choice because they are easier to remove during surgery. The placement of metal stents should be considered if a plastic stent does not improve the clinical picture, as they can be removed at the time of surgery, albeit with some difficulty.

Preparation prior to surgery

- Correction of coagulopathy through administration of vitamin K (or clotting factors if surgery is urgent)
- Preoperative drainage is recommended if there is significant jaundice or cholangitis not responding to antibiotics, even though it may lead to increased morbidity because of biliary infections
- Antibiotic prophylaxis

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Procedure

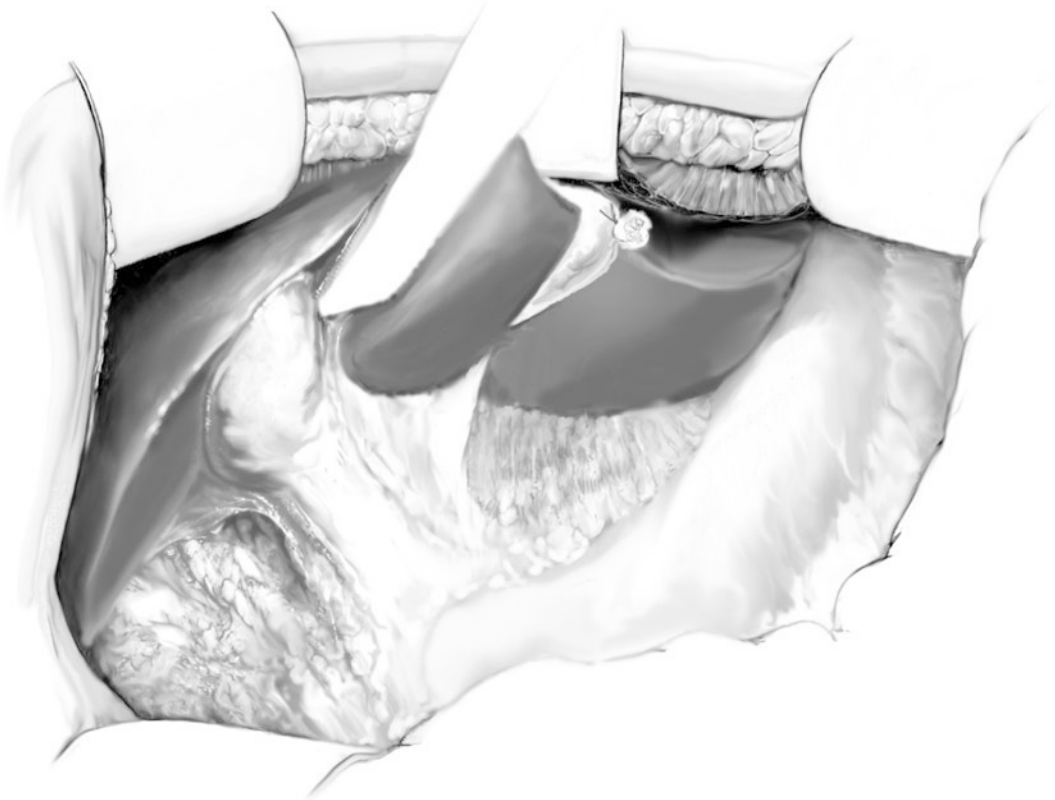
Access

A right upper quadrant transverse or subcostal incision, with the possibility of extending this incision to the left side of the abdomen, or an upper midline incision may be chosen. If a percutaneous transhepatic biliary drain (PTBD) is in place, the incision should be chosen to avoid having to remove the PTBD perioperatively. For a laparoscopic approach, ports should be placed in the upper abdomen, with the primary surgeon standing between the patient's legs, to allow triangulation for dissection and suturing.

Step 1

Exposure

In first-access operations, it is usually not necessary to mobilize the hepatic flexure of the colon and to mobilize the duodenum by means of Kocher's manoeuvre, but doing so may facilitate exposure. In redo operations, the preferred method is to carefully perform adhesiolysis and mobilize the liver from the abdominal wall starting at the right subhepatic area. Then by gentle preparation one should follow the edge of the liver dorsally and cranially in order to reach the hilus of the liver. It is safer to stay close to the liver. After careful mobilization, a retractor (e. g., Omnitract or Thompson) is installed (◘ Fig. 75.1).



◘ Fig. 75.1

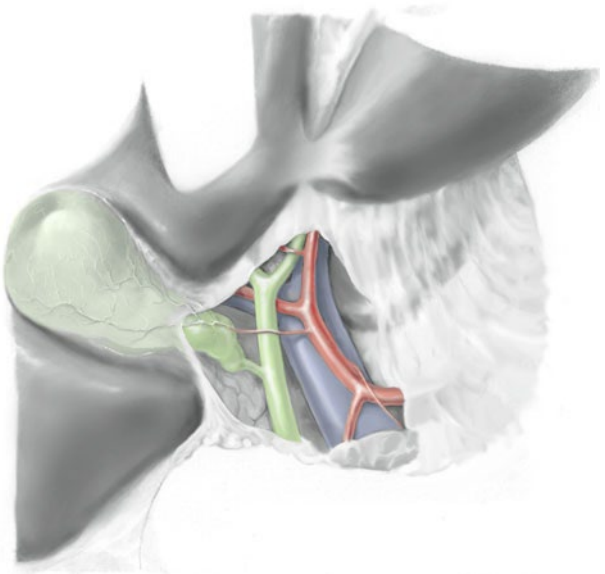
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Step 2

Opening of the hepatoduodenal ligament

Cholecystectomy is performed as described in the ▶ Chap. 67 "Laparoscopic Cholecystectomy, Open Cholecystectomy, and Cholecystostomy." The hepatoduodenal ligament is divided following the cystic duct medially to its entrance in the common hepatic duct.

Because of the multiplicity of anatomic variations and the consequences of inadvertent injury to vascular structures, it is imperative to identify definitely the exact location of the hepatic duct and common bile duct within the hepatoduodenal ligament before any clamping or incising is done. This can be difficult, even when there is proximal dilatation, and the use of a small syringe and needle to perform repeated careful aspirations from the portal hilum can be helpful. Having confidently identified the duct, it can be incised to prepare for a wide biliary-enteric anastomosis. Remember that the right hepatic artery passes anterior to the common hepatic duct in about 12 % of patients, so there is a risk of arterial injury if this artery is not looked for and dissected free with care, if necessary. If the stricturing or tumor invasion extends up the hepatic duct confluence, the use of a probe can help to direct further incision of the left and right hepatic duct to create a wider anastomosis. If there is no access to the common bile duct, the common hepatic duct, or the biliary confluence, consideration should be given to locating and opening the segment 3 hepatic duct by retracting the left lateral section of the liver superiorly and dissecting to the left of the insertion of the ligament teres. Again, a needle and syringe and probe can be helpful. It is best to do all of the biliary dissection first, as there is often bleeding and this will stop if packed off effectively during the next stage of the surgery (◘ Fig. 75.2).



◘ Fig. 75.2

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Side-to-Side Choledochojejunostomy

Step 3

Preparation of Roux-en-Y

Next is the preparation of a Roux-en-Y segment of the jejunum. The duodenojejunal flexure is identified by Treitz's ligament, and 40 to 60 cm is measured distal to this, where it is divided with a surgical GIA stapler or between bowel clamps (to prevent contamination). After dividing the small bowel mesentery appropriately, the distal (blind) end of the planned biliary limb of the jejunal Roux-en-Y is brought in front of the transverse colon (antecolic) up to the portal hilum, ensuring that there is no tension. Then, 40 to 60 cm distal to this point, an end-to-side or side-to-side anastomosis is made, using sutures or surgical staplers according to surgeon preference. The minimum length of the biliary limb should be 40 cm, in order to prevent reflux of enteric contents into the biliary tree.

The purpose of the procedure is to identify healthy bile duct mucosa proximal to the site of obstruction and to direct mucosa-to-mucosa anastomosis between the bile duct and the Roux-en-Y biliary limb. Electrocautery is used to make a hole in the jejunum to match the opening in the bile duct (usually between about 1 and 4 cm) (Fig. 75.3).

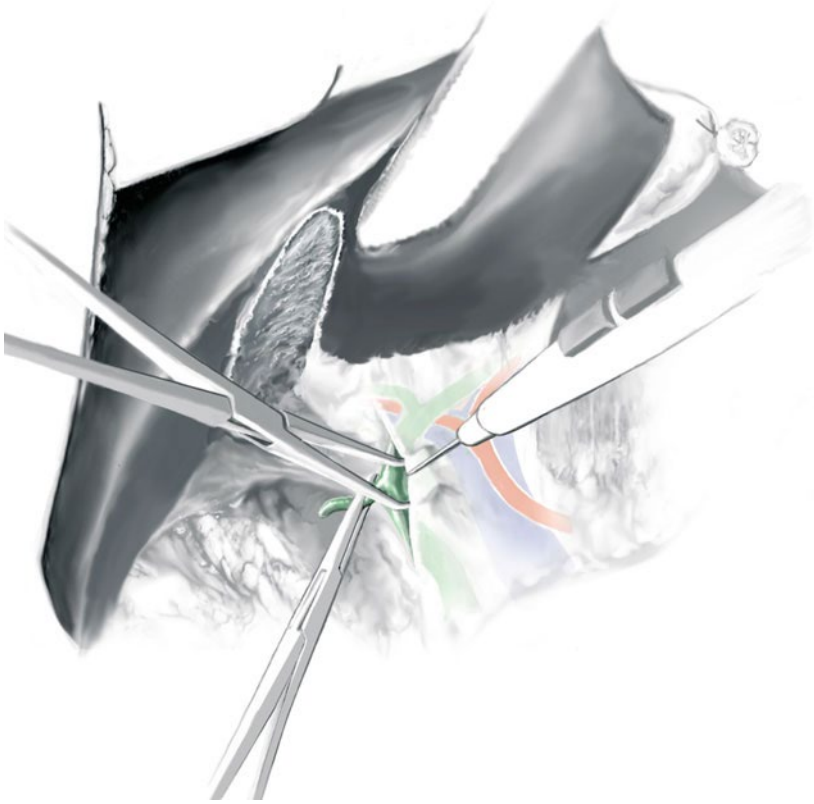


Fig. 75.3

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Step 4

Biliary-enteric anastomosis

If a decision is taken to create a side-to-side anastomosis, the common hepatic duct is opened longitudinally. Suitable sutures are 4-0 or 5-0 Vicryl or PDS. It is often useful to use a parachute technique with interrupted or continuous sutures initially placed without traction; the jejunum is then firmly pulled against the ductal wall when all the sutures are in place (Fig. 75.4).

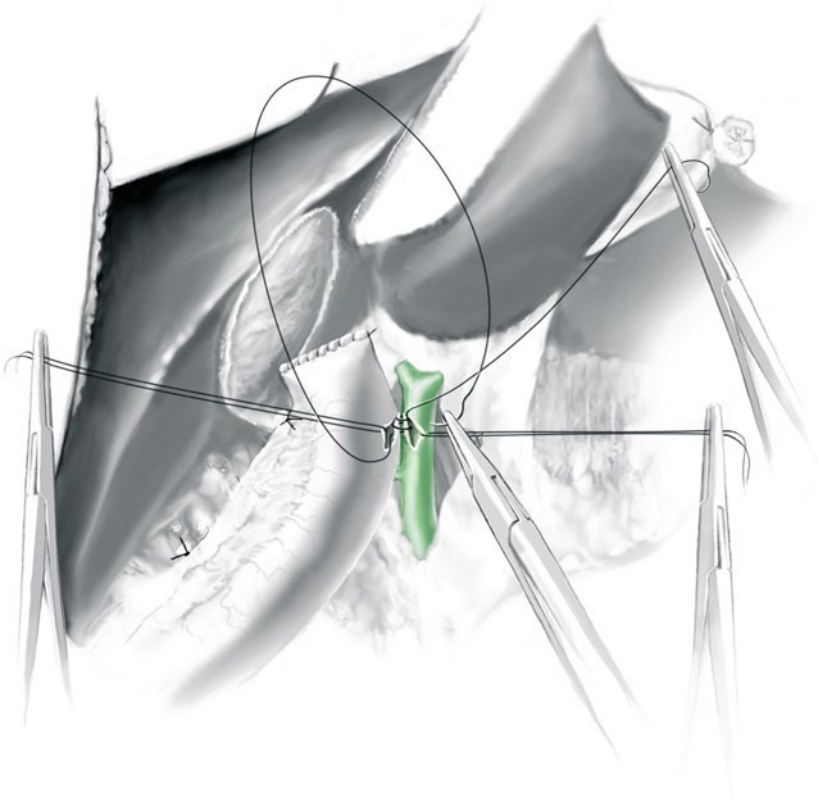


Fig. 75.4

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Step 5

Continuous running suture of the dorsal part of the anastomosis

A continuous running suture of the dorsal side is performed using full-thickness bites of both the duct and the jejunum. With every stitch, mucosa-to-mucosa contact should be ensured, using a forceps while bringing the suture to tension. Intraoperative bile leakage is not a problem. Spill from the intestines should be avoided or removed to reduce the possibility of postoperative infection, possibly leading to dehiscence of the anastomosis (Fig. 75.5).

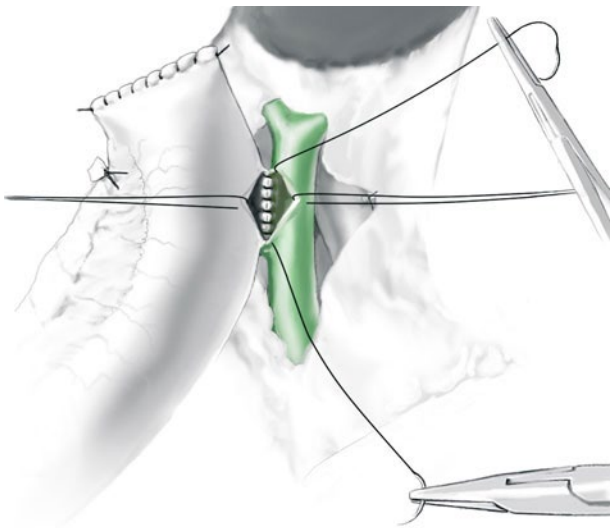


Fig. 75.5

Step 6

Continuous running suture of the ventral part of the anastomosis

One or two sutures are made around the corner at the jejunal side of the anastomosis. Then this side of the suture is put on a clamp, and the other end is used to continue the suture for the ventral part of the anastomosis from the top (Fig. 75.6).

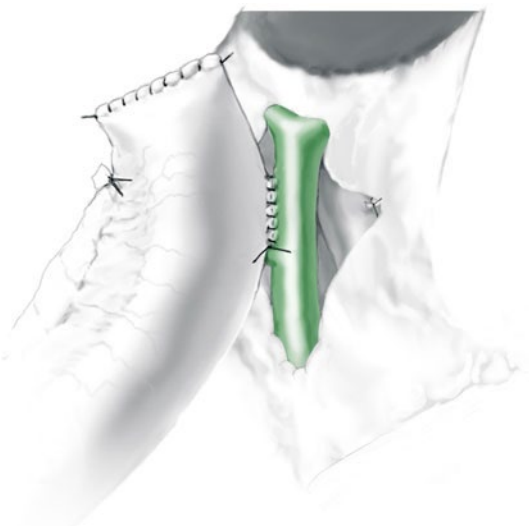


Fig. 75.6

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Step 7

Final situation, side-to-side choledochojejunostomy

After the anastomosis is finished, a silicone closed-system drain is left in situ behind the anastomosis to indicate postoperative blood loss and/or bile leakage. No suction on the drain is needed (Fig. 75.7).

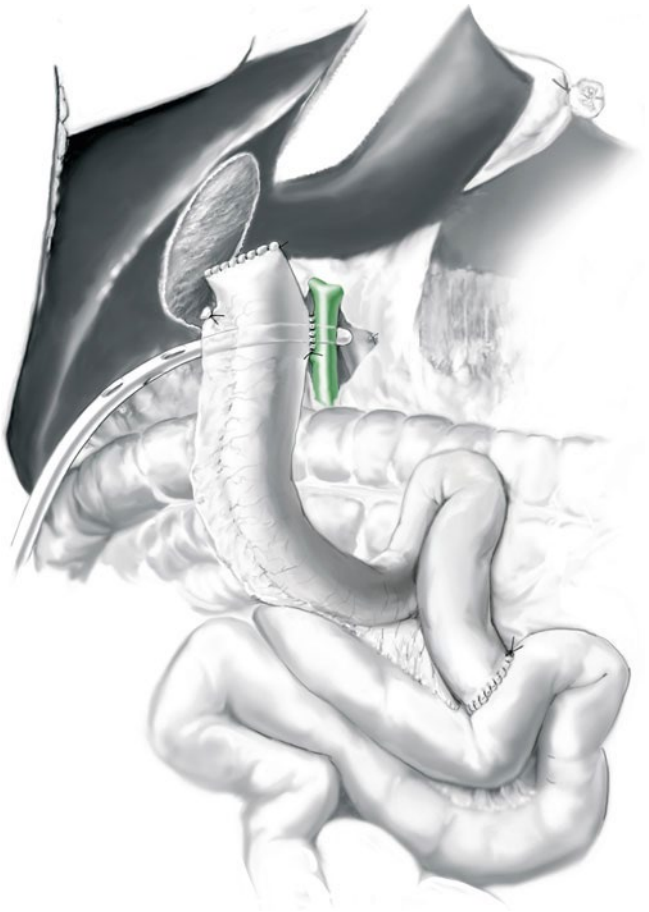


Fig. 75.7

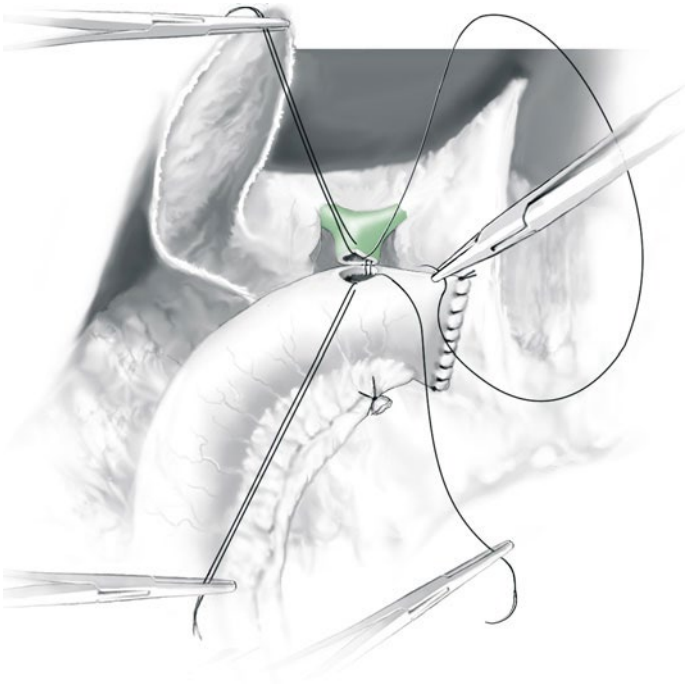
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End-to-Side Choledochojejunostomy

Step 8

Opening of the jejunum and division of the choledochal duct; closure of the duodenal part; placement of stay-sutures

After exploration of the hepatoduodenal ligament (Steps 1 and 2 above), the common hepatic duct is cut and the duodenal side is closed using a continuous, slowly resorbable or non-adsorbable suture. Suitable sutures are 3-0 or 4-0 Vicryl or PDS or Prolene. It is best to use a parachute technique with interrupted or continuous sutures initially placed without traction; the jejunum is then firmly pulled against the ductal wall when all the sutures are in place (◘ Fig. 75.8).



◘ Fig. 75.8

Step 9

Interrupted or continuous running suture of the dorsal part of the anastomosis

Full-thickness bites of both the duct and the jejunum should be taken while suturing. Mucosa-to-mucosa contact should be ensured with every stitch, using a forceps while bringing the suture to gentle tension.

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Step 10

Interrupted or continuous running suture of the ventral part of the anastomosis

One or two continuous sutures are made around the corner on the lateral side of the anastomosis. Then this side of the suture is put on a clamp and the other end is used to continue the suture for the ventral part of the anastomosis. If interrupted sutures are used, there is less chance of iatrogenic narrowing of the anastomosis (Fig. 75.9).

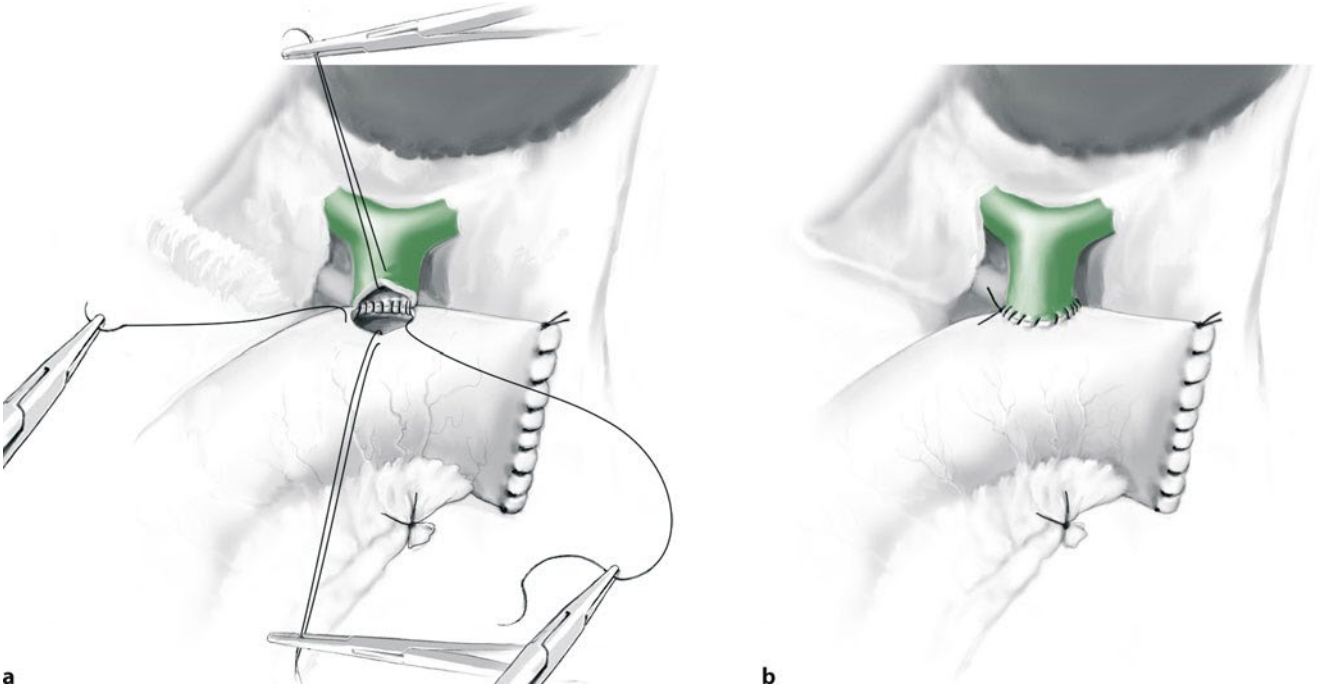


Fig. 75.9

Cholecystojejunostomy

This procedure is really applicable only to frail patients who will not tolerate the prolonged surgery time required for common hepatic duct dissection. Further, it is only effective in patients where the cystic duct inserts high in the common bile duct and there is no danger of impending cystic duct obstruction.

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Step 11

Preparation and dorsal running suture

The gallbladder is left in situ and opened for at least 2 to 3 cm. A jejunal loop is created as described previously, and an opening of the same size is made. Continuous running 4-0 PDS is used to anastomose the gallbladder onto the jejunum, starting on the medial side (Fig. 75.10a).

While suturing, one should take care to take full-thickness bites of both the gallbladder wall and the jejunum. With every stitch, mucosa-to-mucosa contact should be ensured, using a forceps while bringing the suture to tension. The size of the opening in the gallbladder and in the jejunum may be adjusted while making the anastomosis in order to create a perfect fit and thereby avoid postoperative leakage (Fig. 75.10b).

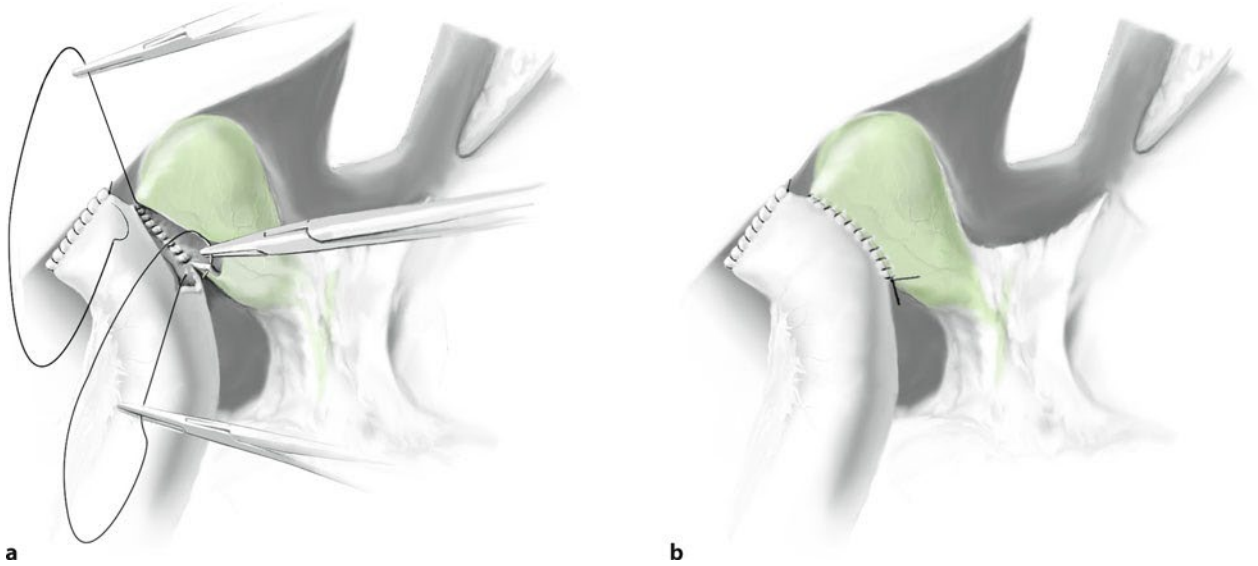


Fig. 75.10

Step 12

Completed cholecystojejunostomy

A drain is left in situ after finishing the anastomosis, to indicate postoperative bleeding or bile leakage.

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Postoperative Tests

- Check daily for clinical signs of biliary obstruction (fever, jaundice, and pain). Bile obstruction may be considered normal for the first few days postoperatively because of edema in the operative area.
- If an enterohepatic drain (such as the old PTBD) is in place, cholangiography through the outside drain on day 5 will reveal possible leakage of the anastomosis. If leakage is identified, the drain should not be removed at day 5 but should be left in place for at least another 6 weeks.

Postoperative Complications

- Bleeding is rare, but if it occurs, it is usually within 24 hours and may require immediate re-exploration for control of the bleeding after full exposure of the cause.
- A degree of bile leakage from the anastomosis is recognized to be common and of no consequence if abdominal drainage is adequate. If the operative drain fails, a percutaneous drain placed under ultrasound or CT guidance will be appropriate.
- Cholangitis, which most often occurs within the first days after surgery, should be treated by antibiotics.
- A restenosis would be evident clinically by recurrent jaundice and cholangitis. As the results of reoperations are poor, the placement of a PTBD and metal stent should be considered in cases of malignancy. For benign strictures, percutaneous dilation should be tried; if this fails, reoperation is appropriate.
- Enterocutaneous fistula (leakage from the blind end of the jejunum) is rare and is usually treated in a conservative way. If it occurs early, reoperation may be appropriate.
- Delayed gastric emptying and/or ileus should always be taken seriously, as it may be a sign of other problems (as mentioned above). A CT scan may be indicated.

Tricks of the Senior Surgeon

- Preoperative stenting (endoprosthesis through ERCP by the gastroenterologist or PTC by the radiologist) may help perioperative localization of the hepatic duct in patients with proximal biliary obstruction.
- In an end-to-side choledochojejunostomy, the hole in the jejunum should be smaller then the diameter of the duct, because it always ends up larger than anticipated.
- Choledochoscopy is helpful to clear any biliary sludge and stones and to check the level of stricturing.

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Choledochoduodenostomy

Theodore Pappas, Kevin N. Shah

Choledochoduodenostomy was first performed by Riedel in 1888 for an impacted common bile duct stone. The main principle of the procedure is that a side-to-side anastomosis is designed to allow free flow of bile from the common bile duct to the duodenum. It offers some advantages over choledochojejunostomy:

- A more physiologic conduit
- Relatively quick and simple, with fewer anastomotic sites
- Ease of access for future endoscopic interventions

Indications and Contraindications

Indications

Biliary dilatation resulting from:

- Benign distal biliary strictures not suitable for transduodenal sphincteroplasty
- Indeterminate biliary stricture in the head of the pancreas, when a preoperative decision has been made not to react if malignancy cannot be confirmed on exploration and open biopsy
- Unresectable malignant stricture where the duodenum comfortably reaches the dilated bile duct
- Primary or recurrent common duct stones, when endoscopic therapies have failed or are not available
- Impacted common duct stone

Contraindications

- Narrow common bile duct (< 8 mm)
- Active duodenal ulceration
- Malignancy preventing easy reach of duodenum to the dilated bile duct
- Obstruction of the 3rd or 4th portion of the duodenum

Preoperative Investigation and Preparation

Preoperative investigation

- *Clinical:* Look for associated symptoms of gastric outlet obstruction, history of duodenal ulceration, evidence of biliary sepsis, coagulopathy, and dehydration
- *Laboratory:* Bilirubin and liver function tests, coagulation parameters, creatinine, electrolytes
- *Radiology:* The most basic imaging study required is ultrasonography, to confirm the degree and site of biliary obstruction. CT scans can aid in the evaluation of mass lesions. The gold standard for noninvasive biliary imaging is MRI/MRCP, which can provide detailed images of biliary anatomy that surpass both ultrasonography and CT.

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Preparation

- Adequate hydration
- Correction of any underlying coagulopathy
- Antibiotic prophylaxis

What not to do

Preoperative biliary stenting increasingly has been used as a reflexive treatment for biliary dilatation. If surgical decompression of the biliary tree is necessary and the time to surgery is acceptably brief, preoperative stenting should be avoided, as it increases infectious complications of surgery. Furthermore, the resultant decompression of the common bile duct will make the choledochoduodenal anastomosis more technically challenging. If a delay before surgical intervention is unavoidable, or if there is evidence of cholangitis, preoperative stenting is appropriate.

Procedure: Open Choledochoduodenostomy

Step 1

Access

Both right subcostal and midline incisions provide appropriate exposure. (See Part I, ▶ Chaps. 2 "Positioning and Accesses" and 3 "Retractors and Principles of Exposure.")

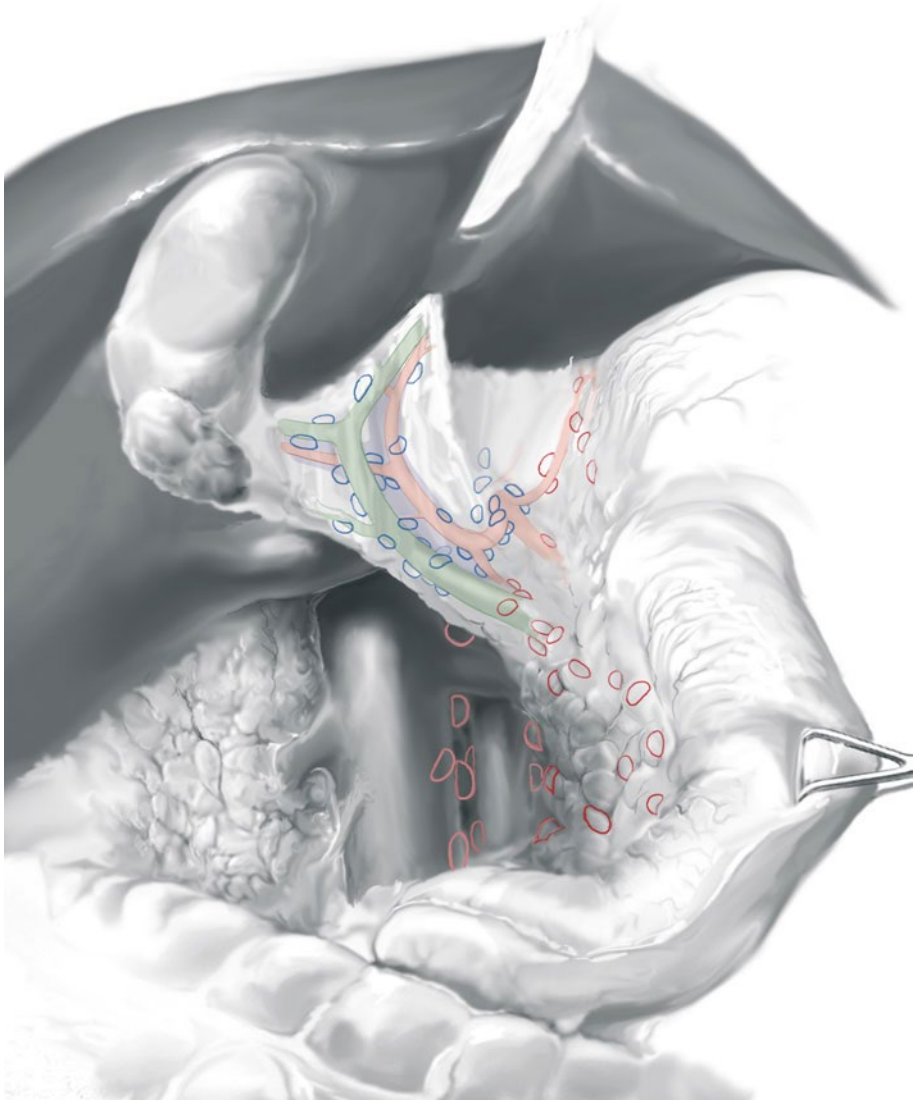
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Step 2

Exposure

After installation of the retractor (Bookwalter), the hepatic flexure of the colon is mobilized and reflected inferiorly. Next, generous kocherization of the duodenum is performed, as shown in the ▶ Chap. 68 "Resection of Gallbladder Cancer, Including Surgical Staging." The duodenal mobility provided by kocherization is critical to ensuring a tension-free anastomosis (◘ Fig. 76.1).

Cholecystectomy should be performed as shown in the ▶ Chap. 67 "Laparoscopic Cholecystectomy, Open Cholecystectomy, and Cholecystostomy."



◘ Fig. 76.1

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Step 3

Defining the common bile duct

Incise the peritoneum of the hepatoduodenal ligament to expose the anterior surface of the common bile duct (Fig. 76.2a). If the anatomy is unclear or the surgery is reoperative, the site of the common bile duct can be confirmed by the aspiration of bile through a small-diameter (26 or 27 gauge) "seeker needle" (Fig. 76.2b). The target site for the choledochotomy is then identified. Typically, this is distal to the cystic duct/common duct junction. Next, 3-0 silk is used to place two stay sutures at the lateral aspects of the anterior common bile duct wall (Fig. 76.2c).

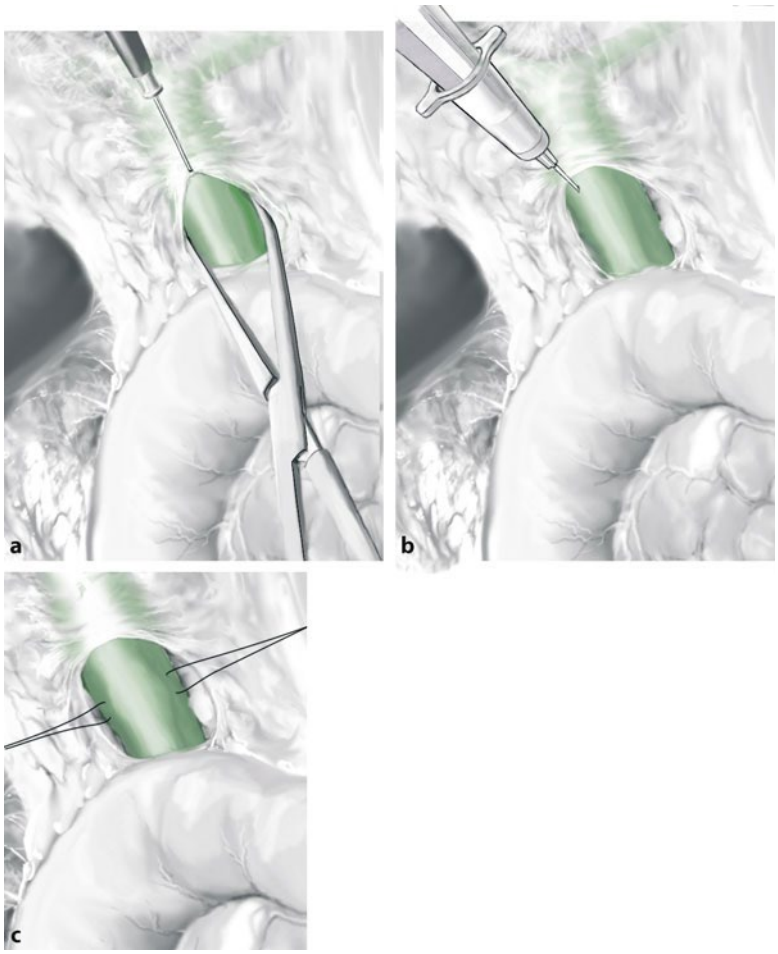


Fig. 76.2

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Step 4

Opening of the bile duct and the duodenum

A 2-cm longitudinal choledochotomy is performed, with the distal extent of the choledochotomy near the superior border of the mobilized duodenum. This location will ensure that the duodenum comfortably reaches the choledochotomy.

A longitudinal duodenotomy is performed on the antimesenteric aspect of the duodenum. The length of the duodenotomy should be approximately 70 % of the choledochotomy's length, as it will stretch to become the same size (Fig. 76.3).

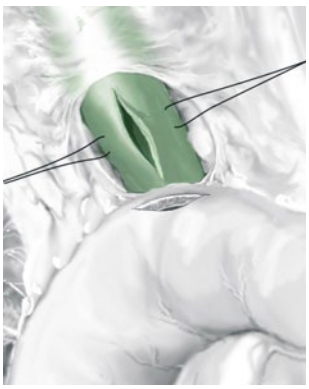


Fig. 76.3

Step 5

Posterior wall anastomosis

The anastomosis is performed using interrupted 4-0 sutures (Maxon, PDS, or Vicryl) with the knots inside the lumen for the posterior wall. The tendency to place too many sutures is a common mistake; 12 sutures are usually sufficient.

Visualizing the anastomosis as a clock face, the first stitch should be placed at the 6 o'clock position, going inside-to-outside on the duodenum and outside-to-inside the lumen on the bile duct (Fig. 76.4a). The suture is left untied and secured with a Crile clamp. Gentle traction on this suture aids in exposure and placement of the subsequent posterior wall sutures. Three additional sutures are placed at regular intervals between the 6 o'clock and 3 o'clock positions. Similarly, three sutures are placed between the 6 o-clock and 9 o'clock positions. All of the posterior row sutures should be placed prior to tying (Fig. 76.4b).

The silk stay sutures can now be cut and removed. The posterior row sutures are all tied, and all but the 3 o'clock and 9 o'clock sutures are cut (Fig. 76.4c).

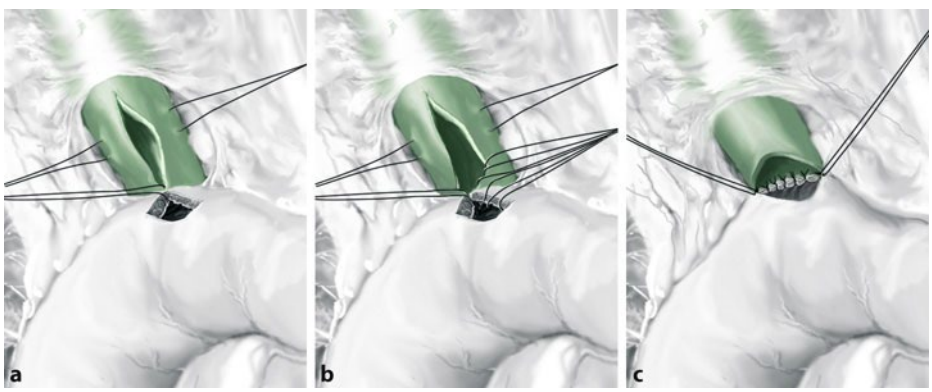


Fig. 76.4

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Step 6

Anterior wall anastomosis

Traction on the corner sutures ensures that the corner is inverted. All of the anterior row sutures are placed from outside-to-inside on the duodenum and then inside-to-outside on the bile duct, so that the knots will be on the outside of the lumen (Fig. 76.5a). All of the sutures are placed prior to tying them (Fig. 76.5b).

The enterotomy is intentionally created shorter than the choledochotomy, as the duodenum always stretches during the creation of the anastomosis. Despite planning for this stretching, there still may be a size mismatch between the duodenum and bile duct. Care should be taken to make sure the sutures are placed evenly on both the bile duct and the duodenum (Fig. 76.5c). Stenting of the anastomosis is not necessary.

Though we prefer the interrupted anastomosis, a running anastomosis has also been described. Two 3-0 absorbable sutures are placed at the 6 o'clock position (Fig. 76.5d) and are then sewn in a running fashion to 12 o'clock (Fig. 76.5e) and tied (Fig. 76.5 f).

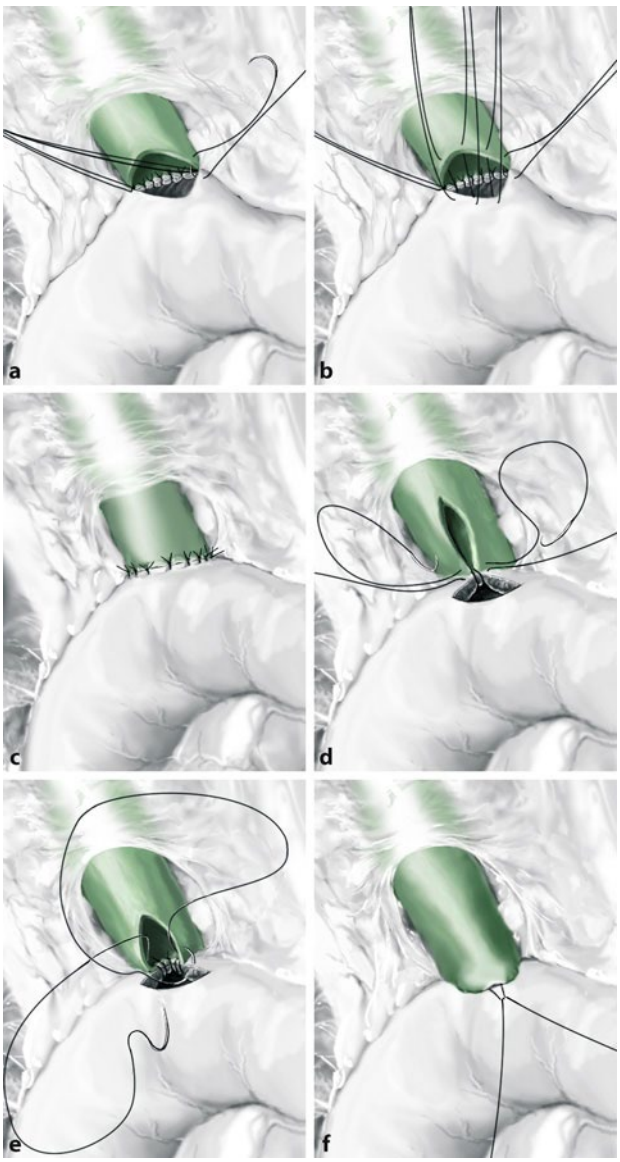


Fig. 76.5

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Procedure: Laparoscopic Choledochoduodenostomy

The basic principles of a laparoscopic choledochoduodenostomy are essentially the same as the open procedure, with several important exceptions that are outlined below.

Advantages and disadvantages

There are no randomized data comparing laparoscopic and open choledochoduodenostomy, but the proposed benefits are similar to those of laparoscopy in general. These include the potential for decreased pain, shorter hospital stays, and lower rate of large hernias and wound infections. The main disadvantages are increased operative time and technical difficulty. Therefore, laparoscopic choledochoduodenostomy should be attempted only by experienced biliary surgeons who are facile with laparoscopic suturing.

Step 1

Access, port placement, and setup

The patient is placed in the supine position and access to the abdomen can be obtained with a Veress needle or open Hasson technique. Our preferred port placement is shown in the diagram below. With the surgeon standing on the patient's right, 5-mm and 12-mm ports are placed in the right upper quadrant. These are the two main working ports. The assistant stands on the patient's left and uses the periumbilical port for the camera and the left upper quadrant port to assist with retraction and suctioning. An additional 5-mm subxiphoid port is placed to be used for liver retraction. All ports should be at least one hand-breadth away from the other ports, to provide enough working space. Use of a 5-mm, 30-degree laparoscope is ideal, as it provides more flexibility than a 0-degree camera (Fig. 76.6).

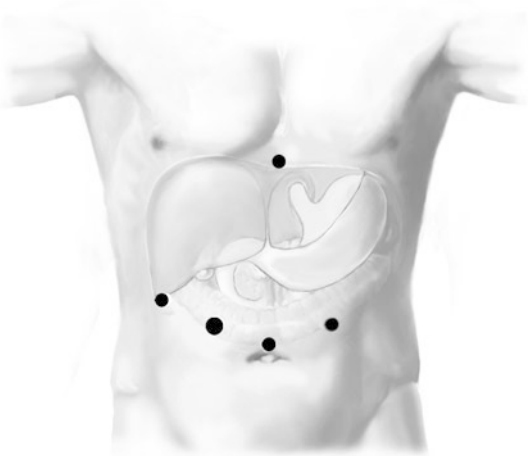


Fig. 76.6

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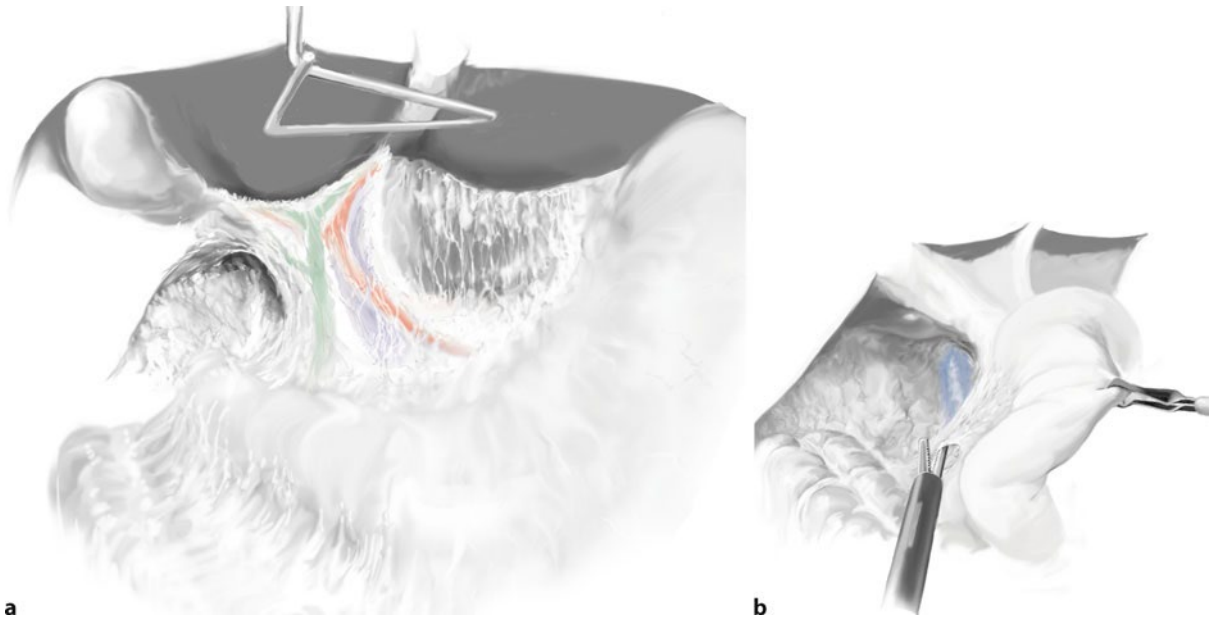
Step 2

Exposure

If a cholecystectomy has not been performed, this should be completed first, as shown in the ▶ Chap. 67 "Laparoscopic Cholecystectomy, Open Cholecystectomy, and Cholecystostomy." The subxiphoid port can be used as the main operative port and the right-sided ports can be used for retraction for this portion of the procedure.

Once the cholecystectomy is completed, place a liver retractor (Snowden-Pencer® Diamond Flex Liver Retractor, Snowden-Pencer® Fast Clamp) in the subxiphoid port. This provides exposure to the duodenum and hepatic hilum.

With the assistant providing gentle medial retraction of the duodenum, the peritoneum lateral to the duodenum is opened and kocherization of the duodenum is carried out using a LigaSure™ (Covidien) or Harmonic ACE® (Ethicon). Hook electrocautery can also be used, but we prefer the LigaSure™ because in addition to its hemostatic characteristics, it can also be used as a dissecting instrument (◘ Fig. 76.7).



◘ Fig. 76.7

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Step 3

Defining the common bile duct

Incise the peritoneum of the hepatoduodenal ligament to expose the anterior surface of the common bile duct. This is often most easily initiated with hook electrocautery. If the anatomy is unclear, the common bile duct can be confirmed by using a seeker needle. Under direct visualization, a 25-gauge butterfly needle is introduced through the 12-mm port and inserted into the bile duct. The presence of bile confirms the duct (Fig. 76.8).

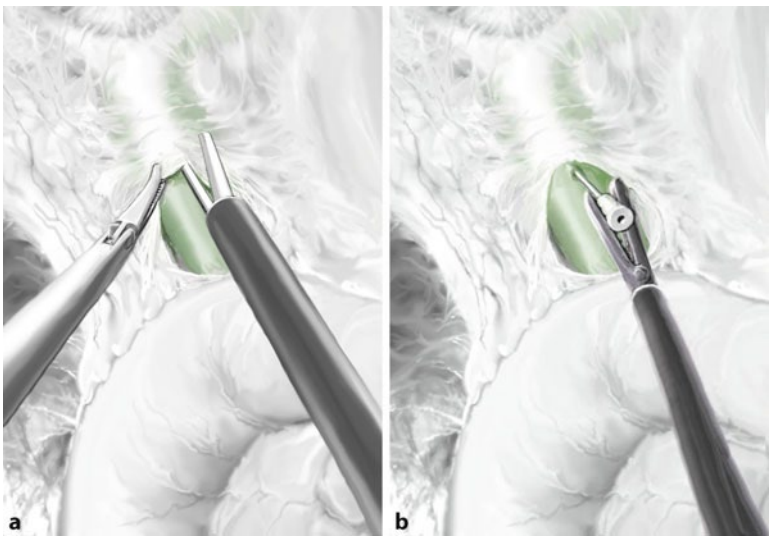


Fig. 76.8

Step 4

Opening of the bile duct and the duodenum

A 2-cm longitudinal choledochotomy is performed using hook electrocautery. Just as in the open procedure, the distal extent of the choledochotomy should be close to the superior border of the mobilized duodenum.

A longitudinal duodenotomy (70 % of the choledochotomy's length) is similarly performed on the antimesenteric aspect of the duodenum, using hook electrocautery (Fig. 76.9).



Fig. 76.9

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Step 5

Posterior wall anastomosis

The anastomosis is performed in a similar fashion to the open technique. The posterior wall is completed first using interrupted sutures (3-0 or 4-0 Vicryl, 4-0 Maxon, or 4-0 PDS) with the knots inside the lumen. Any of these suture choices would be appropriate, but Vicryl is the easiest to handle laparoscopically. Either a free needle or the EndoStitch™ device (Covidien) can be used. Using the EndoStitch™ is faster and less technically demanding than suturing with a free needle, but care should be taken not to excessively torque the short, straight needle of this device when passing it through the wall of the bile duct.

The first stitch should be placed at the 6 o'clock position, going inside-to-outside on the duodenum and outside-to-inside the lumen on the bile duct. Unlike in the open technique, this suture is tied and then handed to the assistant. Gentle traction on this suture aids in exposure and placement of the subsequent posterior wall sutures.

Three additional sutures are placed at regular intervals between the 6 o'clock and 3 o'clock positions. Similarly, three sutures are placed between the 6 o'clock and 9 o'clock positions. Because managing untied suture laparoscopically can be clumsy and challenging, all sutures are tied and cut as they are placed, with the exception of the 3 o'clock and 9 o'clock sutures, which are tied but not cut (Fig. 76.10).

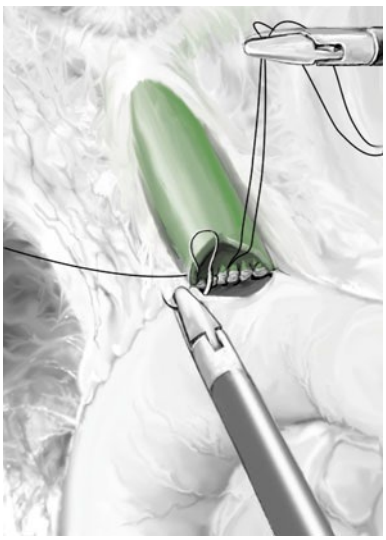


Fig. 76.10

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Step 6

Anterior wall anastomosis

All of the anterior row sutures are placed from outside-to-inside on the bile duct and then inside-to-outside on the duodenum so that the knots will be on the outside of the lumen.

Sutures are placed at 2 o'clock and 10 o'clock. These are tied and cut.

When there are approximately three sutures remaining to be placed (11, 12, and 1 o'clock), these sutures are placed and left untied. Tying these sutures as they are placed will make placing the final stitches quite difficult. Once the final sutures are placed, they are all tied and cut.

If the EndoStitch™ device is being used, the final three sutures are left untied, as described above. To do this, the needle must be released from the device after placing each stitch. The needles are left attached to the suture inside the abdomen. These final sutures can either be tied as one would tie a free suture, or they can be reloaded on an empty EndoStitch™ inside the abdomen and then tied using the standard EndoStitch™ technique (Figs. 76.11 and 76.12).

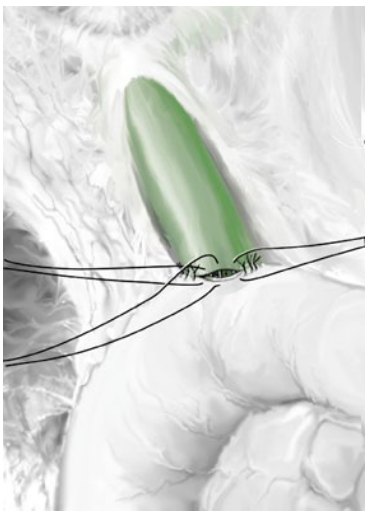


Fig. 76.11

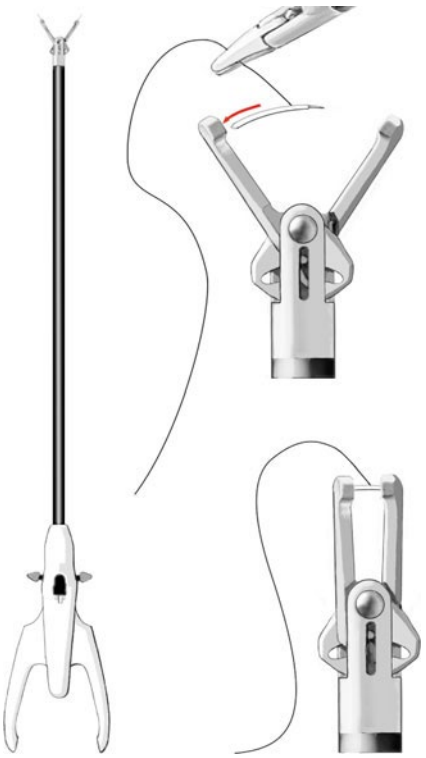


Fig. 76.12

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Postoperative Tests

- Bilirubin and alkaline phosphatase.

Local Postoperative Complications

Short-term

- Wound infection can occur; the incidence is increased in patients who have had preoperative biliary stenting.
- Bile leakage is uncommon and generally indicates a technical issue with the anastomosis. The priority in management is to establish a controlled fistula and to determine whether there is unobstructed biliary-enteric continuity. A CT scan and fistulagram via drain are the initial investigations. Most biliary fistulas will heal spontaneously if there is no downstream obstruction.

Choledochoduodenostomy

Surgical drain is not requisite, but the placement of drain to Morrison's pouch or Winslow foramen might be appropriate in some cases after choledochoduodenostomy.

Medium to long-term

- Recurrent cholangitis can present with symptoms of pain, jaundice, and right upper quadrant pain with signs of sepsis. Cholangitis is most often the result of anastomotic stricture, but can also result from sump syndrome, development of choledocholithiasis, or disease in the more proximal biliary tree. A CT scan or MRI will aid in identifying the level of the obstruction. Endoscopic retrograde cholangiopancreatography (ERCP) is necessary to define the anatomy of the biliary tree and provides therapeutic interventions for several causes of cholangitis.
- Anastomotic stricture typically presents with cholangitis as described above, but in some patients it can present with progressive jaundice without other signs of cholangitis. Stricturing is more likely if the choledochotomy at the time of surgery was less than 2 cm. Some patients may respond to endoscopic dilation and stenting, but patients who fail endoscopic management require conversion to Roux-en-Y hepaticojejunostomy.
- Sump syndrome results from reflux of intestinal contents and biliary stasis within the extrahepatic biliary tree. The typical presenting signs are pain, cholangitis, jaundice, and, less commonly, pancreatitis. Hepatic abscesses can also be seen in association with sump syndrome. The onset is typically months to years postoperatively. Diagnosis is confirmed on ERCP, where the blind end of the common bile duct is found to be full of food debris or calculi. The initial treatment is endoscopic, and revision to Roux-en-Y hepaticojejunostomy is rarely indicated. The risk of developing sump syndrome after choledochoduodenostomy has deterred some surgeons from using this technique, but the incidence of sump syndrome is quite low (about 2.5 %) and it is readily treated with endoscopic interventions.
- Cholangiocarcinoma usually occurs 10 to 20 years postoperatively in patients with a long history of recurrent cholangitis. Early symptoms are nonspecific and include pain, weight loss, and cholestasis. The workup of suspected cholangiocarcinoma is detailed elsewhere.

Tricks of the Senior Surgeon

- Anticipate a 50 % stenosis and make the choledochotomy at least 2 cm long.
- Position the choledochotomy and the enterotomy relatively close together, to minimize tension.
- Generous kocherization is essential to ensuring that there is no undue tension on the anastomosis.

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Reconstruction of Bile Duct Injuries

Steven M. Strasberg

Bile duct injuries have become more common since the introduction of laparoscopic surgery, and they are a major source of morbidity and litigation. These injuries may take many forms, classified as Type A to Type E (Fig. 77.1). In this classification of injuries to the biliary tract, Type E injuries are subdivided according to the Bismuth classification. Type B and C injuries almost always involve aberrant right hepatic ducts. The notations "> 2 cm" and "< 2 cm" for Type E1 and Type E2 indicate the length of common hepatic duct remaining. A Hepp-Couinaud approach can be used for injuries of Types E1, E2, and E3, but not for injuries with an isolated right duct – Types B, C, E4, and E5.

The simpler injuries, such as types A and D, may be treated at the index procedure when discovered intraoperatively, or by endoscopic or percutaneous techniques when they present in the postoperative period. Some injuries, such as E1 and E2 injuries, and occasionally more complex injuries, may be treated by nonsurgical techniques when they present as strictures. This chapter deals with injuries that require operative reconstruction – B and C injuries and most E injuries.

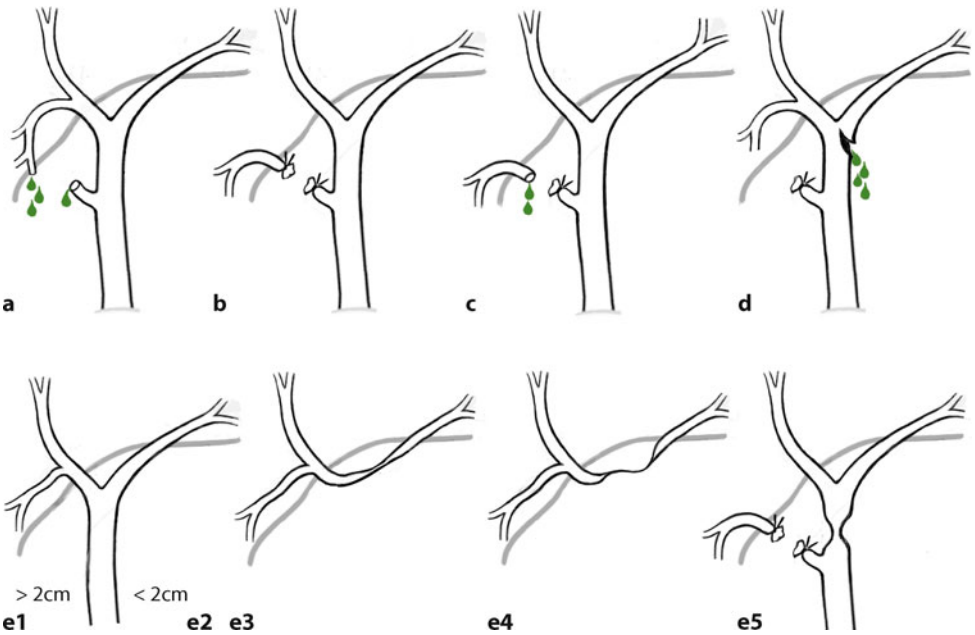


Fig. 77.1

Timing of repair. Early repair is desirable, but timing is influenced by local and general factors and time of referral. Repair at the index procedure should be undertaken only if experience and expertise are available. Otherwise, patients should be referred appropriately. Factors favoring early repair include early referral, less complex injuries, absence of concomitant vascular or thermal injury, and a stable patient. Many patients are referred 10 days to 6 weeks after the primary operation, at a time when considerable local inflammation may be expected. Repair is best avoided during this period. Complex injuries such as Types E4 and E5 may require time for diagnosis and are often associated with undrained bile collections. Concomitant vascular injuries

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may cause biliary ischemia that extends the mechanical injury. The extent of ischemic injury may be uncertain in the early postoperative period, and repair at that time risks anastomosis to an ischemic duct. Similarly, the extent of a thermal injury may be difficult to determine for some time after it has occurred. In these patients, percutaneous tubes are placed to relieve obstruction from affected segments, drain subhepatic collections, and control sepsis. Repair is performed when inflammation has settled and the ischemic area has demarcated, usually about 3 months after the last operation.

Preoperative Investigation and Preparation

It is essential to completely diagnose the injury prior to operation. Failure to do so may result in exclusion of bile ducts from the repair. The diagnostic approach depends on the type of presentation and whether cholangiography was performed intraoperatively after the injury during the index operation.

CT or MR with angiography should be performed to rule out vascular injury in all cases in which a major bile duct injury is suspected. When multiple ducts have been injured and the ducts have been transected (and are therefore decompressed), MRI often lacks the anatomic detail needed to plan reconstruction. In these patients, our experience has shown that drainage of bilomas and retrograde cholangiography with placement of a percutaneous U tube is a reliable approach. When there is more than one isolated portion of the biliary system, additional tubes are placed on the day before surgery. These serve as guides to the position of the injured ducts at surgery. Conciliation between CT studies and percutaneous transhepatic cholangiography (PTC) is done to be sure that all bile ducts are accounted for.

Figure 77.2 shows the diagnosis, management, and preparation for surgery of a complex E4 injury. After waiting 2 weeks for biloma to contract around drains placed during the index procedure, a retrograde injection of right (Fig. 77.2a) and left (Fig. 77.2b) ducts is performed. Right ducts visualized by retrograde injection can then be cannulated percutaneously even though they are decompressed. Using a "rendezvous" technique, a U tube is placed (Fig. 77.2c). The U tube is very stable. It lies in the subhepatic biloma and therefore drains both the left and right ducts. Three months later, on the day before surgery, the left biliary system is cannulated (Fig. 77.2d) to make intraoperative identification of the left hepatic duct easier. Figure 77.2e shows a cholangiogram taken several days postoperatively.

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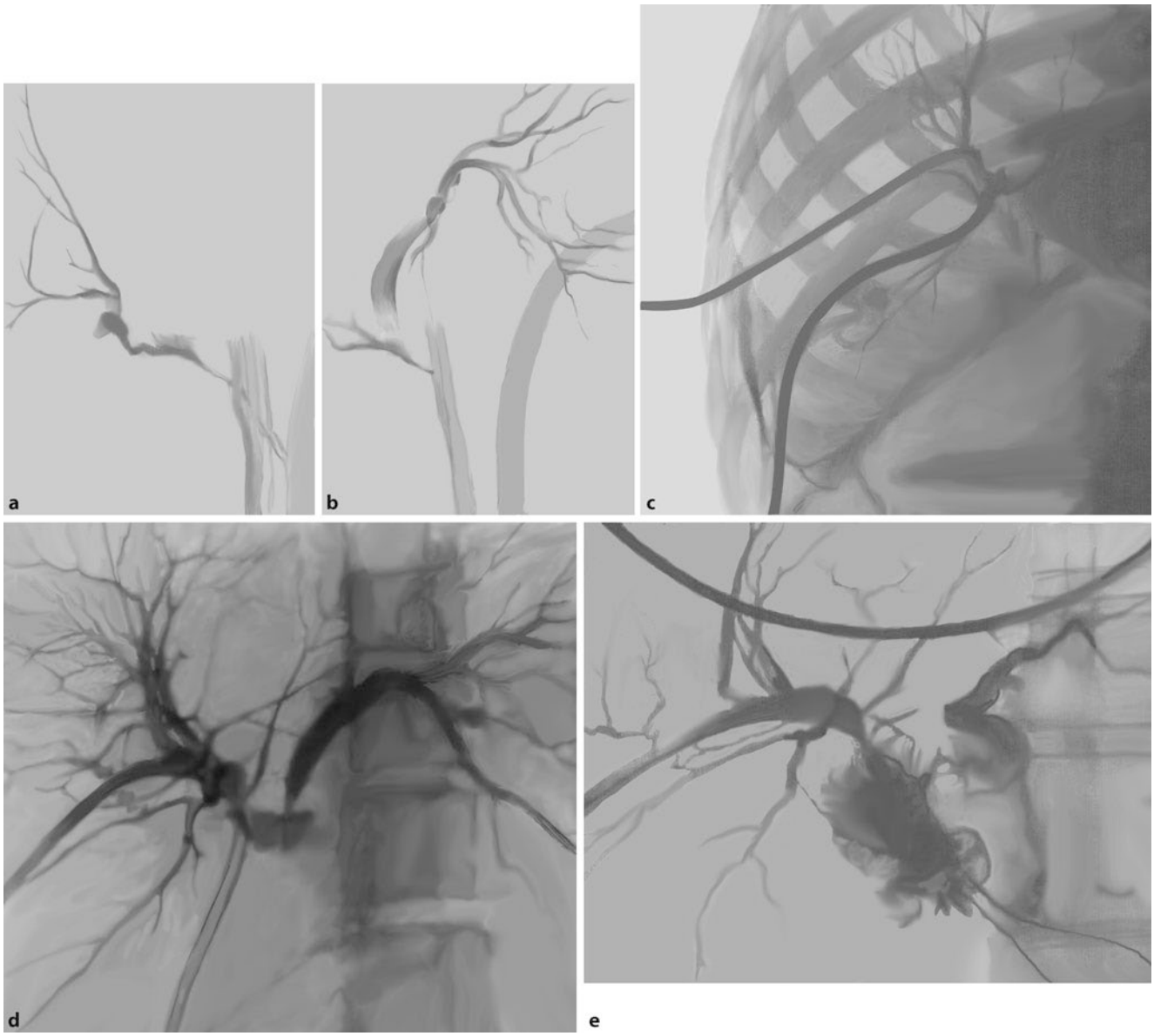


Fig. 77.2

Procedure

Principles of reconstruction

The actual operation has two phases: identification of the ducts and biliary enteric anastomosis. The principles of reconstruction are that the anastomosis should be well vascularized, tension-free, mucosa-to-mucosa, widely patent, and precisely constructed; it also must drain all parts of the liver. Hepaticojejunostomy is used in preference to either choledochocholedochostomy or choledochoduodenostomy, because a tension-free anastomosis is always possible with hepatico-jejunostomy.

Choledochoduodenostomy may be used for low injuries, however, if it can be achieved without tension. Choledochocholedochostomy is not used; it has the additional disadvantage that blood supply to the anastomosis may be poor.

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Whenever possible, side-to-side anastomotic techniques are used because these techniques involve less mobilization of the bile ducts, especially on the posterior surface of bile ducts which may lead to devascularization. Often the anastomosis is done to the extrahepatic portion of the left hepatic duct after lowering the hilar plate (Hepp-Couinaud technique; see below). With Type E1 and some E2 injuries, the common hepatic duct itself may be used. With higher E4 injuries and E5 injuries, multiple ducts must be anastomosed and isolated right ducts are exposed as described below. For high injuries, it may be useful to perform local resections of parts of liver segments 4 and 5 to gain better exposure to the hilum of the liver. This is especially so when the liver has become enlarged and fibrotic and segments 4 and 5 overhang the upper biliary tree.

The use of postoperative stents is controversial. There is no evidence that they are helpful if a large-caliber mucosa-to-mucosa anastomosis has been achieved. We stent only when very small ducts (1–2 mm) have been anastomosed. However, the transhepatic tubes are left through the anastomosis for a few days in order to perform postoperative cholangiography. These baseline postoperative studies may be useful should a postoperative stricture develop at a later time.

Sometimes biliary reconstruction is not advisable. Patients with asymptomatic Type B injuries often do not require repair. "Extreme" vasculobiliary injuries may lead to infarction of the liver. In these life-threatening cases, the biliary injury is a less important component of the injury, and emergency liver resection, transplantation, or vascular repair is the main form of treatment. Failure of reconstructions may lead to secondary biliary cirrhosis and end-stage liver failure. Then liver transplantation or hemihepatectomy may be required, depending on the extent of the problem. In almost all examples of such unfortunate outcomes, surgeons lacking experience in the procedures have attempted high reconstructions.

77

Step 1

Incisions for bile duct reconstruction

The usual incision is a J-shaped right upper quadrant incision (*solid line*) (Fig. 77.3). The vertical length of the incision should be at least 6 cm. The incision can be extended to the left for increased exposure in large individuals. A midline incision may be suitable for thin persons. A large ring retractor is placed after clearing adhesions to the anterior abdominal wall.

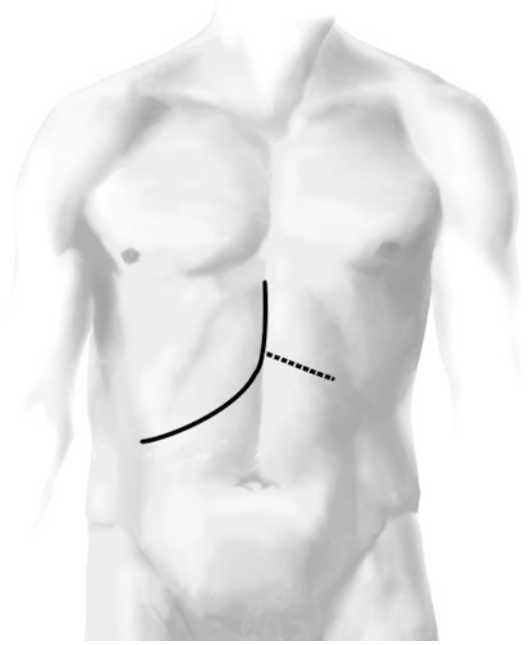


Fig. 77.3

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Step 2

The Hepp-Couinaud approach (E1–E3 lesions)

The Hepp-Couinaud approach is adequate for E1 through E3 lesions. The dissection is started anteriorly at the liver edge and is carried down the face of segments 3 to 5 (Fig. 77.4a). The dissection is continued directly on the inferior face of segment 4 down to the hepatoduodenal ligament. The peritoneum is incised in the plane shown (*double-headed arrow*), and the dissection is carried upward between the liver substance and the hilar plate. The dissection must be carried high enough to actually see liver substance. In this way, the hilar plate and the left hepatic duct are "lowered." The left hepatic duct is approached because it has a longer extrahepatic length than the right duct. The left duct may lie horizontally as shown, or it may lie more vertically, in which case exposure of the duct may be more difficult. The left hepatic duct is opened on its anterior surface (*dashed line*), a task that is aided by palpation of the stent. Stay sutures may help. The duct is opened with needle point cautery set on blended cutting current. A 2-cm opening is adequate. Care should be taken not to extend the incision too far to the left, as the artery to segment 4 (*arrow*) may be injured. The dissection may be facilitated by dividing the bridge of liver tissue between segments 3 and 4 and by re-opening the gallbladder fossa if it has sealed at its lips. Resection of the inferior portion of segment 4 also may be helpful (see below).

Once the left hepatic duct is opened and communication with the right hepatic duct is established by probing with a sound or catheter, a Roux-en-Y loop is laid up next to the left hepatic duct (Fig. 77.4b). The anastomosis is done with 5-0 synthetic absorbable interrupted sutures. The anterior row in the bile duct is placed first, then the posterior is placed in the duct and jejunum and tied. Finally the anterior row is placed in the anterior lip of the jejunal incision and tied. A single suction drain is left. Stents are used only when the bile ducts are very small (2 mm or less), which is very uncommon.

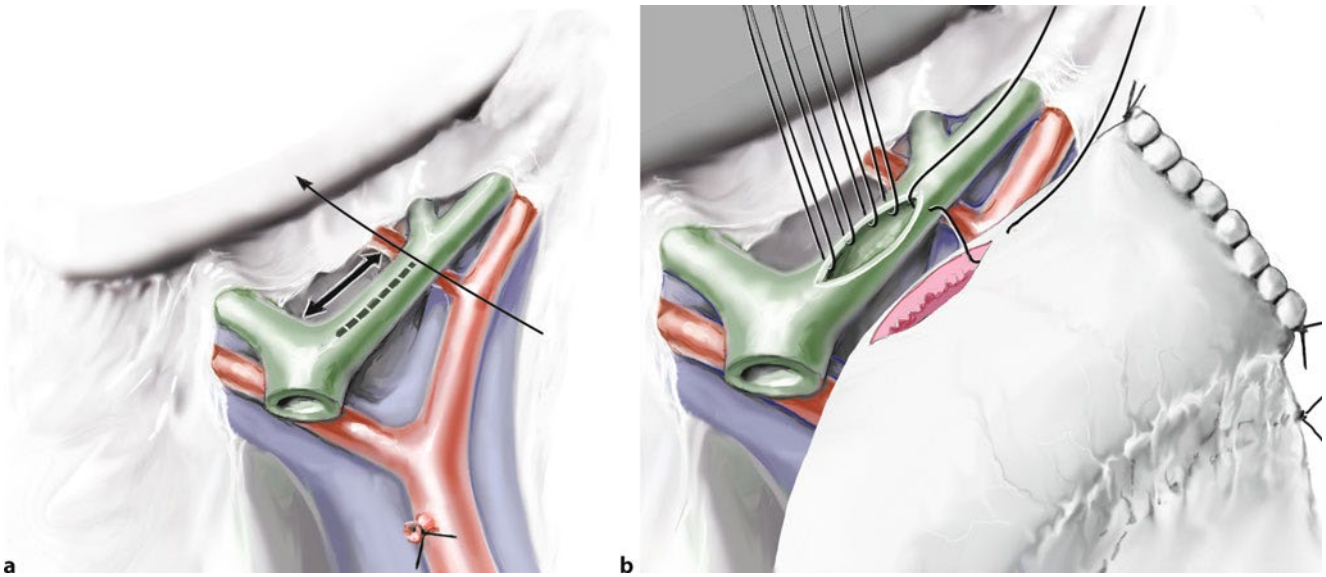


Fig. 77.4

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Step 3

Reconstruction when there is an isolated right hepatic duct (E4, E5, B, C)

In Type E4, E5, B, and C injuries, the Hepp-Couinaud approach will not suffice, as there is an isolated portion of the biliary tree on the right side. The anatomic rationale for our approach to these injuries is based on the fact that the right and left hepatic ducts lie in the same coronal plane, invested in fibrous sheaths. Also of importance is that the gallbladder plate, a layer of fibrous tissue on which the gallbladder normally rests, attaches to the anterior surface of the sheath of the main right portal pedicle. To find the bile duct within the sheath of the pedicle, the cystic plate must be detached from the anterior surface of the sheath of the right portal pedicle.

In our approach, the left hepatic duct is found as usual in the Hepp-Couinaud approach. The liver capsule is then divided toward the right until the cystic plate is met where it attaches to the sheath of the right portal pedicle. (It is a stout ribbon of fibrous tissue about 2 mm thick and 5 to 8 mm wide.) After the cystic plate is divided, the liver lifts off the right portal pedicle. The division of the liver capsule is carried about 1 cm beyond the cystic plate (Fig. 77.5).

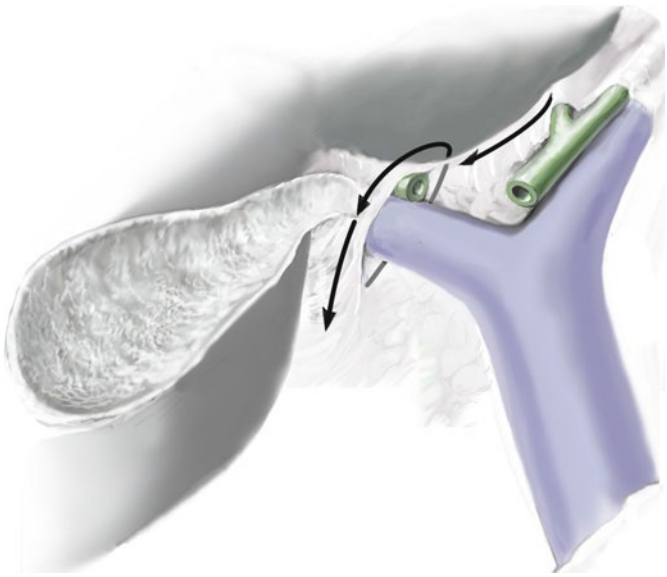


Fig. 77.5

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Step 3 ***(continued)***

Now the liver (segment 5) may be dissected off the portal pedicle by lifting and coring the base of segment 5. This exposes the anterior surface of the sheath of the right portal pedicle. The position of the right duct(s) in the pedicle is evident from the position of the stent (*not shown*). To prepare the right bile duct or ducts for anastomosis, they are opened on the anterior surface. Ideally, the duct is opened for 1 cm and the end of the duct may be closed with 5-0 or 6-0 nonabsorbable sutures. The entire anastomosis is then performed to the anterior surface of the duct, as described above for the left duct. When performing two or more anastomoses, the anterior row in the bile ducts should be placed first and then the posterior row is placed and tied, completing all anastomoses together by placement of the anterior row sutures in the bowel and tying of all anterior row sutures (Fig. 77.6).



Fig. 77.6

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Step 4

Segment 4 resection

In some patients, especially those in whom there have been repeated bouts of cholangitis and the liver has become swollen and fibrotic (a condition most frequently seen after failed hepaticojejunostomy), segment 4 may overhang the upper bile ducts. In these cases, resection or coring of segment 4 is also a useful adjunct (as described by Mercado and Orozco). Resection provides excellent access to the upper part of the porta hepatis without relying on forceful retraction of the liver and provides a space in which the bowel may lie when the hepaticojejunostomy is performed. This maneuver is not restricted only to operations in which a portion of the right biliary tree has been isolated. It is also useful for E3 and some E2 injuries. Bile ducts with stents may be seen at the bottom of the picture (Fig. 77.7).

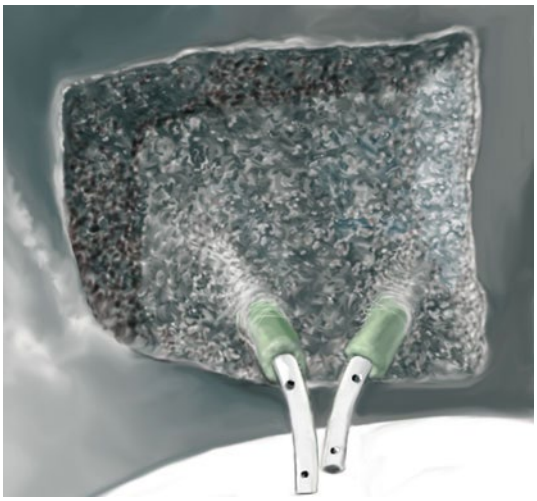


Fig. 77.7

Step 5

Anastomosis (E4)

The following illustrations provide close-up views of the bile ducts in our approach to reconstruction of an isolated right hepatic duct, as discussed above. In this E4 injury, the right bile ducts have been exposed by dividing the gallbladder plate as described, and segment 4 has been partially resected. Preoperatively placed stents are emanating from the ducts, and the ducts have been incised on their anterior surfaces for 1.5 cm (Fig. 77.8). Sutures have been placed in the anterior row of the proposed anastomosis, and a few have been placed in the posterior row.

We chose to do a "cloacal" side-to-side anastomosis rather than a double-barreled anastomosis because the ducts were close and the intervening scar was small. Although the center of the anastomosis may scar, the long lateral horns are mucosa-to-mucosa, and effectively a double-barreled anastomosis results.

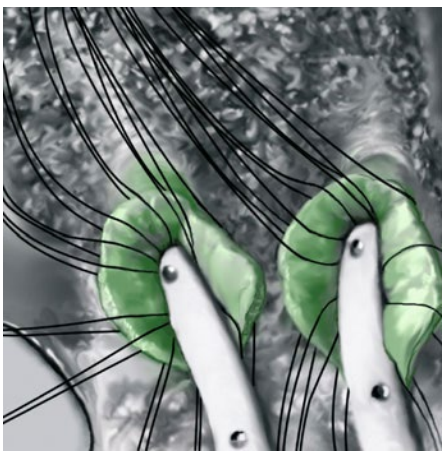


Fig. 77.8

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Step 6

Reconstruction of an E5 injury

In this reconstruction of a Type E5 injury, the Hepp-Couinaud approach has been used to find and open the left hepatic duct, which contains an orange catheter (Fig. 77.9). The right posterior sectional duct was exposed by the method described in Step 3. It contains a white catheter. This duct was lying in the sagittal plane, so it was possible to open the anterior surface for only a few millimeters, and the anastomosis was primarily end-to-side. Because of the distance between the two open ducts, two anastomoses were performed ("double-barreled anastomosis"). Note that the anterior rows are placed first in both ducts. Subsequently the posterior rows are formed and tied. The last step is to complete both anterior rows.

When ducts are closer together, they may sometimes be brought together with sutures and a single anastomosis can be performed. When two ducts lie in an anterior/posterior relationship, the ducts may be sewn together to form a septum. The anterior duct is then treated as the anterior row, and the posterior duct is treated as the posterior row.

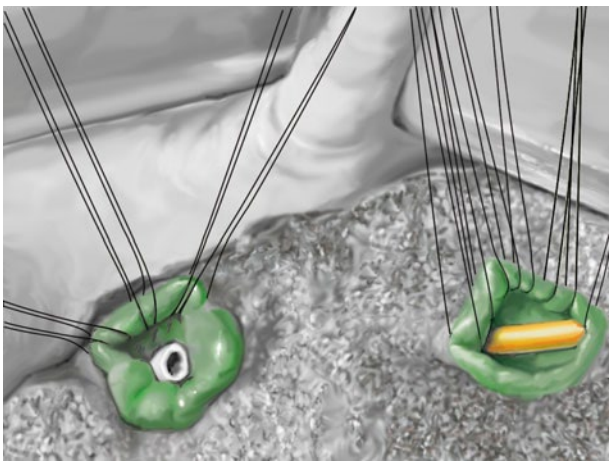


Fig. 77.9

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Operative Treatment of Choledochal Cysts

Benjamin N.J. Thomson, O. James Garden

The earliest description of a choledochal cyst is by Douglas in 1952, involving a 17-year-old girl with jaundice, fever, and a painful mass in the right hypochondrium. The incidence of choledochal cysts in Western countries is about 1 in 200,000 live births; the incidence is higher in Asia. Presentation is usually in childhood, and 25 % are diagnosed in the first year. Frequent association with other hepatobiliary diseases, such as hepatic fibrosis, has been noted. There is also an association with an aberrant pancreaticobiliary duct junction.

Surgical resection is required to prevent episodes of sepsis and pain and because of the association with cholangiocarcinoma. In the Western literature, the incidence of cholangiocarcinoma is lower than in Japanese series. Cystenterostomy should no longer be performed. The classification of choledochal cysts is based on a system proposed by Alonso-Lej et al. and later modified by Todani et al. (*Am J Surg* 1977, 134:263–9.):

- Type I: Solitary cyst characterized by fusiform dilatation of the common bile duct (most common) (Fig. 78.1a)
- Type II: Diverticulum of the common bile duct (Fig. 78.1b)
- Type III: Choledochocele (Fig. 78.1c)
- Type IV: Communicating intrahepatic and extra-hepatic cysts (second most common) (Fig. 78.1e)
- Type V: Caroli disease. Intrahepatic cystic disease with no choledochal cyst (Fig. 78.1 f)

Patients may also have a combination of intrahepatic and extrahepatic cysts (Fig. 78.1d).

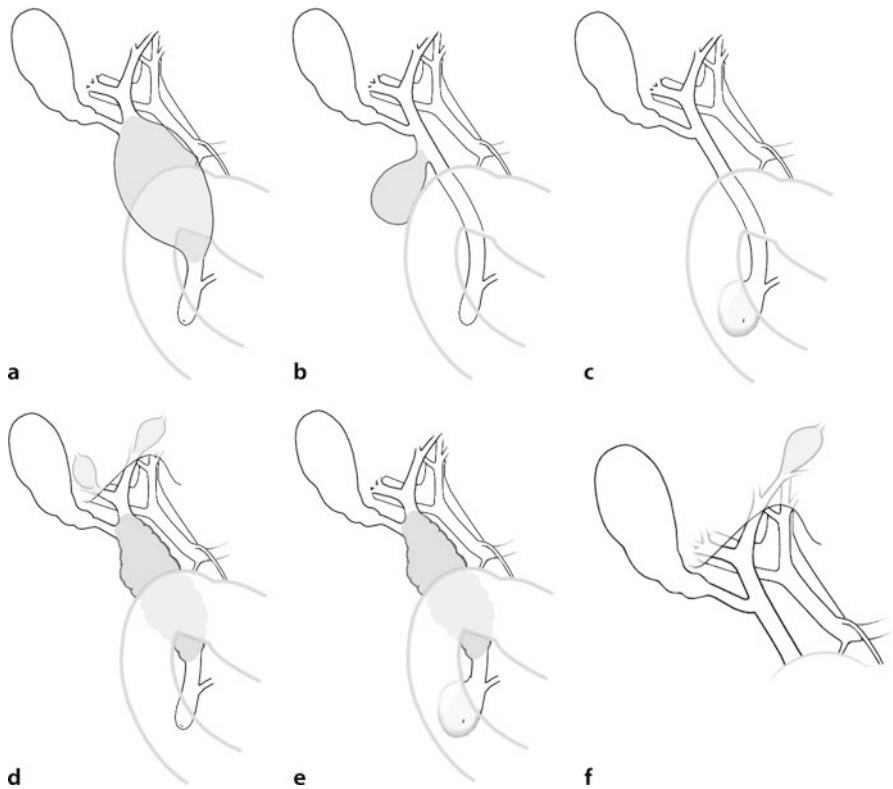


Fig. 78.1

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery*,
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Indications and Contraindications

Indications

- Symptoms (jaundice, pain, cholangitis)
- Type I choledochal cyst
- Type II choledochal cyst
- Type IV choledochal cyst
- Previous cystenterostomy

Type III choledochal cysts are usually managed with endoscopic treatment. Suspected or confirmed malignant transformation should be managed with cyst excision and consideration of pancreaticoduodenectomy.

Contraindications

- Severe liver disease (e. g., Child-Pugh C cirrhosis)
- Severe portal hypertension
- Coagulopathy

Investigation/Preparation

- *Clinical:* Chronic liver disease, prior surgery
- *Laboratory tests:* Bilirubin, alkaline phosphatase, ALT, albumin, prothrombin time, platelets
- *Radiologic tests:* Noninvasive – ultrasound, abdominal CT scan, MRCP; Invasive – ERCP if intrahepatic ducts are not visualized on MRCP
- *Operative preparation:* Antibiotics to cover biliary pathogens

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Procedure

Step 1

Access and exposure

A right subcostal incision is used, with extension to the left rectus if required. Exposure is achieved with a retractor (Omnitract retractor; Thompson retractor; Doyen's blades); the liver is retracted. The incision can be tailored to body habitus and to achieve best access. Laparoscopic approaches are described and should employ the same principles as outlined below.

Intraoperative ultrasound is performed to identify the anatomy and extent of the cyst, to assess cyst wall thickness and intrahepatic extension, and to identify intracyst calculi, which often are found.

The gallbladder is dissected in retrograde fashion with division of the cystic artery. The gallbladder is often shrunken.

The cystic duct is followed to its insertion into the common bile duct/cyst. Mobilization of the cyst is performed from the portal vein and hepatic arteries. This dissection may be difficult because of dense, inflammatory adhesions. The key is to avoid intramural (cyst) dissection by sharp dissection in the adventitial plane around the vessels from which the cyst (and nodes) are dissected.

The gallbladder is left in continuity to facilitate retraction of the cyst. Dissection may be further aided by the placement of a vessel loop around the cyst. (Fig. 78.2)



Fig. 78.2

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Step 2

Kocherization and mobilization of the porta hepatis

Full kocherization is performed to allow access to the lower bile duct and a retropancreatic approach (Fig. 78.3).

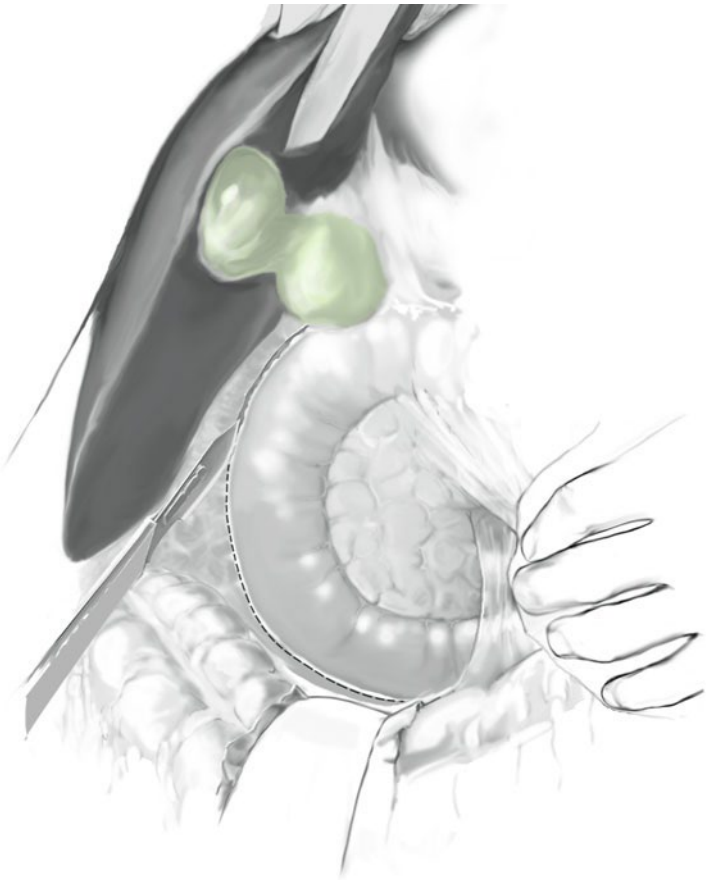


Fig. 78.3

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Step 3

Mobilization of the cyst

The cyst is now mobilized inferiorly to its lowest extent into the head of the pancreas, avoiding damage to the pancreatic duct. Intraoperative ultrasound may provide useful information in this regard. Ultrasonic dissection (CUSA) may aid in dissecting the cyst from the pancreas. Multiple small vessels may be divided with diathermy (Fig. 78.4).

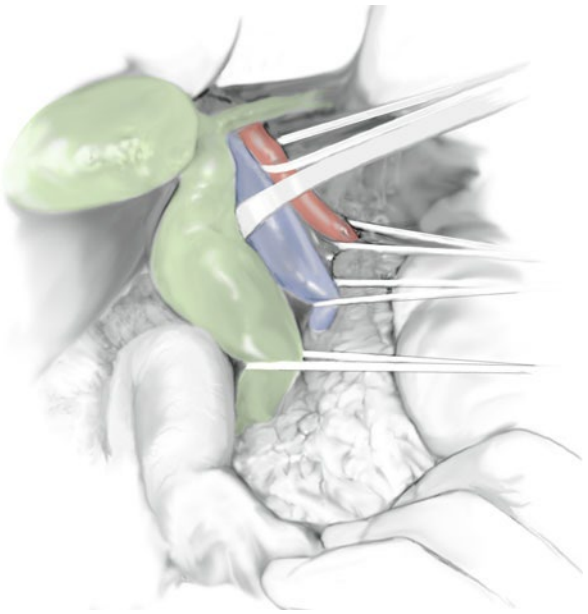


Fig. 78.4

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Step 4

Opening the choledochal cyst

It may be necessary to open the cyst to enable visualization of the pancreatic duct, at its insertion into the common bile duct. The cyst is controlled at its lower end above the junction of the bile duct and the pancreatic duct, which is preserved carefully (Fig. 78.5a). A view is shown looking into the pancreas with a partly mobilized cyst (Fig. 78.5b).

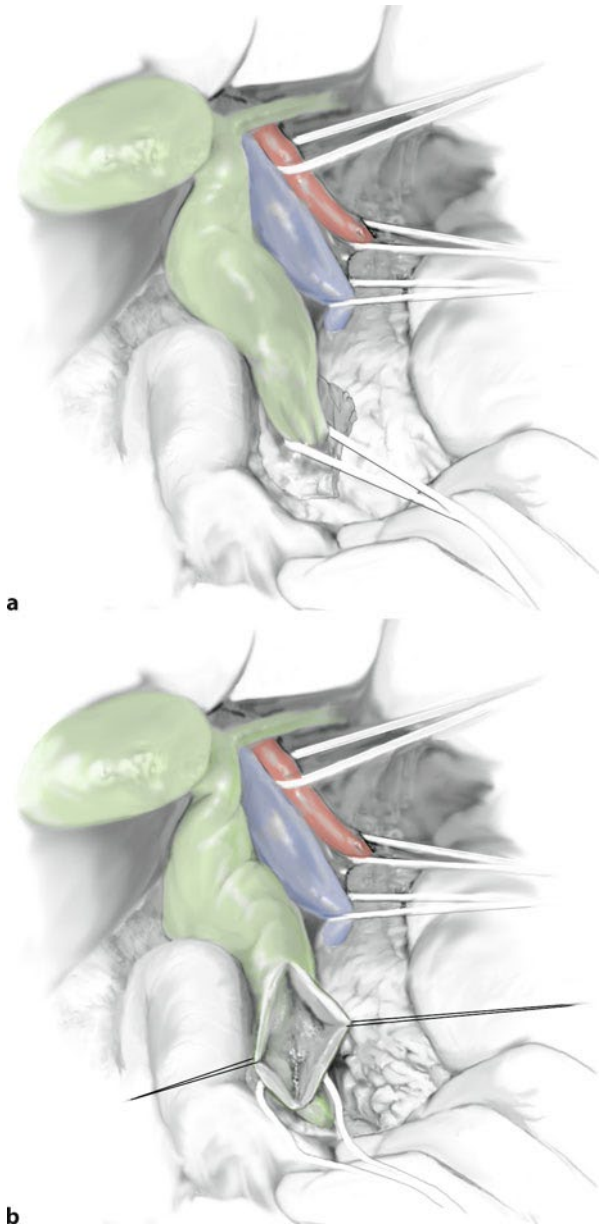


Fig. 78.5

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Step 5

Repair of the distal common bile duct

If residual cyst lining remains, it can be cauterized cautiously with diathermy current.

The lower common bile duct is repaired with interrupted 5-0 PDS sutures just at its junction with the pancreatic duct, damage to which is avoided carefully. The divided distal duct is seen with the pancreatic duct on view and closure started (Fig. 78.6).

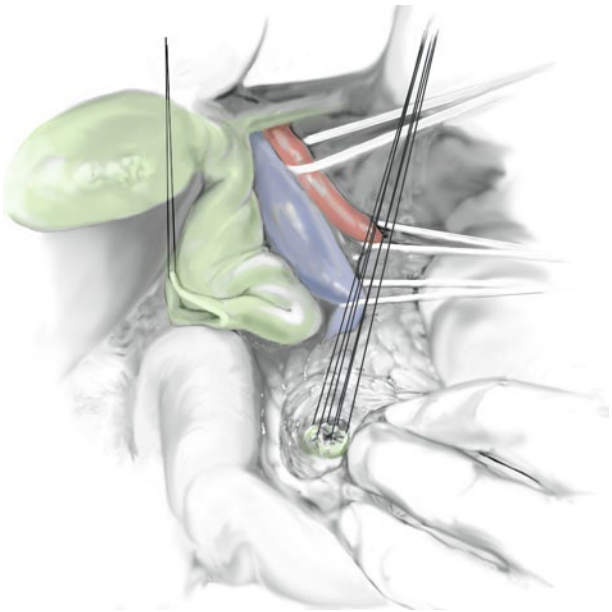


Fig. 78.6

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Step 6

Reconstruction

The cyst is mobilized superiorly to the confluence of the right and left hepatic ducts. Assess carefully for aberrant ducts, which may need to be divided separately. The dissection may need to be extended along the extrahepatic course of the left duct if it is ectatic. Some advocate extended liver resection for cysts extending into the left or right duct. It is possible to anastomose to the cyst at the confluence of the ducts, if this extends more proximally, rather than performing liver resection.

A hepaticojejunostomy is performed in an end-to-side manner with a single layer of interrupted 4-0 PDS sutures. A Roux-en-Y limb of 70 cm of proximal jejunum should be used.

A drain should be left adjacent to the hepaticojejunostomy. The cyst is removed and the hepaticojejunostomy started (Fig. 78.7).

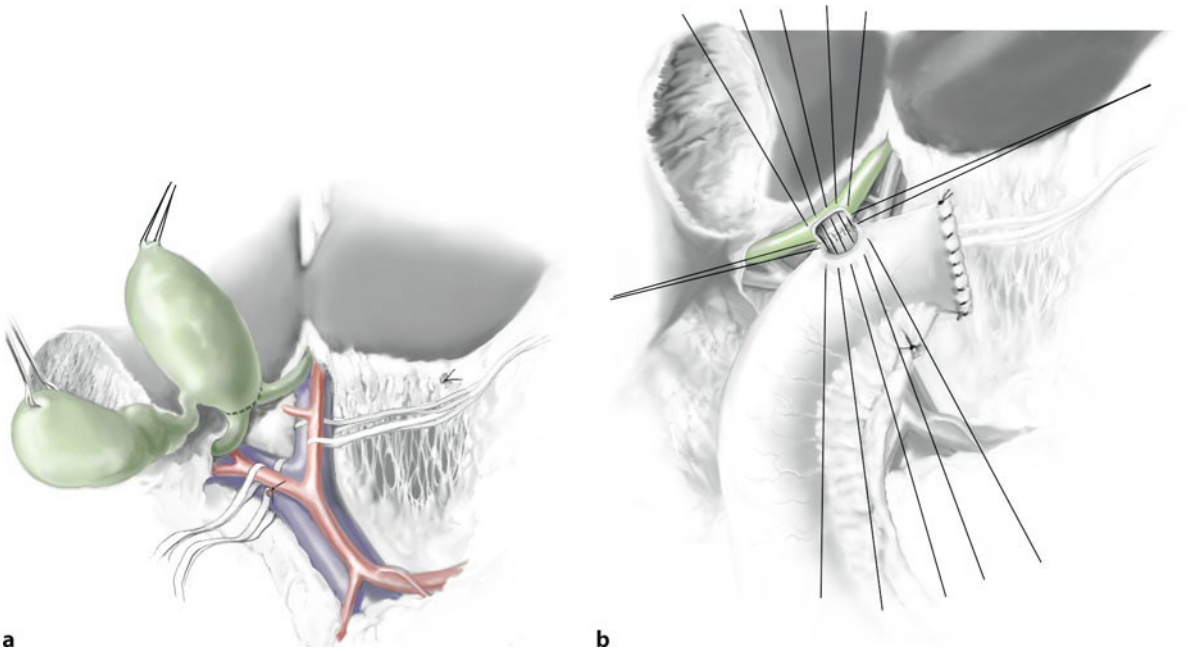


Fig. 78.7

Complications

Biliary leak

- A small amount of bile drainage can be expected in the first 48 hours; it will usually settle.
- Continuing leakage should be managed conservatively with drainage.
- Keep an eye open for amylase-rich fluid if there is difficult pancreatic dissection and/or persistent nonbile leak.

Late complications

- Cholangitis (20–40 %), usually in association with an anastomotic stricture.

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Robotic Cholecystectomy

Yanghee Woo

Gallbladder disorders are the most common cause of hospital admissions in the United States, with about 750,000 patients undergoing laparoscopic cholecystectomies per year.

Currently, 90 % of the 750,000 cholecystectomies performed annually in the United States are done using the laparoscopic approach with a 5–10 % rate of conversion. Laparoscopic cholecystectomy is the standard of care for the surgical treatment of benign gallbladder disease with complications rates comparable to the open cholecystectomies. Since it was first performed by Dr. Erich Mühe of Böblingen, Germany, on September 12, 1985, the minimally invasive approach has been proven to have many benefits over the open cholecystectomy procedure, including decreased postoperative pain, decreased length of hospital stay, and quicker time to recovery.

Robotic cholecystectomy is an alternative to laparoscopic methods in the minimally invasive treatment of gallbladder disease. Attempts to improve the outcome of multiport laparoscopic cholecystectomies and overcome the limitations of the recent single-incision laparoscopic surgery are being made with the robotic surgical technology. Robotic cholecystectomy using the da Vinci Surgical Systems single-site platform is a safe and effective method for the treatment of these patients. The complicated robotic technology offers a simple alternative method of single access cholecystectomies with the potential for application in more complex procedures. The robotic technology of the da Vinci Surgical Systems offers surgeons the benefits of brighter and sharper 3D operative view, greater precision of instrumentation, and better ergonomics. Robotic cholecystectomy procedures using the da Vinci Surgical Systems have been found to be safe and effective minimally invasive method for treating gallbladder disorders.

The initial robotic experience with the multiport da Vinci Surgical System, however, has not gained acceptance due to the prolonged operation room time and markedly increased cost of the operation. Multiport robotic cholecystectomy has been found to be best performed in combination with more complex upper abdominal operations, such as during gastrectomies for gastric cancer or for educational purposes in training residents or fellows in robotic operations.

With the advent of the Single-Site robotic platform, which was developed specifically for the cholecystectomy procedure, robotic single port cholecystectomies are being performed with increasing frequency since its first reported clinical trials in 2011. The initial studies evaluating single-port technology found that surgeons trained on the Single port robotic system can safely and effectively perform Single port robotic cholecystectomies with no deviation in the operative procedure including the ability to create the critical view necessary to ensure safe ligation of the cystic duct and artery, the operative time, the conversion rate and the cost of the operation.

Additionally, the single site robotic platform allows for new technology to be integrated into the operative procedure such as the ability to perform real-time near-infrared (NIR) fluorescent cholangiography. This is a novel method of evaluating the common bile duct during a robotic cholecystectomy, which uses the built-in optical technology of the robotic system. Robotic single port cholecystectomy technology has potential to greatly improve on the technical aspects of the laparoscopic approach but its application is in its infant stages.

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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Indications and Contraindications

Indications

Indications for robotic cholecystectomy are the same as for laparoscopic gallbladder removal:

- Symptomatic cholelithiasis
- Acute cholecystitis
- Gallstone pancreatitis
- Biliary dyskinesia
- Acalculous cholecystitis
- Early stage gallbladder cancer
- Gallbladder polyps

Contraindications

Absolute contraindications to robotic cholecystectomy are the same as that of the laparoscopic approach:

- Inability to tolerate general anesthesia
- Refractory coagulopathy
- Hemodynamic instability
- Advanced gallbladder cancer

Procedure

Step 1

Patient position, port placement, and robot docking

Patient is placed in the supine position and placed under general anesthesia. The arms are tucked to the patient side with adequate padding to prevent nerve injury. A 2.5 cm skin incision is made through umbilicus with equal supraumbilical and infraumbilical extensions (Fig. 79.1).

The fascia is incised sharply and lengthened to 3 cm to accommodate the singe-site silicon port. Using blunt finger dissection, intraperitoneal periumbilical space on the abdominal wall is explored to ensure that it is free of adhesions. The da Vinci single-site access port is inserted with the aide of an S-retractor to lift up the supraumbilical abdominal wall (Fig. 79.2). Once the port is snugly fitted into the umbilical incision, the abdomen is insufflated to 15 mm Hg via the port insufflation catheter. The patient is placed in the usual 15° reverse Trendelenburg and 10° left side-down position.

The insertion of the robotic instruments begins with the 8.5 mm trocar through the designated cannula in the single site access port. The camera is then place through the trocar and the abdomen surveyed. The da Vinci Surgical System is then brought over the right shoulder of the patient at a 45° angle to the OR table. After docking of the 8.5 mm trocar, the camera is reinserted followed by docking of the #2, and then the #1 curved cannulas under direct vision. The 5-mm assist trocar is then placed and a long Bariatric length gasper is used to grasp the gallbladder fundus and retract the gallbladder cephalad to the right-lateral subdiaphragmatic region. This exposes the infundibulum of the gallbladder and facilitates the initial positioning of the robot instruments. The instrument to be controlled by the surgeon's right hand is inserted into the cannula on the patient's right side. The instrument to be controlled by the surgeon's left hand is inserted via the patient's left side. A fundus grasper is used in the left hand to grasp and retract the infundibulum. The Maryland dissector, monopolar cautery hook, Hem-o-lok clip applier, and the curved scissors are used interchangeably in the right hand as needed.

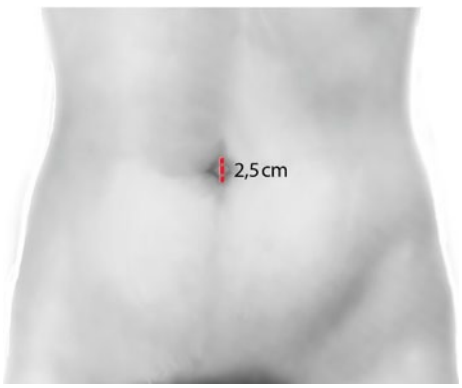


Fig. 79.1

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Step 1 ***(continued)***



Fig. 79.2

Step 2

Retraction of the gallbladder and adhesiolysis

Once the robotic instruments are set up, the surgeon moves to the master console to begin the robotic portion of the procedure. The assistant grasps the fundus of the gallbladder at the edge of the liver and retracts cephalad up and over the liver. This pulls upward any adhesions to the gallbladder and exposes the neck of the gallbladder. The surgeon gains control of the robotic arms at the console and begins the dissection by bluntly taking down the adhesions, usually the omentum from the gallbladder. With the fundus grasper, the Hartmann's pouch is grabbed and pulled inferolaterally to expose the area of Calot's triangle (Fig. 79.3).

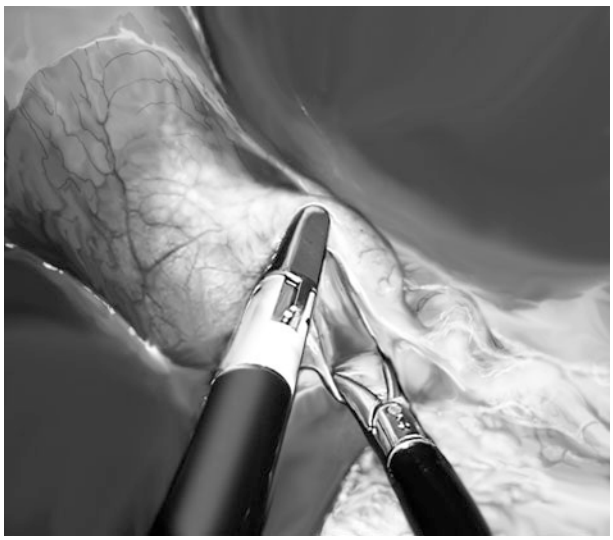


Fig. 79.3

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Step 3

Dissection of Calot's triangle, isolation of the cystic duct and artery

Using the Maryland dissector, the structures of Calot's triangle are bluntly dissected medially and posteriorly as Hartmann's pouch is moved laterally and medially to expose the cystic duct (Fig. 79.4). Care is taken at this point to stay close to inferior edge of the gallbladder as not to deviate too inferiorly to injure the common bile duct and the duodenum. After identification of the cystic duct, the cystic artery at the level of the Lund's node, or Mascagni's lymph node commonly referred to as the Calot's node, is also dissected out. After isolating the cystic duct and the artery, the peritoneum covering the posterior triangle is dissected to clear the space between the cystic artery and liver bed just under the gallbladder. This allows for the critical view, where only two structures are seen entering the gallbladder (Fig. 79.5).

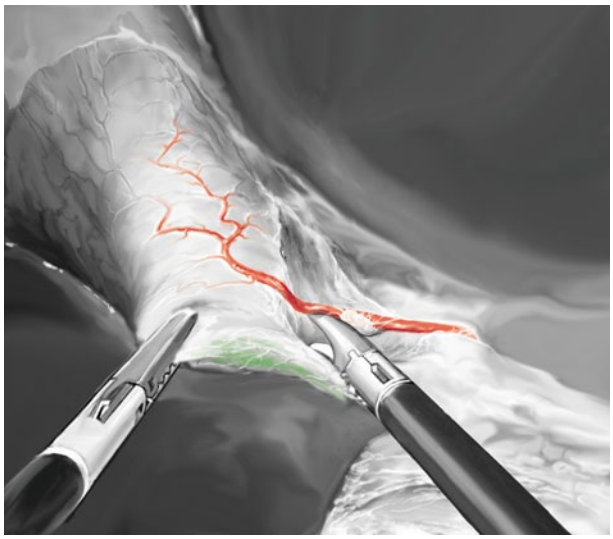


Fig. 79.4

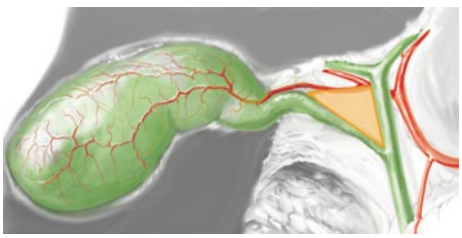


Fig. 79.5

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Step 4

Ligation and division of the cystic artery and duct

Once the cystic duct and the artery have been isolated, the Maryland dissector in the right arm is exchanged for the Hem-o-lok clip applier. The duct and the artery are both clipped three times. Then the right arm instrument is again changed out, this time for the curved shears and the cystic duct and the artery are divided leaving two plastic clips each on the patient side (Fig. 79.6).

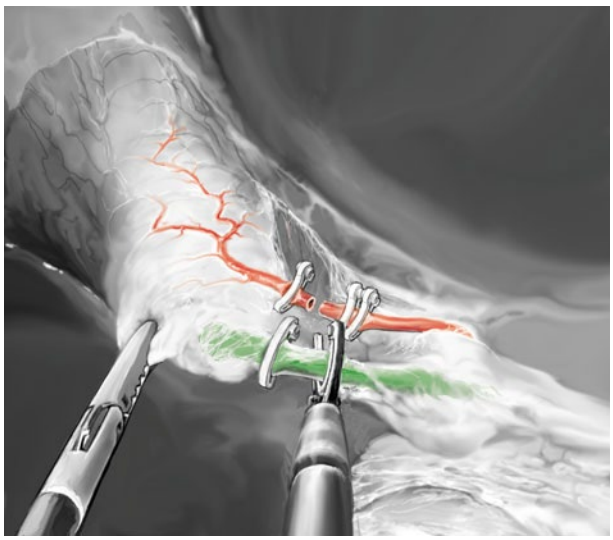


Fig. 79.6

Step 5

Dissection of the gallbladder off the liver bed

The Hook Cautery is inserted into the right arm cannula and the heat dissection of the gallbladder off the liver bed is performed. This is aided by coordination of movement between the assistant and the left robotic arm instrument to create adequate tension on the peritoneal layer between the gallbladder and the liver bed (Fig. 79.7). The monopolar heat is used to gain control of any bleeding during the dissection off the liver bed. Before complete removal of the gallbladder, the gallbladder is used to retract the liver upward to visualize and confirm that the previously placed clips are in place and the liver bed is hemostatic.

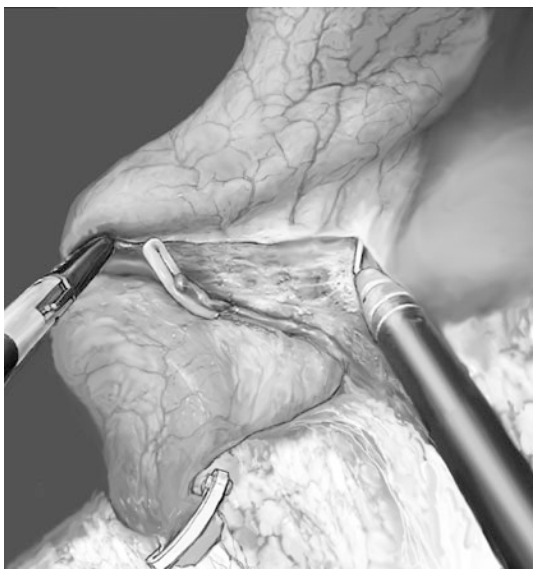


Fig. 79.7

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Step 6

Retrieval and removal of the specimen

Once the gallbladder is freed, the assistant removes the assistant's grasper and inserts a 5 mm Endocatch bag and places it above the liver. After placing the specimen in the Endocatch bag, the robotic instruments are removed from the trocars, the robot arms are undocked, and finally the cannulas are removed from the access port. Finally the single-site access port is removed along with the specimen in the bag. The fascia is closed with a running absorbable suture and skin closed with subcuticular monofilament running closure.

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Portal Hypertension

J. Michael Henderson

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Introduction: Portal Hypertension

J. Michael Henderson

Surgical operations for prevention of recurrent variceal bleeding have significantly diminished over the past decade. This section illustrates the different surgical options for managing variceal bleeding with total, partial, and selective shunts, and devascularization procedures. The peak of non-transplant surgical intervention for variceal bleeding was in the 1970s to 1980s when other management options were not available. Since then, the pathophysiology has been better defined for portal hypertension, and there have been technological advances in endoscopy and radiology.

The pathophysiology of portal hypertension follows the sequences of an initial obstruction to portal venous flow, an increase in portal pressure, development of collaterals, splanchnic hyperemia, and a hyperdynamic systemic circulation. Pharmacologic intervention with non-cardioselective beta-blockade to moderate these pathophysiology changes has been successful in preventing initial bleeding and in reducing the risk of re-bleeding. Reduction of splanchnic hyperemia with somastostatin or its analogues is effective in the acute setting.

Endoscopy has dramatically improved in the last two and a half decades with the universal adoption of videoendoscopy. For managing esophageal varices, treatment has evolved from an almost blind stick of a bleeding esophageal varix of three decades ago to sophisticated multiband-like ligators for both acute and elective management of gastroesophageal variceal bleeding. The lower complication rates with banding as opposed to sclerotherapy have established this as the primary treatment option for acute bleeding and initial prevention of recurrent bleeding.

The radiological evolution of hepatic imaging and ability to access the portal vein has led to transjugular intrahepatic portal systemic shunts (TIPS) over the past decade. TIPS can decompress varices successfully. High stenosis rates with bare stents have been reduced with the evolution of covered stents, but pseudointimal hyperplasia does remain a problem with a requirement for long-term monitoring of TIPS to maintain decompression.

Liver transplantation has also evolved dramatically over the last two decades, becoming the main surgical option for patients with variceal bleeding and advanced liver disease and the only therapy that has significantly impacted mortality. For these patients, liver transplant is the best treatment option.

Is there still a role for the operations for portal hypertension described in this section? These procedures may be useful in some patient populations and are among the treatment options in different parts of the world. It should be recognized that all of the operations described in this part can work very well for some patients. While there is no doubt that the overall use of these procedures has markedly diminished, they should not be lost from the repertoire of surgeons managing complex hepatobiliary disease and should remain part of the repertoire of liver transplant surgeons where there is refractory variceal bleeding with well-preserved liver function. This section presents excellent descriptions of these operations from recognized experts with technical details and tips that make the operations possible for other surgeons with expertise in hepatobiliary surgery.

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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Distal Splenorenal Shunt

J. Michael Henderson

Introduction

The distal splenorenal shunt (DSRS) is widely known as the Warren shunt, and was introduced in 1966 by W. Dean Warren when he worked in Miami. Its development in conjunction with Drs. Zeppa and Foman brought together expertise in decompression of varices and devascularization procedures. The concept of selective decompression of the gastroesophageal segment to control variceal bleeding was combined with maintenance of portal hypertension in the portal vein to keep portal perfusion to the liver. The principle of the procedure is, therefore, that the shunt will control variceal bleeding, and maintenance of portal perfusion will preserve hepatic function.

Indications and Exclusion criteria

- Variceal bleeding refractory to first line treatment with endoscopic and pharmacologic therapy
- Patients with well-preserved hepatic function (Child's Class A and B patients)

Contraindications

- Advanced liver disease
- Splenic vein thrombosis with no shuntable vessels
- Intractable ascites

Relative Contraindications in the next 2–3 years

- Progressive liver disease in patients likely to come to transplant
- Small splenic vein, but there is probably no absolute size contraindication in that the vein can be spatulated to a larger-diameter anastomosis

Investigation/Preparation

- Focus on the varices, the vasculature, and the underlying liver disease.
- Clinical picture: recurrent variceal bleeding that is refractory or not amenable to appropriate endoscopic therapies.
- Laboratory studies to calculate Child's classification.
- Radiologic workup with vascular ultrasound, but arteriography is advisable in reaching a final decision to proceed with DSRS. Superior mesenteric and splenic arteriography followed through the venous phases defines portal venous anatomy and collaterals. The left renal vein should be directly studied because 20 % of the population have abnormal left renal veins.
- Timing and preparation:
  - DSRS should not be performed as an emergency procedure, but patients stabilized and brought to elective operation.
  - Nutritional status should be optimized.
  - Coagulation status should be corrected.
  - Preoperative and perioperative fluid management is important, particularly with limitation of free sodium. Patients should be run "dry" to minimize the risk of postoperative ascites.
  - Appropriate perioperative antibiotic prophylaxis should be used.

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery*,
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Procedure

Step 1

Positioning and access

The patient is positioned with slight left side elevation and the table broken 15° to 20° at the costal margin. This positioning improves access to the retropancreatic space for dissection of the splenic vein.

The incision is a bilateral subcostal incision, primarily on the left side and extended well laterally. Retraction requires a fixed retractor system elevating the left costal margin. Other blades of the retractor are used to aid exposure as indicated below.

Figure 81.1 illustrates the incision and the area of dissection for DSRS.

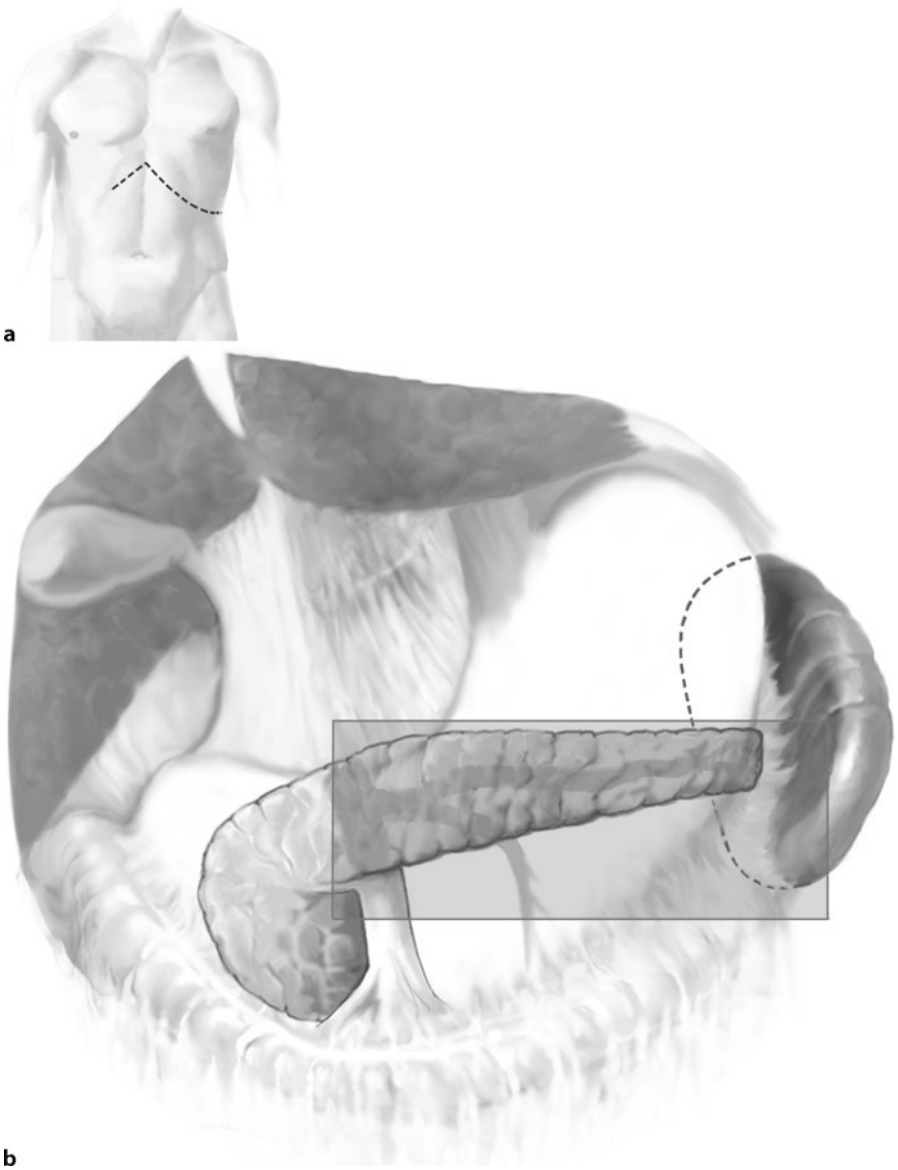


Fig. 81.1

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Step 2

Mobilization

Figure 81.2 illustrates the initial exposure, which requires mobilization of the greater curve of the stomach from the pylorus to the short gastric vessel. The gastroepiploic vessels should be interrupted and ligated. Access is further enhanced by taking down the splenocolic ligament and mobilizing the splenic flexure of the colon inferiorly. These two moves are also a component of the devascularization that separates the low pressure shunt from the high pressure portal venous system. Once this mobilization has taken place, inferior retractors can be placed on the colon, which improves exposure and access to the retropancreatic plane. The stomach should be retracted superiorly.

Dissection then focuses along the inferior margin of the pancreas, which is mobilized from the super mesenteric vein out to the splenic hilus (Fig. 81.2).

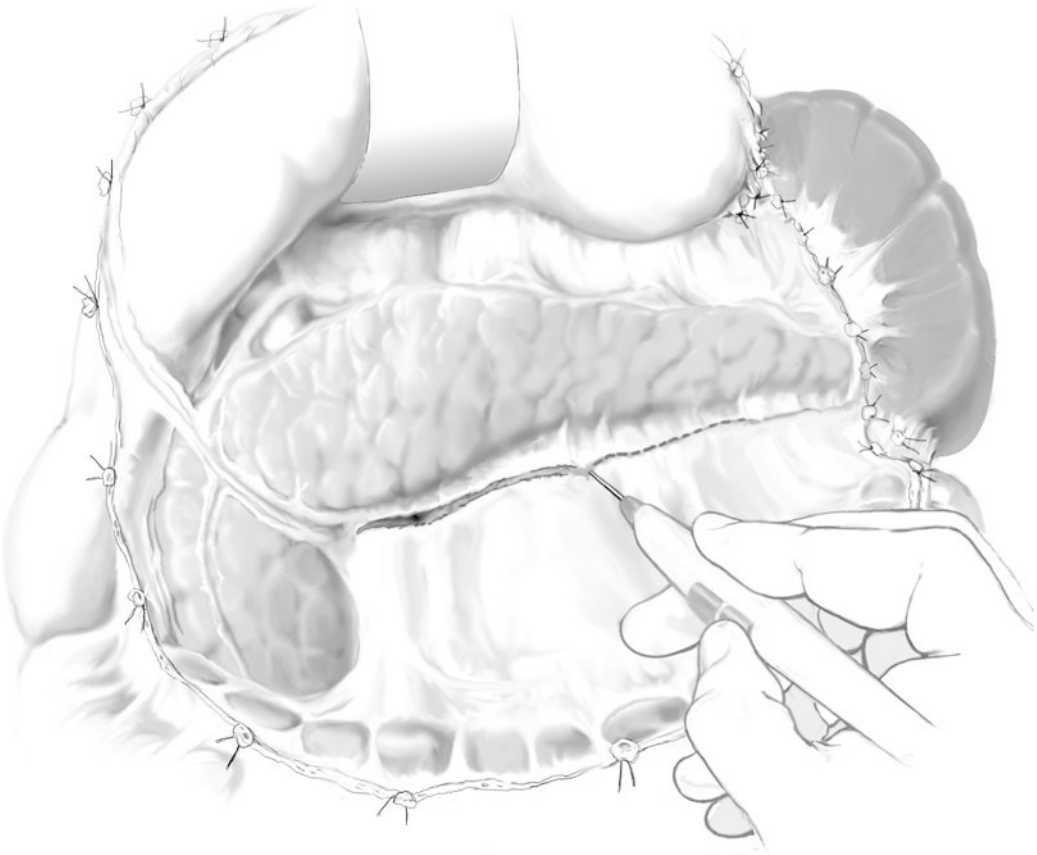


Fig. 81.2

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Step 3

Exposure and dissection of the splenic vein

The splenic vein is initially identified by a combination of palpation and vision. In an obese patient the vein may not be readily seen on the posterior surface of the pancreas, but it can always be felt. Initial dissection of the splenic vein is started where it is most easily seen or palpated. The goal is to mobilize all the overlying adventitia along the inferior and posterior surface of the splenic vein from the superior mesenteric vein to the splenic hilus.

The inferior mesenteric vein enters the splenic vein in 50 % of patients and the superior mesenteric vein in the other 50 %. This is a useful landmark as it is always the first significant vein coming inferiorly as dissection proceeds from left to right. It should be ligated and interrupted.

The other key plane in this phase of the procedure is the plane posterior to the splenic superior mesenteric venous junction, as illustrated in Fig. 81.3. This is a safe plane to open with a finger or the tip of the sucker. The value of opening this plane is if any bleeding is encountered as the anterior dissection of the splenic vein is started, it can always be controlled by finger compression of the vessels (Fig. 81.3).

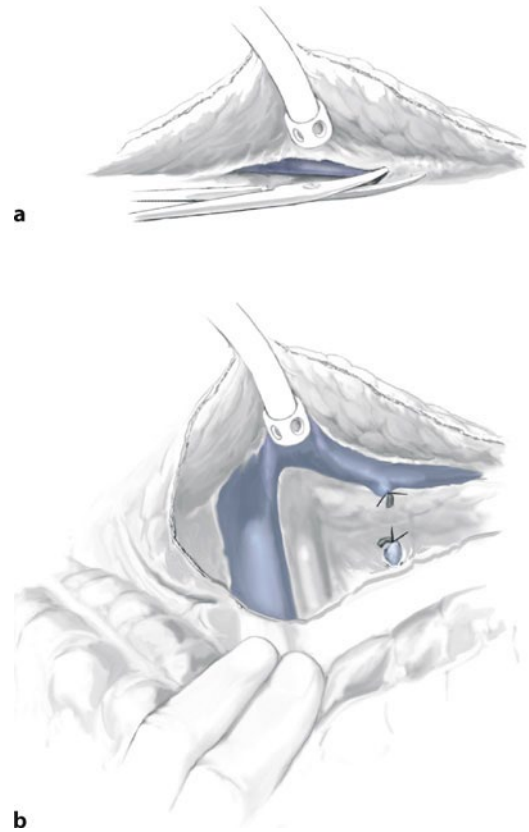


Fig. 81.3

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Step 4

Dissection of pancreatic tributaries to the splenic vein

Pancreatic tributaries to the splenic vein always lie on the superior and anterior surface of the splenic vein. The trick in dissecting these small and fragile vessels is to open the plane on each side of these by spreading directly in the line of the small vessels. They can then be surrounded with a small right-angled clamp, and they should be ligated on the splenic vein side and clipped on the pancreatic side. This is the most delicate and difficult part of this procedure and requires considerable patience. It is facilitated by the step described in Fig. 81.4 of fully mobilizing the posterior and inferior border of the splenic vein before commencing this dissection.

Sufficient splenic vein needs to be fully mobilized to allow for subsequent positioning of the vessel down to the left renal vein. The splenic vein should not be divided at this point (Fig. 81.4).

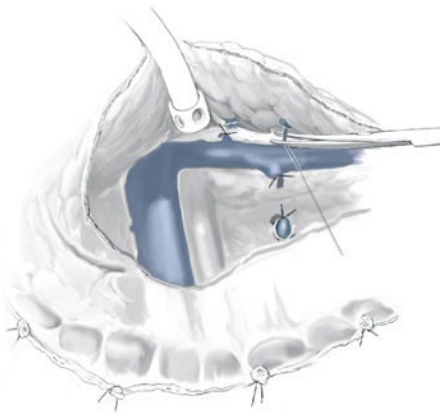


Fig. 81.4

Step 5

Exposure and dissection of the left renal vein

The left renal vein crosses in front of the aorta and behind the superior mesenteric artery. Palpation of these landmarks aids identification of the renal vein at this point. The retroperitoneum is bluntly opened until the vein is identified and then dissection is carried out along the anterior surface of the left renal vein. Tissue should be ligated at this point as it contains numerous lymphatics that if left open may cause chylous ascites. The renal vein is mobilized over sufficient length to allow it to come up comfortably into a Satinsky clamp for subsequent anastomosis. The left adrenal vein should be ligated as it always acts as an inflow to the renal vein. The left gonadal vein should be left intact as it often acts as an outflow tract and helps accommodate increased renal vein flow after the shunt is open (Fig. 81.5).

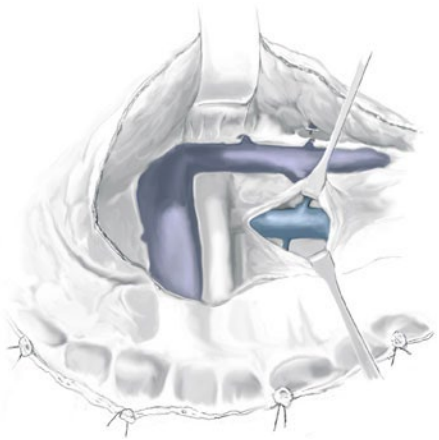


Fig. 81.5

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Step 6

Preparation of the splenic vein

Once the left renal vein has been dissected and is ready for the end-to-side anastomosis, the splenic vein is ligated flush at the superior mesenteric vein. Experience has shown that this is best achieved with a silk tie on the splenic vein stump and a large clip placed behind that. This is given the lowest instance of mesenteric venous thrombus at this site.

The splenic vein can then be moved downwards as shown in Fig. 81.6, its relationship to the left renal vein confirmed, and the splenic vein transected and trimmed to an appropriate length for comfortable anastomosis. The goal is to have the splenic vein come down to the left renal vein without any kinking as the splenic vein emerges from the pancreas.

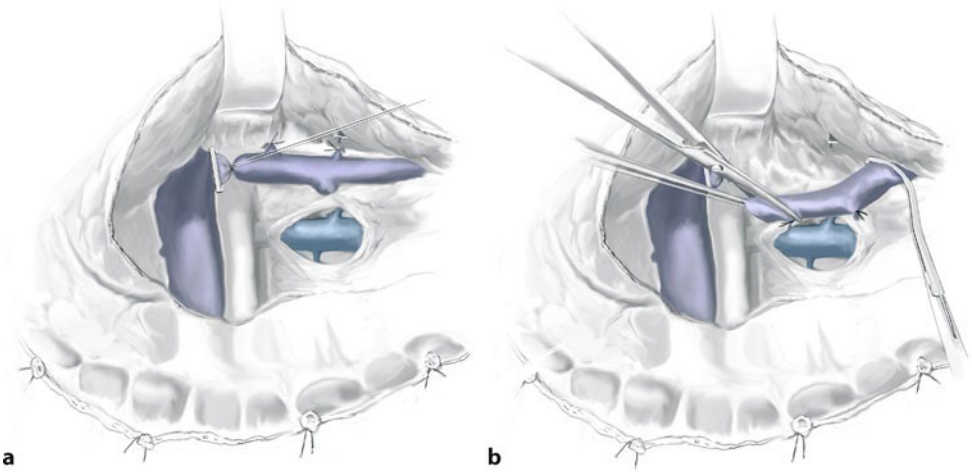


Fig. 81.6

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Step 7

Anastomosis

The anastomosis is made with a running suture to the posterior wall and interrupted sutures to the anterior wall. This is the preferred method to minimize the risk of a purse-string effect at this anastomosis. Suture material should be the surgeon's preference. We use a running 5-0 Ethibond stitch on the posterior wall and interrupted 5-0 silks to the anterior wall. This has proved very satisfactory with a low rate of thrombosis.

This can be a difficult anastomosis because it is sewn in a deep hole, particularly in the obese patient. Minimizing the movement at the depth of this hole aids in the completion of the anastomosis. The left renal vein clamp needs to be held forward by an assistant in the left upper quadrant and the splenic vein clamp may need to be held to keep the tension off the anastomosis. Careful positioning, with stability of these clamps, is key at this stage (Fig. 81.7).

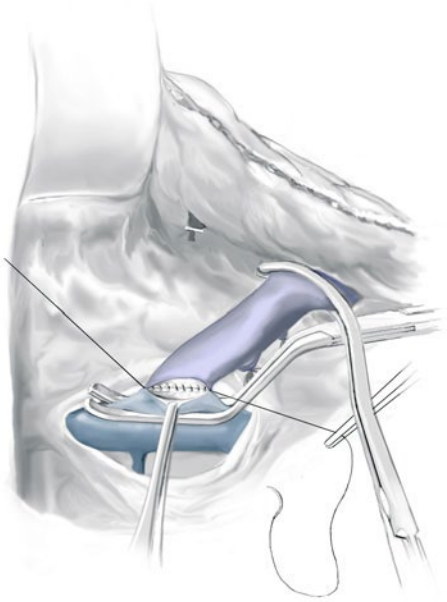


Fig. 81.7

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Step 8

Completion of the anastomosis, devascularization

Clamps are removed on completion of the anastomosis and the pancreas allowed to come down toward the left renal vein. A small amount of bleeding is usually controlled with some Surgicel and light packing for several minutes. Checking the position of this anastomosis is important to make sure there is no kinking or twisting of the splenic vein.

Completion of devascularization. The left gastric vein is identified if possible either as it joins the splenic vein or as it joins the portal vein. If it can be clipped at this site, it should be. It is also identified at the superior margin of the pancreas as shown in this figure and completely interrupted at this site.

Completion of the procedure at this point has now created a low pressure decompression of the spleen, gastric fundus, and distal esophagus, while maintaining portal hypertension and portal flow in the superior mesenteric and portal venous system (Fig. 81.8).

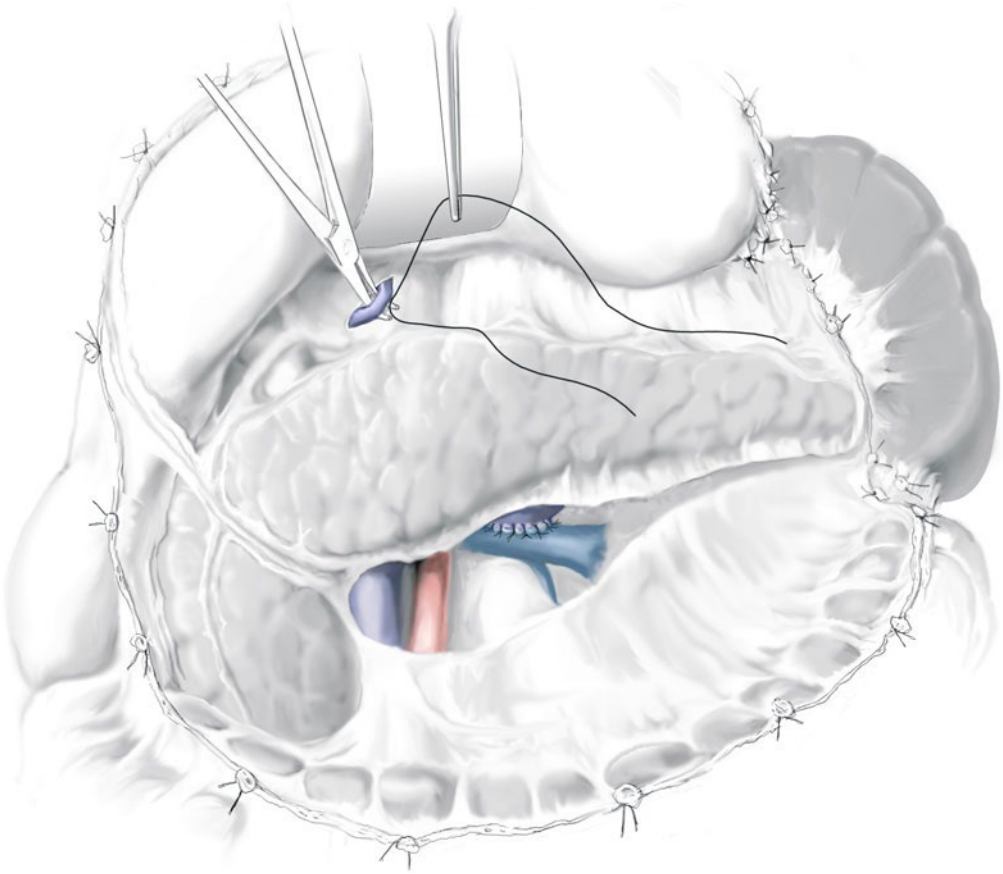


Fig. 81.8

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Postoperative Tests

- Follow liver labs on alternate days and electrolytes daily for 1 week.
- Diet: low sodium (2 g/d) and low fat diet (30 g/d) for 6 weeks. The latter is necessary because of the disruption of lymphatics around the left renal vein that can lead to a chylous ascites.
- Radiologic shunt study: direct catheterization of the shunt at 5–7 days to document patency and no significant pressure gradient.

Postoperative Complications

- **Early:**
  - Liver decompensation
  - Ascites
  - Shunt thrombosis
  - Managing these is primarily based on prevention. Careful patient selection will select good risk patients that should tolerate this operative procedure. Ascites is minimized by careful fluid management perioperatively and diet restrictions postoperatively. Shunt thrombosis is low risk (1–4 %) and is minimized if the operative steps outlined above are followed.

- **Late:**
  - Progressive liver disease. These patients should be kept in long-term follow-up, primarily for monitoring of their cirrhosis.
  - Late shunt thrombosis is unusual, but any recurrence of bleeding requires documentation of shunt patency, usually by catheterization with pressure measurements.

Tricks of the Senior Surgeon

- Proper positioning of the patient helps later exposure.
- Exposure is critical – see Step 2.
- The posterior surface of the splenic vein is the safe dissection plane.
- Mobilize enough splenic vein for it to come down to the left renal vein easily.
- The left renal vein is best located by palpation as described in Step 5.

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Mesocaval Shunt

Miguel A. Mercado, Hector Orozco

Introduction

The mesocaval shunt decompresses portal hypertension with an interposition graft between the superior mesenteric vein (SMV) and the inferior vena cava (IVC). Popularized by Drapanas in the 1970s, it has had several proponents since, and most highlight that it is a shunt performed remote from the hepatic hilus. Similar in physiology to a side-to-side portacaval shunt, a mesocaval shunt diverts all portal flow if ≥ 12 mm diameter, while if 8–10 mm diameter some prograde portal flow is maintained.

Indications and Contraindications

Indications

- Variceal bleeding refractory to endoscopic treatment
- Child's A and B patients

Contraindications

- Advanced liver disease (Child's C)
- Mesenteric venous thrombosis

Investigations

History:	Variceal bleeding
	Absence of advanced liver disease
Laboratory studies:	Child's A/B class
Vascular imaging:	Ultrasound with Doppler
	Angiography with venous phase imaging if SMV patency is questioned

Preparation

- Elective operation preferred
- Stabilize from acute bleed
  - Correct coagulation
  - Diurese ascites
  - Improve nutrition status

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Procedure

Step 1

Access and mobilization

The abdomen is entered through a large median or transverse incision, to obtain adequate exposure of the whole cavity. A retractor (Thompson, Omni-Tract) is placed with blades that expose the root of the mesentery in the inframesocolic compartment. Traction of the transverse colon up and forward of the mesentery (caudal) allows exposure of the third portion of the duodenum. The peritoneum is incised infracolically, in a semicircular fashion, from the root of the mesocolon to the ligament of Treitz. Only lax adhesions are usually found with occasional small veins that need electrocoagulation. The duodenum is freed completely.

The peritoneum is cut at the root of the mesentery, exposing the lymphatics (usually dilated and hypertrophied) that surround the mesenteric vessels. Chronic lymphatic hypertension produces fibrosis that makes dissection difficult. It is necessary to ligate all these structures in order to avoid postoperative lymph leakage. Also, small dilated veins can be found.

Complete dissection of the anterior and right lateral aspect of the SMV is done. All the vessels from the uncinate process of the pancreas (variable in length, diameter, and distribution) are carefully dissected and ligated. The dissection is continued cephalad to the neck of the pancreas. The middle colic vein is ligated. Caudally, the dissection is continued down to the confluence of the ileocolic branch (which in many instances can be preserved). In some instances the ileocolic artery crosses over at this level; it can usually be retracted, but if necessary it can be ligated. It is necessary to dissect free the mesenteric vein 4–5 cm in length. Also, it is important to dissect the whole circumference of the vessel in order to comfortably place the vascular clamp (Fig. 82.1).

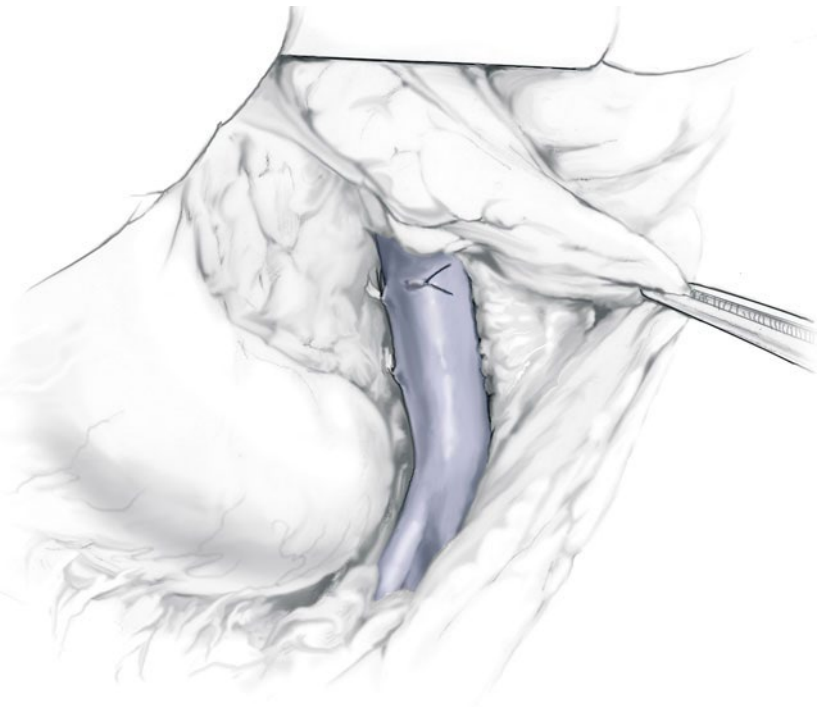


Fig. 82.1

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Step 2

Preparation of the IVC

The infrarenal IVC is dissected free, after removing the lax areolar tissue that surrounds it. Some small veins are found that have to be suture ligated. It is not necessary to dissect the vessel in its whole circumference since it is easy to place the vascular clamp on the anterior wall of the IVC due to its width and low intravascular pressure (Fig. 82.2). Retractors are placed to separate the duodenum (cephalad), the right colon (to the left), and the small intestine (caudal). Lymph nodes around the aorta can be observed; this is the limit of the medial dissection.

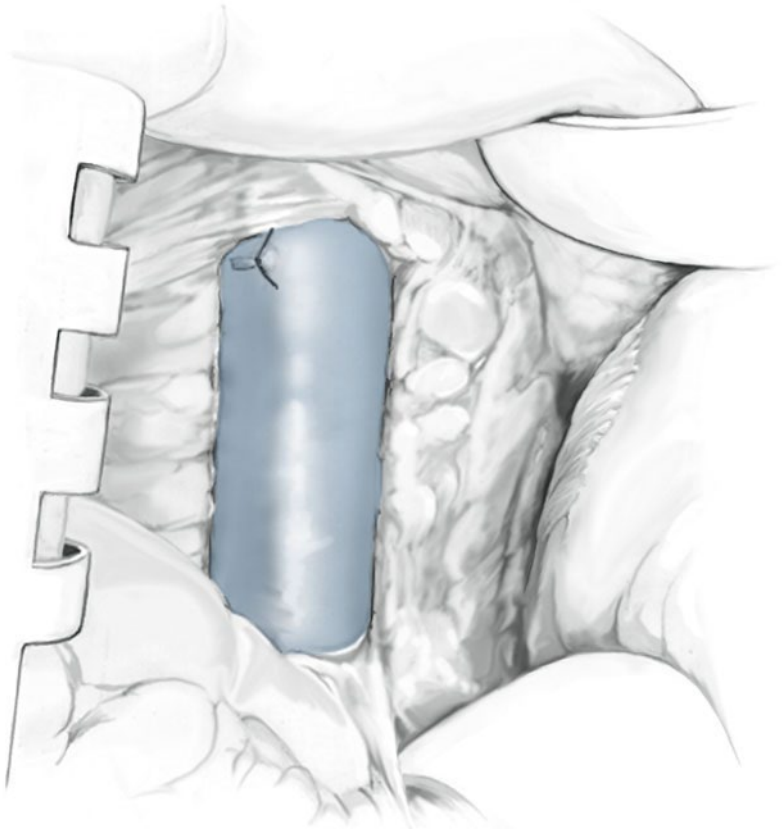


Fig. 82.2

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Step 3

Venotomy of the vena cava

A Satinsky clamp is placed and a longitudinal venotomy is done approximately 12–14 mm in length using DeBakey scissors, in order to obtain an oval venotomy (Fig. 82.3).

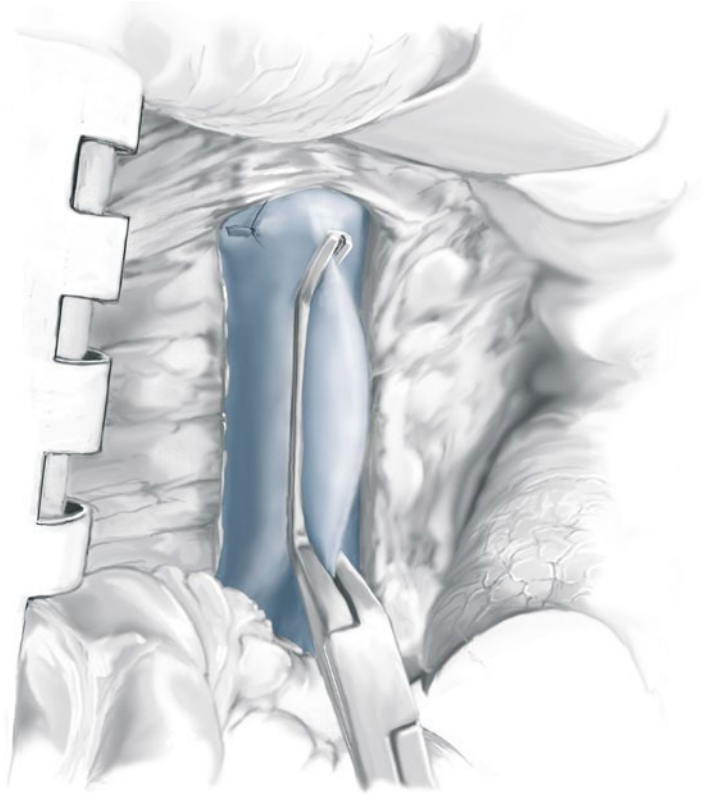


Fig. 82.3

۰۲۱-۶۶۱۹۸۵۱۴ www.myuptodate.com دریافت آخرین نسخه آپتودیت آفلاین

Step 4

Anastomosis to the inferior vena cava

A ring reinforced polytetrafluoroethylene (PTFE) 10-mm graft is cut in tangential fashion in order to obtain a 12- to 14-mm opening for anastomosis. If the decision to place a wider graft has been made, a wider venotomy must be performed.

Using a 5-0 vascular Prolene suture placed at each angle, the graft is sewn with a running suture (Fig. 82.4). The suture is placed from outside. An everted suture is advised at this point in order to minimize exposure of rough areas in the vascular lumen.

When the suture is completed, the graft is filled with heparinized saline.

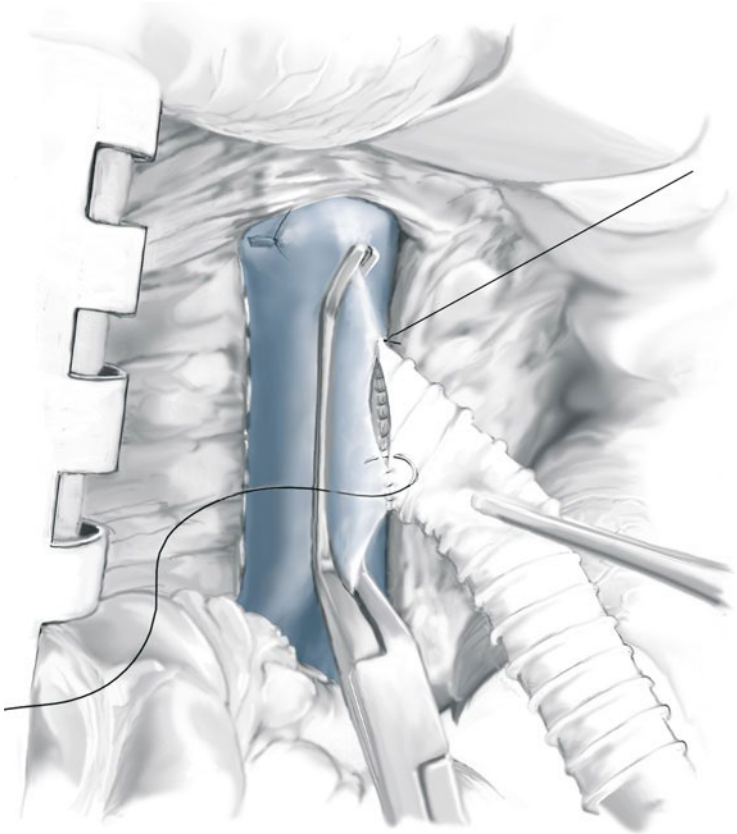


Fig. 82.4

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Step 5

Anastomosis to the SMV

A Satinsky clamp is placed on the SMV and a semicircular cut of the vein is done with Potts scissors (Fig. 82.5). This incision favors the position of the graft in the right and slightly posterior aspect of the vein. Using a 5-0 Prolene suture, each angle is placed and the PTFE graft is approximated close to the vein. The length of the graft has to be cut according to the position of the duodenum.

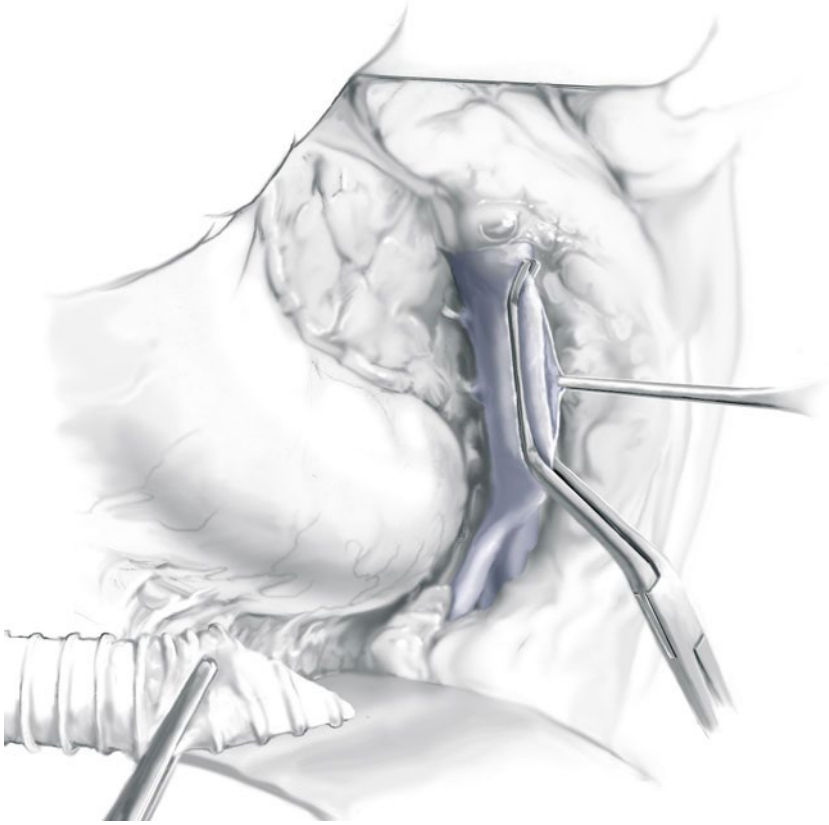


Fig. 82.5

۰۲۱-۶۶۱۹۸۵۱۴ www.myuptodate.com دریافت آخرین نسخه آپتودیت آفلاین

Step 5 ***(continued)***

The anastomosis is completed using a continuous suture. The posterior layer is done from within the lumen, so that the first stitch places the needle inside the lumen (Figs. 82.5 and 82.6). When the posterior aspect is completed, the needle is brought outside and then the anterior layer of the anastomosis is done. An everted suture is advised.

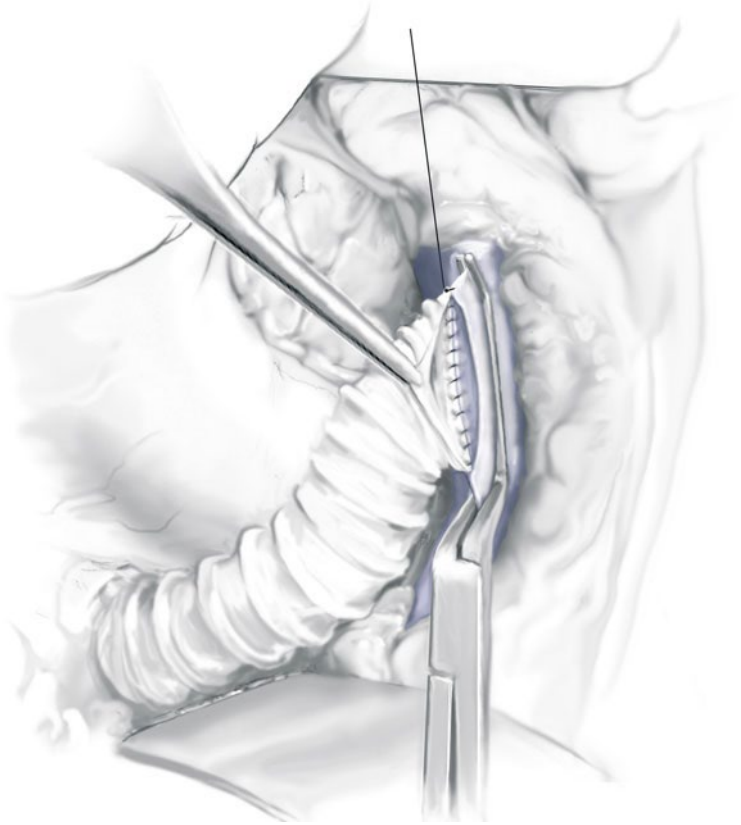


Fig. 82.6

۰۲۱-۶۶۱۹۸۵۱۴ www.myuptodate.com دریافت آخرین نسخه آپتودیت آفلاین

Step 6

Release of the clamps

When the suture is complete, the vascular clamp on the IVC is released first followed by the vascular clamp on the mesenteric vein. Usually a small amount of bleeding at the suture line is observed. This resolves spontaneously with the application of dehydrated cellulose and mild pressure.

Step 7

Final position of the graft

The duodenum is allowed to rest over the graft and the peritoneum is closed over the graft. No drainage is left and the abdominal wall is closed in standard fashion (Fig. 82.7).



Fig. 82.7

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Postoperative Tests

- Daily laboratory studies
- Shunt study prior to discharge
  - Ultrasound
  - Possible angiography

Postoperative Complications

- **Early:**
- Liver failure
- Shunt thrombosis

- **Late:**
- Liver decompensation
- Encephalopathy
- Shunt thrombosis

Tricks of the Senior Surgeon

- Injection of water around the vessels, through a small needle when the vessel is identified, allows separation of dissection planes, making the dissection easier.
- Circumferential dissection of the mesenteric vein permits an easier mobilization of the vessel. Fixed segments of the wall can produce small tears of the vessel at the time of clamping and when traction to the vessel is applied.
- When the posterior side of the mesenteric anastomosis is performed, it is important to maintain the graft close to the vein. Traction to the graft when the first stitches are placed can produce tears in the vein wall and loss of substance.
- When bleeding is observed at the anastomotic suture line, it is better to wait until it stops spontaneously. Placing new stitches can be troublesome because the wall is under tension and a larger hole can be made.

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Small Diameter Side-to-Side Interposition Portacaval Shunt

Alexander S. Rosemurgy II, Dimitris P. Korkolis

Indications and Contraindications

Indications

- Control of acute hemorrhage from esophageal varices not amenable to or failing medical therapy, e. g., pharmacotherapy, balloon tamponade, endoscopic variceal sclerotherapy, in patients with liver cirrhosis and portal hypertension
- Control of bleeding gastric or intestinal varices
- Prevention of recurrent variceal bleeding after initial control
- Complicated Budd-Chiari syndrome

Contraindications

- Portal vein thrombosis, even with recanalization (cavernomatous transformation)
- Inferior vena cava thrombosis
- Extensive adhesions from previous operative procedures in the right upper quadrant (relative contraindication)
- Severe medical comorbidities (e. g., mitral regurgitation, severe aortic stenosis)

Preoperative Investigation and Preparation for the Procedure

History:	Alcohol consumption and alcohol withdrawal syndromes, hepatitis and hepatotoxic medications
Clinical evaluation:	Variceal bleeding, ascites, hypersplenism, hepatic encephalopathy, jaundice, nutritional status, signs of portal hypertension (e. g., caput medusa)
Laboratory tests:	ALT, AST, bilirubin, alkaline phosphatase, albumin, coagulation profile (PT, INR, platelets), tumor markers and serologies (e. g., hepatitis), when indicated. Electrolyte and acid-base profile
Color-flow Doppler	Assessment of portosplanchnic patency, as well as patency of the inferior vena cava
Ultrasound and visceral angiography:	Determination of Child-Pugh score

Procedure

Positioning, access, and mobilization

Initially, the patient is positioned supine on the operating table. A nasogastric tube is placed only if gastric distension requires it. Neither vasopressin nor octreotide need to be given perioperatively, unless active bleeding is occurring. Otherwise, the operation can be undertaken with minimal blood loss and almost always without blood transfusion. The patient is then rolled into a 30° left lateral decubitus position by means of a bed sheet rolled tightly and placed just to the right of the spine.

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
DOI 10.1007/978-3-662-46546-2_83, © Springer-Verlag Berlin Heidelberg 2016

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The patient is operated on through a right transverse upper abdominal incision. The exact placement of this incision depends on the size of the liver, which is often palpable below the right costal margin. The incision is placed over the liver edge. It does not generally cross the midline and includes only a small portion of the musculature lateral to the rectus muscle.

If the falciform ligament is divided during the incision, it should be divided carefully, as it may contain large collateral vessels. Suture ligation of the falciform ligament at the time of the division is usually undertaken.

Step 1

Kocherization and preparation of vena cava

Optimum exposure of the right upper quadrant of the peritoneal cavity should be achieved, with as little dissection as possible. The foramen of Winslow is the key landmark. A limited Kocher maneuver is undertaken, always maintaining orientation with the foramen of Winslow. Visible venous collaterals, as well as large lymphatic channels, should be ligated before division. Cautery is liberally applied. The Kocher maneuver does not need to be extensive but just enough to adequately expose 5 cm of the subhepatic inferior vena cava and enable the placement of a side-biting vascular clamp.

The exposed segment of the inferior vena cava should include the portion that forms the dorsal border of the foramen of Winslow. The cephalad area of this segment of the cava may lie dorsal to the inferior tip of the caudate lobe of the liver. If necessary, this portion of the caudate lobe should be excised with electrocautery (Fig. 83.1).

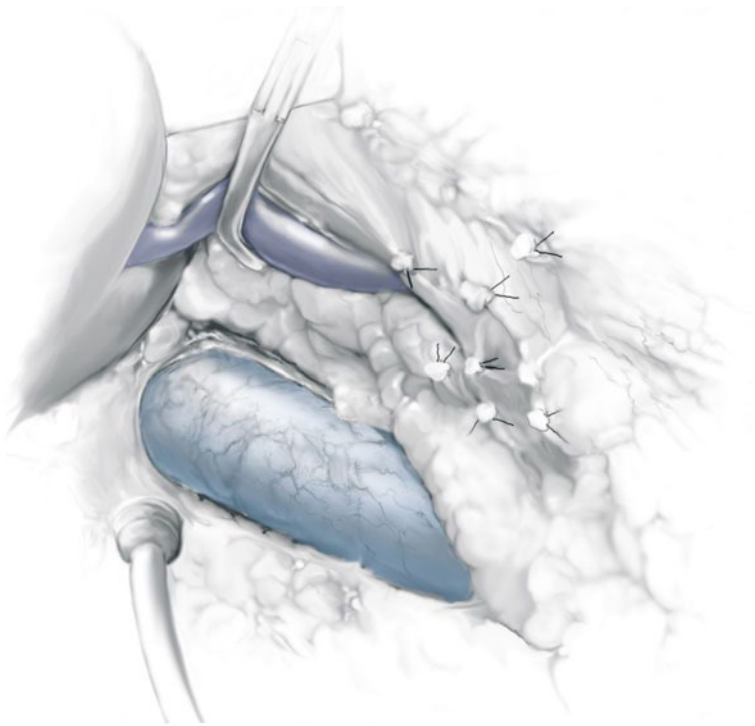


Fig. 83.1

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Step 2

Exposure of portal vein

It is very important that the inferior vena cava is well exposed medially and laterally so a vascular clamp can be placed. Exposure of at least one-half circumference of the 4- to 5-cm segment of the inferior vena cava is usually necessary to facilitate secure clamp placement and anastomosis. After the inferior vena cava is adequately exposed, one or two traction sutures are placed into the loose tissue adjacent to the right side of the cava. These sutures are further placed into the lateral abdominal wall to retract laterally and optimize exposure.

The gallbladder is retracted toward the patient's left shoulder. This lifts and rotates the gallbladder and the common bile duct ventrally and medially. The hepatoduodenal ligament is then dissected posteriorly and laterally, along its whole length with attention to minimize chances of duct injury as well as injury to an accessory or replaced right hepatic artery, if present. The common bile duct should be retracted ventrally and medially with a vein retractor to facilitate exposure of the portal vein. As the portal vein comes into view, a Russian forceps is used to grasp it and a plastic Yankauer sucker is utilized for circumferential dissection of the vein. The portal vein is then controlled by a vessel loop. This vessel loop may be helpful if bleeding develops because it can provide secure control of the portal vein (Fig. 83.2).

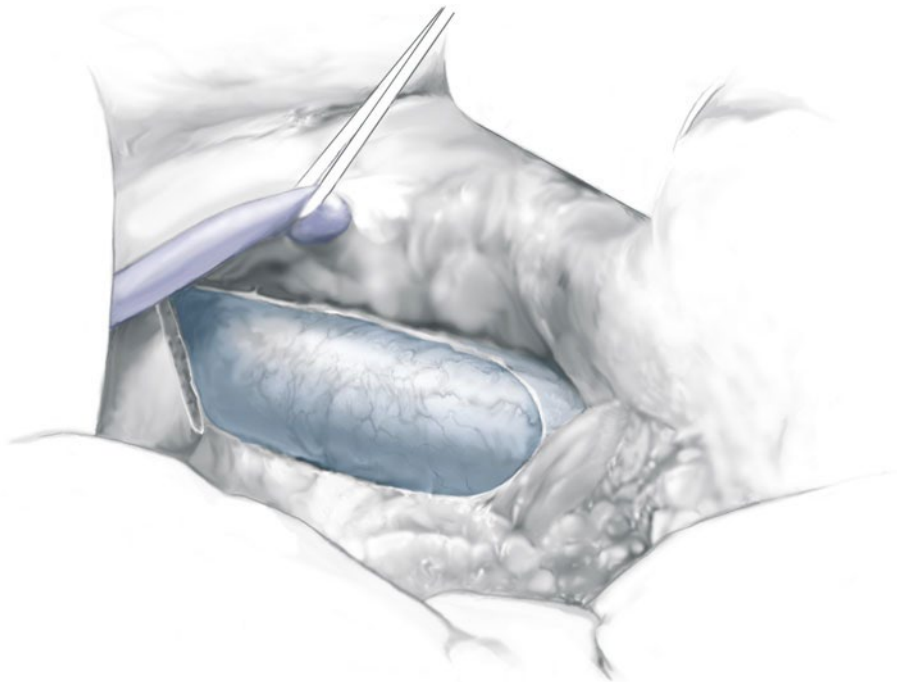


Fig. 83.2

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Step 3

Caval anastomosis

A segment of 6 mm to 8-mm externally reinforced polytetrafluoroethylene (PTFE) graft is used for the portacaval shunt. The graft is 3 cm long from toe to toe and 1.5 cm from heel to heel. The bevels of the graft are oriented at 90° to each other because the portal vein is not parallel to but rather oriented approximately 60° to the inferior vena cava.

The graft is placed in heparinized saline and negative pressure is applied in order to remove any air bubbles. A side-biting Satinsky clamp is then securely placed on the anterior surface of the vena cava. Hypotension is virtually never a problem because of this clamping. An oval segment of the vena cabal wall must be excised from the vena cava so that outflow from the graft is adequate; merely opening the cava is not sufficient. When the vena cava is opened, the excised portion of the vein should be approximately 4 mm long and 1–2 mm wide. This will provide an adequate opening in the vena cava.

The graft is placed on the vena cava so that its bevel allows it to lean cephalad. The anastomosis is undertaken with 5-0 Prolene in a running fashion. This anastomosis is initiated with a horizontal mattress suture so that sewing is always from "inside-out" on the vein and "outside-in" on the graft (Fig. 83.3). The back wall is completed first. Before the knot is tied, a suture is reversed so that the knot is secured across the anastomosis.

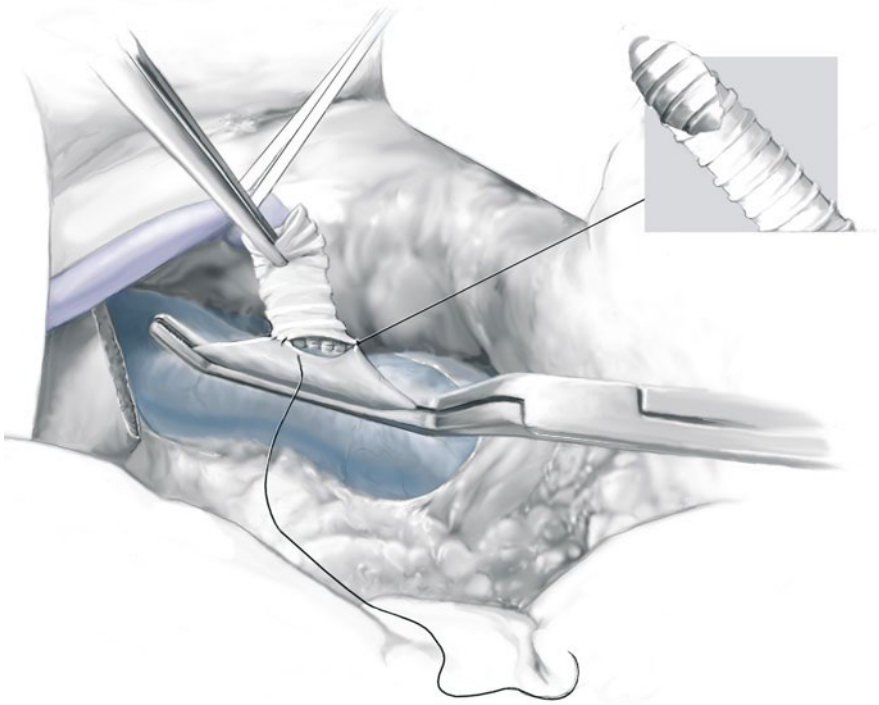


Fig. 83.3

۰۲۱-۶۶۱۹۸۵۱۴ www.myuptodate.com دریافت آخرین نسخه آپتودیت آفلاین

Step 3 ***(continued)***

Once the anastomosis has been completed and the knot tied, a right-angled clamp is placed across the graft, and the side-biting clamp is removed. This tests the anastomosis; it should not leak and it should only bleed at needle holes and then only minimally (Fig. 83.4). The Satinsky clamp is repositioned on the vena cava and the right-angled clamp removed from the graft. The graft is then vigorously irrigated with heparinized saline through an 18-gauge angiocatheter.

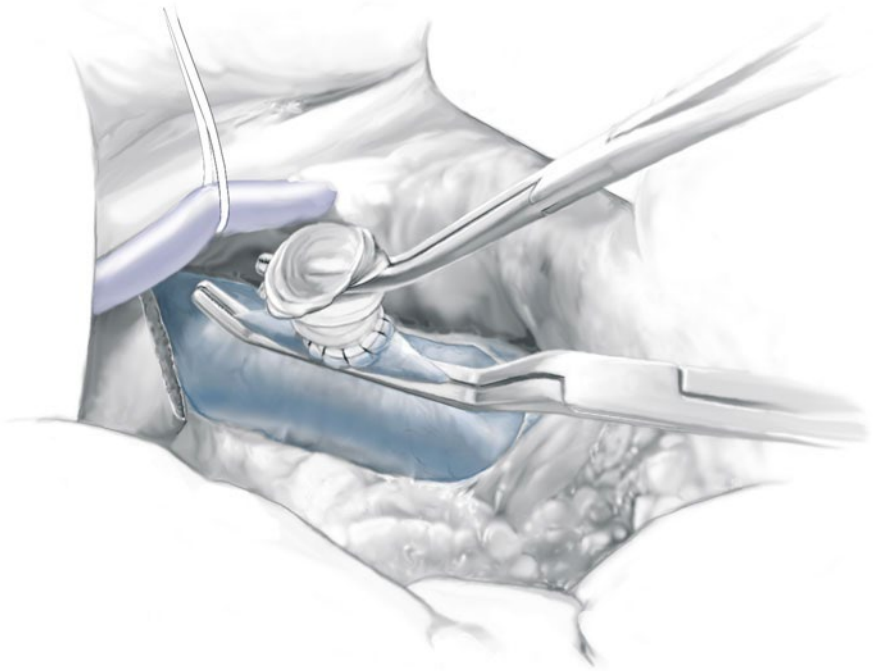


Fig. 83.4

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Step 4

Exposure of the portal vein

The portal vein anastomosis is now constructed. The common bile duct and accessory right hepatic artery, if present, are retracted ventrally and medially, exposing the dissected portal vein. The bevel of the portal vein end of the graft is at 90° to the Inferior vena cava level as shown here (Fig. 83.5).

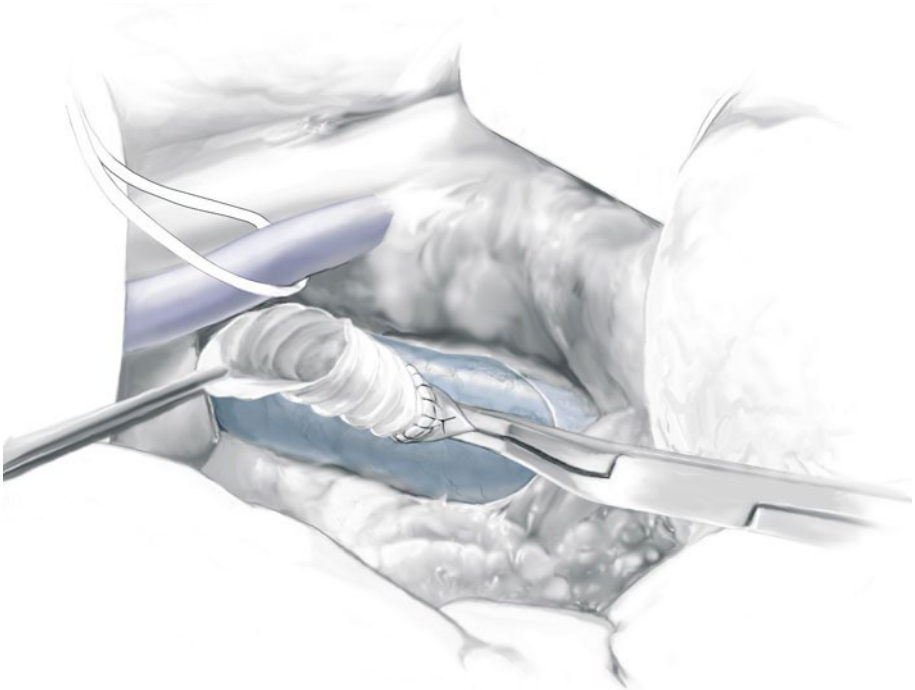


Fig. 83.5

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Step 5

Preparation of the portal anastomosis

A right-angled side-biting clamp is then placed across the portal vein. This clamp does not have to occlude all the portal flow, but it must be placed securely enough to prevent bleeding once the vein is opened. Once the Satinsky clamp is placed, the posterolateral surface of the portal vein is incised with a No. 11 knife blade. Potts scissors are then used to lengthen the opening in order to accommodate the placement of the graft. In contrast to the inferior vena cava, a segment of the wall of the vein does not usually need to be cut in the portal vein. A 5-0 Prolene suture is placed in the ventral edge of the opening in the portal vein to act as a retraction suture, so as to "open up" the hole in the vein (Fig. 83.6).

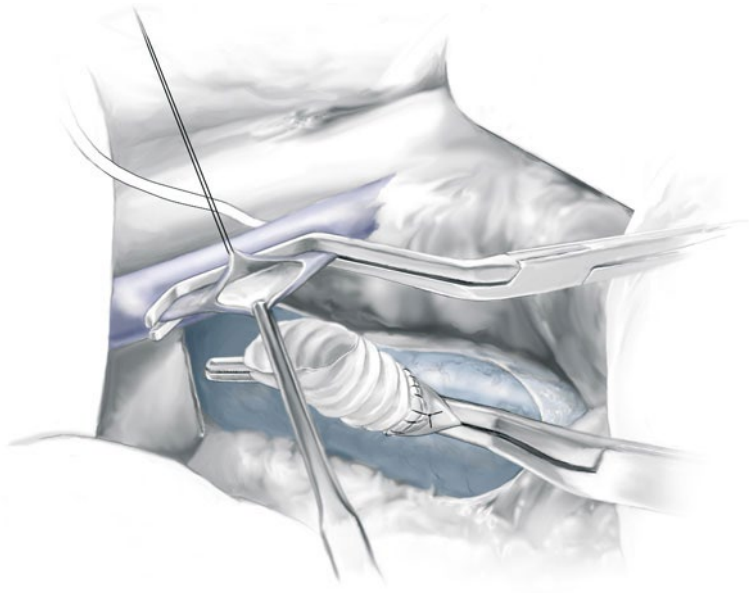


Fig. 83.6

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Step 6

Portal anastomosis

With this exposure, the posterior wall of the portal vein is then sewn to the graft with a 5-0 Prolene suture. The anastomosis is initiated by placing a horizontal mattress suture in the midportion of the posterior wall of the portal vein. Thereafter, all sewing of this anastomosis is "inside-out" on the portal vein and "outside-in" on the graft. As sewing is carried around both the cephalad and the caudad corners of the anastomosis, the sutures along the back wall are drawn taut with a nerve hook. As the sewing continues toward the middle of the anterior portion of the anastomosis, the clamp on the portal vein is momentarily opened so that clot and debris within the vein will be blown out. Heparinized saline is again applied liberally through the anterior defect of the anastomosis into the graft (Fig. 83.7).

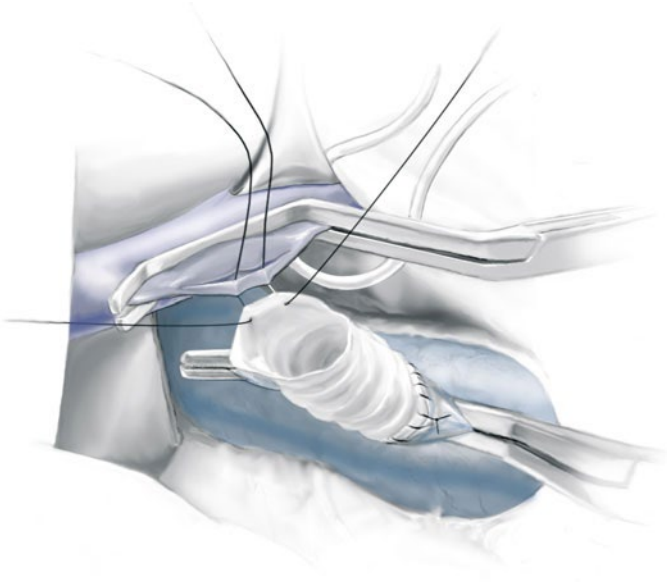


Fig. 83.7

The anastomosis is then completed, with one of the sutures reversed so that the knot is tied across the anastomosis. The clamp on the vena cava is released first, and then the clamp on the portal vein is removed. There should be a thrill in the vena cava, just cephalad to the anastomosis (Fig. 83.8).

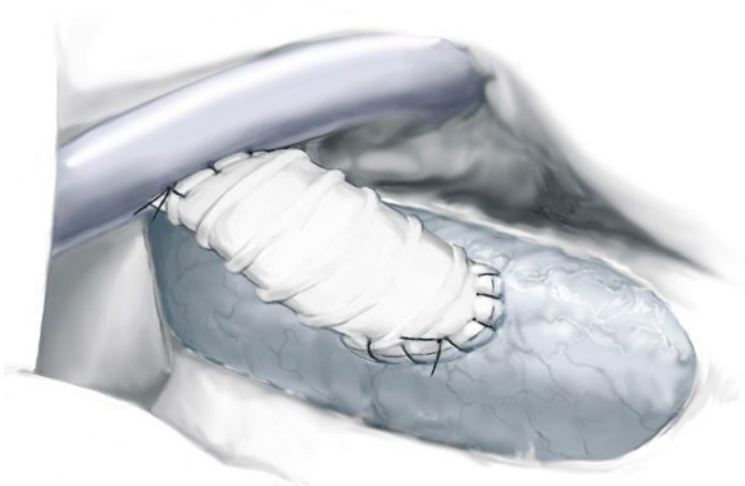


Fig. 83.8

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Postoperative Tests

- Postoperative surveillance in an appropriate hospital setting.
- Remove nasogastric tube, if present, as soon as possible.
- Attention should be given to avoid dehydration. Low urinary output during the first 24–48 hours predisposes to graft thrombosis.
- If hypovolemia is diagnosed, rehydration with normal saline and use of intravenous mannitol are recommended.
- Liver function tests (including SGOT), coagulation parameters, and hemoglobin should be checked for at least 48 hours, postoperatively.
- Daily assessment of clinical signs of liver failure, such as jaundice and encephalopathy.
- Ascites can be controlled with fluid and salt restriction, as well as with judicious use of diuretics.
- The shunt should be evaluated with transfemoral cannulation, in order to document patency and to measure the portal vein-inferior vena cava pressure gradients at 3–6 days postoperatively.

Complications

- Intra-abdominal bleeding
- Recurrence of gastrointestinal hemorrhage due to shunt thrombosis
- Hepatic failure
- Changes in cardiopulmonary dynamics (increased cardiac index)
- Ascites
- Portal-systemic encephalopathy
- Bile duct injury
- Injury to an accessory right hepatic artery
- Wound infection
- Shunt failure

Summary

Pressures within the portal vein and inferior vena cava are measured early in the operation, before the vessels are clamped. These pressures can be recorded with a 25-gauge needle and a pressure-transducing setup. A portal-caval pressure gradient is determined. On completion of the shunt, pressures are measured again. In a satisfactorily completed shunting, we look for a decrease in portal pressure of ≥ 10 mmHg and a gradient between the portal vein and the inferior vena cava of < 10 mmHg.

The vena cava-graft anastomosis is marked with large Hemoclips placed on tissue adherent to the cava and secured both cephalad and caudad to the anastomosis. These clips allow the radiologist to identify and cannulate the inferior vena cava-graft anastomosis during the routine postoperative assessment of the shunt.

After copious irrigation of the operative field, the wound is closed along anatomic layers using #2 Prolene suture. The skin is reapproximated with a running nylon suture, in order to minimize any postoperative ascitic leak.

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Tricks of the Senior Surgeon

- Identify the foramen of Winslow. The Kocher maneuver should be limited.
- Cut out an oval segment of the inferior vena cava.
- Begin each anastomosis with a horizontal mattress suture.
- Check the graft-inferior vena cava anastomosis before proceeding with the portal vein-graft anastomosis.
- If there is significant bleeding when a portion of the caudate lobe is removed, apply pressure and most of the bleeding will drop within minutes.
- Bleeding from either anastomosis is generally best managed by using a figure-of-eight technique.

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Portacaval Shunts: Side-To-Side and End-To-Side

Marshall J. Orloff, Mark S. Orloff, Susan L. Orloff

Indications and Contraindications

Indications

- Bleeding esophageal or gastric varices (BEV or BGV) due to portal hypertension caused by cirrhosis, or, much less commonly, caused by other liver diseases (e. g., schistosomiasis)
- Bleeding from portal hypertensive gastropathy unresponsive to pharmacologic therapy
- Budd-Chiari syndrome with patent inferior vena cava (IVC)
- Intractable ascites unresponsive to nonsurgical therapy
- Failed transjugular intrahepatic portasystemic shunt (TIPS)

Contraindications

- Thrombosis of the portal vein without liver disease (extrahepatic portal hypertension)
- In patients with liver disease, thrombosis of the portal vein that is long-standing and not amenable to venous thrombectomy
- Occlusion of the hepatic artery (e. g., due to hepatic arterial infusion chemotherapy)

Timing Considerations

- *Prophylactive* portacaval shunt in patients with esophageal or gastric varices that have never bled – practiced by some surgeons but not recommended by the authors
- *Elective* therapeutic portacaval shunt in patients who have recovered from an episode of BEV or BGV. This is the most widely used form of portacaval shunt
- *Emergency* portacaval shunt within 48 h of the onset of BEV or BGV, strongly advocated by the authors

Diagnosis of BEV or BGV

- History and physical examination to confirm diagnosis
- Blood studies for complete evaluation
- Esophagogastroduodenoscopy
- Doppler ultrasonography to determine portal vein patency and absence of gross liver tumors
- Other studies occasionally necessary:
  - Visceral arteriography with indirect portography and inferior vena cavography with pressure measurements – usually not necessary in cirrhosis but essential in extrahepatic portal hypertension and Budd-Chiari syndrome
  - Hepatic vein catheterization with venography and wedged hepatic vein pressure measurements
  - Percutaneous liver biopsy – usually not necessary in cirrhosis but helpful in Budd-Chiari syndrome

Preoperative Preparation During Acute Bleeding

- Temporary hemostasis with intravenous infusion of octreotide (50 mcg/h) or vasopressin (0.2–0.4 units/min)

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery*,
DOI 10.1007/978-3-662-46546-2_84, © Springer-Verlag Berlin Heidelberg 2016

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- Temporary hemostasis during endoscopy by injection sclerotherapy or banding of esophageal varices
- Restoration of blood volume by transfusion of packed red blood cells and fresh frozen plasma through large-bore intravenous catheters
- Prevention of portasystemic encephalopathy by instillation via nasogastric tube of neomycin (4 g), lactulose (30 ml), and cathartics (60 ml magnesium sulfate)
- Correction of hypokalemia and metabolic alkalosis by intravenous administration of large quantities of potassium chloride
- Intravenous administration of hypertonic glucose solution containing therapeutic doses of vitamins K, B, and C
- Preoperative administration of antibiotics
- Frequent monitoring of vital functions by an arterial catheter for blood pressure, a central venous catheter, and a urinary bladder catheter. Serial measurements of hematocrit, arterial pH, and blood gases, and rate of blood loss by continuous suction through a nasogastric tube

Procedure

Step 1

Position of patient

The patient is placed on the operating table with the right side elevated at an angle of 30° to the table by two sandbags placed underneath the right posterior trunk. The costal margin is at the level of the flexion break of the table, the right arm is suspended from an ether screen with towels, and the left arm is extended on an arm board cephalad to the ether screen. The table is "broken" at the level of the costal margin and at the knees so as to widen the space between the right costal margin and the right iliac crest, and to make it possible to perform the operation easily through a right subcostal incision (Fig. 84.1). The incision extends from the xiphoid to well into the flank and is made two finger breadths below the costal margin. The skin is incised superficially with the scalpel and the other layers with the electrocautery, which greatly reduces the blood loss and shortens the operating time. When the electrocautery is used, it is usually unnecessary to clamp many blood vessels with hemostats. The right rectus abdominis, external oblique, and transverse abdominis muscles are completely divided and the medial 3–4 cm of the latissimus dorsi muscle is incised. The peritoneum often contains many collateral veins and is incised with the electrocautery to obtain immediate hemostasis.

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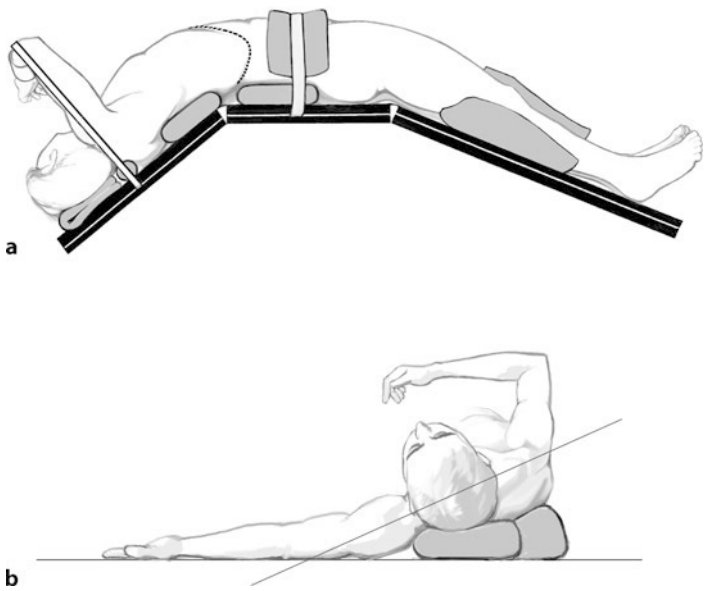


Fig. 84.1

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Step 2

Exposure of operative field

The operative field is exposed by retraction of the viscera with three Deaver retractors positioned at right angles to each other. The inferior one retracts the hepatic flexure of the colon toward the feet, the medial one displaces the descending duodenum medially, and the superior retractor retracts the liver and gallbladder toward the head. Alternatively, a self-retaining retractor may be used to accomplish the same exposure. The posterior peritoneum is often intensely "stained" with portasystemic collateral veins (Fig. 84.2).

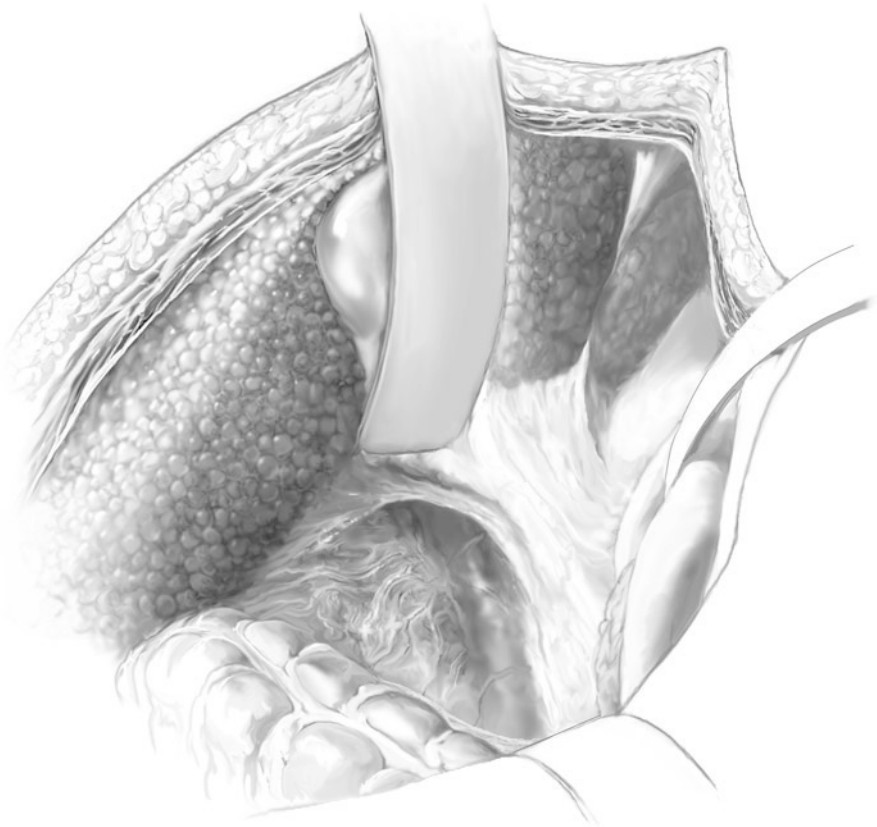


Fig. 84.2

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Step 3

Isolation of IVC and testing for adequate mobilization

The IVC lies behind the descending duodenum. The posterior peritoneum overlying the IVC is incised with the electrocautery by an extended Kocher maneuver just lateral to the descending duodenum, and the retractors are repositioned to retract the head of the pancreas medially and the right kidney caudally. The peritoneum is often greatly thickened and contains many collateral veins. Bleeding usually can be controlled with the electrocautery but sometimes requires suture ligatures. The anterior surface of the IVC is cleared of fibroareolar tissue, and the IVC is isolated around its entire circumference by blunt and sharp dissection from the entrance of the right and left renal veins, below, to the point where it disappears behind the liver, above. The IVC is encircled with an umbilical tape. To accomplish the isolation, several tributaries must be ligated in continuity with fine silk ligatures and then divided. These tributaries often include the right adrenal vein, one or two pairs of lumbar veins that enter on the posterior surface, and the caudal pair of small hepatic veins from the caudate lobe of the liver that enter on the anterior surface of the IVC directly from the liver (Fig. 84.3).

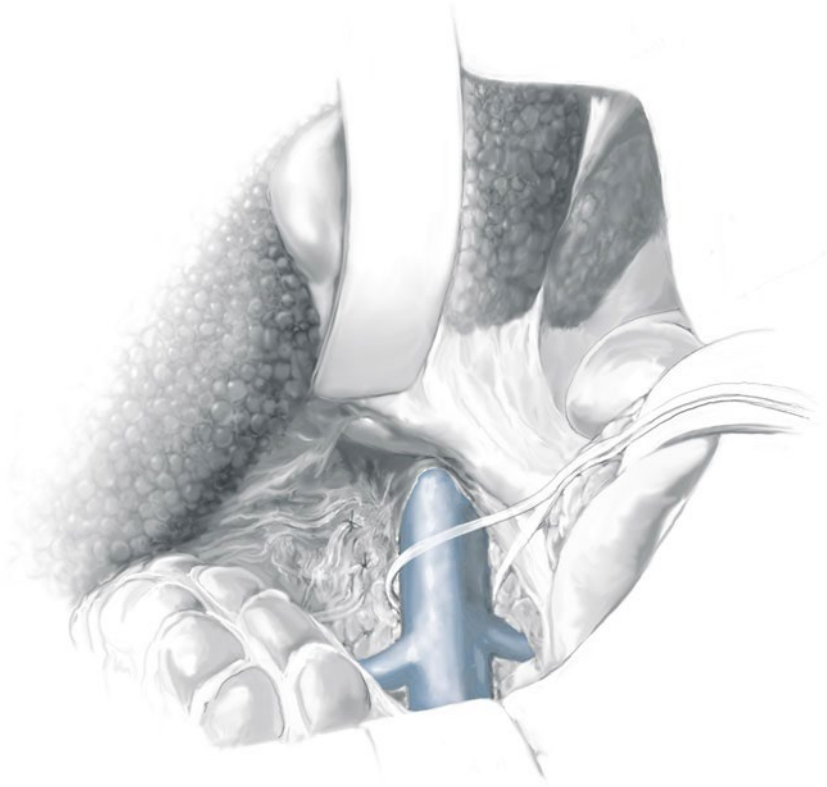


Fig. 84.3

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Step 3 ***(continued)***

When the IVC has been mobilized completely, it can be lifted up toward the portal vein. Failure to isolate the IVC circumferentially is one major reason for the erroneous claim that the side-to-side portacaval shunt often cannot be performed because the portal vein and IVC are too widely separated (Fig. 84.4).

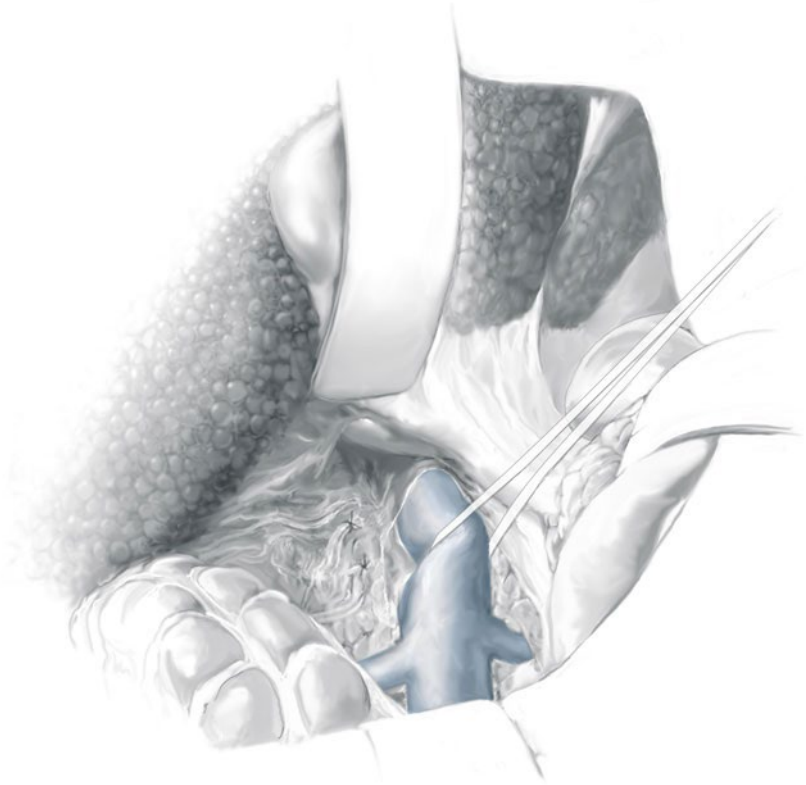


Fig. 84.4

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Step 4

Isolation of portal vein

The superior retractor is repositioned medially so that it retracts the liver at the point of entrance of the portal triad. The portal vein is located in the posterolateral aspect of the portal triad and is approached from behind. The fibrofatty tissue on the posterolateral aspect of the portal triad, which contains nerves, lymphatics, and lymph nodes, is divided by blunt and sharp dissection. This technique is a safe maneuver because there are no portal venous tributaries on this aspect of the portal triad. As soon as the surface of the portal vein is exposed, a vein retractor or Gilbernet retractor is inserted to retract the common bile duct medially. The portal vein is mobilized circumferentially at its midportion and is encircled with an umbilical tape. It then is isolated up to its bifurcation in the liver hilum. Several tributaries on the medial aspect are ligated in continuity with fine silk and divided (Fig. 84.5).

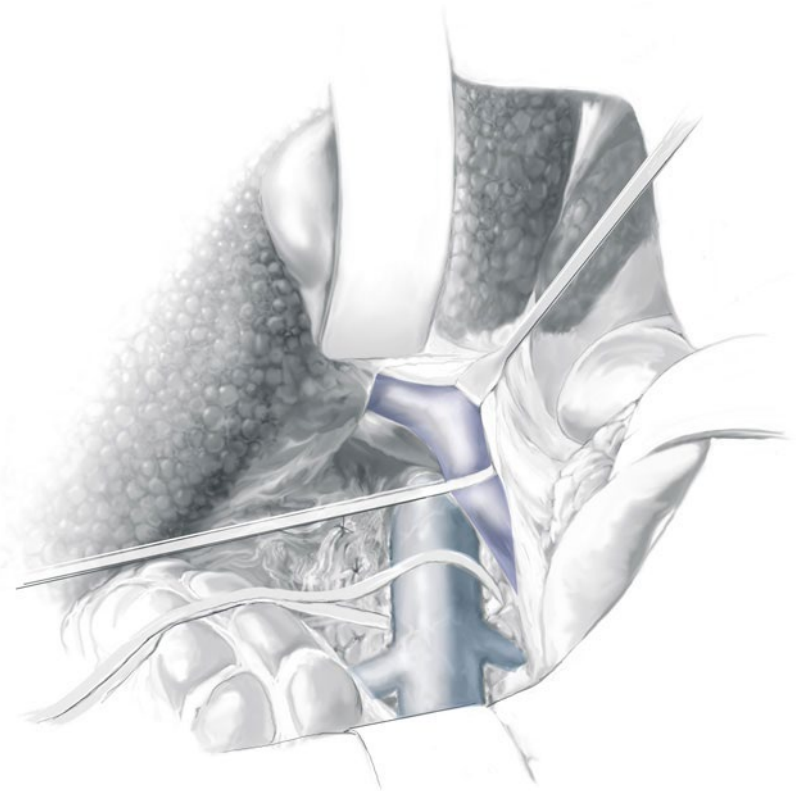


Fig. 84.5

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Step 5

Mobilization of portal vein behind pancreas

Using the umbilical tape to pull the portal vein out of its bed, the portal vein is cleared to the point where it disappears behind the pancreas. The tough fibrofatty tissue that binds the portal vein to the pancreas must be divided. Several tributaries that enter the medial aspect of the portal vein and one tributary that enters the posterolateral aspect are divided. It is usually not necessary to divide the splenic vein. Wide mobilization of the portal vein is essential for performance of a side-to-side portacaval anastomosis. Failure to mobilize the portal vein behind the pancreas is a second major reason for difficulty in accomplishing the side-to-side shunt. In some patients, it is necessary to divide a bit of the head of the pancreas between right-angled clamps to obtain adequate mobilization of the portal vein. Bleeding from the edges of the divided pancreas is controlled with suture ligatures. Division of a small amount of the pancreas is a very helpful maneuver and we have never observed postoperative complications, such as pancreatitis, from its performance. Before incising the pancreas, the surgeon should insert his or her index finger into the tunnel between the portal vein and the pancreas to determine by palpation if there is a replaced common hepatic or right hepatic artery arising from the superior mesenteric artery and crossing the portal vein. Since the portal venous blood flow to the liver is diverted through the portacaval shunt, ligation of the hepatic arterial blood supply may be lethal (Fig. 84.6).

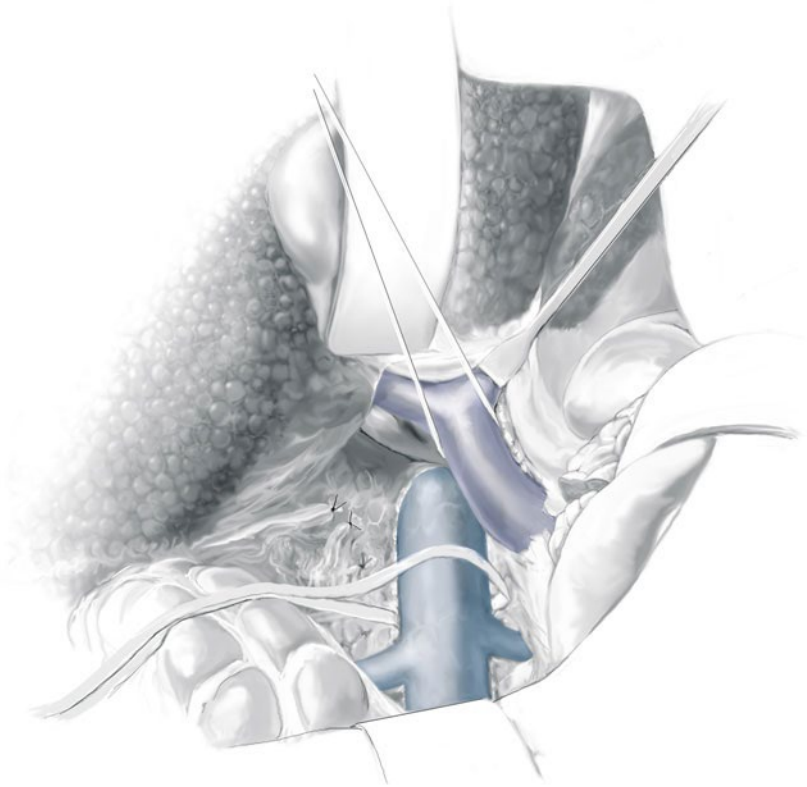


Fig. 84.6

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Step 6

Testing adequacy of mobilization of portal vein and IVC

To determine the adequacy of mobilization of the portal vein and IVC, the two vessels are brought together by traction on the umbilical tapes that surround them. It is essential to determine that the two vessels can be brought together without excessive tension.

If this cannot be done, it is almost always because the vessels have not been adequately mobilized, and further dissection of the vessels should be undertaken. Resection of part of an enlarged caudate lobe of the cirrhotic liver, recommended by some surgeons to facilitate bringing the vessels together, is associated with some difficulties and, in our opinion, is neither necessary nor advisable (Fig. 84.7).

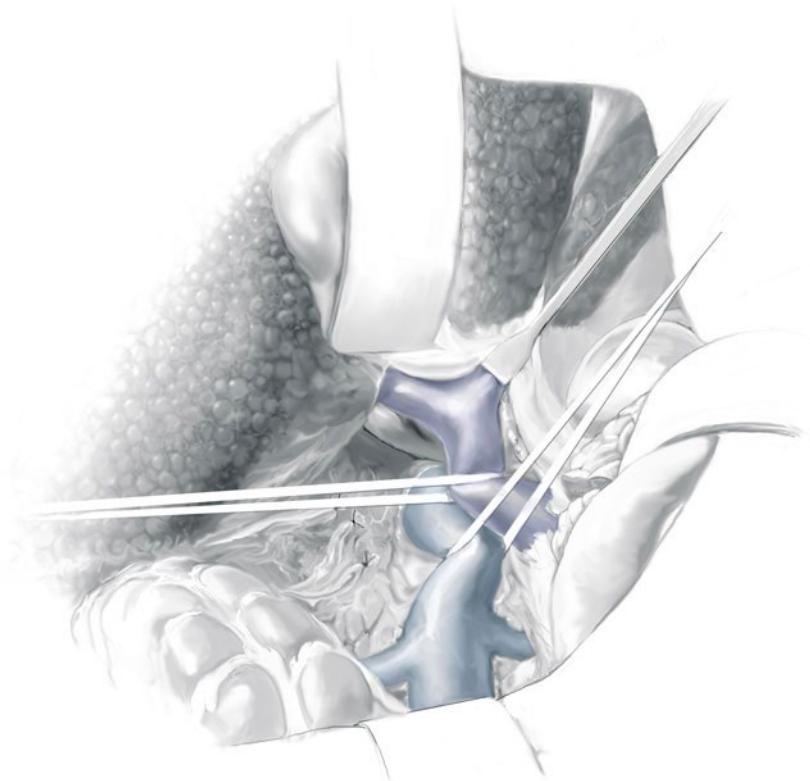


Fig. 84.7

Step 7

Measurement of venous pressures

Pressures in the IVC and portal vein are measured with a saline (spinal) manometer by direct needle puncture before performance of the portacaval anastomosis. For all pressure measurements, the bottom of the manometer is positioned at the level of the IVC, which is marked on the skin surface of the body with a towel clip (Fig. 84.8). All portal pressures are *corrected* by subtracting the IVC pressure from the portal pressure. A portal vein-IVC pressure gradient, also known as the corrected free portal pressure, of 150 mm saline or higher, represents clinically significant portal hypertension. Most patients with bleeding esophageal varices have a portal vein-IVC gradient of 200 mm saline or higher. The pressure measurements include:

- IVCP – inferior vena caval pressure
- FPP – free portal pressure
- HOPP – hepatic occluded portal pressure, obtained on the hepatic side of a clamp occluding the portal vein
- SOPP – splanchnic occluded portal pressure, obtained on the intestinal side of a clamp occluding the portal vein

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Step 7 ***(continued)***

In normal humans, HOPP is much lower than FPP, and SOPP is much higher. In patients with portal hypertension, the finding of an HOPP that is higher than the FPP suggests the possibility that blood flow in the portal vein is reversed because of severe hepatic outflow obstruction.

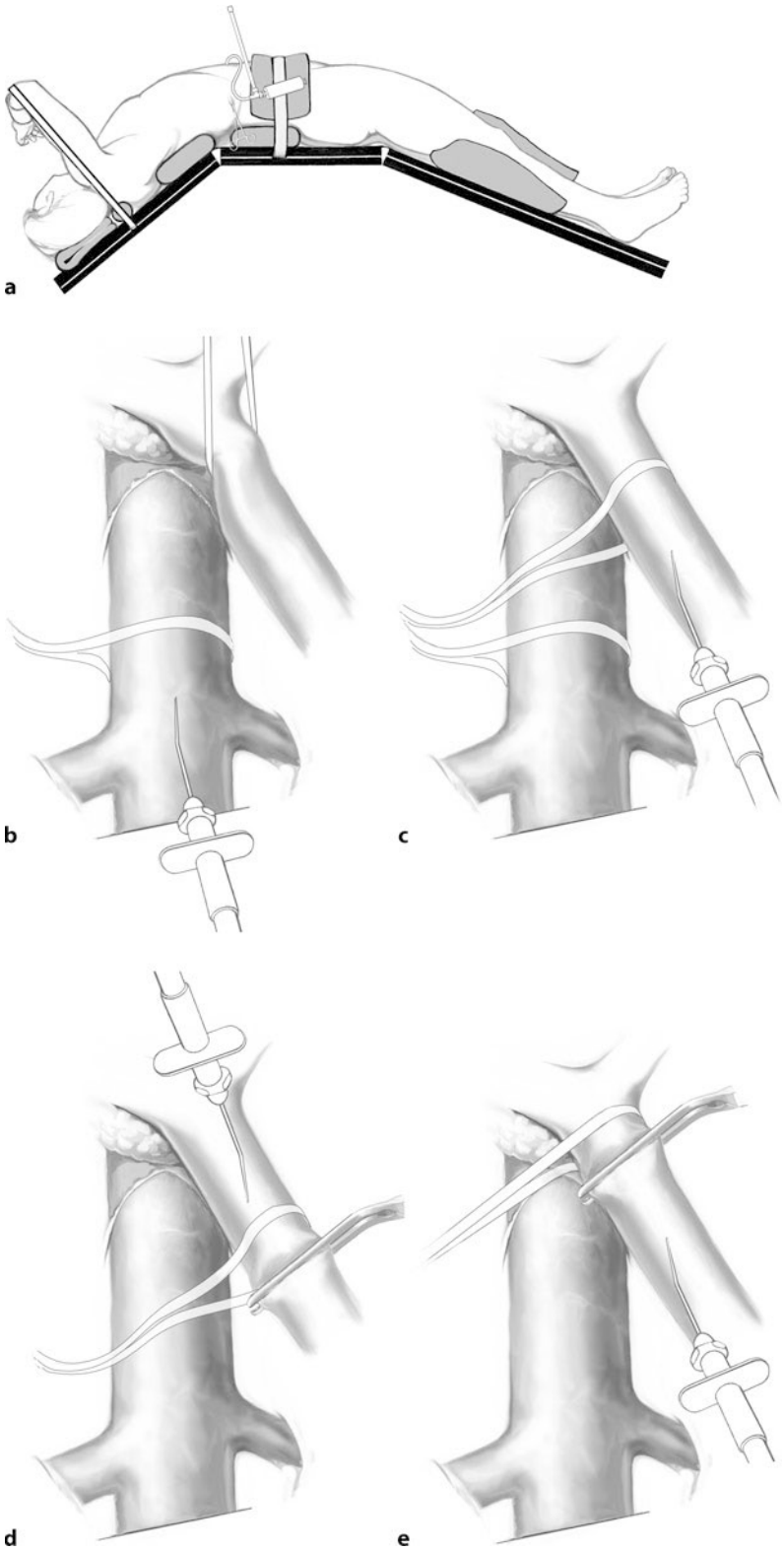


Fig. 84.8

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Step 8

Side-to-side portacaval anastomosis

A Satinsky clamp is placed obliquely across a 5-cm segment of the anteromedial wall of the IVC in a direction parallel to the course of the overlying portal vein and the IVC is elevated toward the portal vein (Fig. 84.9a). A 5-cm segment of the portal vein is isolated between two angled vascular clamps and the portal vein is depressed toward the IVC, bringing the two vessels into apposition.

A 2.0- to 2.5-cm-long strip of the IVC and a 2.0- to 2.5-cm-long strip of the portal vein are excised with scissors (Fig. 84.9b). It is important to excise a longitudinal segment of the wall of each vessel rather than simply to make an incision in each vessel. A retraction suture of 5-0 silk is placed in the lateral wall of the IVC opening and is weighted by attachment to a hemostat to keep the IVC orifice open. The clamps on the portal vein are momentarily released to flush out any clots and then the openings in both vessels are irrigated with saline.

The anastomosis is started with a posterior continuous over-and-over suture of 5-0 vascular suture material (Fig. 84.9c). The posterior continuous suture is tied at each end of the anastomosis.

The anterior row of sutures consists of an everting continuous horizontal mattress stitch of 5-0 vascular suture material started at each end of the anastomosis (Fig. 84.9d). The suture started at the inferior end of the anastomosis is discontinued after three or four throws and is deliberately left loose so that the interior surface of the vessels can be visualized as the anastomosis is completed. In this way inadvertent inclusion of the posterior wall in the anterior row of sutures is avoided. The suture started at the superior end of the anastomosis is inserted with continuous tension until the inferior suture, at which point the inferior suture is drawn tight and the two sutures are tied to each other. Before drawing the inferior suture tight, the clamps on the portal vein are momentarily released to flush out any clots, and the anastomosis is thoroughly irrigated with saline (Fig. 84.9e).

Upon completion of the anastomosis, a single interrupted tension suture is placed just beyond each end of the anastomosis to take tension off the anastomotic suture line. The clamp on the IVC is removed first, the clamp on the hepatic side of the portal vein is removed next, and finally the clamp on the intestinal side of the portal vein is removed. Bleeding from the anastomosis infrequently occurs; it can be controlled by one or two well-placed interrupted sutures of 5-0 vascular suture material.

Pressures in the portal vein and IVC must be measured after the anastomosis is completed. Usually the postshunt pressures in the portal vein and IVC are identical. A pressure gradient of > 50 mm saline between the two vessels indicates an obstruction in the anastomosis, even when no obstruction can be palpated. In such circumstances, the anastomosis should be opened to remove any clots and, if necessary, the entire anastomosis should be taken down and redone. It is essential that there be no more than a 50-mm saline gradient between the portal vein and the IVC to achieve permanently adequate portal decompression and to avoid ultimate thrombosis of the shunt.

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Step 8 *(continued)*

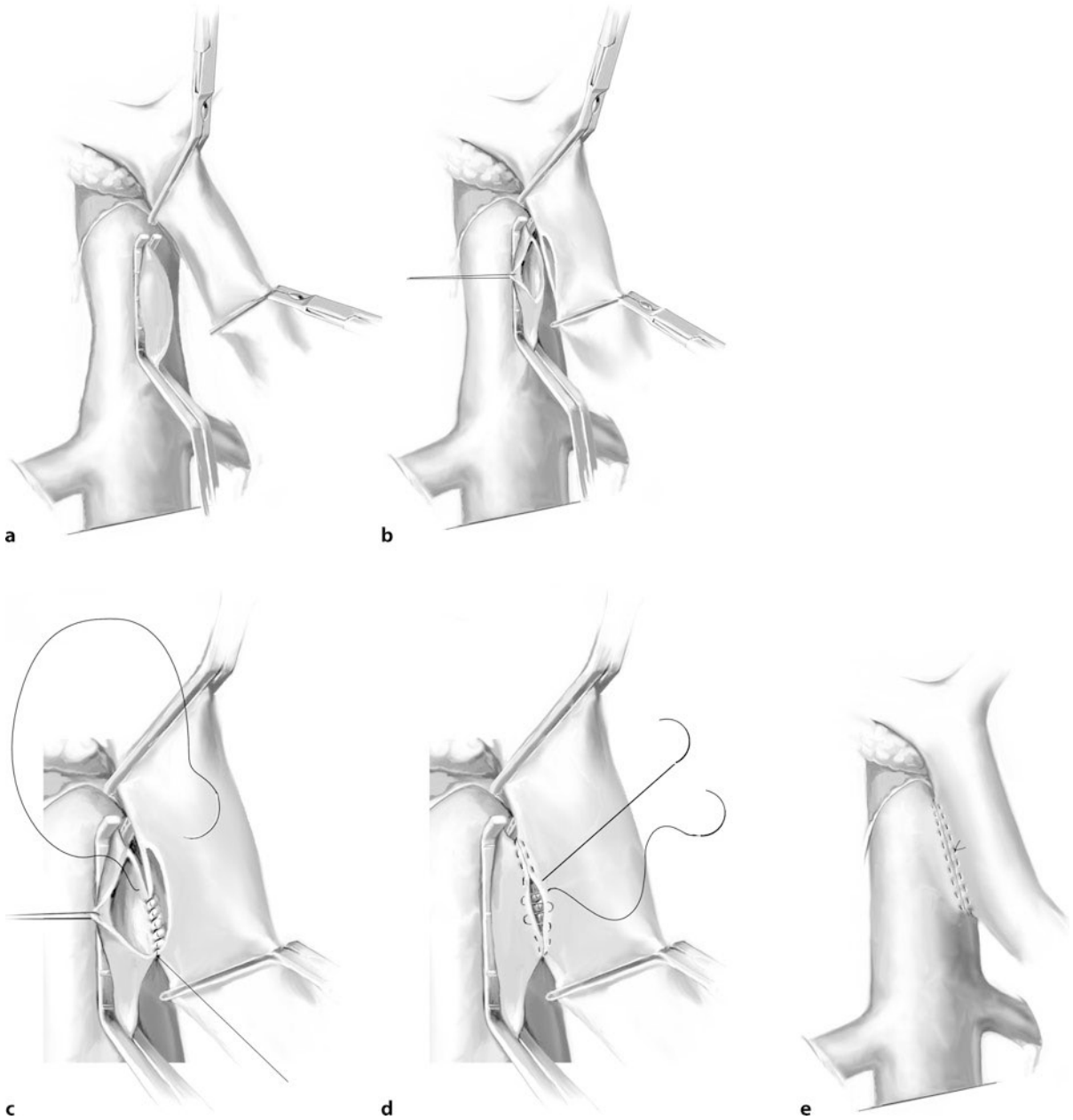


Fig. 84.9

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Step 9

Multiple steps in sewing an end-to-side portacaval anastomosis

The end-to-side portacaval anastomosis is a satisfactory alternative to the side-to-side shunt in most cases, and some surgeons believe that it is somewhat less difficult to perform. It is not essential to isolate the IVC around its entire circumference, and it is often not necessary to clear as long a segment of the portal vein as in the lateral anastomosis. The disadvantage is that the liver sinusoids are not decompressed.

The Satinsky clamp on the IVC is placed obliquely on the anteromedial wall in the direction that will receive the end of the portal vein at an angle of about 45°. A 2-cm-long strip of the IVC is excised and a retraction suture is placed in the lateral wall (Fig. 84.10a). The portal vein is doubly ligated with a free ligature and a suture ligature of 2-0 silk just before its bifurcation in the hilum of the liver. An angled vascular clamp is placed across the portal vein near the pancreas, and the portal vein is divided obliquely just proximal to the ligation site.

In order to maximize the size of the anastomosis, the portal vein is transected tangentially so that the anterior wall is longer than the posterior wall at the transected end (Fig. 84.10b). After transection the clamp on the portal vein is momentarily released to flush out any clots before starting the anastomosis. This maneuver is repeated just before the final sutures in the anterior row of the anastomosis are placed.

The end-to-side anastomosis is performed with a continuous, over-and-over 5-0 vascular suture in the posterior row and a second 5-0 vascular suture in the anterior row (Fig. 84.10c). It is important that the portal vein describes a smooth curve in its descent toward the IVC and that it is attached to the IVC at an oblique angle. Twisting and kinking of the portal vein are the most common causes of a functionally unsatisfactory anastomosis. After the anastomosis is completed, pressure measurements are performed according to the guidelines described for the side-to-side shunt.

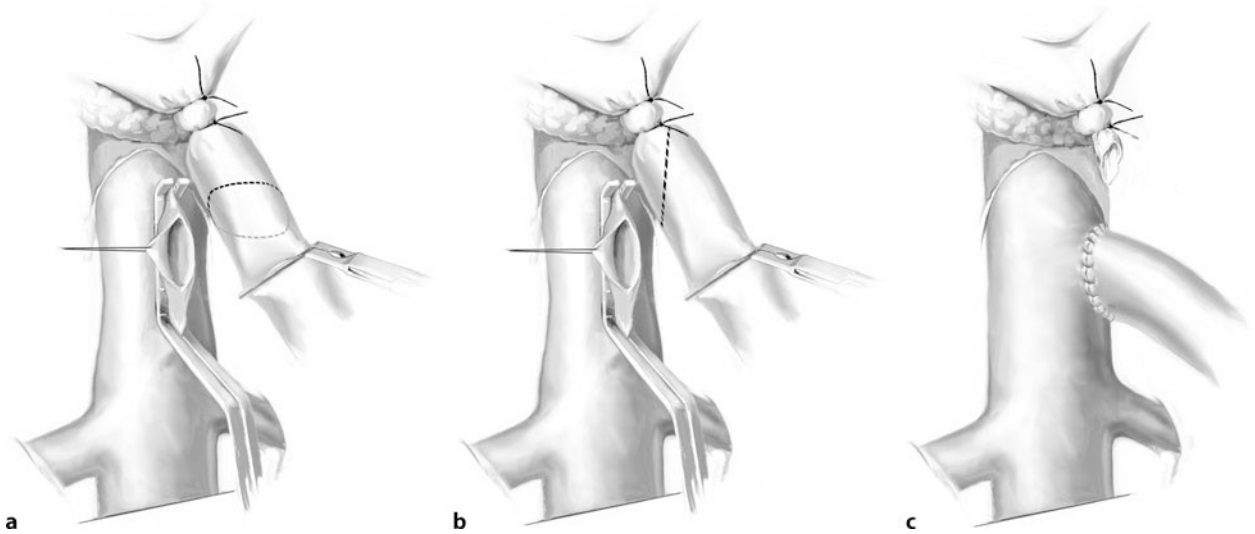


Fig. 84.10

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Liver Biopsy

A wedge liver biopsy is always obtained.

Postoperative Care

All patients should be admitted to an intensive care unit with equipment and personnel geared to managing the complicated problems associated with hepatic disease.

Monitoring

Careful monitoring of vital signs, central venous pressure, urine output, arterial pH, arterial and alveolar gases, fluid balance, body weight, and abdominal girth is essential.

Postoperative Complications

- **Early:**
  - Hepatic failure
  - Renal failure
  - Infection
  - Gastric acid hypersecretion
  - Delirium tremens
  - Ascites
  - Gastrointestinal bleeding
- **Late:**
  - Portasystemic encephalopathy (PSE)
  - Liver failure
  - Shunt thrombosis
  - Hepatocellular carcinoma

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Tricks of the Senior Surgeon

- The position of the patient on the operating table is crucial and can make the difference between an easy and a difficult operation.
- A long subcostal incision is associated with many fewer postoperative complications than a thoracoabdominal incision and is much to be preferred.
- Use of the electrocautery throughout the operation substantially reduces the operating time and the blood loss.
- Bleeding from the many portasystemic collateral vessels is best managed by pressure with gauze sponge packs, particularly as most of the bleeding stops as soon as the portacaval anastomosis is completed and the portal hypertension is relieved. Attempts to control each of the bleeding collaterals with ligatures and sutures prolong the operation and increase the blood loss. The objective is to decompress the portal system as rapidly as possible.
- Circumferential mobilization of the IVC between the entrance of the renal veins and the liver is essential for the side-to-side anastomosis and is neither hazardous nor difficult to perform. Apposition of the two vessels is greatly facilitated by elevation of the IVC toward the portal vein.
- Mobilization of a long segment of portal vein, which includes division of the tough fibrofatty tissue that binds the portal vein to the pancreas and sometimes includes division of a bit of the head of the pancreas, is essential for the side-to-side anastomosis and sometimes for the end-to-side anastomosis.
- Beware of the replaced hepatic artery crossing the portal vein behind the head of the pancreas. Palpate it with the index finger in the funnel between the head of the pancreas and portal vein. Ligation of the hepatic artery may be lethal.
- Resection of an enlarged caudate lobe of the cirrhotic liver to facilitate apposition of the two vessels is hazardous and unnecessary.
- Pressures in the IVC and portal vein should always be measured after completion of the portacaval shunt. A pressure gradient of greater than 50 mm saline is unacceptable and requires revision of the anastomosis.

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Gastroesophageal Devascularization: Sugiura Type Procedures

Norihiro Kokudo, Seiji Kawasaki, Hector Orozco, Miguel A. Mercado, Markus Selzner, Pierre-Alain Clavien

Introduction

To improve the effect of Walker's simple esophageal transection, Sugiura and colleagues refined the technique of esophageal transection, adding the extensive paraesophageal devascularization via abdominal and thoracic incisions. The resulting procedure has been known as the Sugiura procedure. Three different approaches will be described including a spleen-preserving procedure as well as a procedure with an abdominal approach only (i. e., without thoracotomy).

Indications and Contraindications

Indications

- Bleeding or risky esophagogastric varices
- Esophagogastric varices resistant to endoscopic treatment
- Child-Turcotte (Pugh) Class A or B patients

Contraindications

- Child-Turcotte (Pugh) Class C patients

Preoperative Investigation and Preparation for the Procedure

History:	Alcohol, hepatitis, recent overeating or overdrinking
Clinical evaluation:	Hematemesis, melena, encephalopathy, ascites, jaundice, nutritional status, splenomegaly, bleeding tendency
Laboratory tests:	Blood cell count, bilirubin, albumin, ALT, AST, prothrombin time, ammonia, total bile acid, indocyanine green test
Endoscopy:	Assessment of esophagogastric varices and portal hypertensive gastropathy, searching for the bleeding point
CT scan, ultrasound: or MRI:	Assessment of collateral vessels, portal flow, ascites, searching for hepatoma
In emergency cases:	Volume resuscitation, placement of Sengstaken-Blakemore tube, intratracheal intubation (when indicated)

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
DOI 10.1007/978-3-662-46546-2_85, © Springer-Verlag Berlin Heidelberg 2016

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Postoperative Tests

- Postoperative surveillance in an intensive or intermediate care unit
- Blood cell count, bilirubin, albumin, ALT, AST, and prothrombin time for at least 48 h
- Check daily for clinical signs of gastrointestinal bleeding, liver failure, or pneumonia

Postoperative Complications

- **Short term:**
  - Liver failure
  - Gastrointestinal bleeding
  - Anastomotic leakage
  - Pleural effusion
  - Ascites
  - Portal vein thrombosis
  - Subphrenic abscess
  - Pancreatic leakage
- **Long term:**
  - Esophageal stricture
  - Remnant varices

Procedure 1: Thoracoabdominal Approach with Splenectomy

Norihiro Kokudo, Seiji Kawasaki

Outline of the Procedure Thoracoabdominal esophageal transection: The Sugiura procedure is a transthoracoabdominal esophageal transection, which consists of paraesophageal devascularization, esophageal transection and reanastomosis, splenectomy, and pyloroplasty. These thoracic and abdominal operations are performed in one or two stages depending on the surgical risk of the patients. The most important and unique feature of this procedure is an extensive devascularization from the level of the left pulmonary vein to the upper half of the stomach 6–7 cm along the lesser curvature below the cardia (Fig. 85.1).

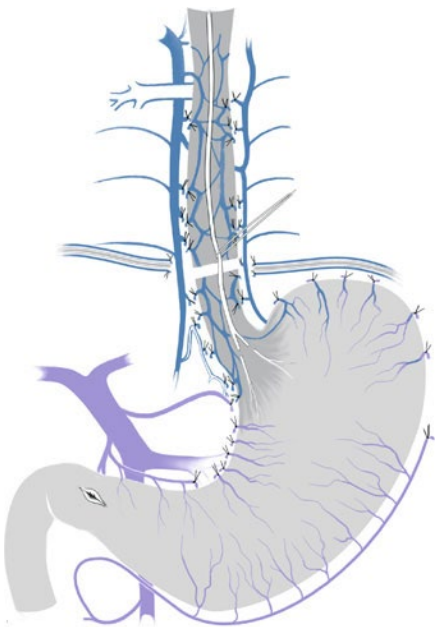


Fig. 85.1

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Step 1

Incision and exposure of the thoracic esophagus

A standard left lateral thoracotomy incision is made, entering via the seventh intercostal space.

The inferior mediastinum is opened at the anterior portion of the descending aorta (Fig. 85.2).



Fig. 85.2

Step 2

Paraesophageal devascularization

Using a curved Kelly forceps, the thoracic esophagus is isolated and taped at a level where collateral veins are scant. In emergency cases, lifting of the tape facilitates hemostasis inside the esophagus. Lifting the esophagus, paraesophageal devascularization is performed. Many dilated collateral veins resembling a vein plexus can be recognized around the esophagus. They are parallel to the vagus nerves and have many shunts to the esophagus. All of these shunting veins must be completely ligated and divided, with care taken not to damage the vagal trunks and collateral veins. There are usually about 30–50 shunting veins to be ligated. The length of devascularization of the thoracic esophagus is about 12–18 cm. The upper edge of the devascularization is the inferior pulmonary vein, and the lower edge is where preperitoneal adipose tissue is exposed (Fig. 85.3).

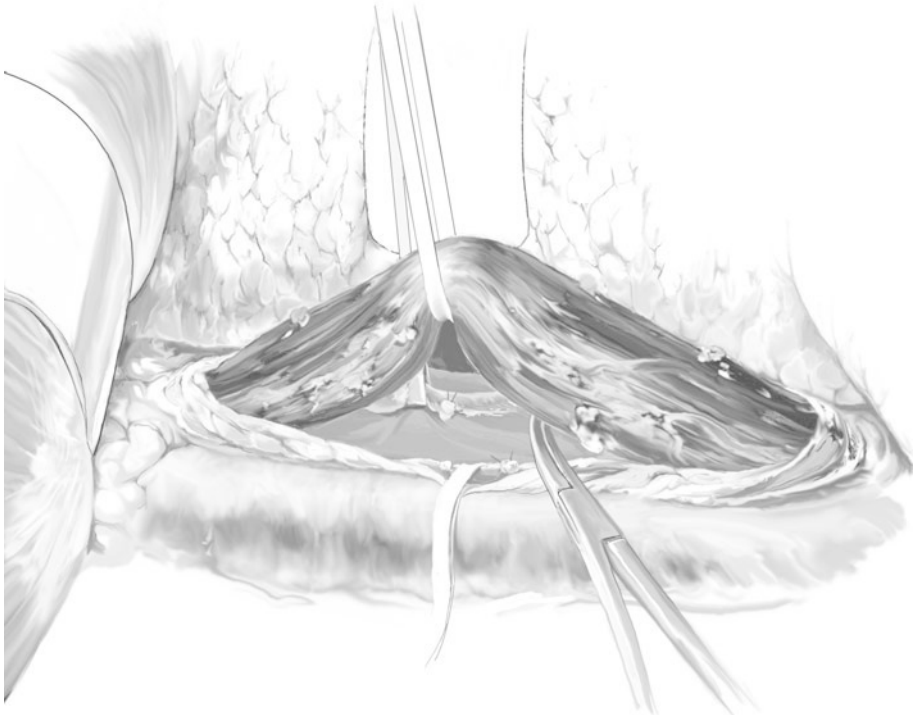


Fig. 85.3

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Step 3

Esophageal transection part 1

Upon completion of devascularization, the esophagus is doubly clamped with pairs of specially ordered esophageal clamps of the noncrushing, nonslipping type similar to Botallo's forceps ("Sugiura's clamp"). The distance between the two clamps is approximately 4 cm. The two clamps are jointed with a thumbscrew in the midportion.

Esophageal transection is performed at the level of the diaphragm. The anterior muscular layer is divided with a knife and a tape passed around the submucosal layer (Fig. 85.4).

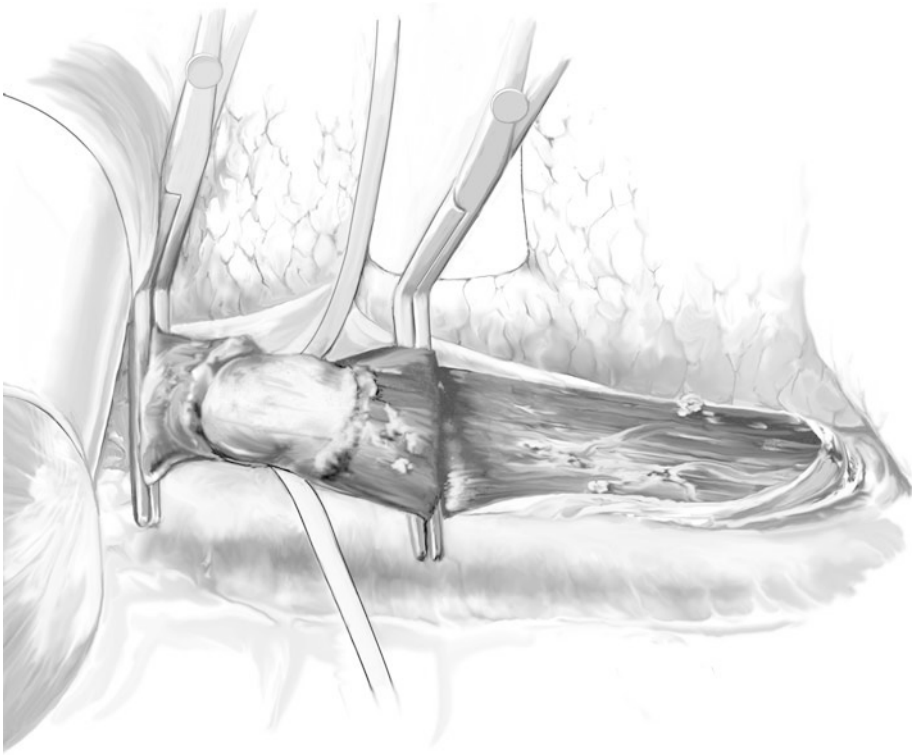


Fig. 85.4

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Step 4

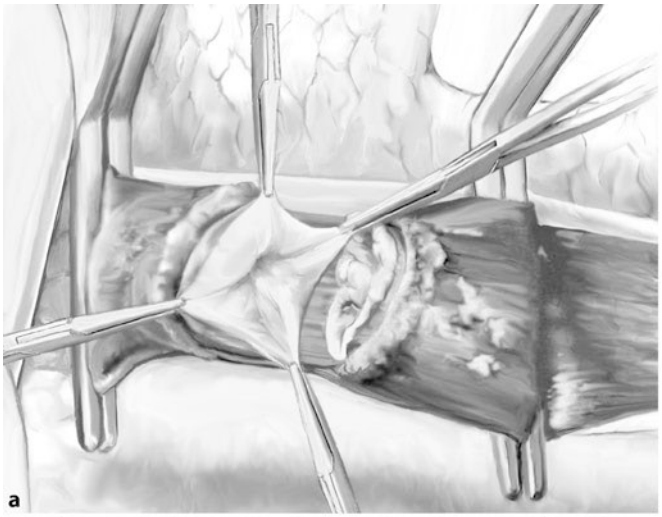
Esophageal transection part 2

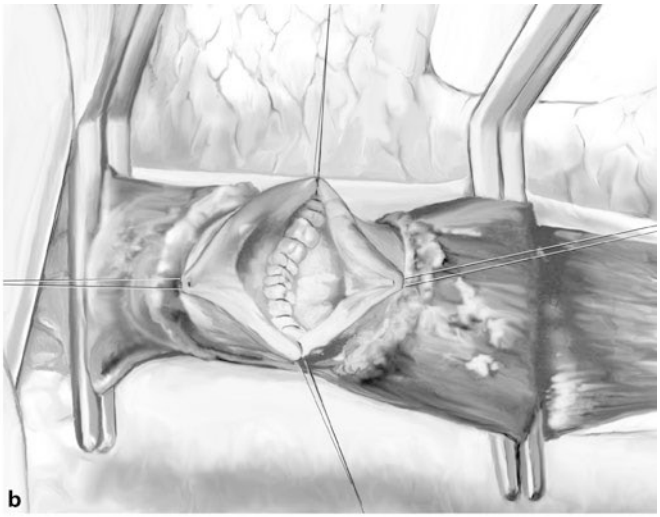
The mucosal layer of the esophagus is completely divided, with the posterior muscular layer left intact (Fig. 85.5a). The posterior muscle layer is preserved to prevent twisting, stricture, and leakage. The divided esophageal varices should not be ligated, because ligation of the divided varices may cause postoperative stenosis.

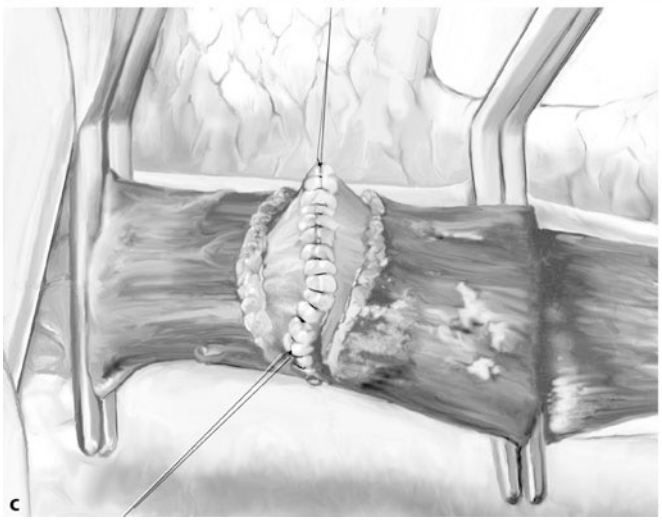
Posterior mucosal layer is sutured using 4-0 or 5-0 Vicryl (Fig. 85.5b).

Anterior mucosal layer is sutured (Fig. 85.5c). About 50–70 interrupted sutures are placed in total, and the divided varices are occluded with sutures.

After the muscle layer of 4-0 Ti-Cron is completed, a nasogastric tube is left in the stomach (Fig. 85.5d).







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Step 4 ***(continued)***

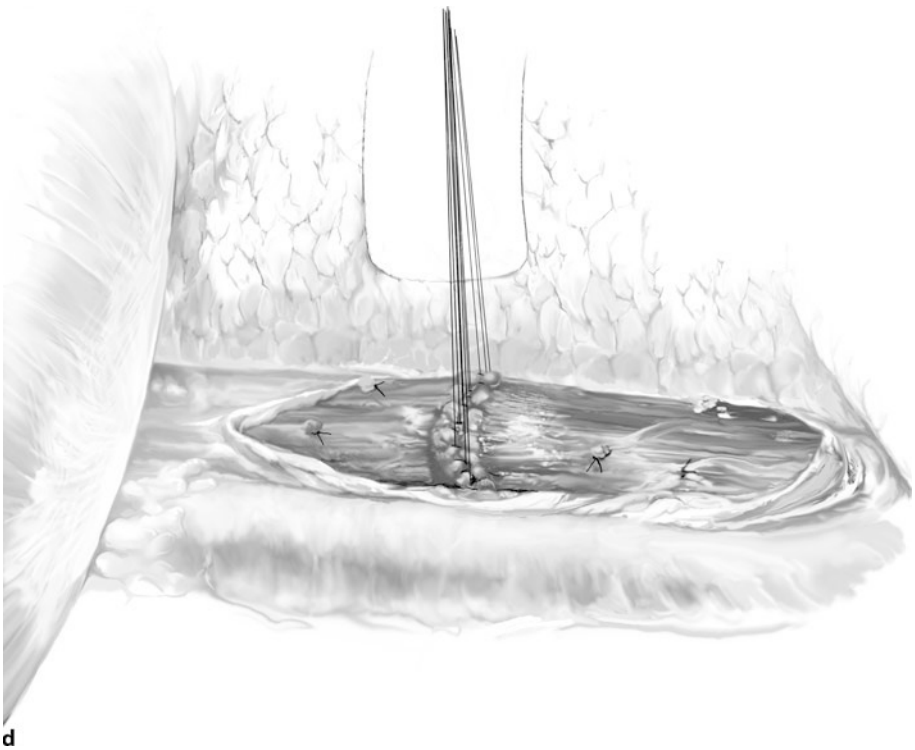


Fig. 85.5

Step 5

Diaphragmatic incision

After completion of esophageal transection, the diaphragm is incised, with care taken not to damage the phrenic nerve and pericardiacophrenic vessels.

The spleen is then exposed and the left triangular ligament of the liver is divided and ligated (Fig. 85.6).

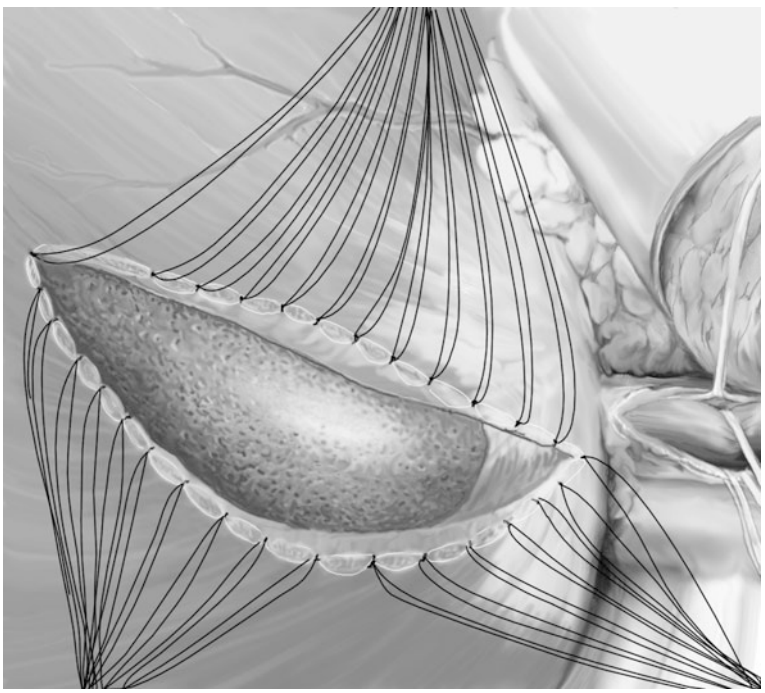


Fig. 85.6

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Step 6

Splenectomy part 1

The splenophrenic, splenorenal, and splenocolic ligaments are divided and the spleen is completely mobilized. The gastrosplenic ligament is divided and short gastric vessels are transected. The dissection is directed toward the hilus of the spleen (Fig. 85.7).

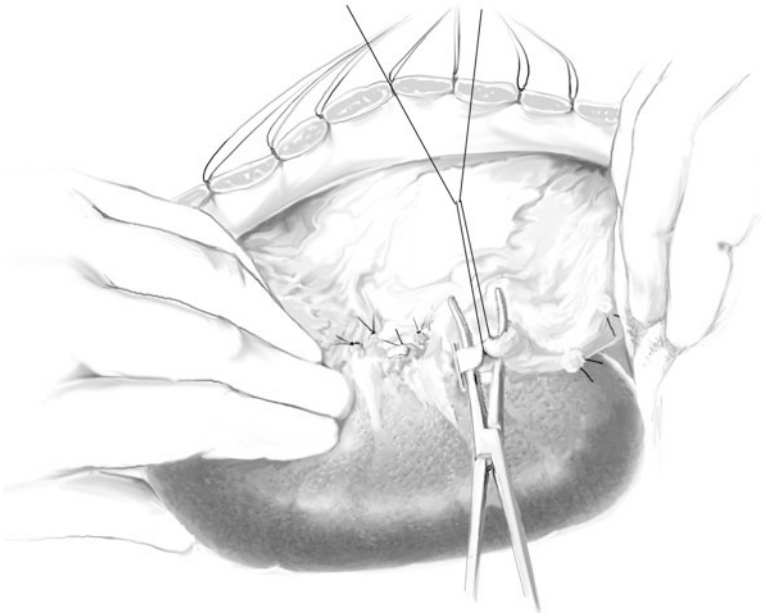


Fig. 85.7

Step 7

Splenectomy part 2

After the ligamentous attachments and short gastric vessels have been divided, all that remains are the main splenic artery and vein. They are doubly ligated and divided. Care should be taken not to damage pancreatic tissue, because even a small tear may cause pancreatic leakage (Fig. 85.8).

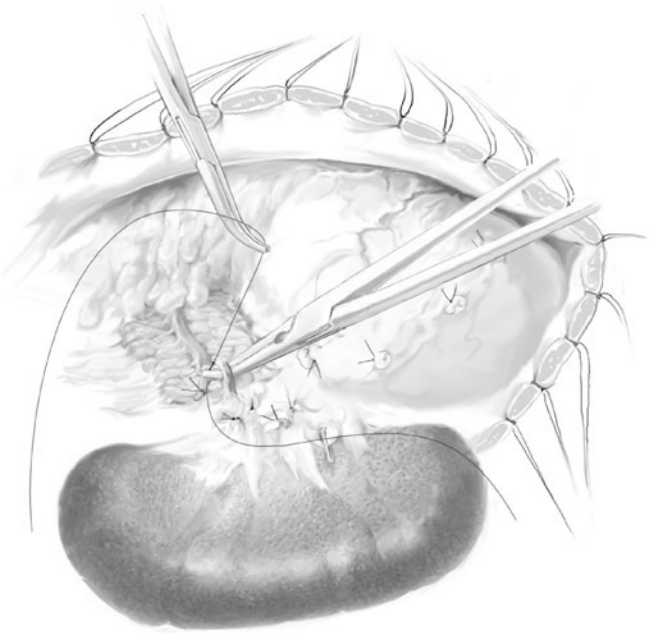


Fig. 85.8

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Step 8

Paraesophagogastric devascularization

The abdominal esophagus and the cardia are devascularized from the greater curvature and the posterior surface of the stomach to the esophagus. The posterior gastric vagus nerve is divided by this procedure because the nerve runs very close to the stomach. Devascularization of the lesser curvature of the stomach and the abdominal esophagus follows, and the cardioesophageal branches of the left gastric vessels are ligated and divided. The length of devascularization is about 7 cm at the lesser curvature of the cardia.

The esophagus and the cardia are completely mobilized and freed from the adjacent structures. A common pyloroplasty is performed because the gastric vagus nerves are divided (Fig. 85.9).



Fig. 85.9

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Step 9

Closure

A drain is inserted in the left subphrenic space and the diaphragm is closed with 2-0 Vicryl (Fig. 85.10a).

The mediastinum is closed with 4-0 Ti-Cron (Fig. 85.10b), and the chest is closed after inserting a chest drain. A tight closure of the mediastinum may prevent thoracic empyema when a minor anastomotic leakage occurs.

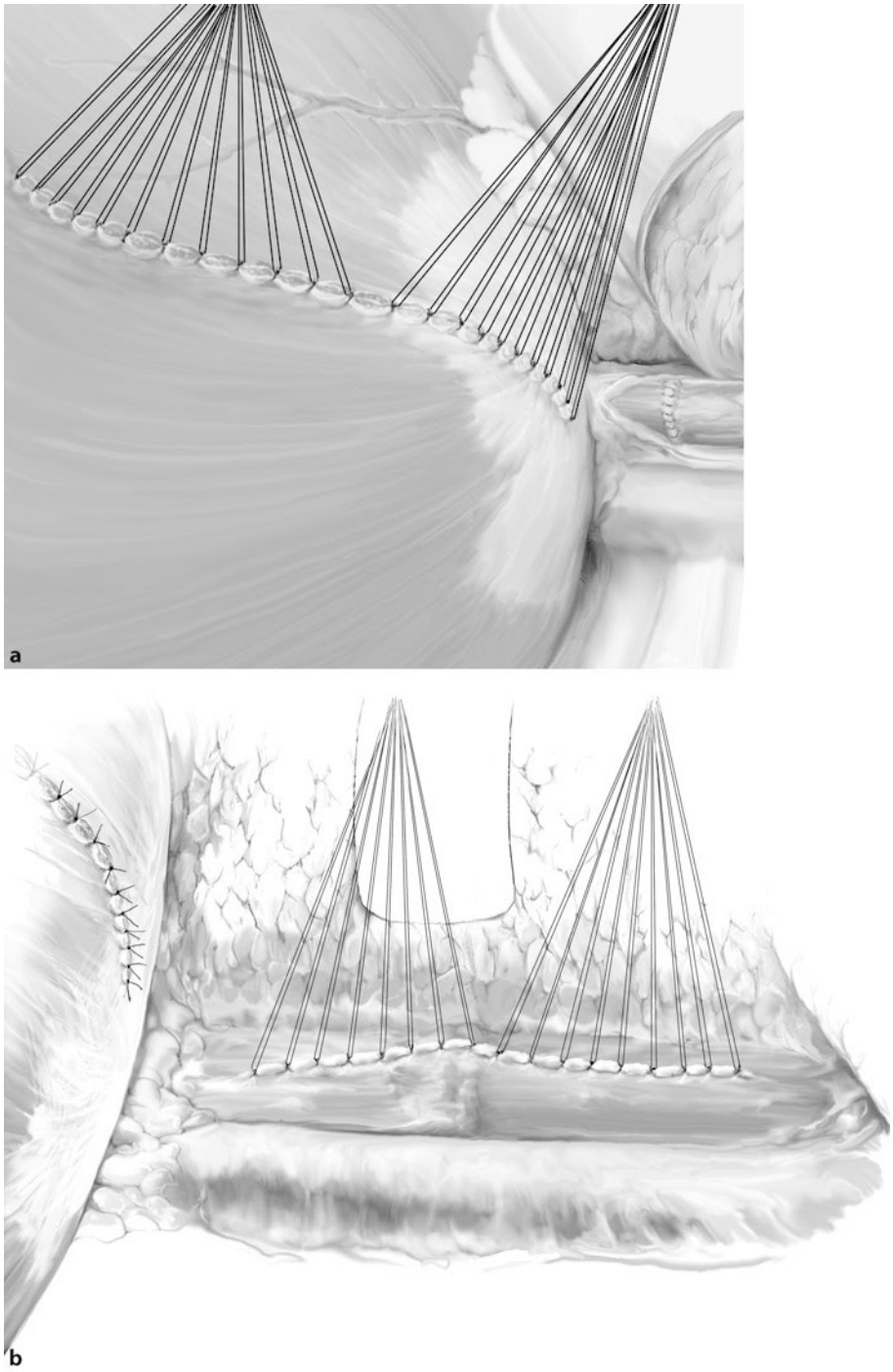


Fig. 85.10

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Tricks of the Senior Surgeon

- During the devascularization procedure, every shunting vein between the dilated paraesophageal collateral veins and the esophageal wall should be ligated. Care should be taken not to damage the vagal trunks and collateral veins, which are theoretically very important in preventing variceal recurrence. Although this is not always practically achievable, collateral channels in the mediastinum are believed to be preserved during the operation.
- A lasting extirpation of esophageal varices after nonshunting operation may depend on the portosystemic collateral changes that take place after the operation. Preserved paraesophageal and mediastinal collateral channels after the Sugiura operation are expected to function as a spontaneous shunt.

Acknowledgments

The authors thank Dr. Shunji Futagawa (Professor Emeritus of the 2nd Department of Surgery, Juntendo University) for supplying original drawings for this chapter.

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Procedure 2: Complete Porto-azygos Disconnection with Spleen Preservation

Hector Orozco, Miguel A. Mercado

Complete porto-azygos disconnection requires both abdominal and thoracic procedures. The following series of illustrations offers the alternative of a spleen preserving abdominal devascularization.

Indications, testing, and preoperative management are the same as for the full thoracoabdominal procedure described in the previous chapter.

Overview of the Abdominal Procedure The abdominal part of the procedure includes the following components (Fig. 85.11):

- Dividing the gastrohepatic ligament – gastrocolic ligament – left gastric artery and vein.
- Ligature the right gastric artery and vein over the lesser curvature.
- Ligature the right gastroepiploic vein.
- Devascularization of the great curvature with preservation of the spleen.
- Devascularization of the abdominal esophagus and transection of the main vagus nerves.
- Pyloroplasty.

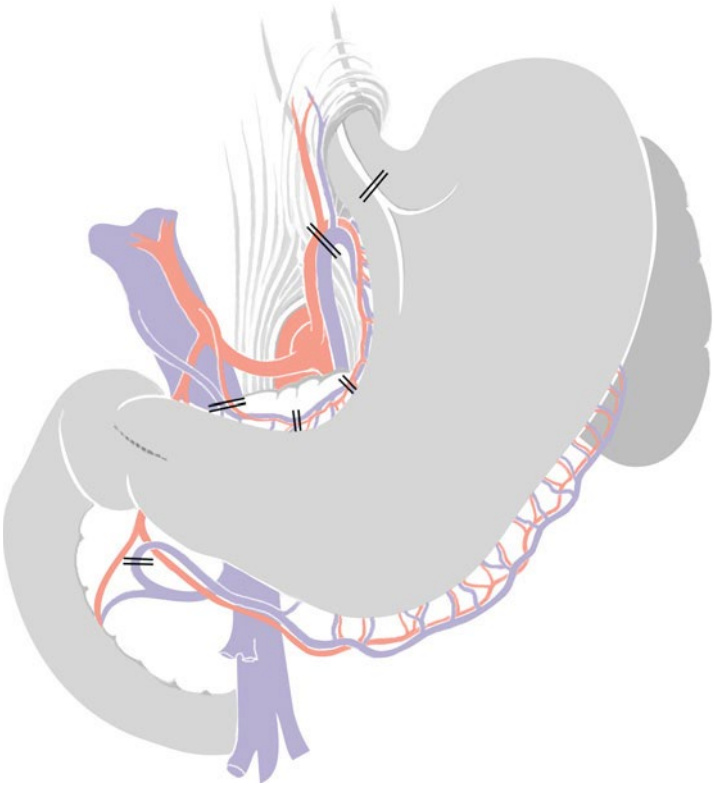


Fig. 85.11

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Step 1

Devascularization of the greater curvature

From the left side, showing the complete devascularization of the greater curvature of the stomach, with all vessels divided from the pylorus up to the esophagus. The short gastric vessels are divided, leaving the spleen in situ (Fig. 85.12).

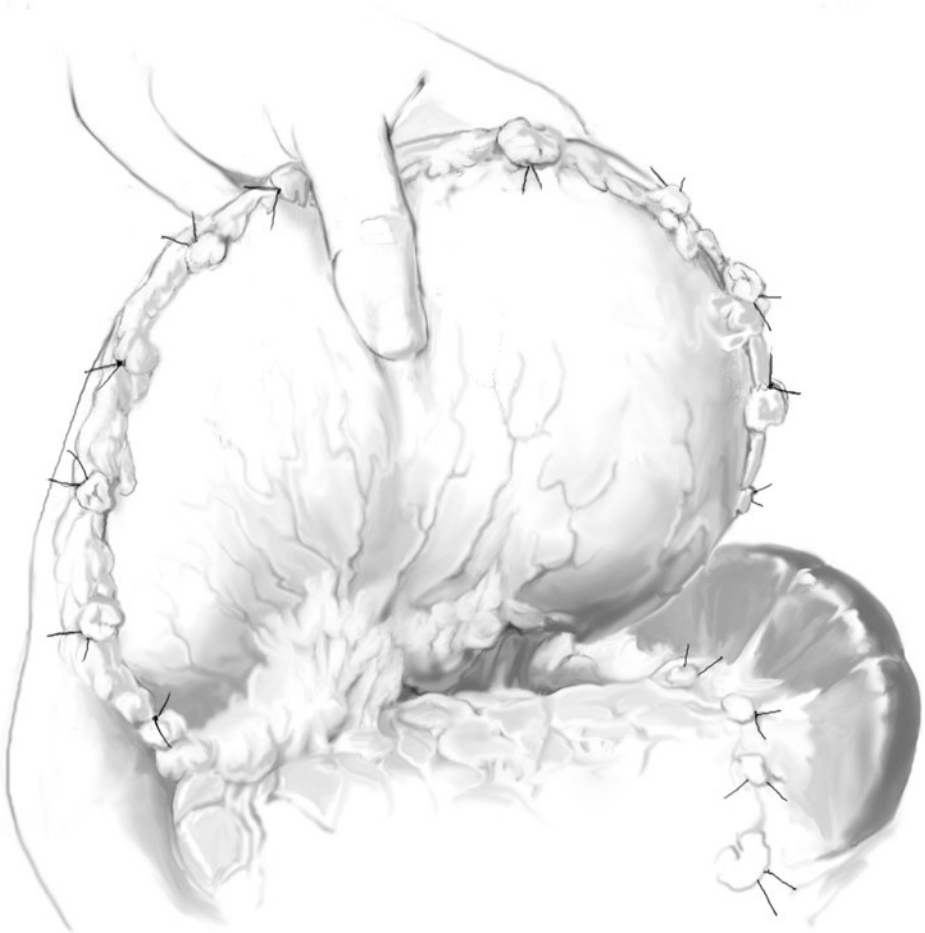


Fig. 85.12

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Step 2

Completion of the devascularization of the lesser curvature

Complete devascularization of the stomach from the right side of the patient. This shows the upper two-thirds of the lesser curvature devascularized up to the esophagus (Fig. 85.13).



Fig. 85.13

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Step 3

Devascularization of the esophagus

Complete devascularization of the esophagus and stomach viewed from behind, from the left side of the patient. The esophagus is circumferentially devascularized for 7 cm above the gastroesophageal junction. The preservation of the spleen can be seen (Fig. 85.14).

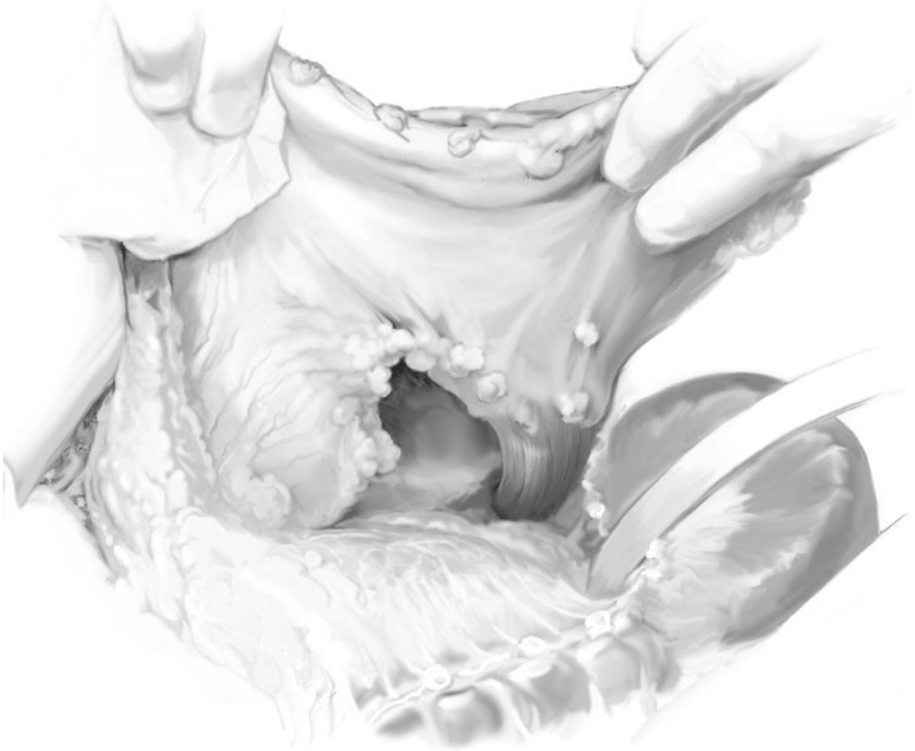


Fig. 85.14

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Step 4

Ligation of the right gastroepiploic vein

The right gastroepiploic vein is ligated below the pylorus while the right gastroepiploic artery is preserved (Fig. 85.15).

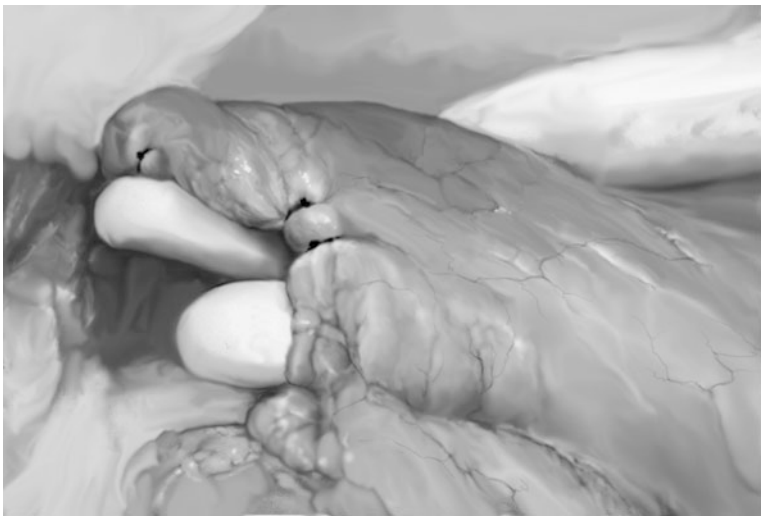


Fig. 85.15

Step 5

Pyloroplasty

Pyloroplasty is performed with a single layer of interrupted sutures as in the first procedure (Fig. 85.16).

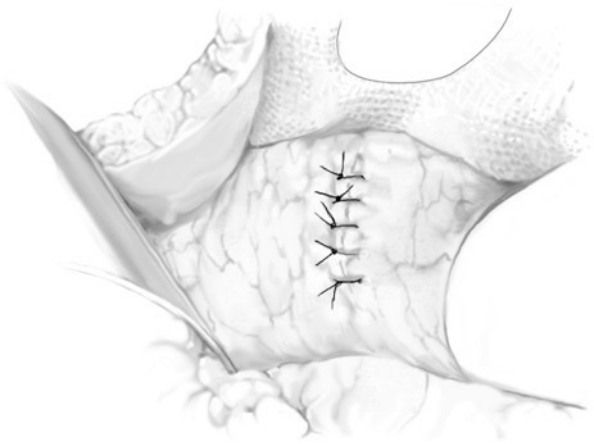


Fig. 85.16

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Procedure 3: Abdominal Approach Only with Splenectomy

Markus Selzner, Pierre-Alain Clavien

Step 1

Access and mobilization

A Thompson retractor is installed after left transverse incision and midline extension. A transverse upper abdominal incision is performed at the left side with a midline extension up to the xyphoid. Both rectus muscles are transected and the abdominal cavity is entered to the left of the midline. The abdominal cavity has to be opened with care since enlarged veins might be present in the setting of portal hypertension.

Step 2

Isolation of the spleen

The splenectomy in the setting of portal hypertension is often the most challenging part of the procedure. The vessels along the large gastric curvature are divided to expose the short gastric vessels, which are isolated and separated. Then the posterior adhesions of the spleen are divided. Afterwards the left colon flexure is retracted downwards and the adhesions between colon and spleen are divided (Fig. 85.17a).

The hilus of the spleen is isolated and the splenic artery and vein are identified whenever possible. The hilar structures are clamped with large Kelly clamps, divided and suture-ligated. Removal of the enlarged spleen results in more space in the left upper abdomen and often facilitates the further preparation of the stomach and the esophagus (Fig. 85.17b).

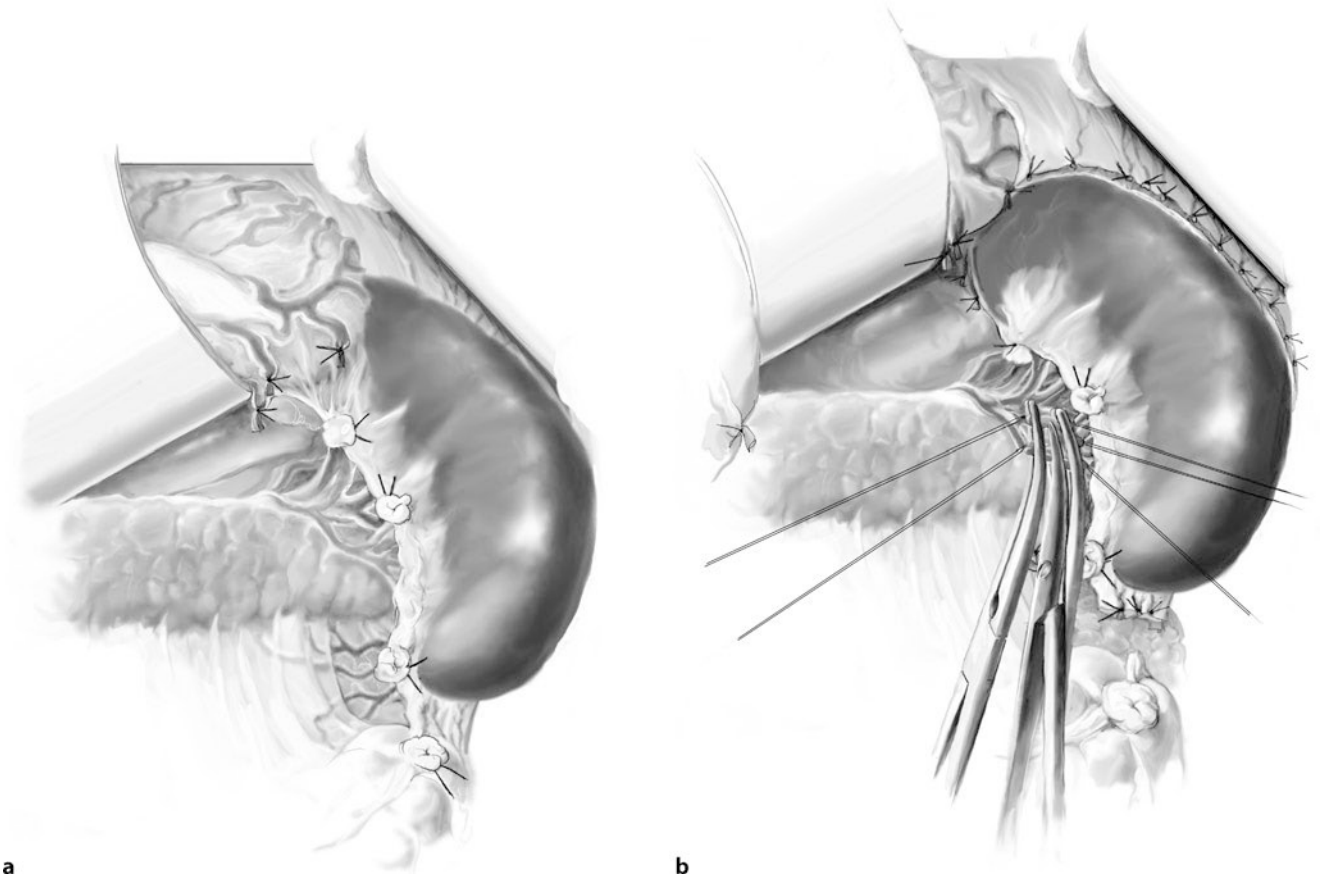


Fig. 85.17

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Step 3

Devascularization of the lesser and larger gastric curvature

The preparation of the stomach is similar to the spleen-preserving technique and has been described in the previous chapters. Briefly, the upper two-thirds of the stomach is isolated. The gastric vessels are ligated close to the stomach wall. Unlike in the spleen-preserving procedure, care must be taken to preserve the right gastric artery and vein as well as the left gastric vein. It is important to perform the gastric isolation close to the stomach wall in order to preserve vessels draining to the azygos veins (Fig. 85.18).

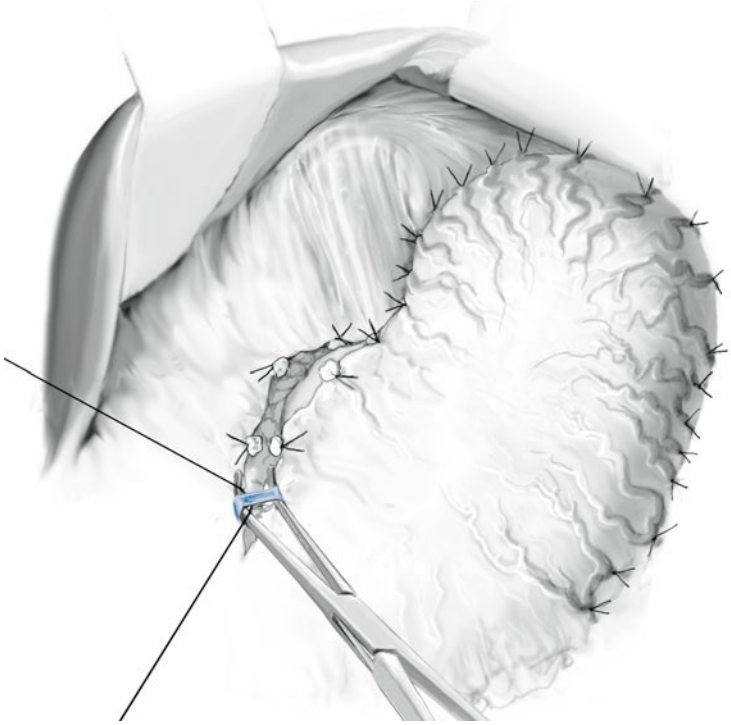


Fig. 85.18

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Step 4

Isolation of the distal esophagus

The lower 12 cm of the esophagus is isolated. The venus plexuses directly on the esophagus are transected. The vagus nerve is also divided during this maneuver. All transverse vessels to the esophagus must be separated and ligated. It is important to preserve longitudinal vessels parallel to the esophagus, which drain in the azygos system (Fig. 85.19).

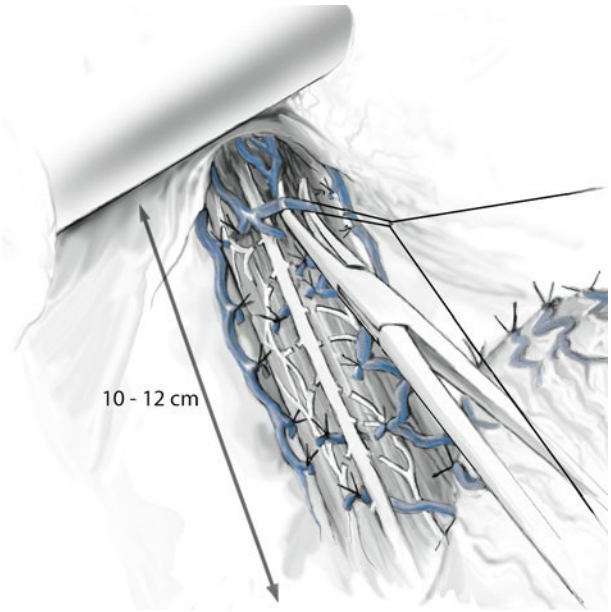


Fig. 85.19

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Step 5

Transsection of the esophagus

A transverse incision is performed in the well-vascularized distal part of the stomach. An end-to-end anastomosis (EEA) stapler is introduced and advanced to the lower esophagus. A ligature is placed around the EEA stapler and the esophagus is transsected 5 cm above the gastroesophageal junction. After firing the EEA stapler an intact mucosa ring must be present in the head of the EEA (Fig. 85.20).

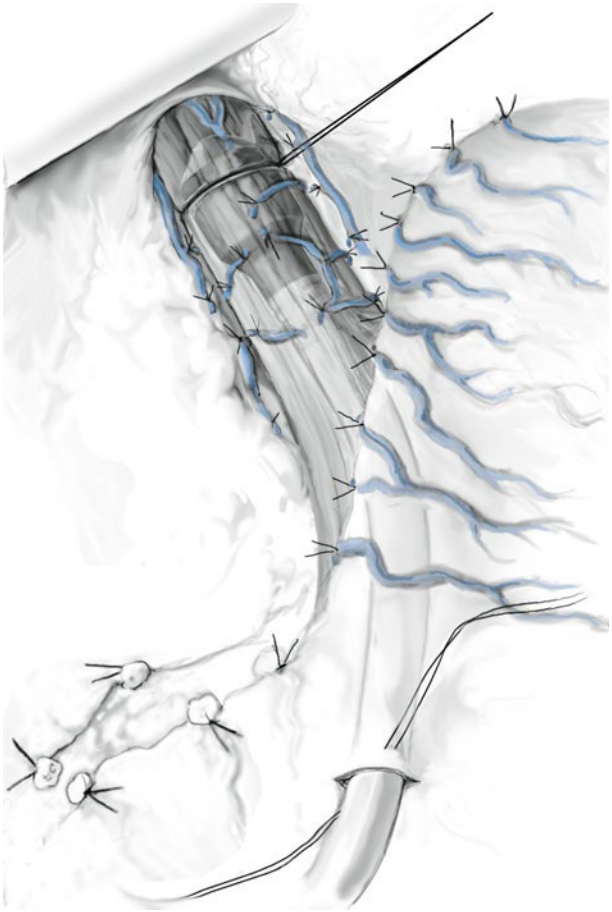


Fig. 85.20

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Step 6

Pyloroplasty

As in the first two procedures, an extramucosal pyloroplasty according to Mikulic is performed. The muscles of the pylorus are divided longitudinally without opening the mucosa. The incision is closed with transverse single sutures (PDS 2-0) (Fig. 85.21).

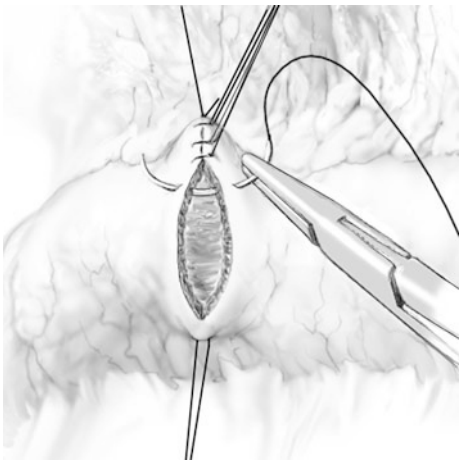


Fig. 85.21

Tricks of the Senior Surgeon

- Preserve the blood flow to the azygos system (left gastric vein).
- Perform gastric devascularization after splenectomy.
- Introduce the EEA stapler in the distal nonischemic stomach.

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Introduction: Pancreas

Michael G. Sarr

The past two decades have witnessed the exploding evolution of surgical thought and approach toward pancreatic diseases and the role of operative intervention. New operations, escalating technology (especially in minimally invasive approaches), and even new philosophies of the operative management of pancreatic disease have been embraced. These changes are based on a better understanding of the etiopathogenesis of pancreatic diseases (e. g., necrotizing pancreatitis), the introduction of new technology (laparoscopy, minimal access approaches, operative robots, interventional radiology/endoscopy), and the vast advances in both diagnosis (CT, endoscopic ultrasonography, MRI, positron emission tomography) and critical care medicine. Indeed, the relatively "new" disease of intraductal papillary mucinous neoplasm and other associated cystic neoplasms have added a new dimension to pancreatic surgery. With these advances, experience with certain operations (e. g., pancreatoduodenectomy) has increased markedly and operative morbidity and mortality have decreased, convincing our colleagues in internal medicine and gastroenterology that aggressive resectional approaches to the pancreas (in experienced centers) are associated with operative mortalities below 5 %, rather than the mortality rates of 20–25 % that were common in the 1960s and 1970s. Indeed, the approach by medical oncologists has also become more aggressive and optimistic.

New operations have appeared:

- Chronic pancreatitis
  - Duodenum-preserving head resection (Beger/Frey procedures)
  - Thoracoscopic splanchnicectomy
- Necrotizing pancreatitis
  - Aggressive necrosectomy with several different techniques of peripancreatic drainage
  - Minimal access necrosectomy (not just drainage)
- Recurrent pancreatitis
  - Sphincterotomy/septectomy
- Pancreas transplantation
  - Islet cell, segmental, whole organ
- New technology
  - Laparoscopic approaches to the enucleation of pancreatic islet cell neoplasms, distal pancreatectomy, internal (enteric) drainage of pseudocyst, gastrojejunostomy, even necrosectomy for necrotizing pancreatitis
  - And now, even laparoscopic or robot-assisted laparoscopic pancreatoduodenectomy
- New philosophies
  - Laparoscopic staging of pancreatic malignancies to avoid nontherapeutic celiotomies

But other basic techniques, approaches, and operations have not changed dramatically and require the same careful, systematic exposure and operative skills.

This part deals with the old and the new. Each part is written by experts and includes their tricks that might facilitate, speed, or improve the exposure and conduct of the operations involved.

The next two decades will continue this relentless evolution in surgery of the pancreas. It will be interesting to watch how the current state of the art changes – won't it?

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery*,
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Drainage of Pancreatic Pseudocysts

Gerard V. Aranha, Gerard J. Abood, Lawrence W. Way

The goals of surgical treatment of most pancreatic pseudocysts are to provide a pathway of internal (enteric) drainage of the "leaking" exocrine secretions to allow the pseudocyst cavity to collapse, thereby either "sealing off" the ductal leak or creating a permanent internal fistula for drainage. Internal drainage includes cystogastrostomy, cystojejunostomy, and less commonly, cystoduodenostomy. Internal drainage can also be accomplished by endoscopic cystogastrostomy or cystoduodenostomy in selected patients.

Indications and Contraindications

Indications

- *Cystogastrostomy:* symptomatic or large pseudocysts of the pancreas adherent to the posterior wall of the stomach (i. e., the posterior wall of the stomach forms the anterior wall of the pseudocyst)
- *Cystojejunostomy:* a pseudocyst not adherent to the posterior gastric wall in any location in the pancreas (head, body, or tail), or pseudocysts that bulge through the transverse mesocolon
- *Cystoduodenostomy:* a pseudocyst of the head of the pancreas anatomically placed so that only a cystoduodenostomy is possible

Contraindications

- *Cystogastrostomy:* Pseudocyst in the head or tail of the pancreas that is not adherent to the stomach, or a pseudocyst that bulges through the transverse mesocolon with the most caudal extent substantially caudal to the stomach
- When the surgeon is not entirely certain that the cystic mass is a pseudocyst of the pancreas
- Grossly infected pseudocysts
- *Cystojejunostomy:* Pseudocysts more amenable to cystogastrostomy or cystoduodenostomy
- *Cystoduodenostomy:* Pseudocyst not immediately adjacent to the duodenum, or concern about disrupting pancreatic ductal entry into the duodenum (major or minor ampulla)

Preoperative Investigations and Preparation for the Procedure

- *History:* Vague abdominal or back pain after an attack of acute pancreatitis; nausea, vomiting, and weight loss, especially in an alcoholic
- *Clinical:* Fullness or mass in the epigastrium
- *Laboratory tests:* Persistent increase in serum amylase after an attack of acute pancreatitis
- *Diagnostic imaging:* CT scans can identify one or more pseudocysts in the pancreas and may help to differentiate a cystic neoplasm from a pseudocyst
- *ERCP:* Endoscopic retrograde cholangiopancreatography (ERCP) is rarely used but can differentiate a pseudocyst that communicates with the main pancreatic duct from a cystic neoplasm, which should not communicate with the pancreatic duct unless it is an intraductal papillary mucinous neoplasm (IPMN)
- *Preoperative preparation:* NPO for 2 to 6 hours before operation. A perioperative prophylactic intravenous antibiotic is repeated, depending on the duration of operation

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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Open Procedures

Gerard V. Aranha

Open cystogastrostomy

Step 1

Exposure of the pseudocyst

- A bilateral subcostal incision is preferred; alternatively, a midline incision may be used.
- After routine abdominal exploration, a mechanical ring retractor is placed to retract the liver and abdominal wall.
- The pseudocyst adherent to the posterior gastric wall is visualized or palpated transgastrically.
- Seromuscular stay sutures are placed in the anterior gastric wall over the cyst.
- A gastrotomy is made, and the anterior gastric wall is retracted using stay sutures (Fig. 87.1).

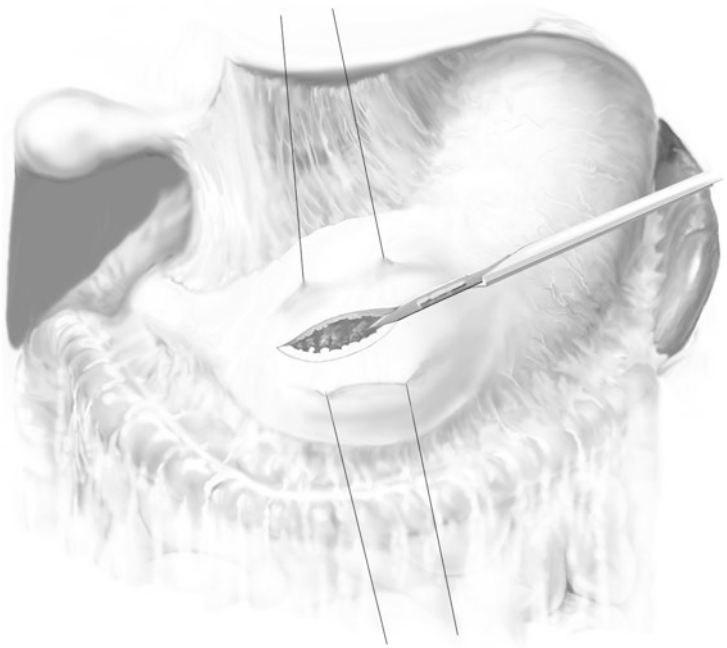


Fig. 87.1

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Step 2

Transgastric opening of pseudocyst

- The cyst should be obvious from the preoperative imaging and is palpated through the posterior gastric wall.
- The cyst is aspirated using a 22-gauge needle. Clear, opalescent, or brownish fluid is usually obtained; if thick, mucoid fluid is obtained, the diagnosis of cystic neoplasm must be entertained (Fig. 87.2a).
- After aspiration, the syringe is removed from the needle, which is left in place and secured with a hemostat.
- A #11-blade knife is used to enter the cyst alongside the needle (Fig. 87.2b).
- Once the cyst is entered, the needle is removed and a right-angled clamp is inserted into the opening, elevating the posterior wall to enlarge the opening to at least 3 to 4 cm, or longer if possible.
- Biopsy of the cyst wall using a long-handled, #15-blade knife should be imperative (Fig. 87.2c).
- The cyst is probed with a finger, loculations gently broken down, and contents aspirated. Thick debris is removed carefully with packing forceps. The inside of the cyst should be examined for any evidence of neoplasm.

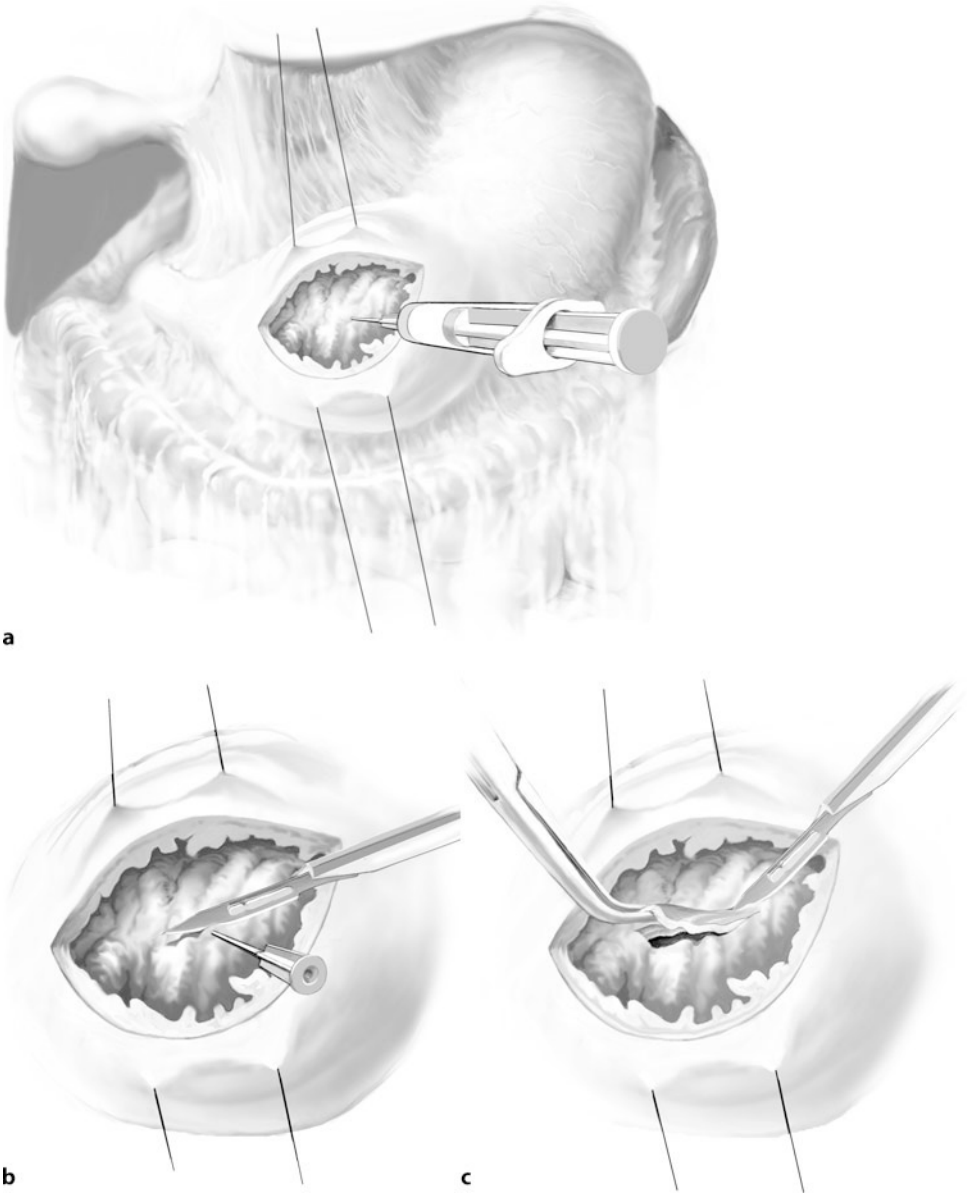


Fig. 87.2

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Step 3

Oversewing of cystogastrostomy

- The posterior common cyst/gastric wall is oversewn ("reefed") with running 3-0 silk suture to minimize the chance of bleeding from the edges of the gastrocystostomy created. One suture is run from 3 o'clock to 9 o'clock and tied, and the other suture is run from 9 o'clock to 3 o'clock; this avoids a "pursestring" effect on the opening and allows the cyst to communicate freely with the stomach (Fig. 87.3).
- The anterior gastrotomy is closed in two layers: the inner, running 3-0 polyglyconate suture is placed in a Connell fashion to invert the mucosa and obtain hemostasis; the outer layer consists of interrupted 3-0 silk seromuscular sutures.
- The abdomen is closed without drainage using running 1-0 polydioxanon for the anterior and posterior rectus fasciae for a subcostal incision, and 1-0 polyglycolic acid for a midline incision.
- The skin incision is closed with staples.

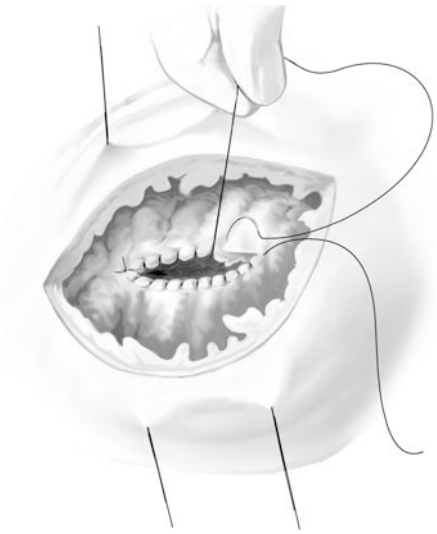


Fig. 87.3

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Open cystoduodenostomy

Specific indications include a pseudocyst in the head of the pancreas anatomically placed so that only a cystoduodenostomy is possible. This usually means that the cyst is small and abuts the medial wall of the duodenum.

Step 1

- The same approach/setup is used as for cystogastrostomy above.
- The pseudocyst is visualized and palpated.
- The cyst is aspirated with a 22-gauge needle (Fig. 87.4).
- A clear, opalescent, or brownish fluid should be obtained; mucoid fluid suggests a cystic neoplasm.
- The syringe is removed from the needle, and a #11-blade knife is used to enter the cyst along the needle.
- A right-angled clamp is inserted to elevate the cyst wall, for enlarging the opening to 2–3 cm or longer; a biopsy is taken of the cyst wall.

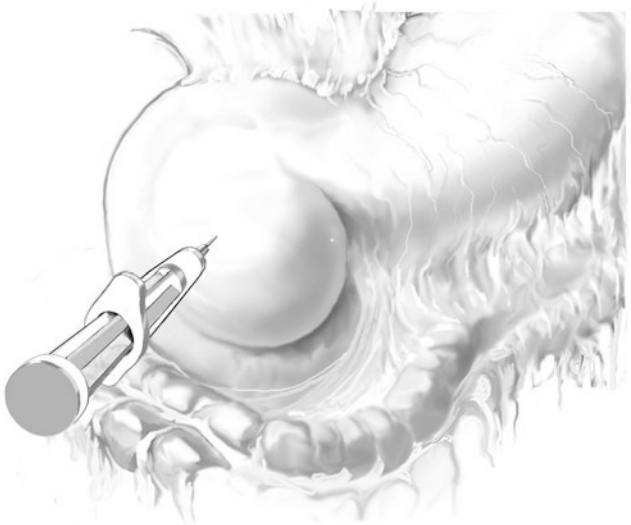


Fig. 87.4

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Step 2

- The duodenum is well Kocherized.
- Anterior vertical duodenotomy of at least 2–3 cm is performed (Fig. 87.5a). In this depiction, a lateral-to-lateral or side-to-side cystoduodenostomy is shown.
- Posterior sutures between the cyst and the duodenum are placed in a single interrupted layer using 3-0 silk or an absorbable suture (Fig. 87.5b).
- Sutures are placed from the duodenum to the cyst to create an anterior wall using a single layer of interrupted 3-0 silk (Fig. 87.5c).
- If a transduodenal cystoduodenostomy can be used, it is similar to cystogastrostomy. However, pseudocyst drainage into the duodenum is done into the first or third portion of the duodenum to avoid injuring the common duct; staying in the midline of the should help to avoid avoids injury to the gastroduodenal and pancreaticoduodenal vessels. Intraoperative ultrasonography can be used to identify the common bile duct and vessels if necessary.
- The abdominal incision is closed as for cystogastrostomy.

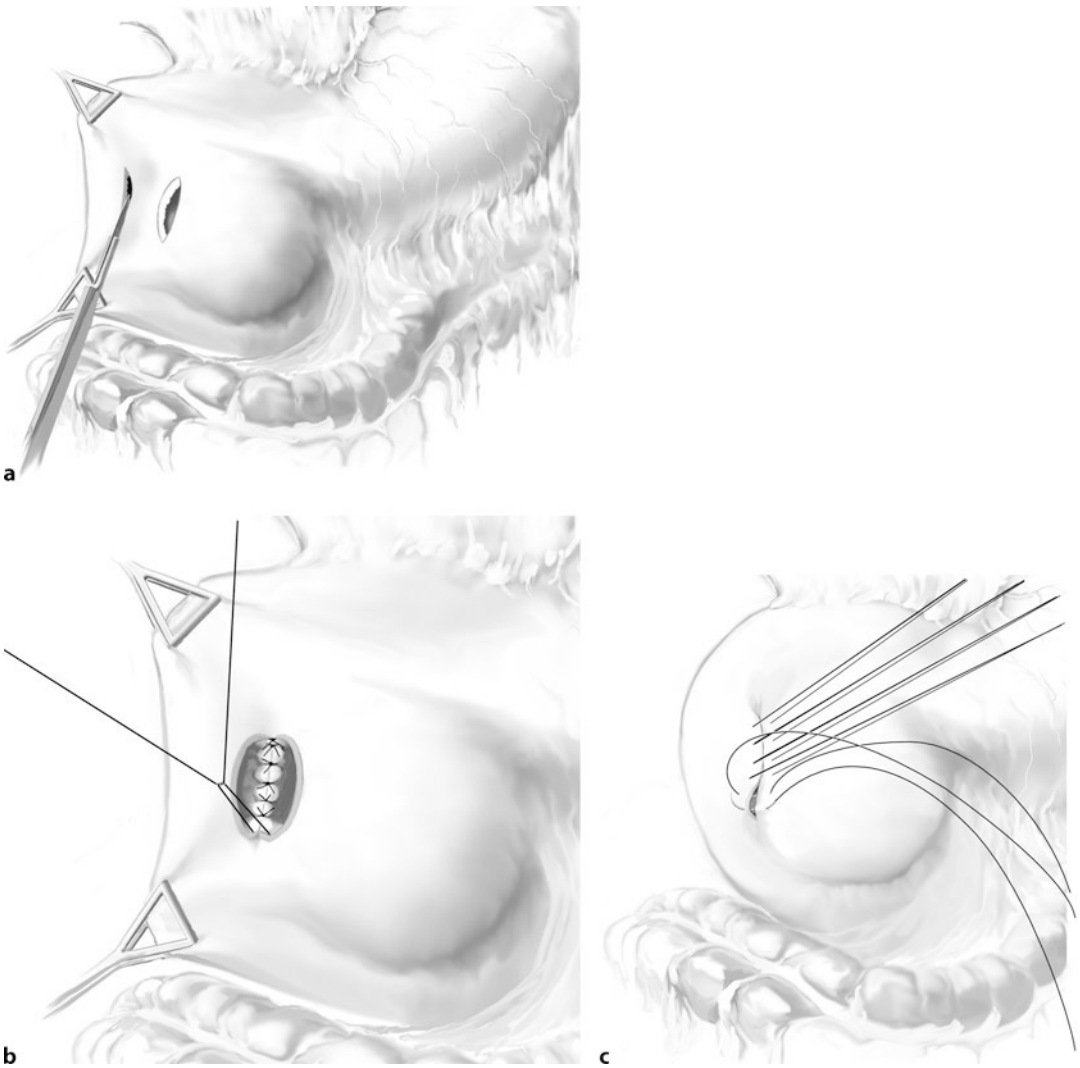


Fig. 87.5

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Open cystojejunostomy

Specific indications include a pseudocyst not adhering to the posterior gastric wall in any location in the pancreas (head, body, or tail) and those pseudocysts that bulge through the transverse mesocolon.

Step 1

Exposure of pseudocyst

- We prefer a bilateral subcostal incision with a mechanical ring retractor.
- The pseudocyst is adherent to the transverse mesocolon.
- Aspirate the cyst with a 22-gauge needle (Fig. 87.6).

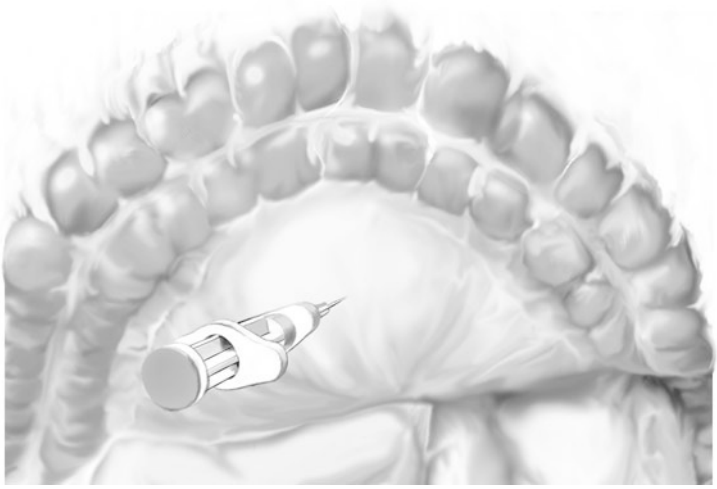


Fig. 87.6

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Step 2

- The jejunum is transected with a mechanical stapler 20 cm from the ligament of Treitz.
- The distal end is oversewn and brought up to the cyst as a Roux limb.
- 3-0 interrupted silk sutures are placed between the cyst wall and midway between the antimesenteric and mesenteric borders of the posterior jejunal wall for 4–5 cm or longer and tied down after all sutures are placed (Fig. 87.7a).
- A cystotomy is made avoiding the middle colic vessels in similar fashion as for cystogastrostomy and cystoduodenostomy; a biopsy is taken of the cyst wall (Fig. 87.7b).
- An interrupted single layer of 3-0 silk sutures is placed between the cyst and the jejunum to create an anterior wall (Fig. 87.7c).
- The cystojejunostomy is completed as for side-to-side cystoduodenostomy (Fig. 87.8).

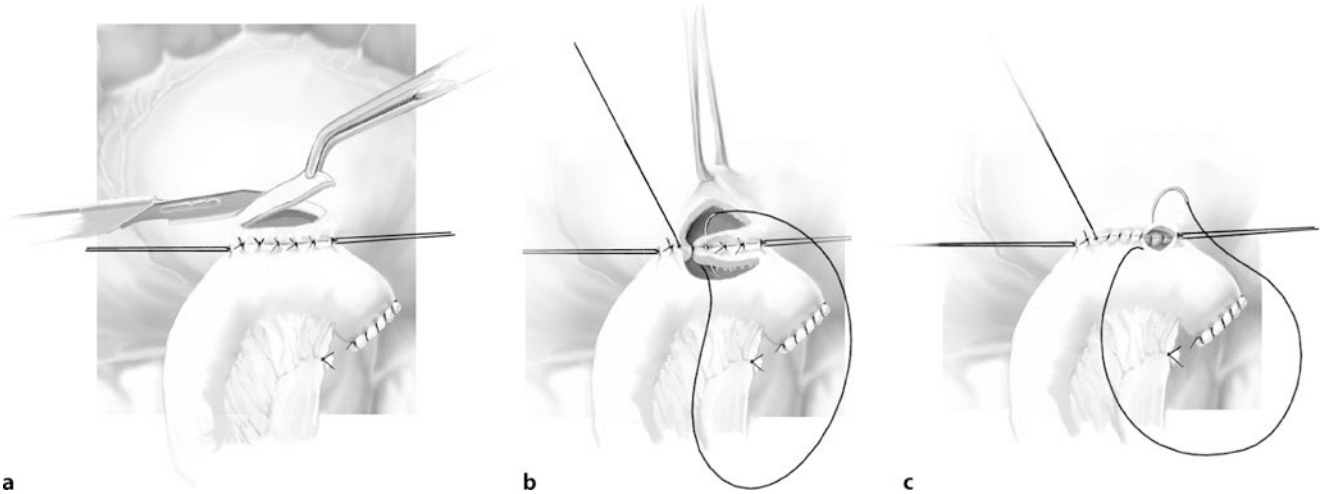


Fig. 87.7

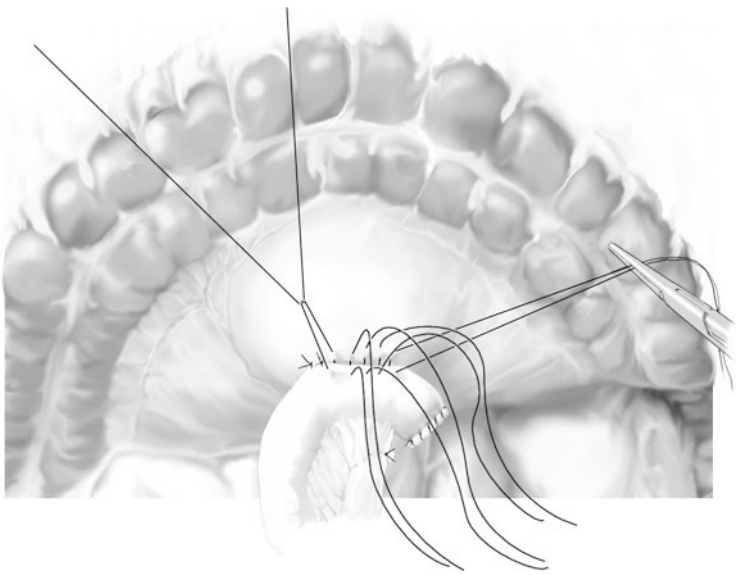


Fig. 87.8

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Step 3

- The proximal jejunum is anastomosed to the Roux limb 60 cm distally (Fig. 87.9).

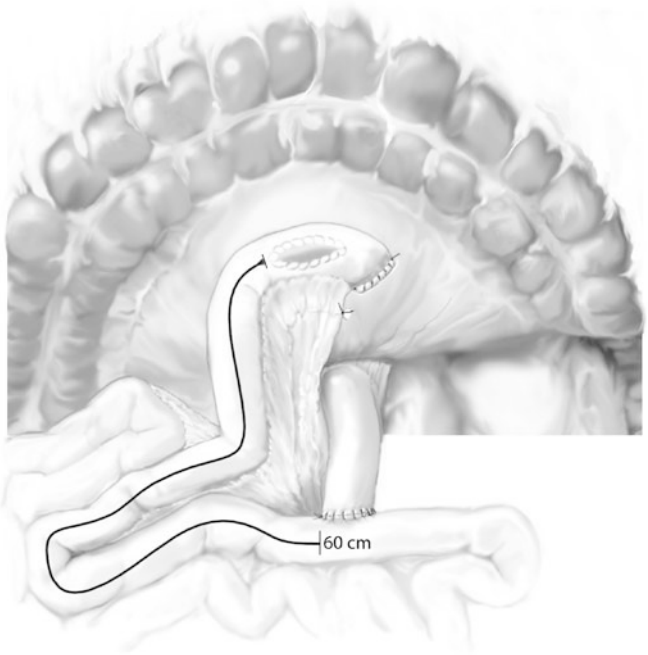


Fig. 87.9

Step 4

- When the pseudocyst does not bulge through the mesocolon and is not adherent to the stomach or duodenum, the gastrocolic ligament is taken down to enter the lesser sac.
- The Roux limb is brought retrocolic either to the right or left of the middle colic vessels (Fig. 87.10).
- The anastomosis of the pseudocyst is done as in Step 2.

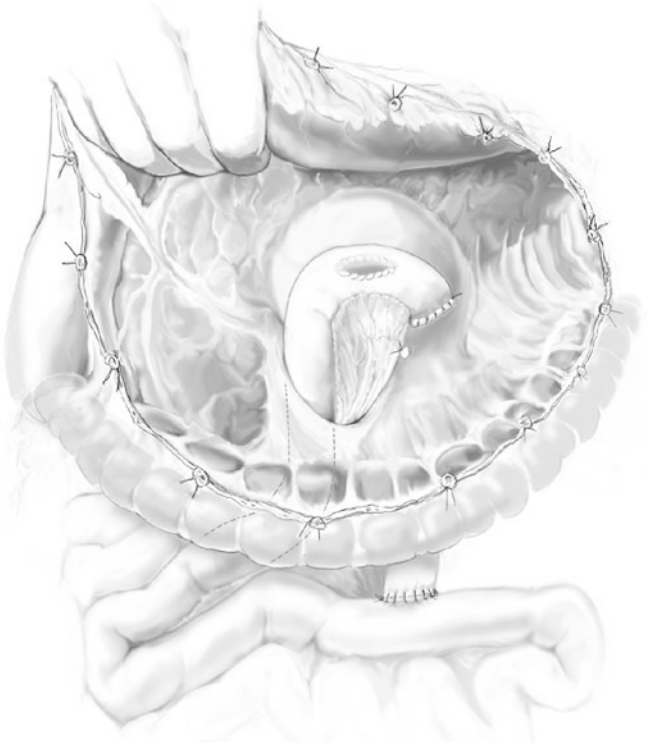


Fig. 87.10

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Laparoscopic Transgastric Drainage of Pancreatic Pseudocyst

Gerard J. Abood, Gerard V. Aranha

Enteric drainage of a pseudocyst (gastrocystotomy) can also be accomplished by totally laparoscopic transgastric drainage.

Step 1

Port placement, cyst identification, and anterior gastrotomy

- The abdomen is entered at the umbilicus, using the Hasson technique. Alternatively, a 5-mm trocar can be introduced at Palmer's point in the left upper quadrant, using an optical trocar.
- Placement of a 10-mm epigastric port and two 5-mm ports at the right midclavicular and right anterior axillary lines completes the initial trocar placement.
- A 30-degree or 45-degree, 5-mm laparoscope is inserted, and the laparoscopic ultrasound probe is introduced into the abdomen to identify the pseudocyst through the anterior wall of the stomach.
- A 6-cm, anterior gastrotomy is performed, with a 5-mm ultrasonic dissector entering the stomach where the pseudocyst is most apparent, bulging into the lumen from the posterior gastric wall.
- The cephalad and caudal edges of the gastrotomy are retracted in a fixed manner with full thickness sutures through each side of the gastrotomy. These sutures are brought through the anterior abdominal with a Carter-Thomason suture retrieval device; alternatively, two Keith needles can be used. The ends of the suture are secured at skin level with a hemostat (Fig. 87.11).

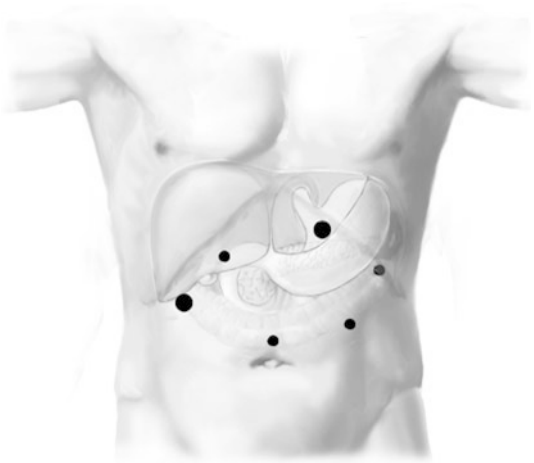


Fig. 87.11

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Step 2

Posterior gastrotomy and stapled cystogastrostomy

- Once adequate transgastric exposure is secured, ultrasonographic localization of the pseudocyst is performed through the posterior gastric wall, with special attention to the location and course of the splenic artery and vein. Simultaneous color duplex should also be performed, given the close approximation and potential adherence of these structures to the pseudocysts. Having identified a safe and effective site for the transgastric cystotomy, the hook cautery is then inserted through the posterior gastric wall into the pseudocyst cavity.
- After evacuation of the cystic component of the pseudocyst, the posterior gastrotomy is enlarged to 1–2 cm to accommodate an endovascular stapler. The stapler is introduced into the posterior gastrotomy-pseudocyst channel, fired, and hemostasis verified (Fig. 87.12a). Bleeding from the staple line should be controlled with clips, cautery, or suture ligatures. Upsizing one of the lateral 5-mm ports to a 10-mm port, as well as addition of a left lower quadrant 10-mm port to accommodate the laparoscopic stapler, may be necessary based on the orientation of the pseudocyst. A wedge-shaped or diamond-shaped cystogastrostomy should be created to ensure patency; the resulting wedge should be a sufficient tissue sample for pathology review.
- The suction catheter and blunt graspers can then be used to carefully débride the cavity, which should be copiously irrigated and removed. After verifying hemostasis, the anterior gastrotomy is re-approximated using sutures or endoscopic staplers (Fig. 87.12b).

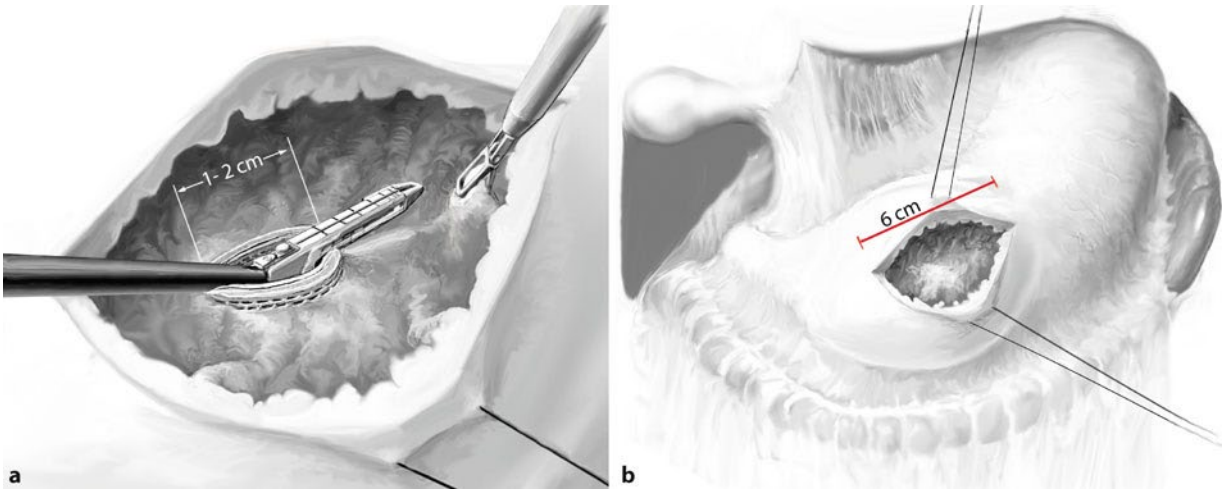


Fig. 87.12

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Laparoscopic Cystogastrostomy

Laurence W. Way, MD

Alternatives to open cystogastrostomy include either a totally endoscopic approach to cystogastrostomy or a less well-standardized, percutaneous, radiologic, transgastric cystogastric tube placement to accomplish the same overall goals. The laparoscopic approach provides another access route, which allows a better view as well as the ability to use laparoscopic surgical techniques not limited to the narrow access port of the gastroscope.

Step 1

- First, a standard laparoscopy is performed into the peritoneal cavity. Insert three ports: midline (subumbilical) and right and left midclavicular lines. Two trocars are placed into the lumen of the gas-distended stomach to provide access for the cystogastrostomy. The gastric lumen becomes the counterpart of the gas-filled peritoneal cavity used for conventional laparoscopic operations (Fig. 87.13a).
- A nasogastric tube is passed into the stomach and attached to a laparoscopic insufflator. Carbon dioxide gas is instilled to inflate the gastric lumen until the anterior gastric wall comes within a few millimeters of the anterior abdominal wall, as seen via the laparoscope.
- A radially expanding 10-mm trocar is inserted into the stomach as follows: First, pass the trocar through the abdominal wall where the anterior surface of the stomach abuts the abdominal wall, usually in the left epigastrium. Then poise it at the desired entry site on the anterior gastric wall and pop it into the stomach using a quick snap of the wrist. Pass a 5-mm, 30-degree laparoscope down the trocar and look into the gastric lumen; because the gastric walls reflect light so well, the view is bright and full of detail. Insert a second trocar into the stomach 6–10 cm from the first one. Check that positioning is satisfactory for intragastric surgery by passing the 5-mm scope down each of the trocars. The radially expanding trocars create snug, gas-tight puncture wounds in the stomach; this method will not work with cutting trocars, which make wounds that leak (Fig. 87.13b).

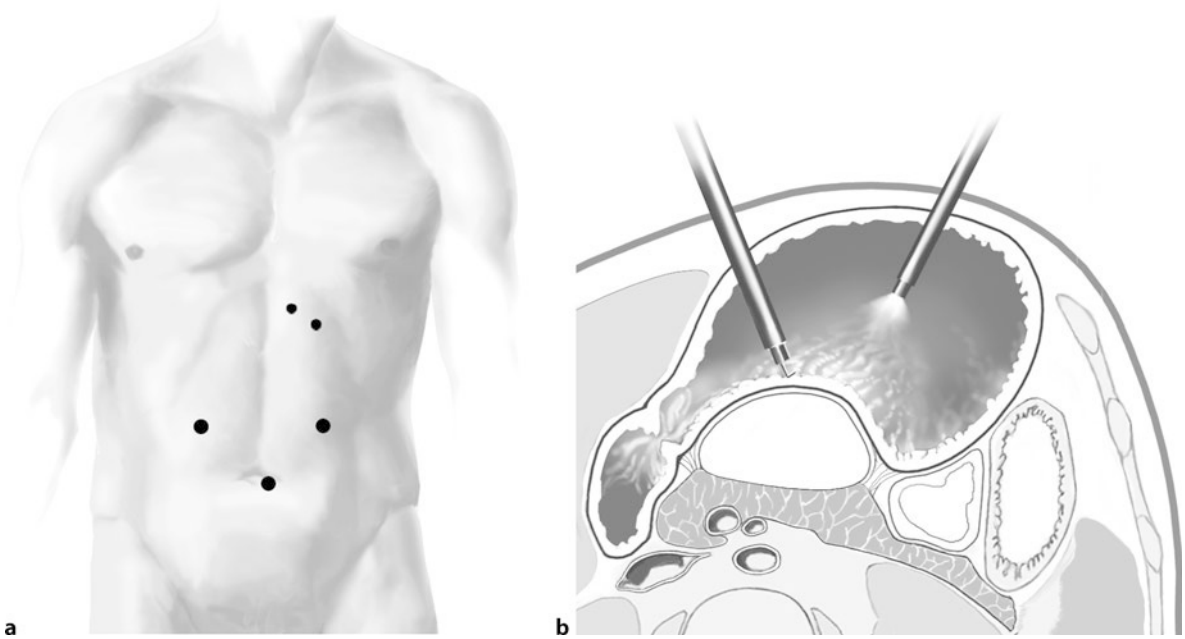


Fig. 87.13

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Step 1 ***(continued)***

- Next, shut off gas insufflation into the peritoneal cavity and open the valves on these trocars to room air, to allow any small amount of gas that might leak from inside the stomach around the gastric trocars to escape instead of accumulating in the peritoneal cavity and competing for space with the distended stomach. The insufflation pressure in the gastric lumen should be set at 20 cm H_2O, with insufflation connected to one of the trocars.
- It is usually possible to see a convexity on the posterior gastric wall created by the pseudocyst. To localize the pseudocyst, pass a long aspirating needle through the back wall of the stomach into the cyst and aspirate some cyst fluid. If fluid is not obtained, either the needle is not in the cyst (most likely) or the cyst contents are too thick to aspirate (uncommon); check the CT scan, recalculate the cyst location, and try again. In our experience, finding the cyst has rarely been difficult and laparoscopic ultrasonography has never been needed, but one might try this technique if necessary.
- Having located the cyst, use the hook monopolar electrocautery (at a high power setting) to cut a hole through the posterior gastric wall into the pseudocyst; do not make the full cystogastrostomy incision, just a 1-cm hole (Fig. 87.14).
- Next, aspirate the cyst contents and pass the scope into, or almost into, the cyst cavity. After determining where your entry hole lies in relation to the cyst's circumference and area of contact with the stomach, extend the cystogastrostomy incision so that it involves the center of the common wall between cyst and stomach and spans one third to one half of the cyst diameter. Check for bleeding; control it with further electrocautery or suture ligation.
- Remove semisolid necrotic debris from within the cyst lumen and temporarily deposit this material in the dependent fundus of the stomach; the debris should be pushed through the pylorus into the duodenum before removing the gastric trocars. Do not try to débride the wall of the pseudocyst, for it may contain blood vessels that are already inflamed.

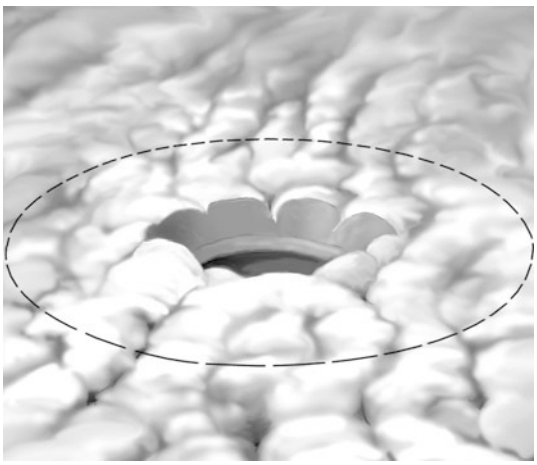


Fig. 87.14

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Step 2

- Withdraw the intragastric scope and any other instruments from the gastric trocars, reinstate the pneumoperitoneum, and insert a laparoscope in the periumbilical trocar. The gastric trocars are withdrawn from the stomach under direct vision but are not pulled out of the abdomen, because the port sites will leak gas. Decompress the stomach through the nasogastric tube.
- Using intracorporeal suturing and knot tying (or alternatively, an endoscopic stapler), place two interrupted Lembert stitches of 2-0 silk to close the puncture sites in the anterior gastric wall. All five trocars and the nasogastric tube can be removed (Fig. 87.15).

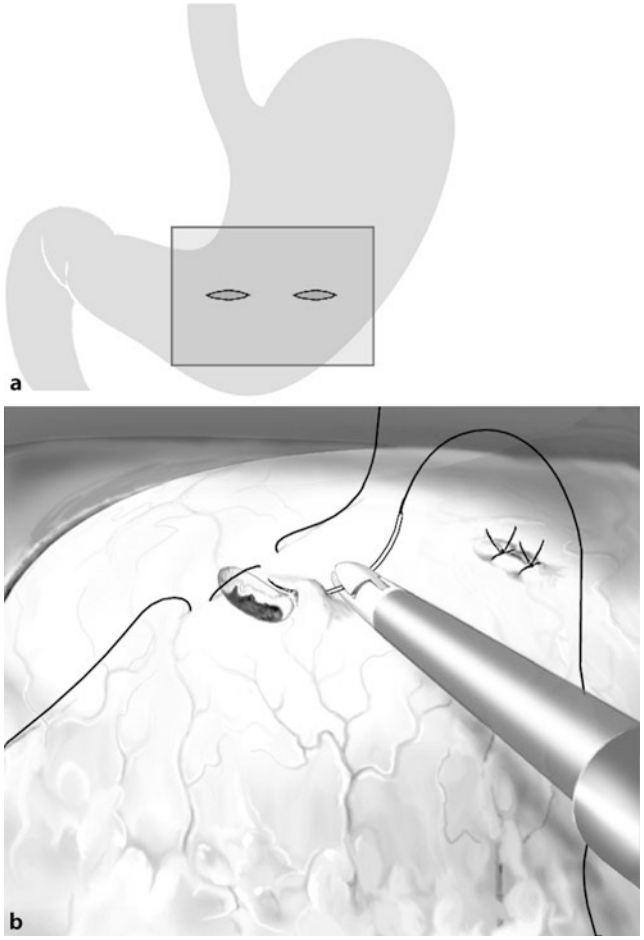


Fig. 87.15

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Postoperative Care

- Observation in the Intensive Care or Intermediate Care Unit is required only for selected patients.
- Nasogastric suction is discontinued the next day.
- The patient may be allowed to eat an unrestricted diet 1 to 2 days after the operation.

Local Postoperative Complications

- **Early complications**
  - Upper GI bleeding, usually from the anastomotic site
  - Anastomotic leak, intra-abdominal abscess, or both
  - Alcohol withdrawal
- **Late complications**
  - Recurrent pseudocyst
  - Error in diagnosis: Mistaking a cystic neoplasm of pancreas for a pseudocyst leads to a persistent recurrent cyst with symptoms

Tricks of the Senior Surgeon

Open internal drainage of pseudocysts

- Always make sure that the cyst contents are that of a pseudocyst: clear, opalescent, or brownish and not mucoid, as in a cystic neoplasm.
- Leave the aspirating needle in place, to enter the cyst with a knife alongside the needle.
- Use a right-angled clamp to elevate the cyst wall, to make an adequate-sized opening.
- Virtually always biopsy the cyst wall.
- If the cyst contents appear purulent, send the fluid for Gram stain. If only white cells are seen, then internal drainage can be done; if numerous bacteria are seen and the fluid is purulent, external drainage is probably preferable.
- Use intraoperative ultrasonography liberally, because it can identify and locate more than one cyst. It can also locate the common bile duct and pancreatic duct. Finally, it can reveal the relationship of the pseudocyst to adjacent visceral and vascular structures.

Laparoscopic cystogastrostomy

- This laparoendoscopic approach recapitulates the open transgastric cystogastrostomy. Others have described a side-to-side cystogastrostomy via a laparoscopic approach using a linear endoscopic stapler, but the approach we have described avoids the risk of an intraperitoneal "anastomotic leak."
- The initial short cystogastrostomy can be lengthened using an endoscopic linear stapler or even the harmonic scalpel, but we have not found it necessary to do so; these techniques just increase the cost of the procedure.
- Carefully inspect the site of the cystogastrostomy; if there is any bleeding, the incision can either be reefed or oversewn intragastrically via the two trocars using a 2-0 silk suture, or it can be further controlled with electrocautery.
- Beware of the patient with a large "pseudocyst" of the pancreatic body after an episode of necrotizing pancreatitis. Be certain to exclude the presence of splenic vein compression or occlusion and gastric varices; these varices can be quite large and may lead to severe hemorrhage during the cystogastrostomy.

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Denervation: Pain Management

Michael G. Sarr, Keith D. Lillemoe, Bhugwan Singh, Jake Krige

The pain of both benign and malignant pancreatic disease can be incapacitating. Attempts to relieve pancreatic pain by extensive operative denervation have proved to be ineffective. Newer, less invasive techniques of selective denervation appear effective as short- and medium-term palliation.

Indications and Contraindications

Indications

- Epigastric and back pain related to unresectable pancreatic, periampullary, and other upper gastrointestinal (GI) cancers
- Chronic pancreatitis not amenable to other operative therapy

Contraindications

- Lack of response to other attempts at percutaneous or endoscopic chemical splanchnicectomy

Procedures

Intraoperative chemical splanchnicectomy

Michael G. Sarr, Keith D. Lillemoe

Intraoperative chemical splanchnicectomy can be useful, especially in patients who are found at the time of exploration for resection to have unresectable pancreatic cancer. Rather than having these patients undergo percutaneous or endoscopic chemical splanchnicectomy postoperatively, an intraoperative approach is easy, effective, and warranted.

- The celiac plexus contains visceral afferent (pain) nerves from the stomach, pancreas, hepatobiliary tree, kidneys, and mid gut.
- There are one to five ganglia on each side of the celiac and superior mesenteric arteries, which lie anterior to the diaphragmatic crura and medial to the adrenal glands.
- Supplies needed include a 10-mL or 20-mL syringe, a 20-gauge spinal needle, and 40 mL of a 50 % alcohol or 5 % phenol solution.
- The lesser curvature of the stomach is retracted caudally.
- The first two fingers of the surgeon's left hand "straddle" the aorta.
- The index finger palpates the pulse of the splenic artery, while the second finger palpates the thrill of the common hepatic artery.
- The surgeon's right hand controls the syringe with the neurolytic agent.
- The spinal needle is advanced into the right para-aortic region just cranial to the hepatic artery and is clamped by the assistant to prevent displacement.
- The surgeon aspirates the syringe; if no blood is obtained (confirming that the needle is not in a vessel), 10 mL of the neurolytic agent is injected, the needle is removed, and the area is compressed with a gauze pack.
- The syringe is refilled, and the same maneuver is carried out just caudal to the common hepatic artery in the right para-aortic area and cranial and caudal to the splenic artery in the left para-aortic region (Fig. 88.1).

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
DOI 10.1007/978-3-662-46546-2_88, © Springer-Verlag Berlin Heidelberg 2016

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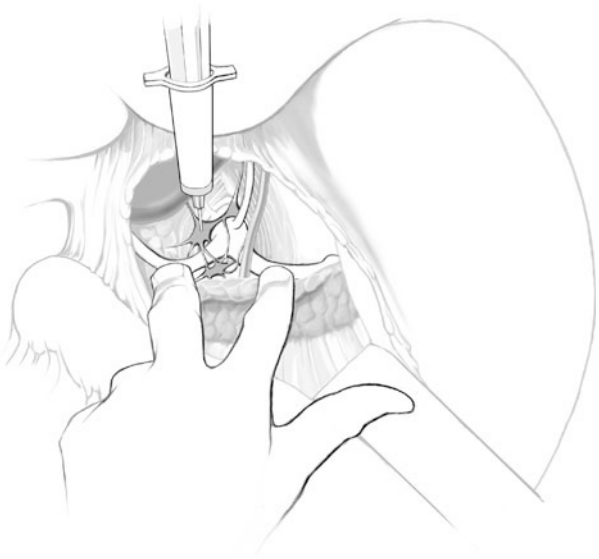


Fig. 88.1

Thoracoscopic splanchnicectomy

Bhugwan Singh, Jake Krige

Step 1

- With the introduction of minimal access thoracostomy, interest in and experience with a thoracoscopic approach to splanchnic nerve transection has grown. This procedure avoids the need for a major thoracotomy.
- A standard general anesthetic is administered using a single-lumen endotracheal tube.
- The patient is positioned in a prone position; pillows support the epigastric and sternal areas to facilitate breathing.
- The arms are abducted and the elbows flexed.
- A pneumothorax is induced using a Veress needle placed in the intercostal space adjacent to the inferior scapular angle (usually 5th intercostal space); the pneumothorax is maintained with carbon dioxide insufflation to an intrapleural pressure of 8 cm water; total lung collapse is not necessary, because an 8 cm pressure pneumothorax is adequate to visualize the splanchnic nerves.
- A 5-mm cannula is introduced in the 7th intercostal space in the posterior axillary line; a laparoscope/"thoracoscope" is passed through this cannula, connected to a video monitor, and passed into the pleural space.
- A second 5-mm cannula, inserted at the site of Veress needle placement, provides access for the dissecting instrument.
- On the right side, the procedure commences at the 4th intercostal space at the level of the azygous vein, which is usually the origin of the most proximal splanchnic root (Fig. 88.2).

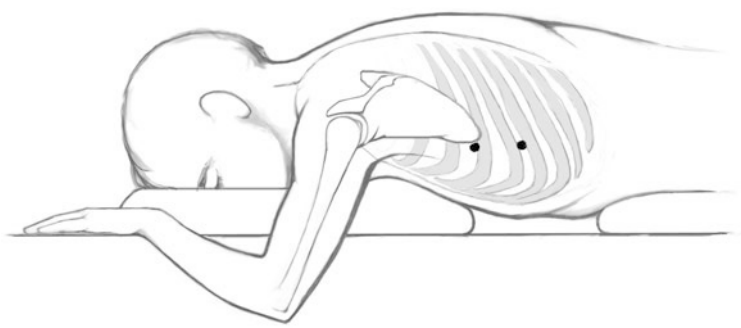


Fig. 88.2

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Step 2

- Accurate identification of the splanchnic nerves is the critical initial step in this procedure (Fig. 88.3).
- The greater splanchnic nerve (GSN), lesser splanchnic nerve (LSN), and least splanchnic nerve (lsn) have their origin medially from the sympathetic chain, usually from the lower eight ganglia.
- Whereas the GSN is consistently present, presence of the LSN ranges from 86 % to 100 % and that of the lsn from 16 % to 98 %.
- The GSN is formed usually by contributions from the 5th to 9th ganglia, but contributions range widely from the 3rd to 11th thoracic ganglia.
- Variable intersplanchnic connections occur between the splanchnic roots and nerves and provide an alternate neural pathway for transmission of pancreatic pain.

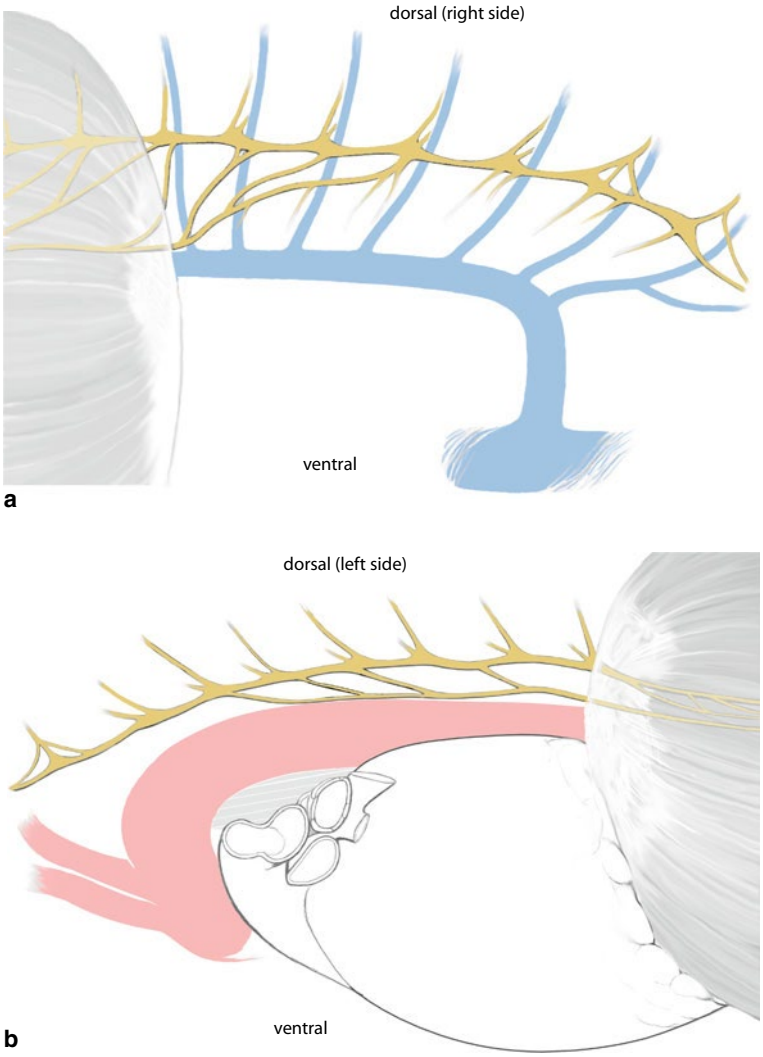


Fig. 88.3

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Step 3

- Using an electrosurgical hook, the parietal pleura is entered approximately 10 mm medial to the sympathetic chain; the pleura is stripped off the posterior chest wall up to the diaphragmatic recess so that a 10-mm-wide longitudinal pleurotomy is achieved.
- Commencing from the most proximal contribution to the GSN and working distally, all branches passing medially from the sympathetic chain are mobilized sequentially using the hook dissector and transected using cautery; in this fashion, all roots to the GSN, LSN, and lsn (if present) are transected. When there is any doubt, gentle traction on the sympathetic chain confirms complete dissection of splanchnic nerves.
- On the left side, the procedure commences at the 4th intercostal space at the level of the aortic arch, usually the origin of the most proximal splanchnic root; the principles of this technique are the same as on the right side.
- Extension of peripancreatic inflammation to the retropleural space may cause thickening of the pleura, impairing visualization and impeding easy dissection of the sympathetic chain and splanchnic nerves.
- Troublesome bleeding can be controlled by judicious use of cautery.
- After completion of the neurotomy, carbon dioxide insufflation is stopped and gentle suction is applied through the dissecting port with positive end expiratory pressure applied by the anesthetist.
- Intercostal chest drains are not placed provided reexpansion of the lung occurs up to the intercostal musculature.
- A chest radiograph is taken when respiratory distress, progressive desaturation, or unremitting surgical emphysema develops.
- The patient may be discharged after overnight hospital stay (Fig. 88.4).

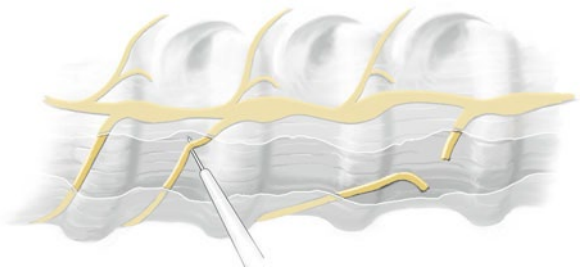


Fig. 88.4

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Postoperative Tests

Thoracoscopic splanchnicectomy

- Surveillance in an intermediate care unit with monitoring of oxygen saturation
- Routine chest radiograph to exclude residual pneumothorax

Local Postoperative Complications

Intraoperative splanchnicectomy

- **Short-term:**
  - Intra-arterial injection of neurolytic agent; this can be prevented by aspirating the syringe containing the neurolytic agent before injecting
  - Retroperitoneal bleeding (unusual); minimized by applying topical pressure after instillation of the neurolytic agent
  - Transient orthostatic hypotension (unusual, lasts only 1–2 days)
  - Very rare, anecdotal case reports of paraplegia secondary to intrathecal injection of neurolytic agent; preventable with careful technique
- **Long-term:**
  - Recurrent pain

Thoracoscopic splanchnicectomy

- **Short-term:**
  - Pneumothorax, hemothorax, or hemo-pneumothorax; treat by closed intercostal chest drainage. Less common is chylothorax requiring ligation of the thoracic duct.
  - Transient ileus; managed conservatively.
  - Inadvertent injury or transection of sympathetic chain may predispose to retrograde ejaculation.
- **Long-term:**
  - Recurrence of pain

Tricks of the Senior Surgeon

Intraoperative splanchnicectomy

- Use a 20-gauge spinal needle (longer than a regular needle).
- Use of a smaller-volume syringe allows the surgeon to easily manage the needle/syringe with one hand.
- Do not disrupt the peritoneum overlying the retroperitoneum in the region of the celiac plexus.
- Two minutes of topical pressure will prevent hematomas.

Thoracoscopic splanchnicectomy

- Meticulous positioning of the ports aids visibility of the entire sympathetic chain.
- Total collapse of the lung is unnecessary; pneumothorax with a pressure of 8 cm water is usually adequate to identify the splanchnic nerves.
- The proximal contribution to the GSN is identified by tracing the sympathetic chain distally as it courses over the necks of the proximal ribs.
- Gentle traction on the sympathetic chain brings the splanchnic branches into profile.
- Troublesome bleeding from an intercostal vein can be controlled with pressure, cautery, or clip.
- Accurate placement of ports in the intercostal spaces avoids postoperative intercostal neuralgia.

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Enteric Ductal Drainage for Chronic Pancreatitis

William H. Nealon

The concept of draining an apparently obstructed main pancreatic duct was first addressed by opening either the proximal end of the pancreatic duct at the ampulla, by doing a sphincterotomy, or the distal end of the pancreatic duct, by removing the tail of the pancreas and performing a pancreatojejunostomy (Duval procedure). Puestow is credited with the concept of a longitudinal incision along the main pancreatic duct, through the body and the head of the pancreas, after resecting the pancreatic tail. Partington and Rochelle determined that a tail resection was unnecessary and carried out only a side-to-side lateral pancreaticojejunostomy. The principle of the procedure is to decompress an apparently obstructed main pancreatic duct (and perhaps also to decompress the pancreatic parenchyma, overcoming the pancreatic compartment syndrome suggested by Reber). This assumption is based on the fact that the pancreatic duct is markedly dilated, suggesting a restriction to flow.

Indications and Contraindications

Indications

- To resolve chronic, persistent pain
- To prevent episodes of acute exacerbations in chronic pancreatitis
- To facilitate resolution of symptomatic pancreatic pseudocyst
- To prevent further loss of pancreatic exocrine and endocrine function

Contraindications

- "Small duct" (< 5 mm) chronic pancreatitis
- Extrahepatic venous obstruction, because of the risk of hemorrhage
- Suspicion of malignancy
- Advanced cirrhosis

Preoperative Investigations and Preparation for Procedure

- *History:* History of chronic, unremitting epigastric abdominal pain or acute exacerbations of typical pancreatic pain; history of ethanol abuse or other possible causes of chronic pancreatitis
- *Clinical evaluation:* Establish presence or absence of narcotic use and requirement (if narcotic addicted, stress the need for postoperative detoxification); frequency of hospitalizations; nutritional status; pancreatic functional status (endocrine and exocrine); American Society of Anesthesiology (ASA) risk status
- *Laboratory tests:* Serum amylase and/or lipase, prealbumin, alkaline phosphatase, gamma-glutamyl transpeptidase (GGT), bilirubin, coagulation parameters, carbohydrate antigen (CA) 19-9, Hgb A_1 C
- *Imaging:* CT or MRI/MR cholangiopancreatography (MRCP); endoscopic retrograde cholangiopancreatography (ERCP) if indicated; endoscopic ultrasound (EUS)
- *Preparation for surgery:* Maximize nutritional status (insulin); maximize exocrine status (enzyme replacement); bowel preparation if necessary; perioperative prophylactic antibiotics

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Procedure: Lateral Pancreaticojejunostomy (Modified Puestow Procedure)

Step 1

- Exposure and exploration are facilitated by insertion of a retractor (Thompson).
- Perform a generous Kocher maneuver and palpate the head of the pancreas.
- First, the lesser sac is entered through the gastrocolic omentum and the transverse colon. Take care to identify and exclude the right gastroepiploic artery and vein, which are situated between the head of the pancreas and the pylorus.
- Any "congenital" or acquired adhesions between the posterior surface of the stomach and the anterior surface of the pancreas are transected, exposing the anterior surface of the pancreas, including the head of the pancreas (Fig. 89.1).



Fig. 89.1

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Step 2

- Mobilize the inferior border of the body of the pancreas.
- Identify and avoid the inferior mesenteric vein to the left of the spine.
- Extend the dissection from the body toward the head of the pancreas. This facilitates bimanual examination and palpation of the anterior surface of the gland.
- Place a broad, curved retractor behind the posterior wall of the stomach and retract superiorly.
- Palpate and determine the location of the main pancreatic duct (Fig. 89.2).

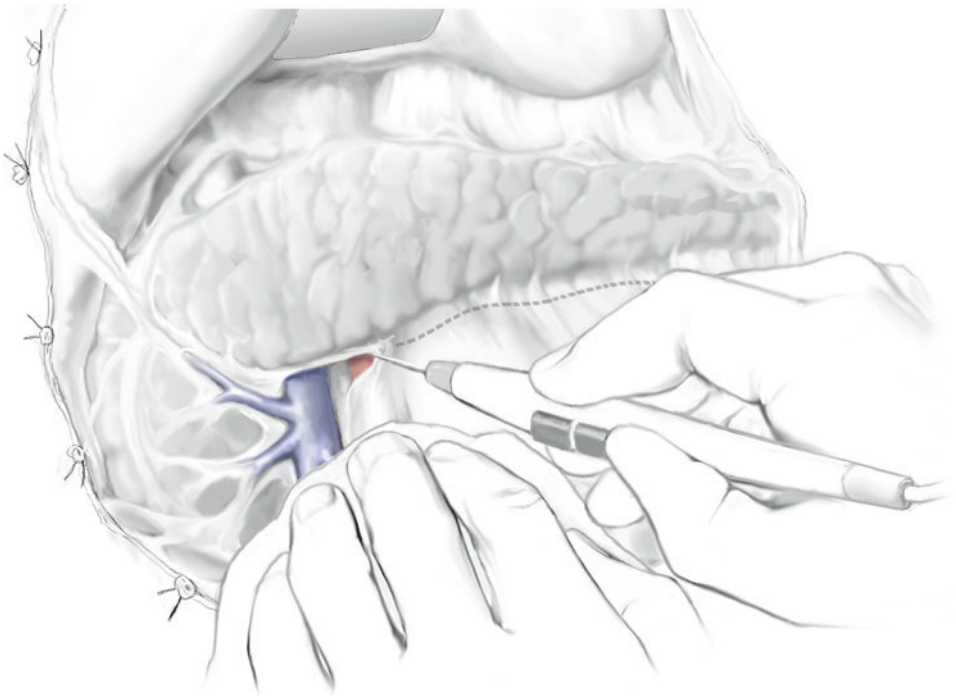


Fig. 89.2

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Step 3

- The pancreas should be easily appreciated because of its hard, fibrotic texture.
- The dilated main pancreatic duct feels a bit like a large vein on the arm, with a ballotable texture and a definite "trough."
- The superior and inferior borders of this softer area feel like a canyon or a cliff; this represents the fibrotic pancreas on both sides.
- Once the palpation is conclusive, an 18-gauge needle is passed through the anterior surface of the pancreas and into the pancreatic duct; on removing the needle, you should see clear fluid return, confirming that the main pancreatic duct has been accessed. The purpose of this maneuver is to avoid incising into the splenic vein or another structure mistaken for the main pancreatic duct.
- Once pancreatic juice is determined, then electrocautery is used to incise the anterior surface of the body of the pancreas into the pancreatic duct parallel and adjacent to the needle, which is left in the pancreatic duct as a guide (Fig. 89.3).

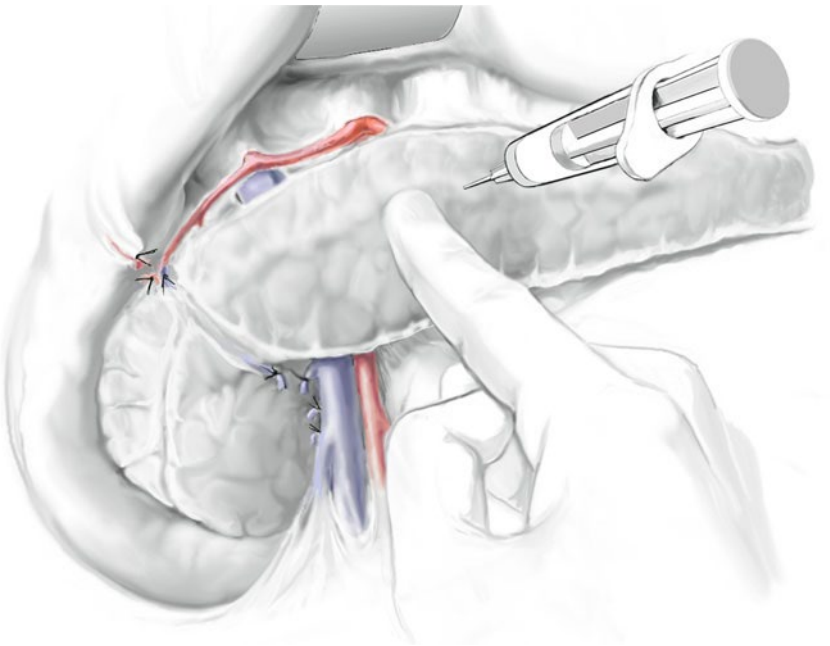


Fig. 89.3

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Step 4

- A right-angle clamp facilitates using the electrocautery to open widely the duct out to the tail of the pancreas laterally and toward the head of the pancreas. As you reach the genu of the main pancreatic duct, it is important to extend the incision through the genu and toward the ampulla. This maneuver requires not only turning the incision inferiorly but also considerably increasing the depth of incision through the parenchyma of the pancreas in the head of the gland, because the duct goes more posteriorly. This area also has a rich blood supply, and some amount of hemorrhage may be encountered during this incision. To a great extent, success rates are thought to depend on adequate drainage into the head of the pancreas in this manner. There appears to be less significance to the extent of drainage into the tail of the pancreas, except in patients who have more localized disease in the tail.
- Once adequate space is established, a Seurat clamp may be used. All stones encountered should be removed from the duct, along with any secondary ductular stones (Fig. 89.4).
- If the head of the pancreas has an enlarged (>4 cm) dimension then excavation of the tissue should be excised to a thickness at the outer shell of 1 cm (Frey procedure).

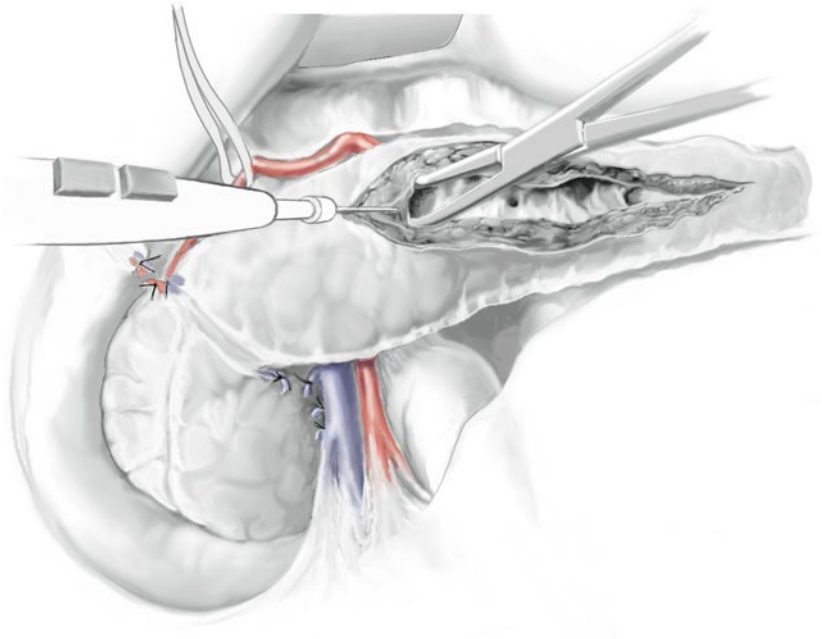


Fig. 89.4

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Step 5

Roux-en-Y jejunal preparation

- An area is chosen approximately 15 cm distal to the ligament of Treitz, in a position that will facilitate easy performance of the jejunojejunostomy. The mesenteric attachments are divided between clamps to mobilize the Roux limb. An energy source such as a LigaSure or a harmonic scalpel may be substituted. A gastrointestinal anastomosis (GIA) stapling device is used to divide the jejunum at this site.
- The avascular area is then chosen in the left transverse mesocolon. A window is created, through which the distal, divided end of the jejunum may be brought. It is important to avoid undue tension at the mesentery; at times, it is necessary to divide the truncal branches of the jejunal mesenteric vessels below the arcade to permit a flexible limb. The divided end of the jejunum is aligned toward the tail of the pancreas, and a side-to-side approach is established (Fig. 89.5).

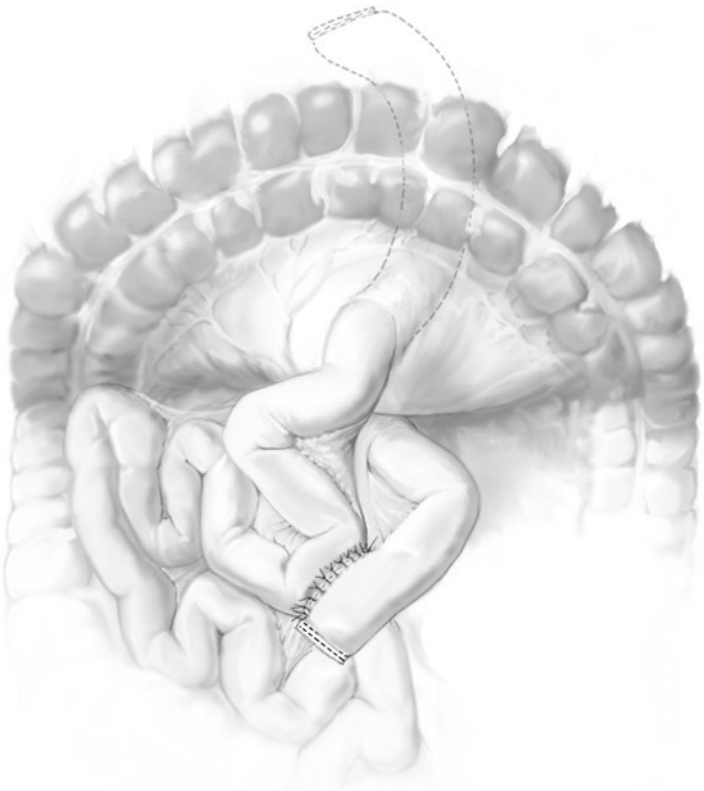


Fig. 89.5

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Step 6

Pancreaticojejunostomy

- The anastomosis is performed using a single layer of absorbable suture. We use two, separate, 3-0 PDS sutures. The posterior suture line is placed first, before opening the jejunum (Fig. 89.6a). It is important to make smaller advances in the jejunum than in the open pancreatic duct. The first suture is placed just at the corner of the ductal incision in the tail of the pancreas, and each suture is placed in a progression toward the head of the pancreas (Fig. 89.6b). The advance on the jejunum may be no more than 3 mm, whereas the advance on the pancreatic duct may be 6 mm. The depth of insertion of the needle into the pancreatic body or into the duct depends upon the pancreas. In a relatively thin parenchyma, the sutures are placed into the duct itself. On occasion, a very thick pancreatic parenchyma is better managed by placing sutures into the capsule of the pancreas, but they may be tied above the epithelium of the main pancreatic duct. Sutures are not tied until each suture has been placed over to the corner toward the head of the pancreas.
- At this point, the limb of jejunum is lowered and placed in its position for anastomosis, and all sutures are tied.
- An incision is then made in the jejunal limb to match the size of the pancreatic duct incision. The reason for placing the sutures more closely on the jejunum is the fact that once the jejunum is opened, it typically dilates, so you may be left with a very poor match in size for your anterior suture line.

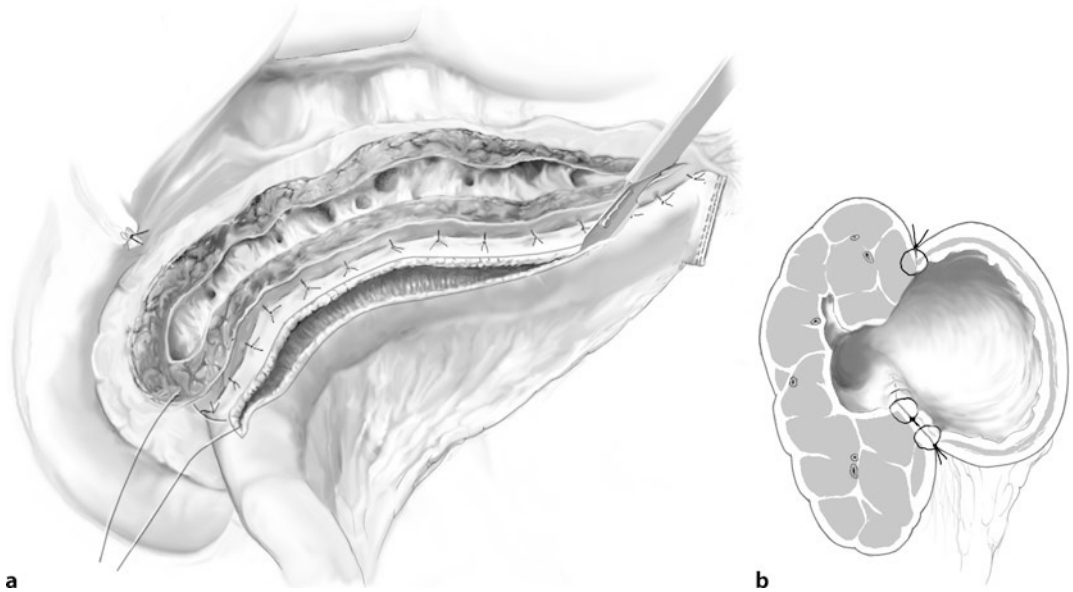


Fig. 89.6

- The anterior suture line is performed by first burying the corner stitch from the posterior suture line by drawing that suture toward the pancreatic ductal incision and placing a Lembert suture in the jejunal limb at the very corner. A transition is made from the sutures being placed "outside-in" on the posterior suture line to "inside-out" on the anterior row. The sutures should be placed at both corners, and the suture from the corner on the posterior suture line may be cut. In contradistinction to the posterior suture line, each suture is tied after being placed in the anterior suture line. This is particularly helpful to assure alignment and a proper size match for the anastomosis (Fig. 89.7).
- After the two corner sutures have been placed, a Lembert suture is placed in the jejunal limb halfway between the left and right borders of the pancreatic duct incision, to establish alignment of the jejunal limb. Finally, halfway between this center suture and the two corners, another similar suture is placed in the jejunum and fixed to the incision on the superior border of the pancreatic ductal incision. It is then easy to fill the gaps between the sutures that have already been placed, to complete the anastomosis with interrupted 3-0 PDS suture.

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- The point where the jejunum passes through the transverse mesocolon should be fixed to the mesocolon using an interrupted 3-0 silk stitch; this obliterates the internal hernia defect.
- Finally, 40 cm distal to the pancreaticojejunostomy, a jejunojejunostomy is performed in a side-to-side fashion. We prefer a hand-sewn anastomosis with an outer layer of interrupted 3-0 silk sutures and an inner suture line of continuous absorbable suture such as polyglycolic acid.
- A 10 mm Jackson-Pratt drain is placed at the pancreatic anastomosis and brought out through a separate stab wound on the left side of the abdomen.

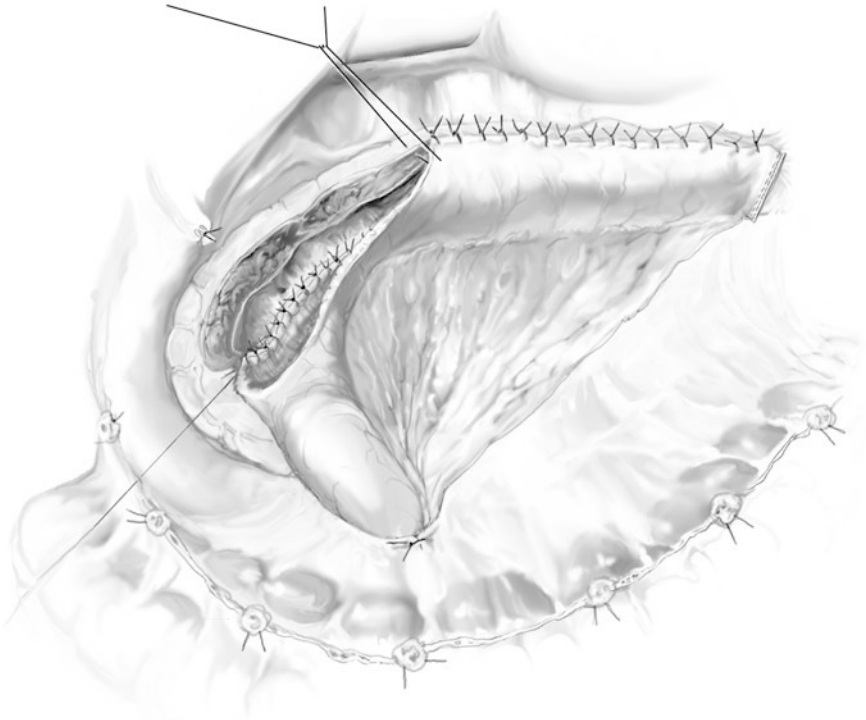


Fig. 89.7

Postoperative Tests

- During the first 24 h, monitor for hemorrhage.
- Monitor serum glucose concentrations for possible glucose intolerance, even in patients who had not required insulin preoperatively.
- Reinforce the need for progressive weaning from narcotic use after discharge from the hospital.
- Although the final outcome is determined only when the patient is free of narcotic use, pain scales may be of some value.

Local Postoperative Complications

- **Short-term:**
- Intra-abdominal hemorrhage
- Pancreatic ductal leak (persistent drain output)
- Glucose intolerance resulting from the stress of operation
- Alcohol withdrawal syndrome
- Wound infection

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- **Long-term:**
  - Failure to resolve pain
  - Ongoing narcotic addiction
  - Recurrent episodes of pancreatitis
  - Progressive loss of pancreatic function

Tricks of the Senior Surgeon

- Rarely, it may be difficult to palpate the duct, and various maneuvers may help (e.g., intraoperative ultrasonography).
- Kocherize the duodenum and palpate carefully the head of the pancreas.
- Perform intraoperative ultrasonography. Choose an area in the mid body of the pancreas and perform a vertical incision in hope of bisecting the duct.
- Once some incision has been made in the parenchyma, the surgeon may safely massage the tail and proximal body of the pancreas in hope of expressing pancreatic juice.
- Avoid trying to access the pancreatic duct directly over the junction of the superior mesenteric vein, portal vein, and splenic vein; too deep an incision may lead to serious bleeding.
- Concentrate on getting a good size match between the ductal incision and the jejunal incision; mismatches in size can lead to pancreatic leak.
- Some surgeons prefer to bring the Roux limb up through the left lateral transverse mesocolon and position the end of the Roux limb toward the head of the pancreas; in doing so, potential future access to the superior mesenteric vein at the caudal surface of the pancreas will not be covered by the mesentery of the Roux limb.

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Resection for Neoplasms of the Pancreas

Kathleen K. Christians, Douglas B. Evans, Sergio Pedrazzoli, Cosimo Sperti, Robert Beaulieu, Frederick Eckhauser, Michael L. Kendrick

Pancreatoduodenectomy performed at high-volume centers of excellence can be accomplished with 30-day in-hospital mortality rates of less than 2 %. Improvements in imaging modalities and heightened awareness of less well-appreciated pancreatic neoplasms (nonfunctional neuroendocrine neoplasms, primary cystic neoplasms, and especially intraductal papillary mucinous neoplasms) have increased the visibility of formal pancreatectomy. The following four sections focus on specific types of pancreatic resections.

Proximal Resection

Kathleen K. Christians, Douglas B. Evans

Kausch, Hirschel, and Teani described resections of portions of the duodenum and pancreas in the early 1900s, but Whipple was the first surgeon to perform a complete resection of the duodenum and pancreatic head in his initial two-stage procedure (1935) and subsequent one-stage procedure (1940); Whipple has largely been given credit for the operation. Waugh and Clagett modified the operation in 1946 to its current one-stage procedure. The operation involves the en bloc removal of the pancreatic head, duodenum, gallbladder, and bile duct, with the gastric antrum. Traverso and Longmire popularized the pylorus-preserving technique. Because the goal of the operation is complete removal (R0 resection) of the neoplasm, the preoperative assessment of local tumor resectability is of critical importance.

Indications and contraindications

We advocate objective, anatomic criteria for defining resectability based on high-quality, multidetector CT images. Local tumor resectability (relationship of the neoplasm to the celiac axis, superior mesenteric artery [SMA] and superior mesenteric-portal vein [SMPV] confluence) cannot be determined accurately before operatively burning bridges (gastric and pancreatic transection); thus, preoperative assessment of critical tumor-vessel relationships is mandatory (Table 90.1).

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Table 90.1 Medical College of Wisconsin CT-based Clinical Staging of Pancreatic Cancer
Resectable
Tumor-artery relationship: No radiographic evidence of arterial abutment (celiac, SMA, or hepatic artery)
Tumor-vein relationship: Tumor-induced narrowing < 50 % of SMV, PV, or SMV-PV
Borderline Resectable
Artery: Tumor abutment (< 180°) of SMA or celiac artery. Tumor abutment or short segment encasement (> 180°) of the hepatic artery
Vein: Tumor-induced narrowing of > 50 % of SMV, PV, or SMV-PV confluence. Short segment occlusion of SMV, PV, SMV-PV with suitable PV (above) and SMV (below) to allow for safe vascular reconstruction.
Extrapancreatic disease: CT findings suspicious, but not diagnostic of, metastatic disease (for example, small indeterminate liver lesions which are too small to characterize)
Locally Advanced
Artery: Tumor encasement (> 180°) of SMA or celiac artery
Vein: Occlusion of SMV, PV, or SMV-PV without suitable vessels above and below the tumor to allow for reconstruction (no distal or proximal target for vascular reconstruction)
Extrapancreatic disease: No evidence of peritoneal, hepatic, or extra-abdominal metastases
PV – portal vein; SMA – superior mesenteric artery; SMV – superior mesenteric vein.

Indications

Resectable neoplasms have the following CT characteristics:
- Absence of extrapancreatic disease
- Normal tissue plane between the low-density tumor and the SMA; no direct tumor extension to the celiac axis, SMA, or hepatic artery (HA)
- Tumor-induced narrowing no more than 50 % of the SMV, PV, or SMV-PV; patent SMPV confluence (assumes ability of the surgeon to resect and reconstruct isolated segments of the SMV or SMPV)

Borderline resectable neoplasms include:
- Tumor-inducing narrowing of more than 50 % of SMV, PV, or SMV-PV confluence. Short segment occlusion of the SMPV confluence with an adequate vessel for grafting above and below the site of occlusion (assumes the technical ability to resect and reconstruct the SMV or SMPV)
- Neoplasms that demonstrate short-segment abutment (≤ 180°) of the SMA or celiac artery, or abutment or short-segment encasement (> 180°) of the HA
- CT findings suspicious, but not diagnostic of, metastatic disease (small indeterminate liver or lung lesions)

Absolute contraindications

- Extrapancreatic metastatic disease
- Locally advanced tumors as defined above, which do not improve after induction (neoadjuvant) therapy

Preoperative investigations and preparation for the procedure

- *Predisposing factors:* Tobacco, obesity, recent onset of impaired glucose tolerance, smoking, family history (~ 10 %), familial pancreatitis, hereditary breast and ovarian cancer syndrome (*BRCA1* or *BRCA2*, *PALB2*), Peutz-Jeghers syndrome, familial atypical multiple-mole melanoma (FAMMM) syndrome, hereditary nonpolyposis colon cancer (HNPCC)
- *Physical examination:* Nutritional status (weight loss), cardiovascular health, performance status (most important for assessment of operative risk), jaundice, left supraclavicular adenopathy, ascites
- *Laboratory tests:* CA 19–9, CEA, liver function tests, coagulation profile, complete blood count

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- *Chest imaging:* To rule out metastatic disease
- *Multidetector abdominal CT:* To assess resectability; for pancreatic head tumors, the relationship of the tumor to the right lateral wall of the SMA is the most critical aspect of the staging evaluation
- *Endoscopic ultrasonography (EUS):* Indicated if a presumed pancreatic head mass is not visualized on CT
- *EUS-guided fine needle aspiration (FNA):* Needed to establish a tissue diagnosis in patients with resectable disease being considered for protocol-based, preoperative systemic therapy and/or chemoradiation, and in all patients with borderline resectable disease; if neoadjuvant therapy is not planned, a preoperative biopsy is not necessary
- *ERCP:* To allow endobiliary decompression when operative intervention is delayed (for poor performance status, further investigation of medical comorbidities, or neoadjuvant therapy)
- *Mechanical bowel preparation:* Prophylactic IV antibiotics 30 to 60 min prior to operation

Procedure: Pancreatoduodenectomy

Diagnostic laparoscopy is performed routinely after induction of anesthesia and prior to proceeding with laparotomy to exclude the presence of extrapancreatic metastatic disease. Biopsy-proven liver or peritoneal metastases are a contraindication to pancreatoduodenectomy.

Intraoperative ultrasonography of the liver is used selectively in patients whose CT scans are indeterminate but suspicious, to help identify lesions for potential biopsy.

Lymph node biopsy for frozen-section analysis is controversial. In a good-risk patient with localized, resectable pancreatic cancer, lymph node metastases are not a contraindication to pancreatoduodenectomy when performed as part of a multimodality approach to pancreatic cancer, especially in those who have received neoadjuvant chemotherapy or chemoradiation. In a high-risk patient (with medical comorbidities or oncologic concerns), a grossly positive regional lymph node may sway the risk-benefit ratio against proceeding with pancreatoduodenectomy.

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Step 1

Isolation of the infrapancreatic superior mesenteric vein (SMV)

We use a midline incision and a Thompson retractor. When opening the abdomen, the falciform ligament is preserved to cover the gastroduodenal artery (GDA) stump prior to abdominal closure.

- First, enter the lesser sac by mobilizing the greater omentum anteriorly off the transverse colon.
- Mobilize the right colon and hepatic flexure to expose the entire duodenal sweep.
- Incise the visceral peritoneum along the inferior border of the pancreas from the patient's left of the middle colic vessels toward the patient's right to expose the junction of the middle colic vein and the SMV (Fig. 90.1).
- We may divide the middle colic vein prior to its junction with the SMV to allow greater exposure of the infrapancreatic SMV; this minimizes the risk of traction injury to the SMV, especially in patients with an increased BMI.
- We do not attempt to develop a plane of dissection between the anterior surface of the SMV and the posterior surface of the pancreatic neck, because the pancreatic head neoplasms involve the posterolateral aspect of the SMV or SMPV confluence, not the anterior surface of these vessels. We rarely divide the gastroepiploic vein at this time, unless it is coming off of a common trunk with the middle colic vein; this vessel is much easier to divide after the pancreatic transection (Step 6).

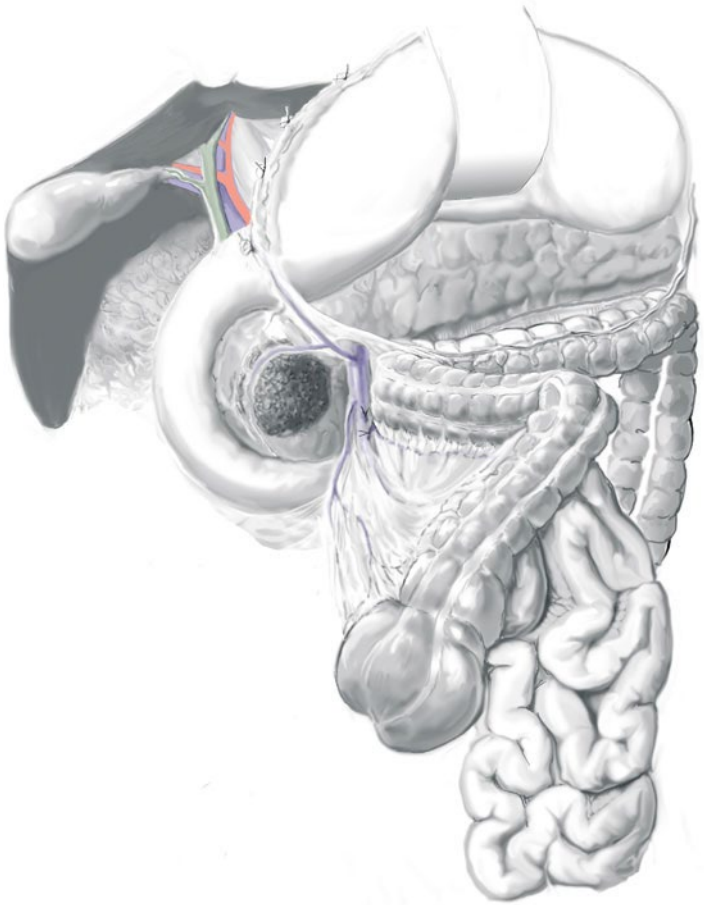


Fig. 90.1

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Step 2

Extended Kocher maneuver

- Begin the Kocher maneuver at the transverse (3rd) portion of the duodenum by exposing the inferior vena cava (IVC).
- Mobilize all fibrofatty and lymphatic tissue medial to the right ureter and anterior to the IVC with the specimen. (We usually preserve the gonadal vein as it courses anterior to the right ureter, because it is a good landmark to avoid inadvertent injury to the right ureter.)
- Fully mobilize the pancreatic head and duodenum to the cephalad aspect of the left renal vein as it crosses the aorta (Fig. 90.2). The SMA origin can often be exposed at this level by rotating the pancreatic head and duodenum medially and incising the perineural tissue, which becomes the inferior aspect of the root of mesentery. The perineural tissue surrounding the proximal SMA is usually not divided at this time.

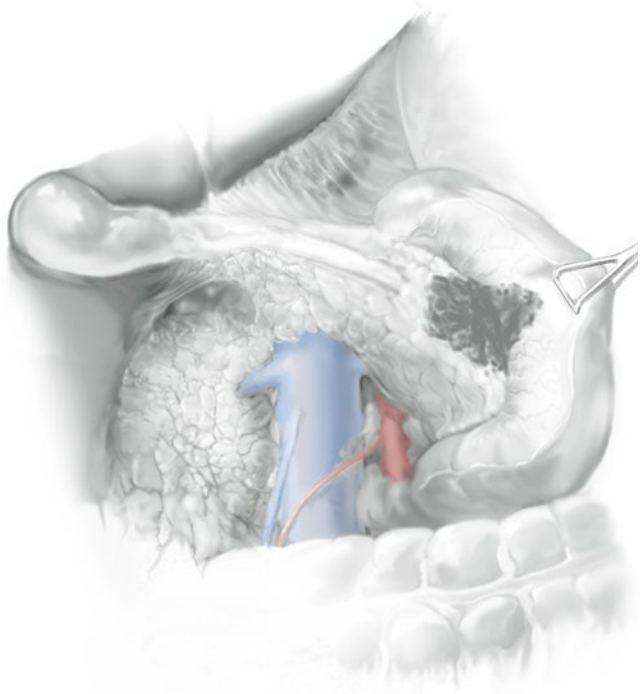


Fig. 90.2

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Step 3

Dissection of the porta hepatis, hepatic artery exposure, cholecystectomy, and bile duct transection

- Expose the common hepatic artery (CHA) by removing the lymph node that lies directly anterior to the CHA proximal to the right gastric artery and the gastroduodenal artery (GDA); the portal vein (PV) lies posterior to the inferior border of the CHA just proximal to the origin of the GDA.
- Ligate and divide the right gastric artery and the GDA (Fig. 90.3). If the tumor extends to within a few millimeters of the GDA origin, do not attempt blunt dissection of the origin of the GDA; instead, obtain proximal control of the CHA and distal control of the proper hepatic artery and then divide the GDA flush at its origin. The hepatic artery is fragile; aggressive blunt dissection may create an intimal flap. We close the arteriotomy at the GDA origin with 6-0 polypropylene suture under inflow occlusion.
- Perform a cholecystectomy and transect the common hepatic duct (CHD) at its junction with the cystic duct, thereby exposing the underlying PV. Be aware of the location of a right hepatic artery running posterior to the CHD. Careful palpation prior to division of the bile duct should alert one to the possibility of a replaced right hepatic artery originating from the SMA and traveling posterior to the lateral aspect of the bile duct. If the foramen of Winslow was closed due to adhesions, it should have been reestablished at the time of the Kocher maneuver. Access to the foramen of Winslow is necessary to palpate the porta hepatis and appreciate a replaced right hepatic artery.
- Place a gentle bulldog clamp on the transected CHD to prevent bile spillage until the bile duct reconstruction.
- Divide the loose connective tissue anterior to the PV caudally to the junction of the PV and the neck of the pancreas. The PV should not be extensively mobilized at this point, because iatrogenic injury to the PV prior to gastric and pancreatic transection may result in excessive blood loss due to inadequate vascular exposure.
- Also, be aware of anomalous hepatic arterial circulation. Rarely, the hepatic artery (distal to the origin of the GDA) courses posterior to the PV. An accessory or replaced right hepatic artery may also course posterolateral to the PV but would arise from the proximal SMA, not from the celiac axis. The entire common hepatic artery may also arise from the SMA. Careful preoperative review of CT imaging should alert the clinician to these vascular anomalies.

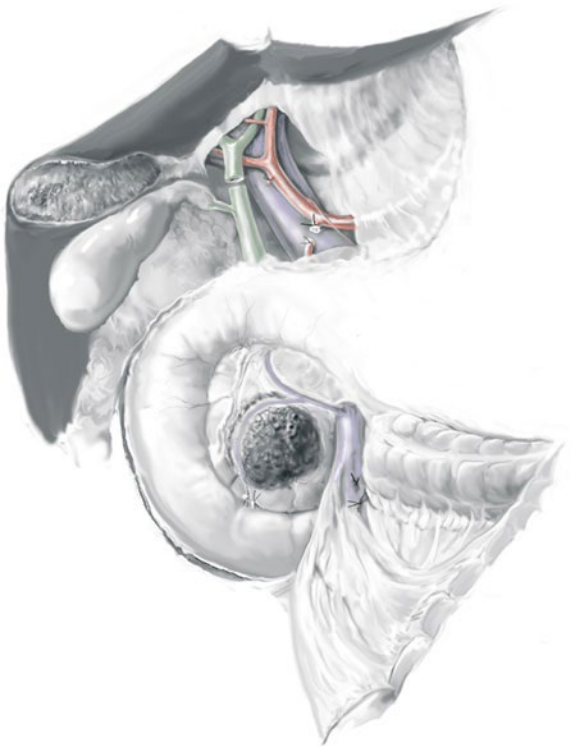


Fig. 90.3

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Step 4

Transection of the gastric antrum (or the duodenum if pylorus preservation is planned)

- Ligate and divide the terminal branches of the left gastric artery along the lesser curvature of the stomach prior to gastric transection.
- Transect the antrum of the stomach with a stapler (we use a blue load) at the third or fourth transverse vein on the lesser curvature and at the confluence of the gastroepiploic veins on the greater curvature (Fig. 90.4a).
- Divide the omentum at the site of transection of the greater curvature transection.
- Pylorus preservation may be considered in patients with small periampullary neoplasms. We believe that a pylorus-preserving resection should not be performed in patients with bulky neoplasms of the pancreatic head, neoplasms involving the first or second portions of the duodenum, or lesions associated with grossly positive pyloric or peripyloric lymph nodes (Fig. 90.4b).
- When pylorus preservation is performed, divide the gastroepiploic arcade and the duodenum at least 2 cm beyond the pylorus whenever possible. At the time of reconstruction, we trim another 1.0 cm off of the duodenum to create the duodenojejunostomy 1.0 to 1.5 cm from the pylorus, to ensure an adequate blood supply to this part of the duodenum.

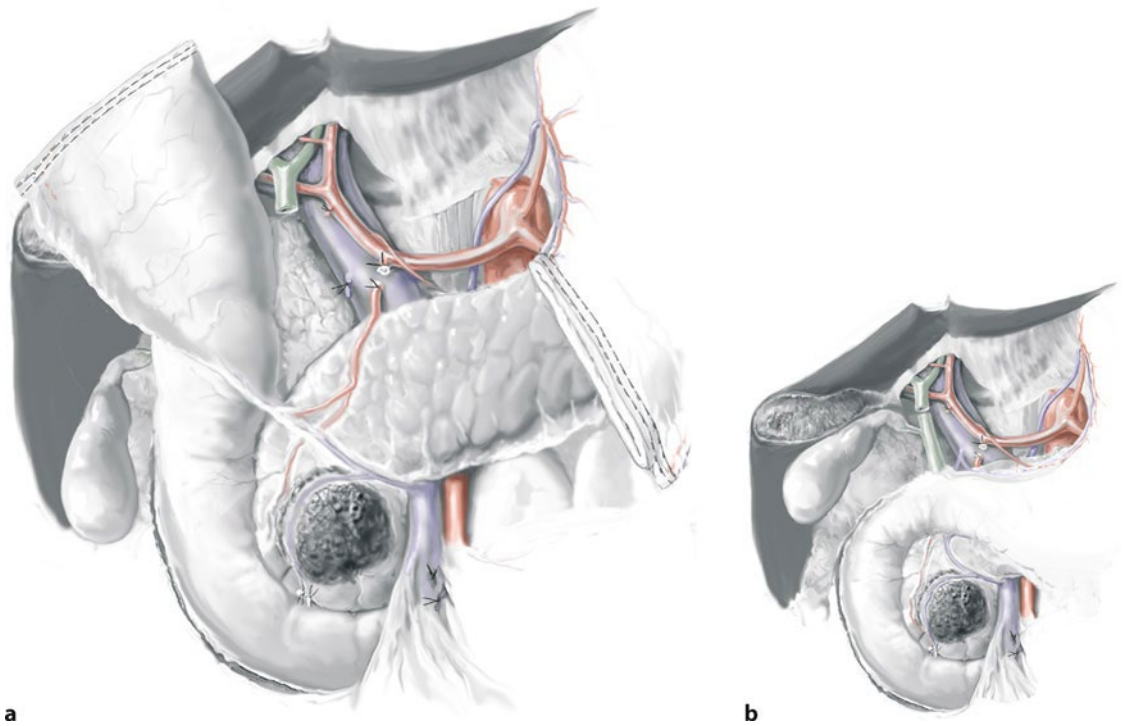


Fig. 90.4

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Step 5

Transection of the jejunum

- Take down the loose attachments of the ligament of Treitz, with care to avoid the inferior mesenteric vein.
- Transect the jejunum with a stapler (we usually use a white load) about 10 cm distal to the ligament of Treitz, and ligate and divide the mesentery (Fig. 90.5). We frequently use the LigaSure™ device (Covidien, Mansfield, MA, USA) for the mesenteric transection.
- Continue this dissection to involve the fourth and third portions of the duodenum.
- Reflect the devascularized duodenum and jejunum posterior to the mesenteric root and into the right quadrant (Fig. 90.6).

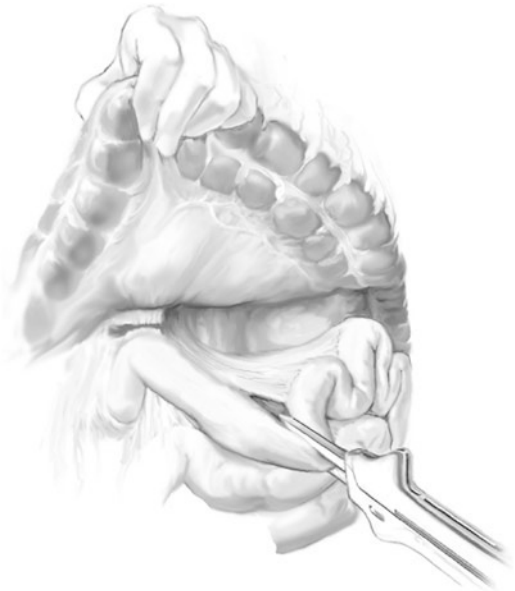


Fig. 90.5

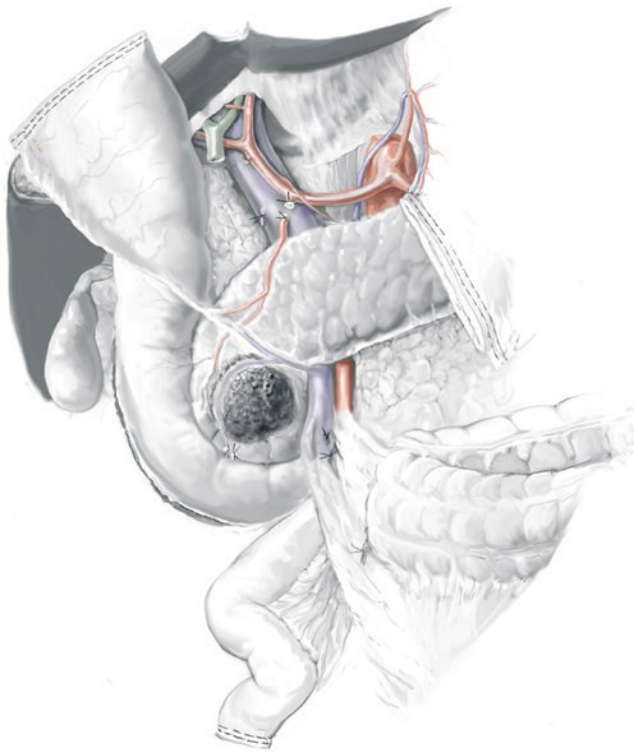


Fig. 90.6

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Step 6

Transection of the pancreas and completion of the retroperitoneal dissection

- The most important and difficult part of the operation involves complete mobilization of the SMPV confluence and separation of the specimen from the right lateral border of the SMA (SMA margin).
- Place traction/hemostatic sutures on the superior and inferior borders of the neck of the pancreas. This maneuver is especially important along the inferior border of the pancreas, where a small artery will be found in most patients.
- Transect the pancreas (we usually use electrocautery) down to the anterior surface of the SMPV confluence.
- If there is evidence of tumor adherence to the PV or SMV, the pancreas can be divided at a more distal location (along the left or medial border of the SMPV confluence) in preparation for segmental venous resection.
- Reflect the specimen to the patient's right and separate it from the PV and SMV by ligation and division of the small venous tributaries to the uncinate process and pancreatic head. Note: The relationship of the tumor to the lateral and posterior walls of the SMPV confluence can be inspected directly only after gastric and pancreatic transection. This relationship cannot be assessed accurately intraoperatively by simply developing a plane of dissection between the anterior surface of the SMPV confluence and the posterior aspect of the neck of the pancreas (which is why this age-old maneuver is no longer performed earlier in the operation) (Fig. 90.7).

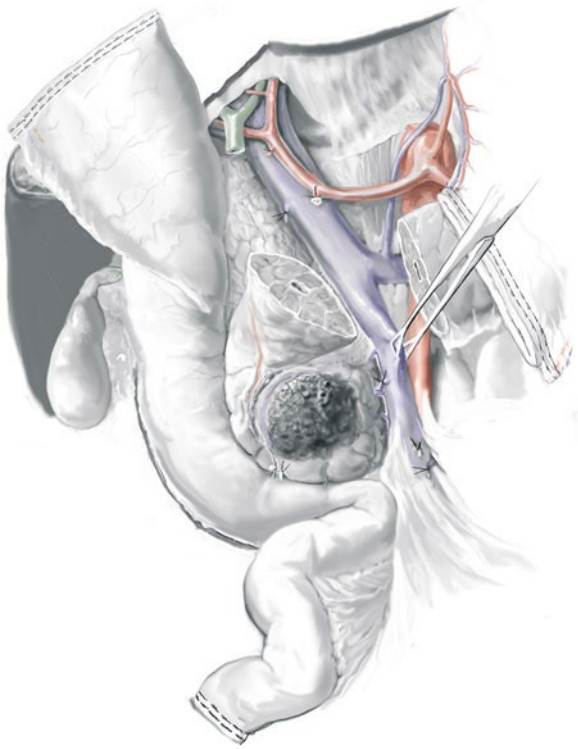


Fig. 90.7

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Step 7

Removal of uncinate process from the SMV

Complete removal of the uncinate process from the SMV and its first jejunal branch is required; to mobilize the SMPV confluence, reflect it to the patient's left. This maneuver is necessary for proper identification of the SMA unless the SMA has been exposed medial to the SMV. The first jejunal branch of the SMV originates from the right posterolateral aspect of the SMV at the level of the uncinate process, usually travels posterior to the SMA, and enters the medial (proximal) aspect of the jejunal mesentery, giving off two or three branches directly to the uncinate process that need to be divided (Fig. 90.8). If tumor involvement of the SMV at this location prevents dissection of the uncinate process from the SMV, the first jejunal branch can be divided. Injury to the SMV at the level of the first jejunal branch or a tangential laceration in the first jejunal branch (as it courses posterior to the SMA) is hard to control and represents the most frequent cause of iatrogenic SMA injury. In such cases, we avoid this potentially disastrous complication by first exposing the SMA medial to the SMV, prior to dissecting the junction of the SMV and its first jejunal branch (which we believe is an underutilized technique).

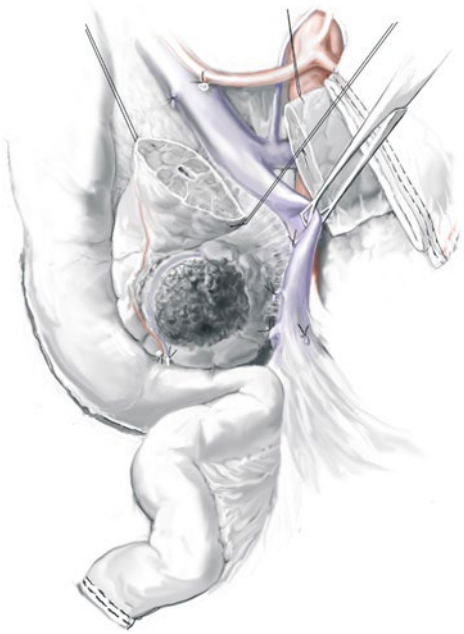


Fig. 90.8

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Step 8

Exposure of the SMV

- Medial retraction of the SMPV confluence allows identification of the SMA lateral to (to the patient's right of) the SMPV confluence and facilitates dissection of the pancreatic head and soft tissues off of the right lateral wall of the proximal SMA (Fig. 90.9). Failure to fully mobilize the SMPV confluence and expose the SMA usually results in a positive resection margin owing to incomplete removal of the uncinate process and the mesenteric soft tissue adjacent to the SMA.

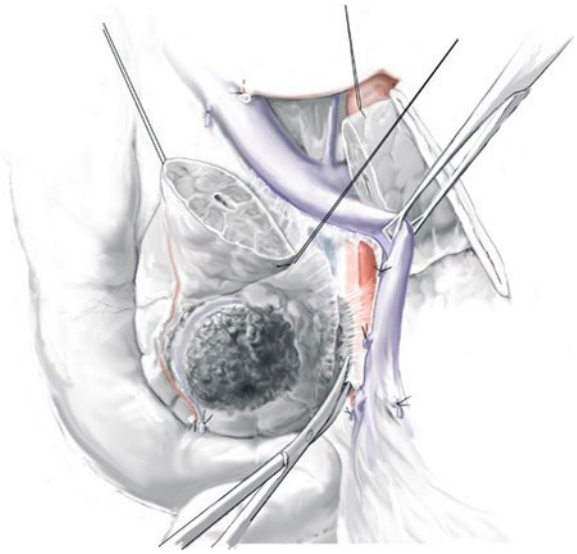


Fig. 90.9

Step 9

Ligation of inferior pancreatoduodenal arteries

- Failure to identify and individually dissect and ligate the inferior pancreatoduodenal artery or arteries is the major cause of postoperative retroperitoneal hemorrhage because these vessels may retract (if ligated with a large amount of mesenteric soft tissue) and bleed in the postoperative period (Fig. 90.10).

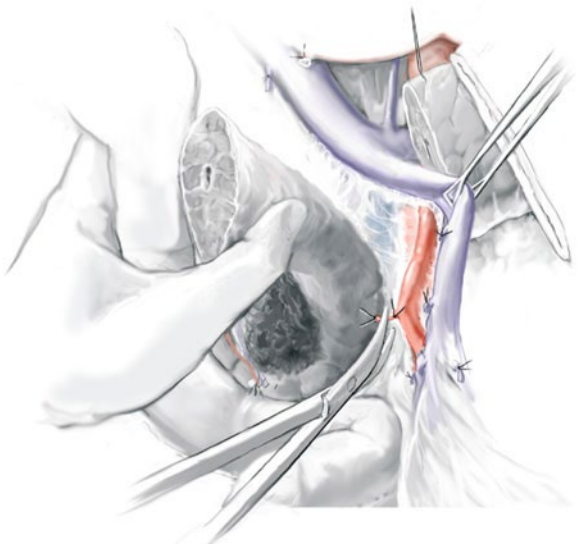


Fig. 90.10

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Step 10

SMA margin

- Properly orient the specimen to enable accurate assessment of the SMA margin (also historically termed the *retroperitoneal* or *uncinate* margin) and other standard pathologic variables (Fig. 90.11). The soft tissue adjacent to the proximal 3 to 4 cm of the SMA represents the SMA margin; this area should be inked by the pathologist for permanent-section evaluation. A grossly positive SMA margin (R2 resection) should not occur if high-quality preoperative imaging is performed. A microscopically positive SMA margin (R1 resection) will occur in 10 % to 20 % of resections.
- We perform frozen section analysis of pancreatic and CHD transection margins and re-resect these if a positive margin is found.

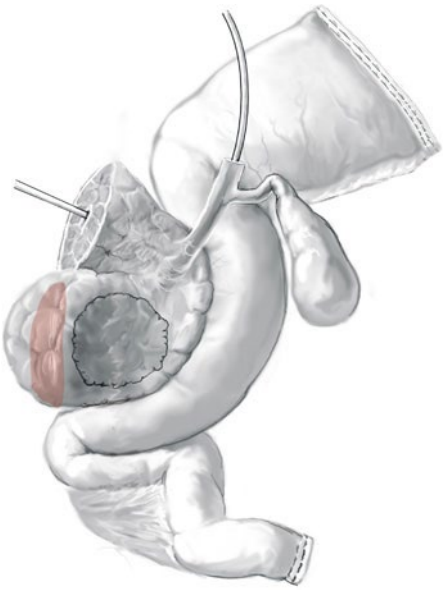


Fig. 90.11

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Step 11

Vascular reconstruction

- Steps 1 through 5 of the pancreatoduodenectomy are completed as described above. Tumor adherence to the lateral wall of the SMPV confluence prevents dissection of the SMV and PV off the pancreatic head and uncinate process, thereby inhibiting medial retraction of the SMPV confluence (and lateral retraction of the specimen).
- The standard technique for segmental venous resection involves transection of the splenic vein. Division of the splenic vein allows complete exposure of the SMA medial to the SMV and provides increased SMV and PV length (because they are no longer tethered by the splenic vein) for a primary venous anastomosis in most cases. The retroperitoneal dissection is completed by sharply dividing the tissues anterior to the aorta and to the right of the exposed SMA; the specimen is then attached only by the SMPV confluence. Venous resection is always performed with inflow occlusion (Rommel tourniquet) of the SMA to prevent small bowel edema (which makes pancreatic and biliary reconstruction more difficult).
- Systemic heparinization is employed prior to occluding the SMA. Vascular clamps are placed 2 to 3 cm proximal (on the PV) and distal (on the SMV) to the involved venous segment, and the vein is transected, allowing removal of the specimen (Fig. 90.12a).
- A generous (2-cm to 3-cm) segment of SMPV confluence can be resected without the need for interposition grafting if the splenic vein is divided. The free ends of the vein are reapproximated using interrupted sutures of 6-0 polypropylene (Fig. 90.12b). If the inferior mesenteric vein (IMV) enters the splenic vein, it will provide for splenic vein decompression via retrograde flow to the systemic venous circulation. If the IMV enters the SMV and the splenic vein is divided, the patient is at risk for sinistral (left-sided) portal hypertension, and in such cases we anastomose the splenic vein to the left renal vein (distal splenorenal shunt) to prevent the development of gastroesophageal varices.

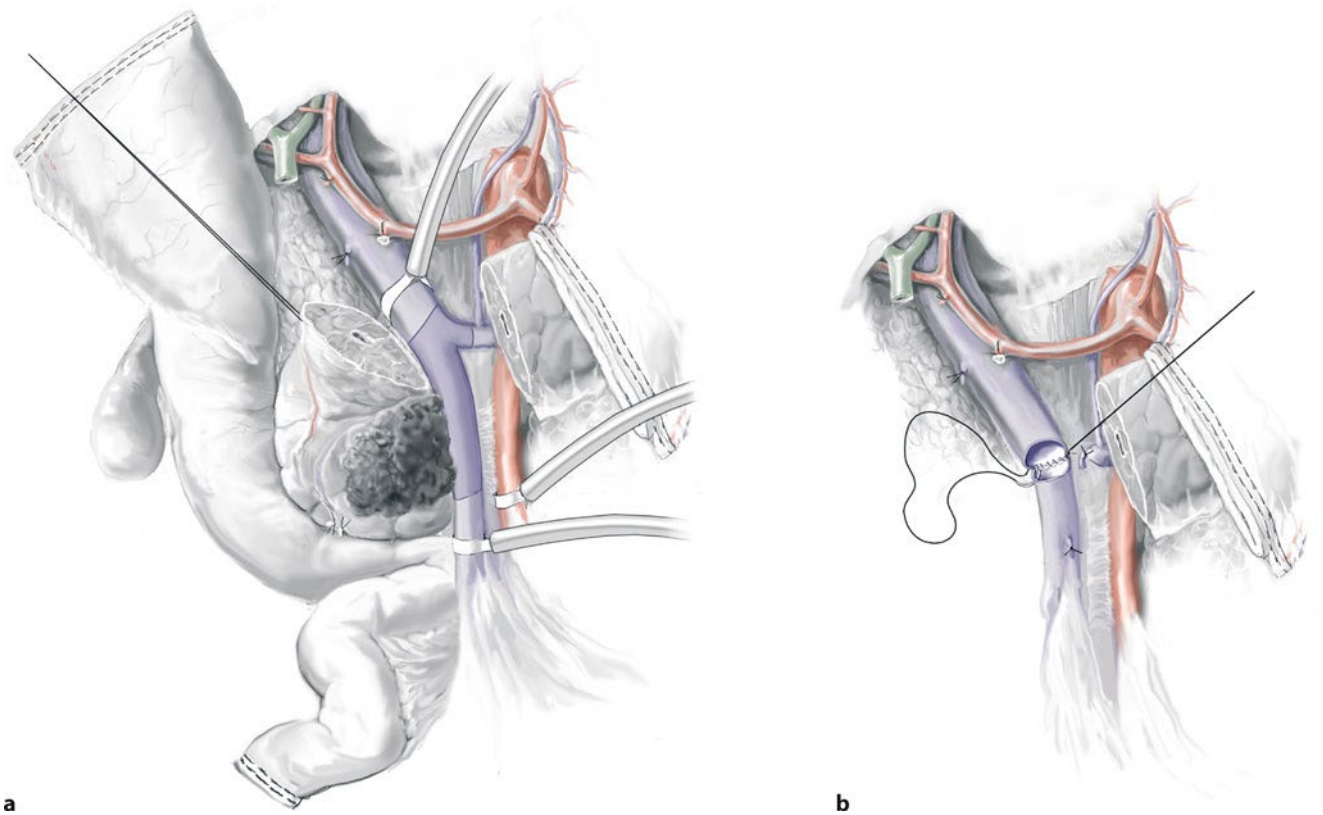


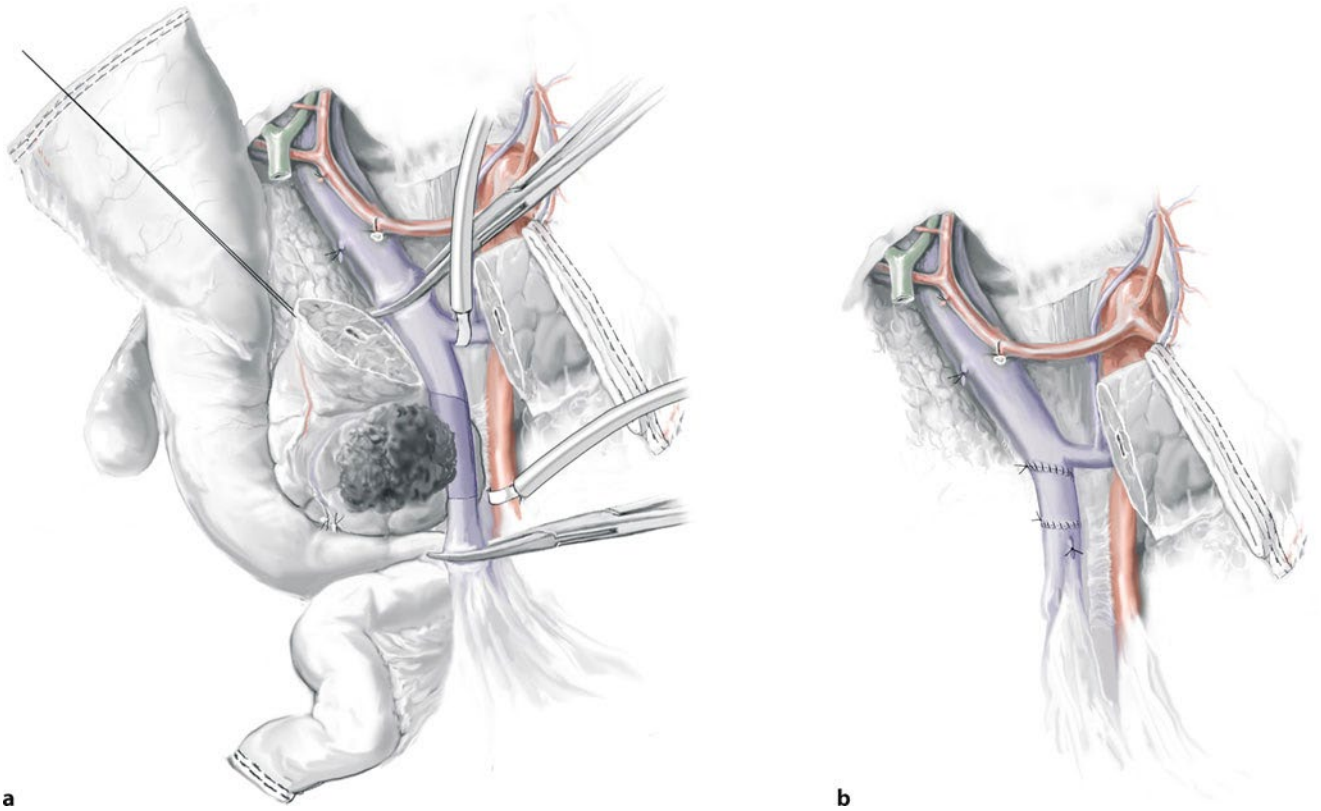
Fig. 90.12

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Step 12

SMV reconstruction

- When tumor involvement is limited to the SMV, we usually preserve the splenic vein-PV junction. Splenic vein preservation is possible only when tumor invasion of the SMV or PV does not involve the splenic vein confluence. Preservation of the splenic vein-SMV-PV confluence limits substantially the mobility of the PV and prevents primary anastomosis of the SMV (after segmental SMV resection), unless segmental resection is limited to less than 2 cm (Fig. 90.13a).
- Therefore, in most patients who undergo SMV resection with splenic vein preservation, an interposition graft using the internal jugular vein is necessary. Preservation of the splenic vein adds complexity to venous resection, because this situation prevents direct access to the most proximal 3 to 4 cm of the SMA (medial to the SMV). Venous resection and reconstruction are performed after complete mesenteric dissection by separating the specimen first from the SMA (Fig. 90.13b). If the SMA dissection is expected to be difficult (because of tumor abutment of the artery), we would divide the splenic vein to improve access to the root of mesentery. In such cases, the splenic vein would be anastomosed to the left renal vein, unless the IMV provided adequate decompression, as discussed above. These techniques require significant experience with pancreatoduodenectomy as well as with vascular resection and reconstruction.



a b

Fig. 90.13

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Step 13

Pancreatic reconstruction

- The pancreatic remnant is mobilized from the retroperitoneum and splenic vein for a distance of 2 to 3 cm to allow suture placement for the pancreaticojejunal anastomosis.
- We bring the transected jejunum retrocolic through a generous defect in the transverse mesocolon to the left of the middle colic vessels. We usually prefer a two-layer, end-to-side, duct-to-duct mucosal pancreaticojejunostomy (over a small stent when the pancreatic duct is not dilated). The outer row consists of interrupted 4-0 or 5-seromuscular, monofilament sutures. The inner row consists of 4-0, interrupted, monofilament sutures approximating full-thickness pancreatic duct to full-thickness jejunum. Posterior knots are tied on the inside; the lateral and anterior knots are tied on the outside. If a stent is used, the stent is placed across the anastomosis prior to securing the anterior sutures, so that the stent extends into the pancreatic duct and small bowel for a distance of approximately 2 cm (Fig. 90.14).

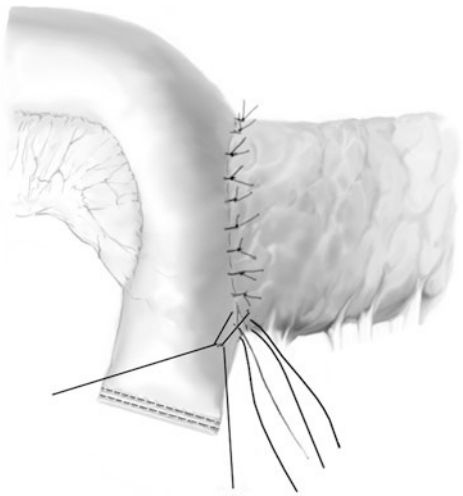


Fig. 90.14

Step 14

Biliary reconstruction

- Distal to the pancreaticojejunostomy, we create a one-layer, end-to-side hepaticojejunostomy with 4-0 or 5-0, absorbable, monofilament sutures. (This anastomosis is not stented even when the CHD is of normal size.) It is very important to avoid tension and leave an adequate length of jejunum between the pancreatic and biliary anastomoses (Fig. 90.15).

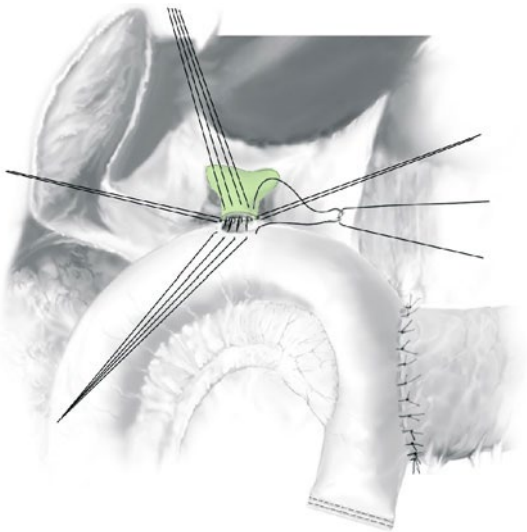


Fig. 90.15

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Step 15

Gastric or duodenal reconstruction

- The gastrojejunostomy is usually constructed antecolic and is hand-sewn in two layers (Fig. 90.16a). We allow at least 45 to 50 cm between the hepaticojejunostomy and the gastrojejunostomy to prevent reflux (gastric contents) cholangitis.
- When the pylorus is preserved, the duodenojejunostomy is created in an end-to-side fashion with a single layer, hand-sewn technique, using monofilament absorbable sutures (Fig. 90.16b). Again, the distance between the biliary and gastric/duodenal anastomoses is approximately 45 to 50 cm, and we gently dilate the pylorus prior to completing the anastomosis.
- A 10-Fr. feeding jejunostomy tube for postoperative enteral feeding is placed distal to the gastrojejunostomy in most patients, using the Witzel technique.
- The falciform ligament is also placed between the CHA and the afferent jejunal limb, to cover the stump of the GDA. This strategy may help to prevent pseudoaneurysm formation at the GDA stump in the event of a pancreatic anastomotic leak and resulting abscess formation. We usually do not place a drain near the pancreatic or biliary anastomoses.

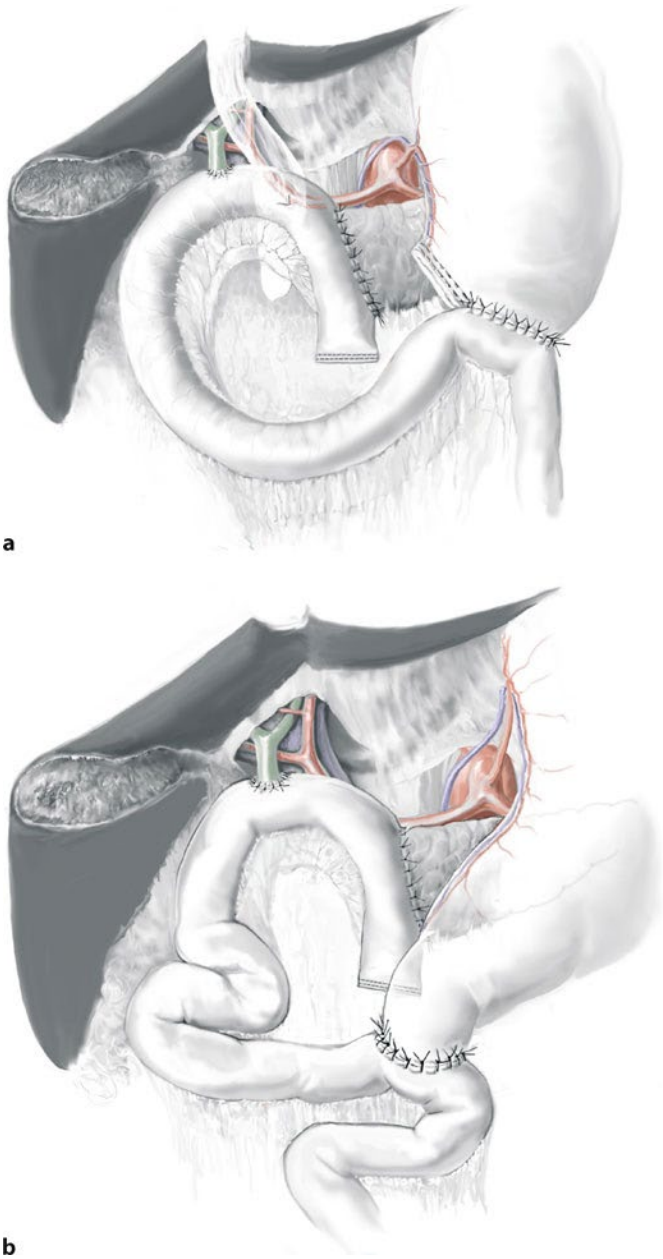


Fig. 90.16

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Postoperative tests

- Complete blood count (hemoglobin, WBC, platelet count); arterial blood gas
- Electrolytes/creatinine (standard chemistries)
- Total serum bilirubin
- CT imaging if fever, leukocytosis, or sepsis occurs; the most likely cause is a leak at the pancreaticojejunostomy

Local complications

- **Short-term:**
  - Intra-abdominal abscess/pancreatic anastomotic leak, shown by fever, leukocytosis, ileus, and abdominal distention, usually after postoperative days 4 or 5. CT imaging of the abdomen and pelvis should be performed; CT-guided aspiration and percutaneous catheter drainage can address the development of an infected fluid collection.
  - GDA-enteric fistula: Gastrointestinal or drain tract bleeding is rare before postoperative day 10. This complication is usually due to pancreatic anastomotic leak with surrounding infection and inflammation resulting in GDA stump blowout. The treatment of choice is angiography with hepatic artery embolization or stenting; operative exploration is a last resort.
  - Delayed gastric emptying: Jejunostomy tube placement allows for use of enteral feeding, preventing the need for intravenous alimentation.

- **Long-term:**
  - Recurrent pancreatic cancer: local in bed of pancreas; distal in liver, lungs, or peritoneum
  - Development of pancreatic exocrine insufficiency (~40%) or endocrine insufficiency (~20%)
  - Pancreatic anastomotic stricture with recurrent pancreatitis or pancreatic pain
  - Small intestinal obstruction

Tricks of the Senior Surgeon

- Assess resectability preoperatively with high-quality, multidetector CT imaging, as the relationship between the tumor and the SMV and SMA is usually impossible to assess accurately intraoperatively before gastric and pancreatic transection.
- Do not attempt blunt dissection of the GDA origin, as an intimal dissection may result in occlusion of the hepatic artery. When the tumor extends close to the origin of the GDA, obtain proximal and distal control of the hepatic artery and sharply divide the GDA at its origin, utilizing inflow occlusion; the resulting arteriotomy can be closed with 6-0 polypropylene with or without a vascular pledget.
- Always mobilize fully the SMPV confluence and expose the SMA. If the SMPV is involved by tumor, expose the SMA medial to the SMPV and finish the SMA dissection first, leaving the tumor attached to the vein only. The SMA will not be injured if the surgeon keeps the SMA in direct vision.
- Bring the jejunum retrocolic and not retroperitoneal (in the bed of the resected duodenum) for pancreatic and biliary reconstruction. The incision in the transverse mesocolon should be to the patient's left of the middle colic artery.

Central Resection

Sergio Pedrazzoli, Cosimo Sperti

In 1959, Letton and Wilson reported the first nonresective treatment of traumatic rupture of the neck of the pancreas. The right stump of the pancreatic head was oversewn, and a Roux-en-Y loop of jejunum was anastomosed to the left body/tail of the pancreas. In 1984, Dagradi and Serio reported the first central pancreatectomy for an insulinoma, and in 1988, Fagniez, Kracht, and

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Rotman reported two central pancreatectomies performed for an insulinoma and a serous cystadenoma. More than fifteen hundred central pancreatectomies, performed in more than 110 centers, have been reported so far, with a very low mortality. Therefore, central pancreatectomy (also referred to as middle segment pancreatectomy and segmental pancreatectomy) is a widely accepted operative procedure for the treatment of benign or borderline lesions of the pancreas. Central pancreatectomy is the forerunner of several other parenchyma-preserving procedures, such as duodenum-preserving pancreatic head resection, inferior head resection, dorsal pancreatectomy, and middle-preserving pancreatectomy.

As for standard pancreatic resections, there is growing experience with laparoscopic or robotic-assisted central pancreatectomy in specialized centers.

Central pancreatectomy involves anatomic removal of benign or borderline lesions of the neck and/or proximal body of the pancreas together with 1 cm of normal pancreatic parenchyma on both sides. The goal is to preserve at least 5 cm of the normal pancreatic tissue of the body and tail of the pancreas that would otherwise be removed with a complete distal pancreatectomy, without increasing the surgical risk significantly. We must remember that the benefit of central pancreatectomy will be seen only after at least 5 years.

Indications and contraindications

Indications

- Small, centrally located lesions (< 5 cm in diameter) not amenable to enucleation
- Traumatic transection of the neck of the pancreas
- Benign, borderline, or low-grade malignant lesions (e. g., selected neuroendocrine neoplasms, serous or mucinous cystic neoplasms, solid pseudopapillary neoplasms, branch-type intraductal papillary mucinous neoplasms, solitary true cysts, parasitic cysts, solitary metastasis from renal cell carcinoma)
- Maintenance of a distal pancreatic stump at least 5 cm in length
- Biologically young and fit patients

Contraindications

- Overtly malignant pancreatic lesions
- Involvement of the pancreas by contiguous malignant neoplasms
- Insulin-dependent diabetes

Relative contraindications

- Life expectancy less than 10 years
- Intermediate and high-risk patient
- Non-insulin-dependent diabetes mellitus (NIDDM)

Preoperative investigations and preparation for the procedure

- *History:* Presence or family history of an endocrine syndrome (e. g., insulinoma, gastrinoma, glucagonoma), acute pancreatitis, upper abdominal pain
- *Clinical evaluation:* Exclude diarrhea secondary to exocrine insufficiency, diabetes, and portal hypertension
- *Laboratory tests:* Amylase, lipase, and/or peptide hormones (insulin, gastrin, glucagon, vasoactive intestinal polypeptide, pancreatic polypeptide, somatostatin, chromogranin A), tumor markers (CA 19–9, CEA, MCA, etc.). If an endocrine neoplasm is suspected, store a preoperative sample of serum, plasma, or both for specific assays based on histologic and immunohistochemical characterization of the resected lesion
- *Imaging:*
  - Differential diagnosis and assessment of resectability based on ultrasonography, CT, MRI, or endoscopic ultrasonography (EUS); the latter may allow tumor sampling
  - Radiolabeled somatostatin analogues: endocrine neoplasms
  - 18-FDG positron emission tomography (PET) helps to differentiate between benign and malignant lesions

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- *Preoperative preparation:*
  - Somatostatin analogues: no specific study on central pancreatectomy
  - Perioperative antibiotics: as for any clean-contaminated operation

Procedure: Central pancreatectomy

Step 1

Exposure of central part of pancreas

- Optimal access is via a midline incision.
- The pancreas is exposed by detaching the greater omentum from the transverse colon and freeing the superior aspect of the middle colic vessels until the anterior aspect of the pancreas is exposed completely; the stomach is retracted rostrally.
- The superior mesenteric vein (SMV) is identified, and its anterior surface cleared caudal to the neck of the pancreas. Care must be taken not to injure venous tributaries; occasionally a middle colic branch of the SMV requires division, especially if it joins in a V-shaped way with the right gastroepiploic vein. Gastroepiploic vessels are preserved, unless the lesion reaches the right border of the superior mesenteric-portal vein (SMPV) (Fig. 90.17).

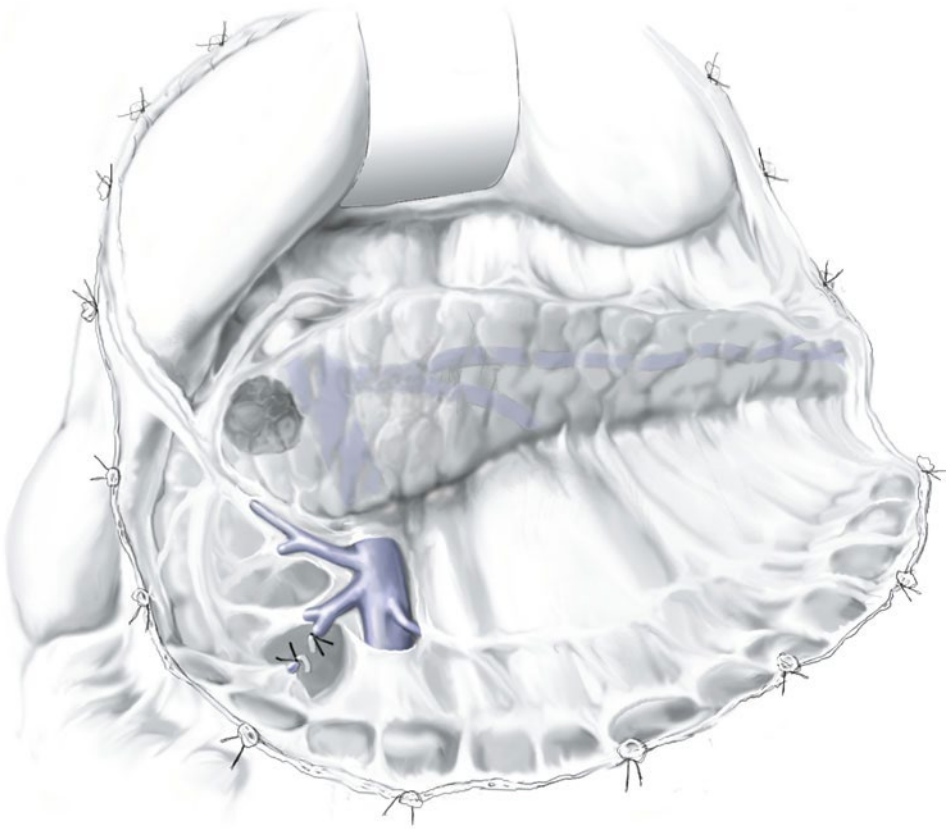


Fig. 90.17

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Step 1 ***(continued)***

- Evaluate the extent of the lesion by intraoperative ultrasonography (IOUS); this technique is useful particularly for small, deeply located lesions (Fig. 90.18). Mark with electrocautery the exact extent of the planned central pancreatectomy, including 1 cm of normal pancreatic tissue on both sides. Identify the intrapancreatic course of the bile duct before transecting the pancreas very close to the gastroduodenal artery.

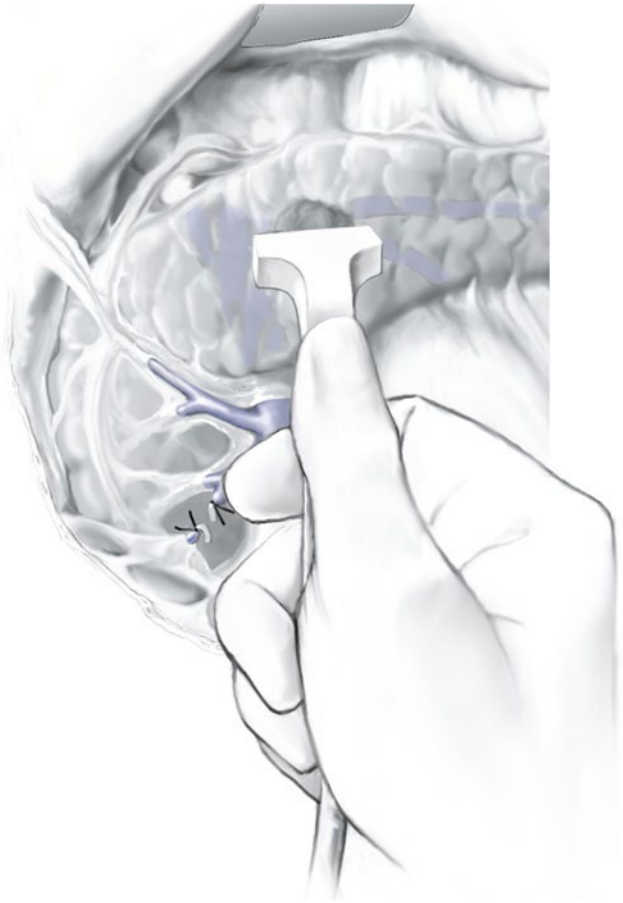


Fig. 90.18

Step 2

Mobilizing pancreas to be resected

- The posterior peritoneum is incised with electrocautery along the inferior border of the part of the pancreas to be removed until the splenic vein is visualized. Attention should be paid to ligate and divide a small artery and vein that are often present between the left side of the SMV and the inferior border of the pancreas (Fig. 90.19a).
- Lymph node(s) anterior to the common hepatic artery are removed when a neoplasm is suspected, and the common hepatic artery is detached from the superior border of the pancreas extending from the celiac axis to the gastroduodenal artery.
- The hepatic artery is retracted rostrally (Fig. 90.19b).
- When the tumor extends to the left of the origin of the splenic artery, the splenic artery should first be mobilized and retracted rostrally, taking care to divide the dorsal artery.

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Step 2 ***(continued)***

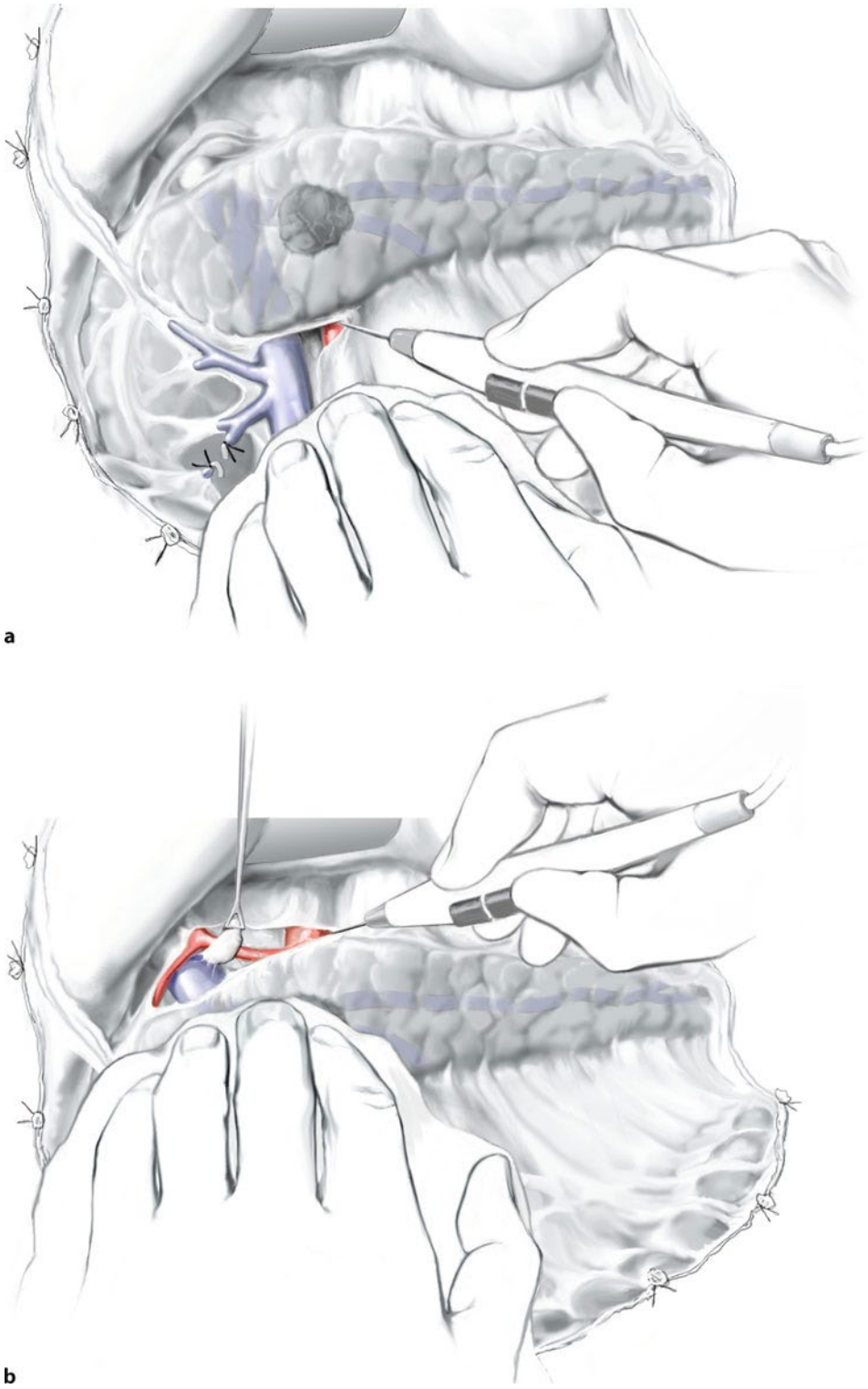


Fig. 90.19

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Step 3

Mobilization of superior mesenteric and splenic vein

- The plane between the SMPV and the neck of pancreas is teased gently apart; usually no veins transgress this space. In the rare event of a pancreatic vein joining the anterior surface of the portal vein, the pancreas can be transected progressively from below until the vein is exposed, thereby allowing division of the vein between ties.
- The pancreas is encircled with a tape and retracted anterorostrally, allowing visualization and ligation of the veins from the posterior pancreas (to be resected) entering the splenic vein (Fig. 90.20a).
- The splenic vein is then separated carefully from the pancreas to be resected.
- Transection of the proximal pancreas (right side) begins 1 cm proximal to the lesion; anterior retraction of the left pancreas may allow better visualization and ligation of the veins from the posterior pancreas to the splenic vein (Fig. 90.20b).

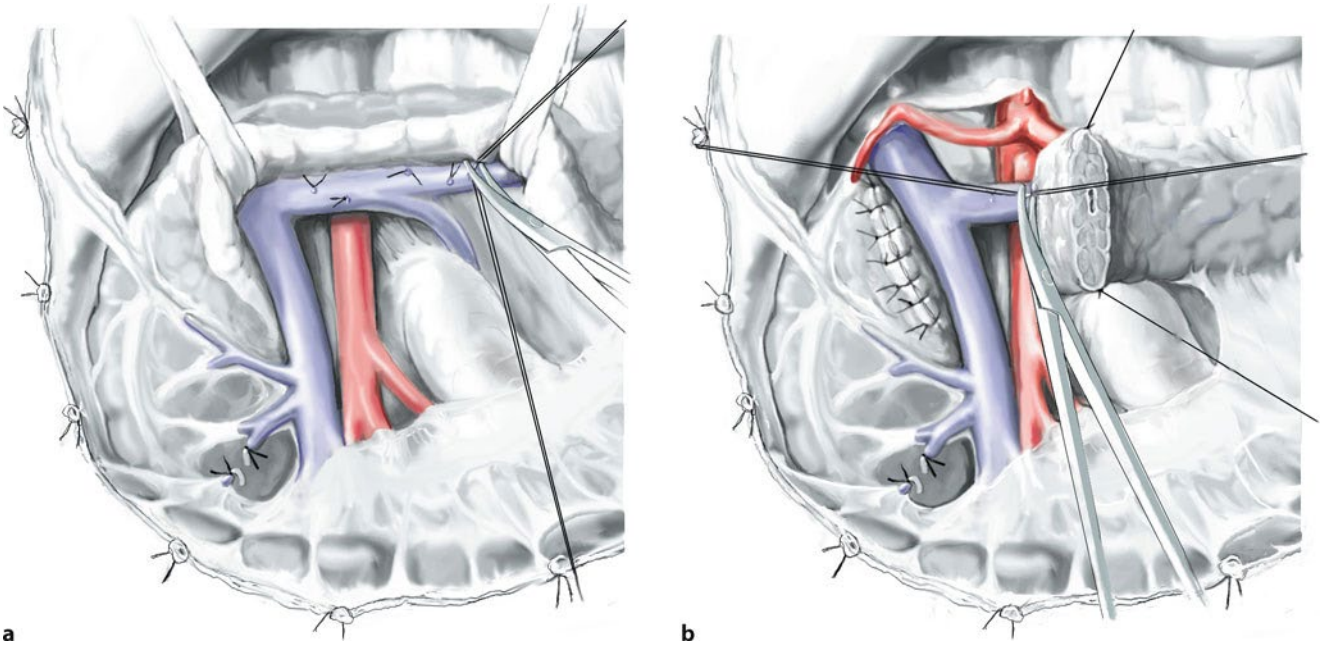


Fig. 90.20

Step 4

Removal of central pancreas

- Transection of pancreas: Stay sutures are placed on the superior and inferior pancreatic margins just to the right and left of the proximal and distal lines of division, to occlude the superior and inferior pancreatic vessels running transversely in the parenchyma (Fig. 90.21a).
- The pancreas is divided by scalpel, using a V-shaped incision on the patient's right side of the tumor to facilitate closure in fish-mouth fashion; the pancreas is transected 1 cm to the left of the tumor with suture ligation of the larger arterial bleeders in the cut edge (Fig. 90.21b).
- The pancreatic duct in the right side of the remnant gland is suture-ligated with 5-0 nonabsorbable monofilament, and the pancreatic tissue is closed in a fish-mouth fashion with interrupted, 3-0 synthetic absorbable sutures (Fig. 90.21b).
- A very thin neck of pancreas can also be closed with a stapler, and bleeding from small arteries controlled with absorbable synthetic sutures; the pancreatic duct is still identified and suture-ligated individually with 5-0 nonabsorbable monofilament (Fig. 90.21c).
- The right-sided limit of a central pancreatectomy is the left side of the gastroduodenal artery; transecting the pancreas to the right of the gastroduodenal artery can injure the common bile duct.
- The specimen is sent to the pathologist for frozen section examination and for checking the right and left resection margins. A suture on one margin will orient the specimen for the pathologist.

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Step 4 ***(continued)***

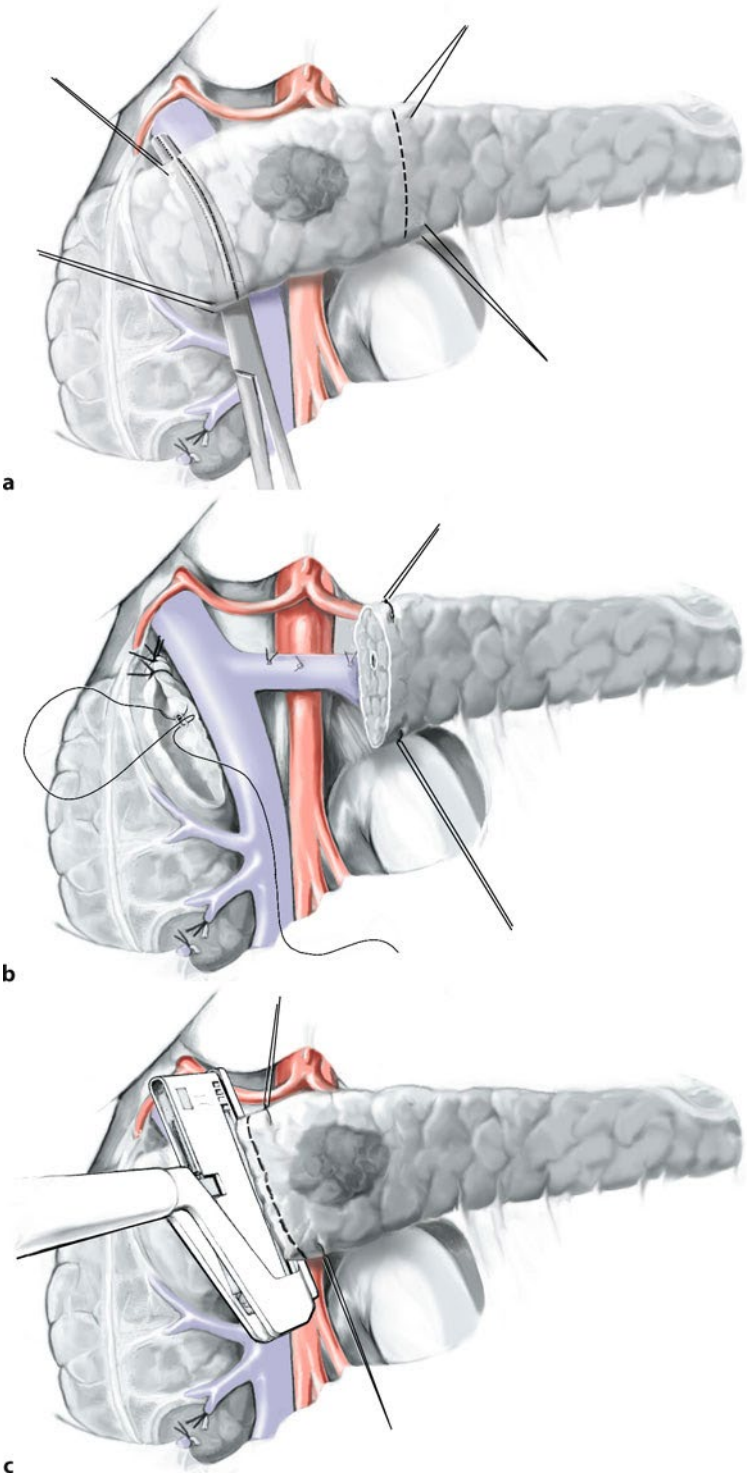


Fig. 90.21

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Step 5

Invagination/dunking pancreatojejunostomy

- The left pancreatic stump is mobilized distally for 2.5 to 3 cm; the first layer of interrupted, 3-0 absorbable monofilament is placed between the jejunum and the posterior aspect of the pancreatic stump 2 cm from the transected edge; the second layer of continuous, 3-0 absorbable monofilament approximates the cut end of the jejunum and the transected edge of the pancreatic stump (Fig. 90.22a).
- An anterior layer of interrupted, 3-0 absorbable monofilament is applied between the seromuscular layer of the jejunum and the pancreatic capsule 2 cm from the pancreatic border. By means of this layer, the first 2 cm of the pancreatic stump invaginates progressively into the jejunum (Fig. 90.22b).
- When a difficult invagination is expected due to a large, fat pancreatic stump, one trick to complete the procedure safely involves excising the muscular layer of the last 2 cm of jejunum (Fig. 90.22c).
- Invagination as described above leaves an inner cylinder only of mucosa and a full-thickness external cylinder (Fig. 90.22d).

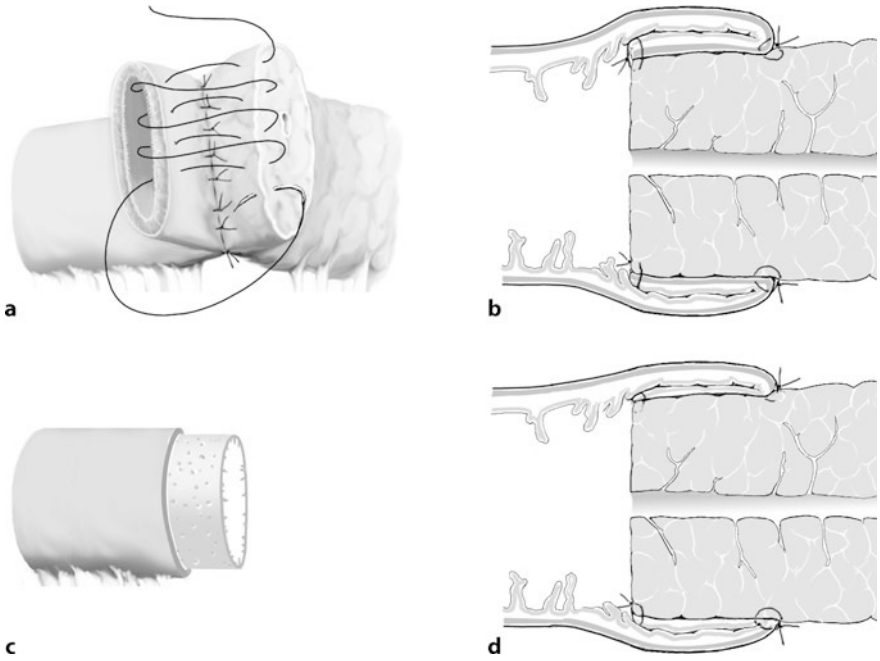


Fig. 90.22

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Step 6

Alternative: duct-to-mucosal pancreaticojejunostomy

- The left pancreatic stump is not mobilized beyond the stay sutures; the end of the jejunum is stapled and oversewn.
- A small opening calibrated to the diameter of the pancreatic duct is made in the jejunum on the antimesenteric border, 3 to 4 cm from the stapled end; the mucosa is everted and fixed to the seromuscular layer with 6-0 absorbable monofilament (Fig. 90.23a).
- A mucosa-to-mucosa anastomosis is performed with 5-0 or 6-0 double-armed monofilament absorbable sutures, with the knots outside the lumen; magnification aids this procedure greatly.
- Anterior (Fig. 90.23b) and posterior (Fig. 90.23c) layers of interrupted 3-0 absorbable monofilament approximate the jejunum and the anterior and posterior aspects of the pancreatic stump.
- After completing the pancreaticojejunostomy, the same jejunal limb can be used to cover the right-sided pancreatic stump, using a technique similar to a serosal patch. Posterior and anterior layers of continuous, 3-0 absorbable monofilament approximate the jejunum and the posterior and anterior aspects of the right-sided pancreatic stump.

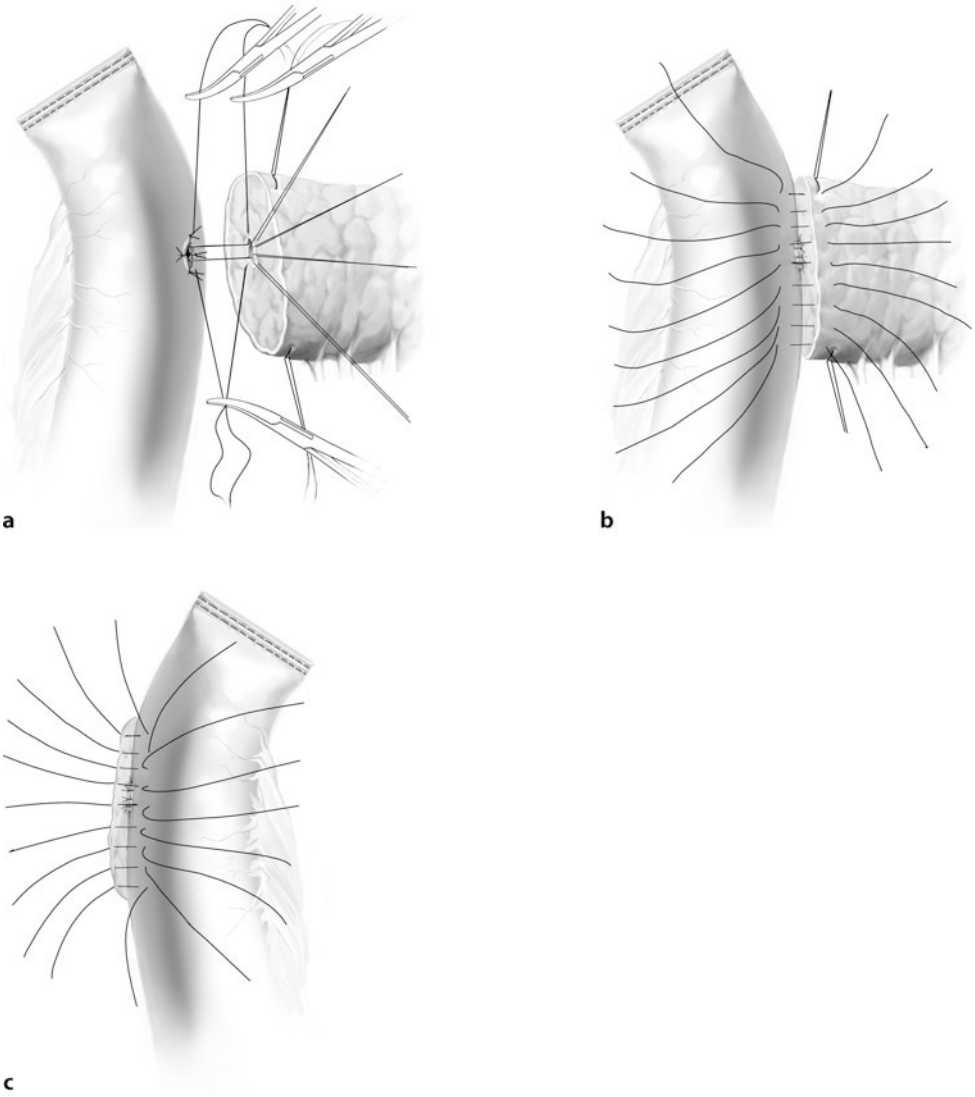


Fig. 90.23

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Step 7

Pancreaticogastrostomy

- The left pancreatic stump is mobilized distally for about 3 to 3.5 cm, and a first layer of interrupted 3-0 absorbable monofilament approximates the posterior wall of the stomach (as near to the fundus as possible) and the anterior aspect of the pancreatic stump 2 cm from the transected edge (Fig. 90.24a).
- An opening calibrated to the diameter of the pancreatic stump is made in the posterior wall of the stomach (Fig. 90.24b).
- An interrupted 3-0 absorbable monofilament is applied between the full-thickness opened gastric wall and the posterior and anterior border of the pancreatic stump (Fig. 90.24c).
- An interrupted 3-0 absorbable monofilament approximates the seromuscular wall of the stomach and the posterior aspect of the pancreatic stump; the pancreatic stump is progressively invaginated into the stomach (Fig. 90.24d).

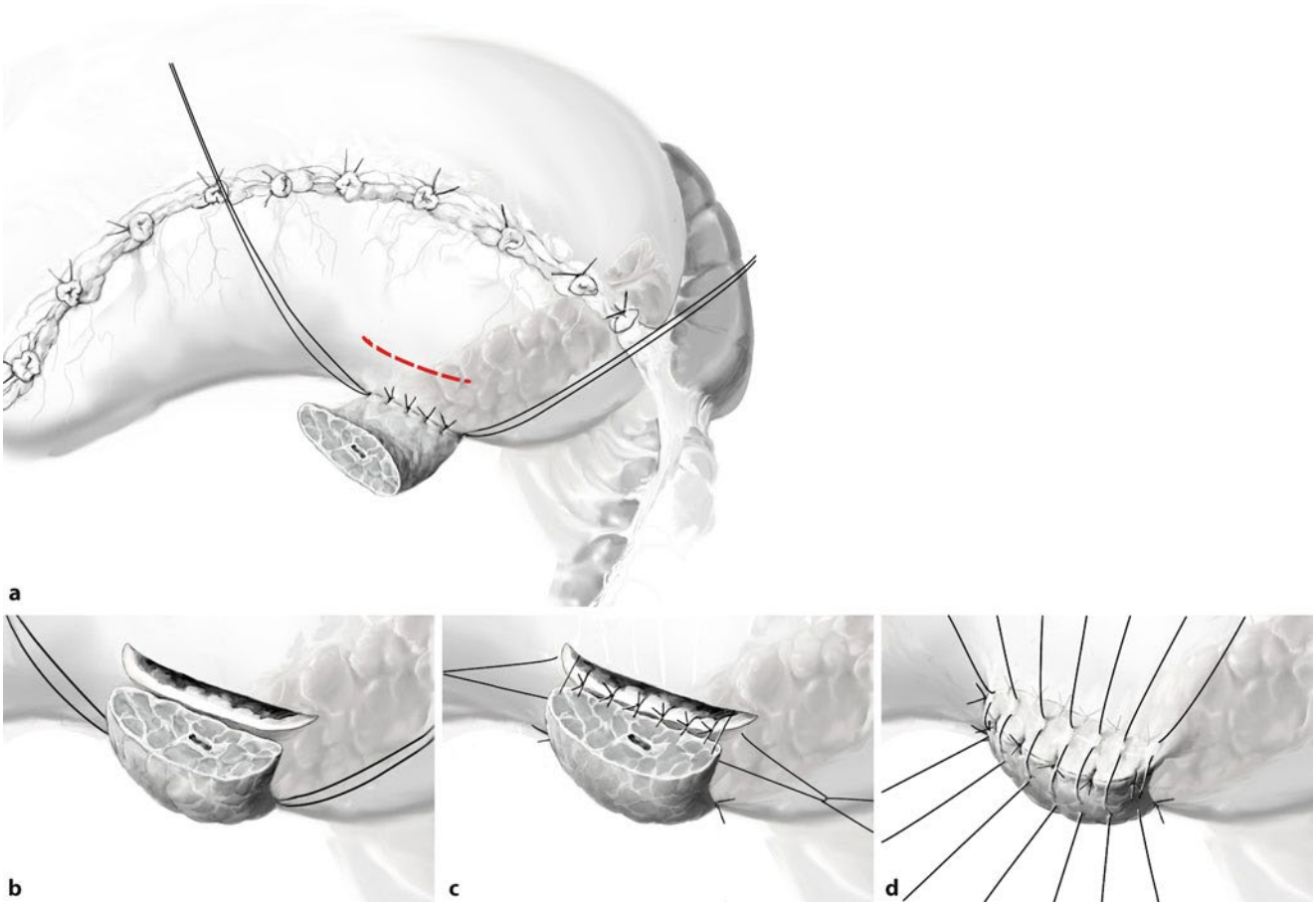


Fig. 90.24

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Postoperative care and tests

- Postoperative surveillance in an intensive care unit if necessary
- Serum amylase and/or lipase activity
- Check for amylase and lipase activity in drain fluids

Local postoperative complications

- **Short-term:**
  - Anastomotic disruption
  - Pancreatic fistula
  - Peripancreatic abscess
  - Intra-abdominal bleeding
  - Acute pancreatitis
  - Subdiaphragmatic abscess
  - Splenic-portal vein thrombosis
  - Pleural effusion
- **Long-term:**
  - Pancreatic pseudocyst
  - Pancreatic ascites
  - Pancreatitis
  - Diabetes

Tricks of the Senior Surgeon

- If the approach to the superior mesenteric portal (SMPV) trunk is difficult, Kocherization of the head of the pancreas is advisable; control of bleeding will be easier.
- If the SMPV or one of its branches is injured, do not panic and use instruments blindly! Compress the venous trunk between the fingers, which are inserted posteriorly behind the head of the pancreas (after the Kocher maneuver), and the thumb, which is on the anterior aspect of the pancreas; suture the tear with 5-0 polypropylene.
- If the pancreas is too large for an invagination/dunking pancreaticojejunostomy, choose either a duct-to-mucosal anastomosis or a pancreaticogastrostomy. Oversewing of the left pancreatic stump is followed by gland fibrosis, which compromises endocrine secretion and nullifies the long-term benefits of the central resection.
- Suture-ligate and transect the splenic vein if it is injured beyond repair during the procedure; also suture-ligate and transect the splenic artery to prevent sinistral (splenic) hypertension. The left pancreatic remnant is vascularized adequately through the short gastric vessels.

Distal Pancreatectomy

Robert Beaulieu, Frederick Eckhauser

Ductal adenocarcinoma of the pancreatic body and tail is resectable less often than cancer of the head of the pancreas because of the delay in symptoms and diagnosis. When resection is feasible, however, the survival after R0 resection of a distal ductal cancer is similar to that of proximal resections. Furthermore, the principles of negative margins and removal of involved N1 nodes are maintained with distal resections, as with classic pancreatoduodenectomies. With the improvements in imaging as well as screening of more high-risk populations, the number of distal pancreatectomies for malignancy appears to be increasing. Moreover, cystic neoplasms of the pancreas and nonfunctional neuroendocrine neoplasms also occur in the body and tail of the pancreas and are more commonly resectable.

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Indications and contraindications

Indications

- Neoplasms: ductal adenocarcinoma, islet cell neoplasms, and cystic lesions of the body and tail of pancreas

Contraindications

- Major visceral vessel encasement (celiac axis, proximal splenic or hepatic artery); widespread local metastatic disease; or distant metastases to liver, peritoneum, or distal nodes (celiac, superior mesenteric, or para-aortic)
- Local extension to spleen, stomach, colon, or left kidney is frequently (but not always) a contraindication

Preoperative investigation and preparation for the procedure

- *History:* Weight loss, abdominal or back pain, pancreatitis, new-onset diabetes mellitus, family history of pancreatic cancer; jaundice is uncommon and should raise the suspicion of liver metastases
- *Clinical evaluation:* The following should raise concern about unresectability: Jaundice, nutritional status, ascites, palpable left supraclavicular ("Virchow's") node, signs of sinistral portal hypertension (splenomegaly, gastric varices)
- *Laboratory tests:* Tumor markers (i. e., CA 19–9, CEA), liver function tests (AST, ALT, alkaline phosphatase, bilirubin)
- *ERCP, EUS, CT, MRI:* Assessment of resectability (no distant metastases, no major visceral vessel encasement), staging extent of neoplasm
- *Other considerations:* Preoperative vaccination against pneumococcus, meningococcus, and *Haemophilus influenzae* (ideally 14 days in advance); staging laparoscopy (before *vs* at time of proposed resection), use of radical antegrade modular pancreaticosplenectomy (RAMPS) approach versus traditional open approach; full bowel preparation may be necessary for involvement of the transverse colon

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Procedure: Distal pancreatectomy

Step 1

Exposure and exploration

- The patient is placed supine, with slight reverse Trendelenburg and rotation to the patient's right.
- An upper midline or left subcostal incision is best, depending on the angle of the patient's costal margin.
- The exposure and exploration are aided by a fixed-blade retractor.
- A careful, systematic exploration of the abdomen is performed to detect distant metastases (peritoneum, bowel, liver, distant nodal basins).
- The lesser sac is entered through the gastrocolic ligament to expose the entire ventral surface of the pancreas from the gastroduodenal artery medially to the splenic hilum laterally.
- The splenic flexure of the colon is mobilized caudally; exposure of the pancreatic bed requires anterocephalad retraction of the stomach and caudal retraction of the transverse colon.
- Vessels along the greater curvature of the stomach, including the short gastrics, are ligated with fine silk ties or secured and divided using an energy device such as the LigaSure™ (Fig. 90.25).

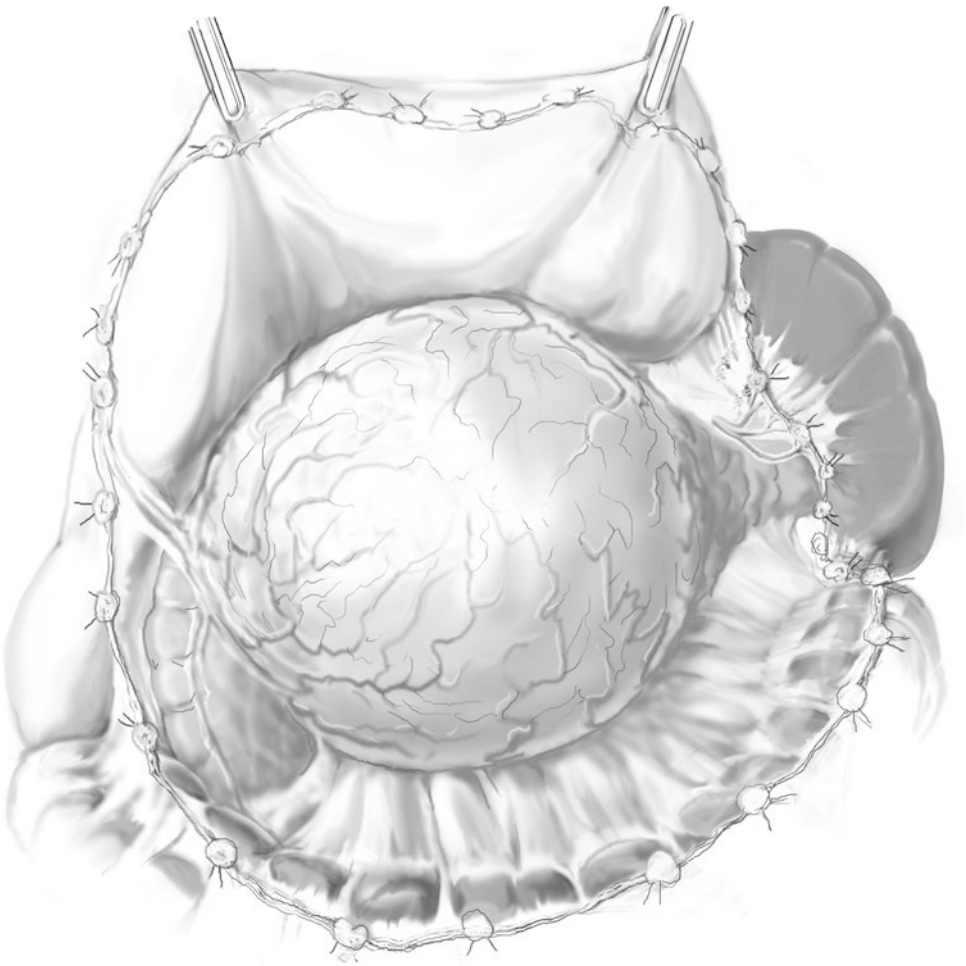


Fig. 90.25

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Step 2

Deliver the pancreas and spleen from the retroperitoneum

- The peritoneum along the inferior border of the pancreas is incised sharply or with electrocautery, maintaining a margin between the border of the tumor mass.
- The spleen is then mobilized laterally and posteriorly by dividing its peritoneal attachments.
- The splenocolic ligament is next divided carefully to prevent injuring the splenic flexure of the colon. A thorough bimanual palpation of the pancreas is performed to assess mobility of the mass and the tumor stage.
- If the neoplasm shows no evidence of distant metastases but is adherent to the stomach, diaphragm, mesocolon/colon, retroperitoneum, adrenal gland, or kidney, an en bloc resection is advised.
- The spleen and pancreas are mobilized anteromedially from the retroperitoneum using either blunt or sharp dissection depending on tumor extension (Fig. 90.26).

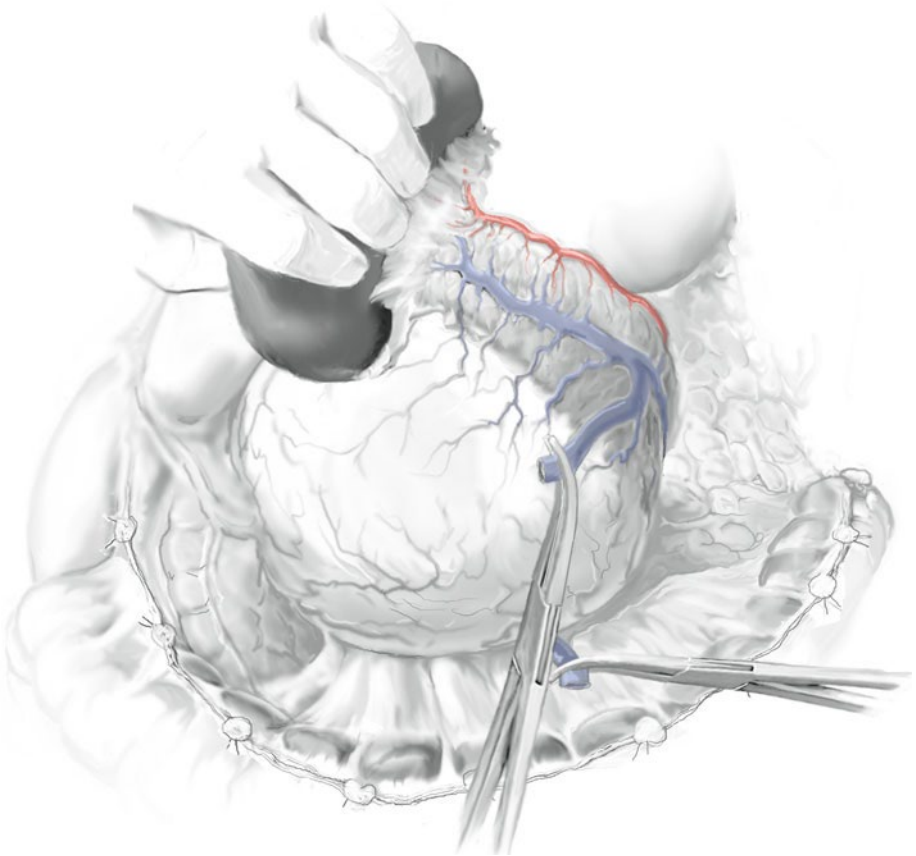


Fig. 90.26

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Step 3

Isolate and secure the splenic vasculature

- The splenic artery is identified and suture ligated as it passes along the posterosuperior border of the body and tail of the pancreas; in the RAMPS approach, division of the splenic artery should occur at or near its origin at the celiac axis.
- The splenic vein is usually identified inferior and posterior to the splenic artery, where it is ligated and divided; if the inferior mesenteric vein joins the splenic vein near the confluence of the splenic vein and the superior mesenteric vein (SMV), it may be preserved; otherwise, it can be ligated with impunity. If using the RAMPS approach, division of the splenic vasculature and inferior mesenteric vein is performed during anteromedial dissection (Fig. 90.27).

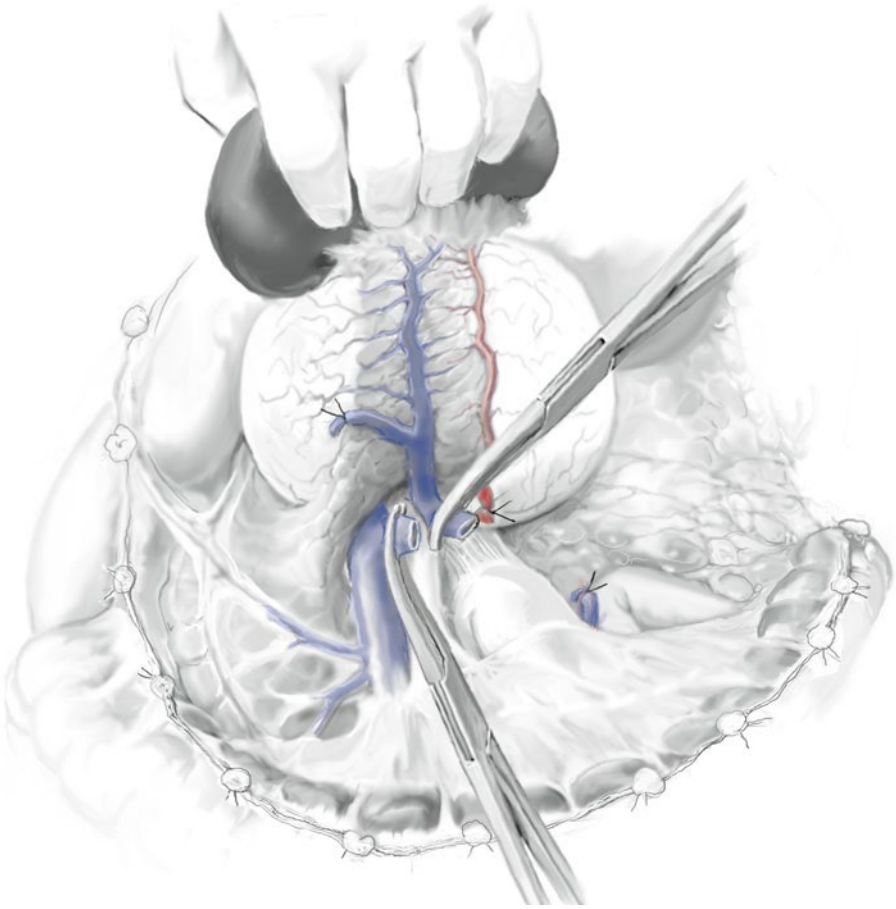


Fig. 90.27

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Step 4

Divide the pancreas

- Stay sutures are placed through the superior and inferior margins of the pancreas on both sides of the transection margin, to provide hemostasis and traction. A Penrose drain may be placed behind the pancreas to aid in sharp division and elevation of the pancreas.
- The pancreas is divided sharply to minimize the effects of cautery artifact on the frozen section of the proximal margin, which is imperative to check for tumor involvement.
- Alternatively, the pancreas can be divided using a linear stapler at the margin of the pancreatic remnant, provided that the pancreas is not too thick (≥ 1 cm).
- The resected specimen of the distal pancreas and spleen is sent for frozen section evaluation of the proximal pancreatic margin (Fig. 90.28).

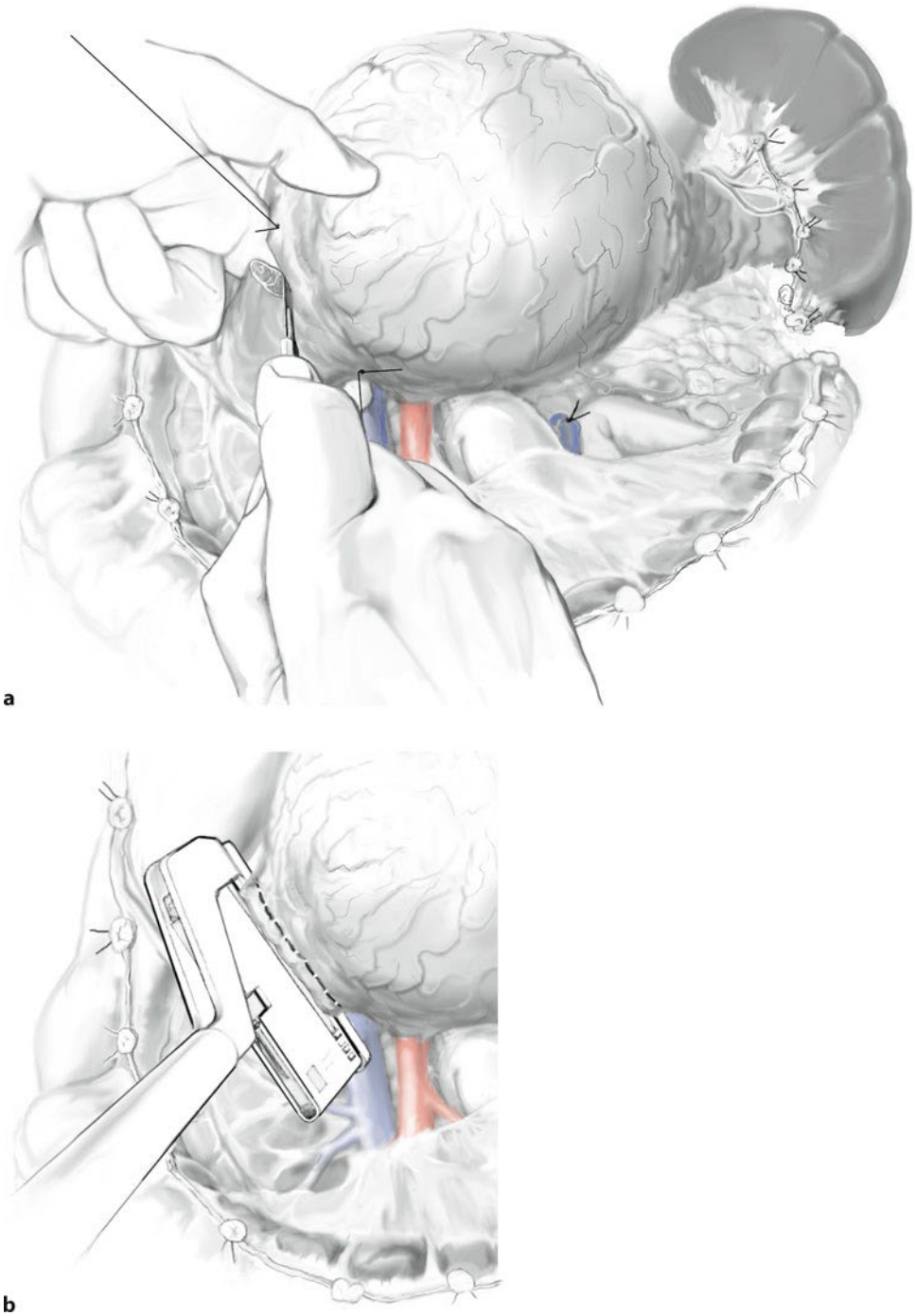


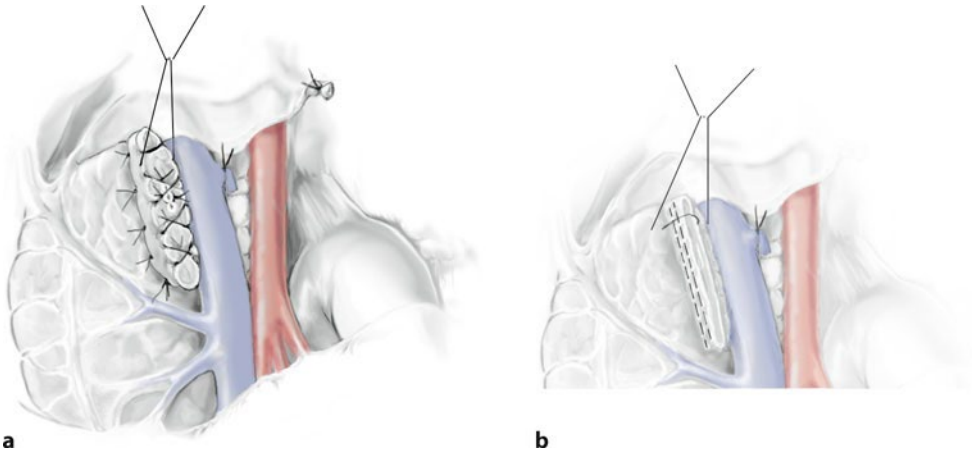
Fig. 90.28

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Step 5

Close the pancreatic duct

- The transected pancreatic duct is closed with a fine, synthetic monofilament suture (e. g., polypropylene), placed either as a figure-of-eight or as a U stitch proximal to the divided open end of the duct; when the pancreas is divided with a stapler technique, suture closure of the pancreatic duct is not necessary (Fig. 90.29a).
- The divided end of the pancreatic remnant is closed with interrupted, partially overlapping 3-0 polypropylene mattress sutures.
- When a stapling instrument used, it is not necessary to oversew the divided end of pancreas, but some surgeons prefer a continuous suture of fine polypropylene to reinforce the staple suture. If the pancreas is thick, a staple closure is not suggested (Fig. 90.29b).
- A closed suction drain is placed in the bed of the resected gland, in proximity to the divided end of the pancreas but not in direct apposition.



a b

Fig. 90.29

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Step 6

Radical antegrade modular pancreatosplenectomy (RAMPS)

- The pancreatic neck is isolated by ligating and dividing the right gastric artery, using the gastroduodenal artery to serve as the medial border for dissection. Division of the neck of the pancreas is carried out in the same manner as "Step 4" of the traditional approach. Dissection is then carried out from medial to lateral, and all areolar and nodal tissue along the common hepatic, celiac, and splenic arteries is included with the specimen. The splenic artery is ligated at its origin from the celiac artery. The dissection laterally can be performed anterior or posterior to the left adrenal gland, depending on the extent of the neoplasm. The splenic vein is isolated and ligated at its junction with the SMV. The dissection then proceeds along the right side of the superior mesenteric artery, removing fibronodal tissue anterior to the aorta between the celiac artery and superior mesenteric artery.
- Plane anterior to left adrenal gland (Fig. 90.30a). When the neoplasm is located anteriorly, the plane of dissection occurs anterior to the adrenal gland. The left renal vein and its anterior surface, as well as the surface of the adrenal vein and adrenal gland, serve as the posterior plane of dissection. Laterally, the superior half of Gerota's fascia also can be resected, for more distal neoplasms.
- Plane posterior to the adrenal gland (Fig. 90.30b). When the neoplasm is posterior and/or involves the adrenal gland, the plane of dissection is more posterior. The left renal artery represents the new posterior plane of dissection, with the left renal vein as the posterocaudal margin. The adrenal vein is divided at its entrance into the left renal vein. Now the specimen, with the left adrenal gland, retroperitoneal fat, and Gerota's fascia, can be elevated anteriorly out of the retroperitoneum. The inferior mesenteric vein is also ligated. The last step involves transection of the lienorenal ligament.

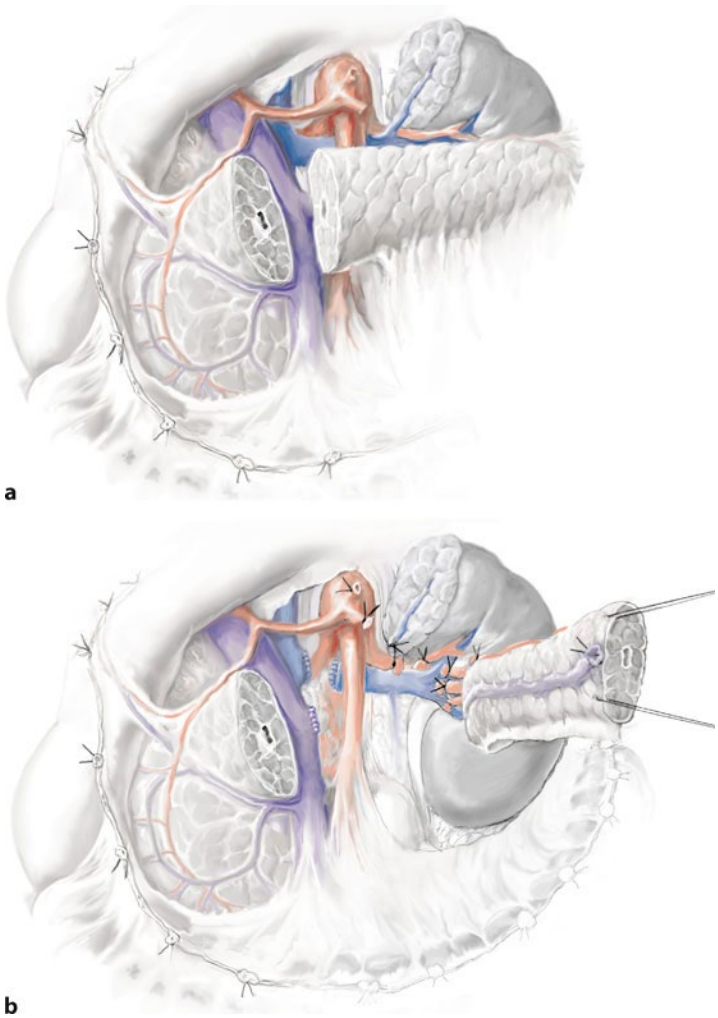


Fig. 90.30

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Postoperative care and tests

- Postoperative surveillance in an intermediate care or general care unit; monitoring in an intensive care unit is not necessary
- Monitor hemoglobin, coagulation parameters, and acid/base and electrolyte balance at regular intervals

Postoperative complications

- **Short-term:**
  - Intra-abdominal bleeding
  - Pancreatic fistula
  - Peripancreatic fluid collection
  - Subphrenic abscess
  - Pleural effusion
  - Diabetes mellitus
  - Portal vein thrombosis
  - Ascites (differentiate pancreatic from nonpancreatic origin)
- **Long-term:**
  - Pancreatic exocrine insufficiency
  - Diabetes mellitus
  - Local or distant recurrence
  - Pancreatic pseudocyst

Tricks of the Senior Surgeon

- Patient position is important; a moderate reverse Trendelenburg position with the patient rolled slightly to the right facilitates the exposure by dropping the pancreas and spleen away from the left hemidiaphragm. It also allows displacement of the left transverse and splenic flexure of the colon away from the pancreas and spleen.
- When easily accessible, the proximal splenic artery should be secured prior to mobilizing the pancreas and spleen from the retroperitoneum; this maneuver facilitates rapid, secure, and immediate hemostasis if the splenic capsule is torn during mobilization.
- The splenic artery and vein should be suture-ligated and divided individually rather than securing both together with a mass ligature, to decrease the risk of postoperative splenic arteriovenous fistula.
- Whenever possible, monofilament suture material, rather than silk, should be used to close the divided end of the pancreas. Monofilament such as polypropylene has a lesser slip coefficient and can be pulled through tissue more easily (and potentially with less trauma); monofilament also lacks interstices and may be more resistant to infection than polyfilamentous sutures.

Laparoscopic Pancreatoduodenectomy

Michael L. Kendrick

Gagner and Pomp reported the first laparoscopic pancreatoduodenectomy in 1994. Though two decades have passed, reports suggesting the realistic possibility and validity of this approach have only recently emerged.

Early single-center outcomes suggest the typical benefits of minimally invasive approaches, including decreases in blood loss, pain, wound morbidity, and hospital stay, and a quicker recovery. The need for advanced laparoscopic skills and the prolonged learning curve limit the widespread application of this approach even amongst experienced pancreatic centers, however.

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Indications and contraindications

Indications

- Benign or malignant disease requiring pancreatoduodenectomy
- Patient who meets criteria for open approach
- Patient preference or refusal of open approach

Contraindications

- Prohibitive comorbidities or functional status
- Surgeon inexperienced in pancreatic or advanced laparoscopic surgery
- Relative contraindications (dependent on surgeon experience) may include locally advanced malignancy, proximity to major vasculature, and patient-related factors such as obesity and previous major abdominal operations.

Preoperative investigations and preparation for procedure

- CT scan (preferred) or MRI to evaluate extent of disease and define pertinent anatomy
- Complete cardiopulmonary evaluation with optimization of all medical comorbidities

Procedure: Laparoscopic pancreatoduodenectomy

Step 1

Setup, access, and initial exposure

- The patient is positioned supine in 15 degrees of reverse Trendelenburg. Peritoneal access is gained through a left subcostal site using a 12-mm transparent, cone-tip trocar, and a CO_2 pneumoperitoneum with a pressure of 15 mm Hg is established.
- All accessible peritoneal and visceral surfaces are visualized to exclude metastases.
- Five additional 12-mm trocars are placed (Fig. 90.31a).
- The gastrocolic ligament is divided with the harmonic scalpel (Ethicon Endosurgery, Cincinnati, OH, USA), widely exposing the lesser sac. The gastroepiploic vessels are divided with the LigaSure™ device or are ligated and divided. The duodenocolic ligament is resected en bloc with the specimen to allow lymphadenectomy of the duodenocolic lymph nodes.
- A fan retractor is placed under the gastric antrum to provide exposure of the pancreatic head and neck (Fig. 90.31b).

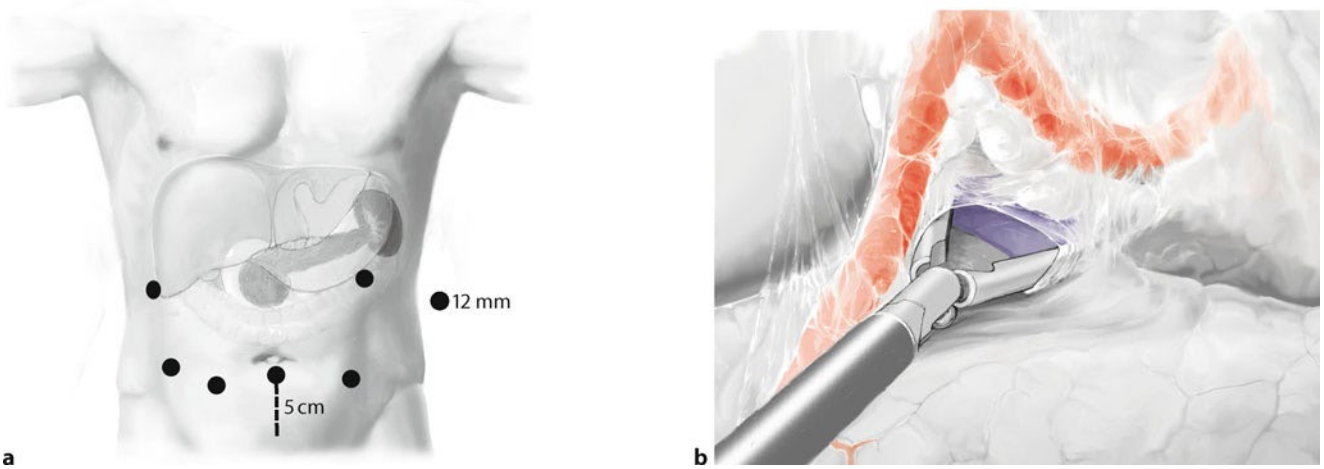


Fig. 90.31

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Step 2

Pancreatic neck dissection

- The pancreatic neck is approached with the surgeon positioned on the patient's left. The common hepatic artery lymph nodes are removed, and the common and proper hepatic artery are identified to verify tumor clearance. The portal vein is exposed by dissecting between the superior border of the pancreatic neck and the caudal aspect of the common hepatic artery (Fig. 90.32a).
- The gastroduodenal artery (GDA) is dissected, ligated, clipped, and divided (Fig. 90.32b).
- The superior mesenteric vein (SMV) is dissected at the inferior border of the pancreatic neck medial to the gastrocolic venous trunk. The plane between the posterior aspect of the pancreatic neck and the anterior portal vein/SMV is developed (Fig. 90.32c).
- A reticulating grasper is passed posteriorly, and an umbilical tape is placed around the pancreatic neck and secured (Fig. 90.32d).

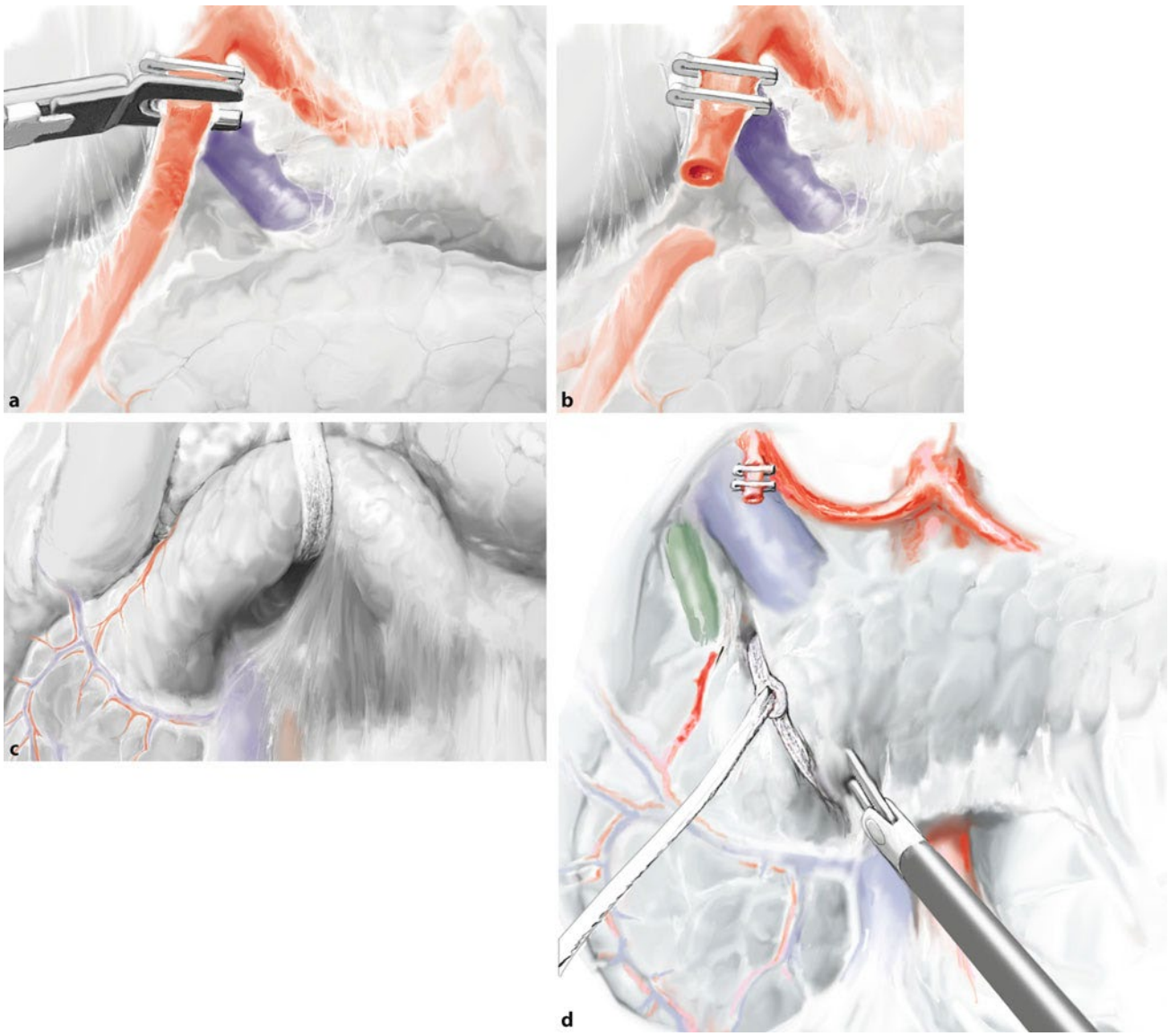


Fig. 90.32

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Step 3

Duodenal mobilization

- The first portion of the duodenum is dissected and divided 2 cm distal to the pylorus with an endoscopic linear stapler. Then the right gastric artery is ligated and divided at its origin, using a LigaSure™ device.
- The transverse colon is retracted cephalad, exposing the ligament of Treitz. The third and fourth portions of the duodenum are dissected off the aorta and inferior vena cava, being careful to avoid the inferior mesenteric vein located just lateral to the ligament of Treitz. The jejunum 15 cm distal to the ligament of Treitz is divided with the linear stapler, and the jejunal mesenteric vessels are divided with the LigaSure™ device back to the uncinate process.
- The hepatic flexure of the colon is mobilized inferiorly and the ascending and transverse colon are retracted inferiorly with a fan retractor. The surgeon moves to the patient's right side, and the duodenum is Kocherized cephalad to the hepatic hilum.

Step 4

Hepatic hilar dissection

- A cholecystectomy is performed, leaving the cystic duct intact. The hilum of the liver is dissected, and the common hepatic duct is identified, ligated and either ligated distally or occluded with a bulldog clamp; the proximal common hepatic duct (hepatic side) is occluded with a bulldog clamp and the common hepatic duct is transected. Hilar lymphatic tissue is dissected inferiorly with the specimen. The lateral aspect of the portal vein is cleared caudally until the superior pancreaticoduodenal vein is identified, ligated, and divided with the LigaSure™.
- The jejunal stump is brought into the supramesocolic compartment through the bed of the duodenum and then the anterolateral aspect of the SMV is dissected proximally to the inferior border of the pancreas.

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Step 5

Pancreatic head resection

- The pancreatic neck is divided with the harmonic scalpel, with the exception of the pancreatic duct, which is divided sharply with scissors, leaving a 1-mm to 2-mm duct stump to facilitate the anastomosis (Fig. 90.33a).
- Using the umbilical tape for retraction, the pancreatic head and uncinate process are dissected off the portal vein, SMV, and superior mesenteric artery (SMA). The inferior pancreaticoduodenal artery and vein are dissected, ligated and clipped, and divided with LigaSure (Fig. 90.33b). Dissection of the uncinate is performed immediately adjacent to the adventitia of the SMA to assure a maximal margin.

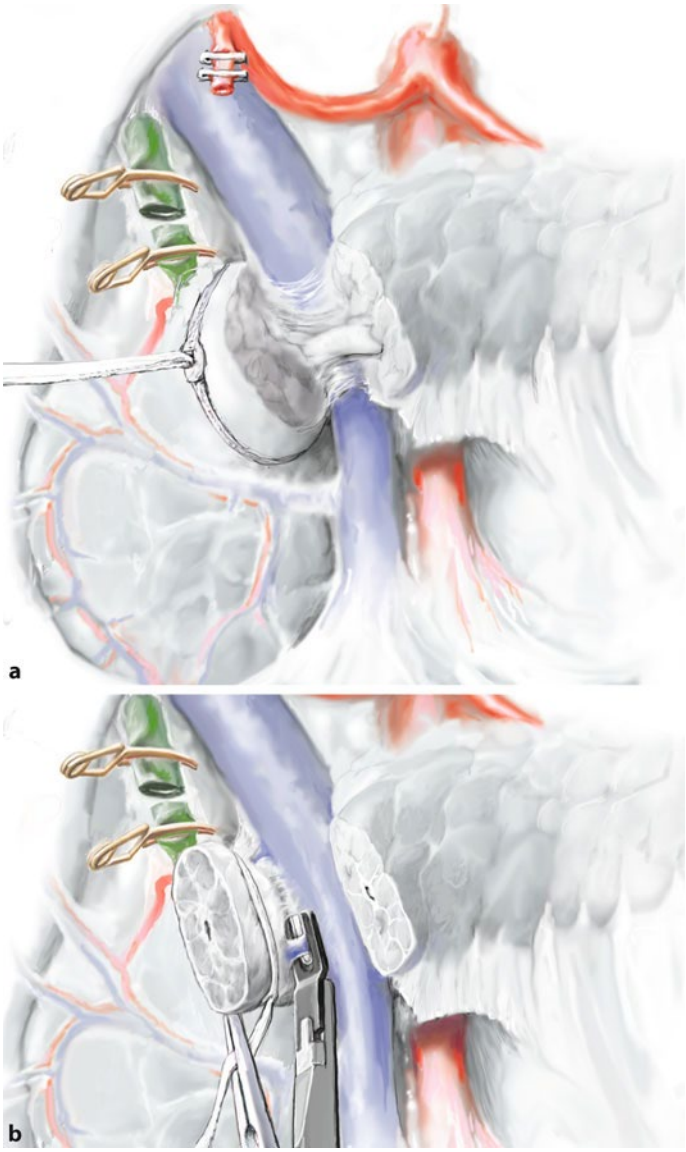


Fig. 90.33

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Step 6

Specimen removal

- The specimen is placed into an endobag and removed via the infraumbilical trocar site, which is extended to a length of 3 to 5 cm to accommodate the specimen.
- Specimen inspection is performed on the back table; separate margins of pancreatic neck and bile duct are harvested and sent for frozen-section analysis. The portal vein groove and uncinate (retroperitoneal) margins are inked. The extraction site is closed with interrupted suture, and the pneumoperitoneum is re-established.

Step 7

Anastomotic reconstruction

- The jejunum is brought through the bed of the duodenum (retromesenteric tunnel). An end-to-side, duct-to-mucosa pancreaticojejunostomy is constructed with an inner layer of interrupted 5-0 Vicryl suture and an outer layer of interrupted 3-0 PDS suture (Fig. 90.34a).
- Approximately 10 cm distal to the pancreaticojejunostomy, the hepaticojejunostomy is performed. The surgeon stands on the right with instruments and camera in the right-most trocars. This setup allows sewing toward the surgeon. as in an open approach. An end-to-side hepaticojejunostomy is constructed with a single layer of interrupted (duct size ≤ 6 mm) or running (duct size > 6 mm) 5-0 Vicryl suture (Fig. 90.34b).
- A handsewn, antecolic, end-to-side duodenojejunostomy is constructed approximately 40 cm distal to the hepaticojejunostomy, using two layers of running 3-0 Vicryl suture. The completed reconstruction is shown (Fig. 90.34c).
- A single, 5-mm, round, closed suction drain is brought through the right abdominal wall and positioned posterior to the hepaticojejunostomy and anterior to the pancreaticojejunostomy.
- The trocars are removed under direct vision and the skin incisions are closed with a subcuticular, 4-0 monofilament absorbable suture. The nasogastric tube is removed at the completion of the procedure.

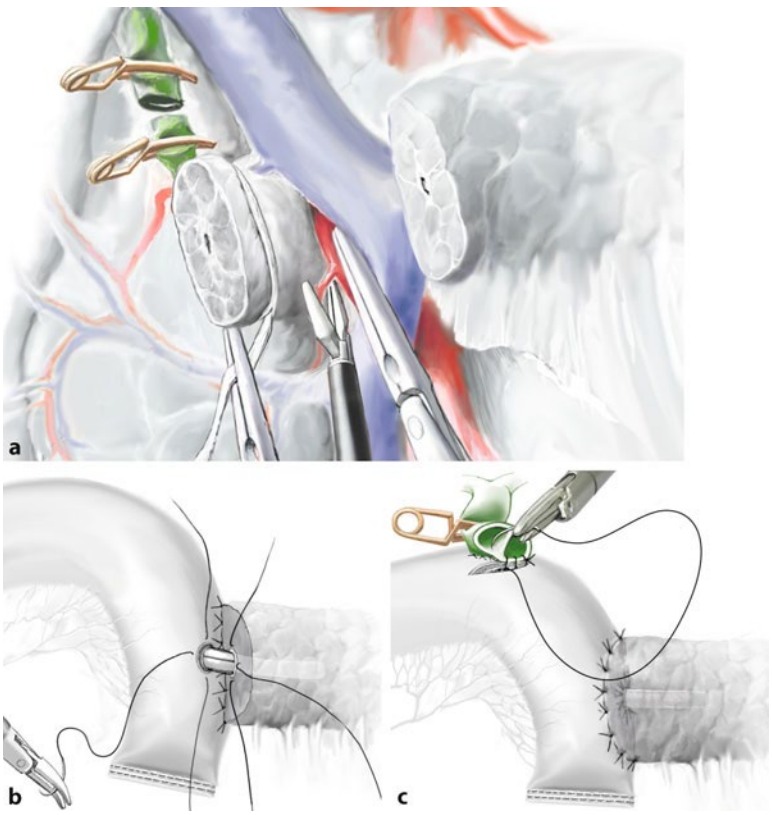


Fig. 90.34

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Postoperative care

- Clear liquids are given the first postoperative morning and the diet is advanced over the next 48 h.
- Routine postoperative imaging is unnecessary.
- The drain is removed on postoperative day 4 if drain amylase is low and there are no other signs of pancreatic fistula.
- Hospital discharge occurs on the 5th postoperative day if the patient is tolerating a soft diet and is without evidence of complication.

Postoperative complications

- Pancreatic fistula occurs in 10 to 25 % of patients, as for open approaches. Treatment is conservative when possible, with prolonged percutaneous drainage. Additional percutaneous drainage or antibiotics may be necessary; reoperation is rarely required.
- Delayed gastric emptying occurs in 10 to 25 % and is treated conservatively with nasogastric tube decompression and gastric motility agents. Prolonged symptoms may require postpyloric tube feeding or parenteral nutrition.
- Clinically relevant postoperative GI hemorrhage is most often from the pancreaticojejunostomy or from the duodenojejunostomy; it may require transfusion, angiographic embolization, and rarely reoperation. The surgeon must exclude bleeding from a pseudoaneurysm of the GDA.
- Surgical site infections are minor, given the small incisions and peripheral location relative to the pancreas. Trocar site hernias are uncommon, but their early consideration and detection are important, as incarceration or strangulation are possible.

Tricks of the Senior Surgeon

- Trocars should be 12 mm in size to allow versatility in camera position and instrument access, a key factor for optimizing visualization and ergonomics.
- Extended dissection of the third and fourth portions of the duodenum from the patient's left side allows early exposure of the posterior aspect of the uncinate process, IVC, aorta, SMA origin, and left renal vein with limited retraction on the tumor, as opposed to the typical Kocher maneuver from the patient's right.
- The umbilical tape around the pancreatic neck allows safe retraction and facilitates a "no-touch" technique.
- Dividing the pancreatic duct separately and leaving a duct stump of 1 to 2 mm facilitates the duct-to-mucosa anastomosis.
- Dissection adjacent to the adventitia of the SMA maximizes margin and allows clearer identification of the origin of the pancreatoduodenal vessels.

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Enteric Drainage of Pancreatic Fistulae with Onlay Roux-en-Y Limb

Peter Shamamian, Stuart Marcus

Most pancreatic fistulae will resolve with conservative measures, including improving pancreatic duct drainage through the ampulla, nutritional support, and somatostatin analogues. When pancreatic fistulae result from pancreatic ductal disruption, and pancreatic secretions are produced in a portion of the pancreas that is no longer in continuity with the gastrointestinal (GI) tract, however, operative intervention is indicated.

Indications and Contraindications

Indications in non-resolving fistulae

- Pancreatic ductal disruption secondary to pancreatic trauma
- Fistulae following débridement of pancreatic necrosis
- Fistulae from complications of pancreatic surgery (i. e., enucleation of endocrine neoplasms)
- Fistulae from pancreatic injury during surgery on juxtapancreatic organs (i. e., stomach, colon, left kidney, left adrenal, spleen)
- Fistulae secondary to external drainage of pancreatic pseudocysts
- Fistulae associated with pancreatic ascites
- Pancreato-pleural fistulae

Contraindications

- Ongoing acute pancreatic inflammation
- Pancreatic abscess
- Undrained peripancreatic fluid collection
- Untreated pancreatic neoplasms
- Portal hypertension

Preoperative Investigation and Preparation for the Procedure

- *History:* Pancreatitis, pancreatic trauma, pancreatic pseudocyst, prior pancreatic surgery, prior nonoperative therapy with internal or external drains; exclude alcohol abuse, cirrhosis, portal hypertension
- *Clinical evaluation:* Quantify fistula output, optimize and achieve adequate nutritional status; provide adequate external drainage; protect the skin from pancreatic secretions
- *Laboratory tests:* Serum electrolytes, amylase, lipase, and liver chemistries; bacterial culture; cytology and amylase of any drained peritoneal or pleural fluid
- *Preoperative preparation:* Consider the risk of splenectomy; if likely, vaccinate patient against encapsulated bacteria. Advise patients of the risk of splenectomy and to seek medical attention if they develop a febrile illness. Consider pre-operative vaccination at least 14 days prior to the operation:
  - *Streptococcus pneumonia* (polyvalent pneumococcal vaccine [Pneumovax 23]), *Haemophilus influenzae* type B (*Haemophilus influenzae* b vaccine [HibTITER]), and *Neisseria meningitides*
  - Age 16–55: Meningococcal (groups A, C, Y, W-135) polysaccharide diphtheria toxoid conjugate vaccine (Menactra)
  - Age > 55: Meningococcal polysaccharide vaccine (Menomune–A/C/Y/W-135)

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- *Preoperative imaging:*
  - CT: exclude presence of undrained collections or abscess
  - ERCP: delineate pancreatic ductal anatomy, site of duct disruption, obstructing strictures or calculi
  - Fistulogram: anatomy of pancreatic segment from which fistulous tract originates; adequate external preoperative drainage is essential
  - MRCP (MR cholangiopancreatography) may help delineate ductal anatomy
  - Angiogram: if suspicion of a pseudoaneurysm

Procedure

Step 1

- Access: midline or bilateral subcostal incision, depending on patient habitus (*see* Part I, ▶ Chap. 2, "Positioning and Access"). The first step involves exposure into the lesser sac and installation of the mechanical retractor.
- The preoperative fistulogram helps to locate the disrupted pancreatic duct.
- Carefully trace the external drainage catheter into the lesser sac; dissection continues through the peripancreatic inflammatory tissue to the anterior surface of the pancreas (Fig. 91.1a).
- It is often possible to visualize the fistulous tract directly as it exits the pancreas parenchyma.
- When the site is not visualized clearly, intraoperative intravenous administration of secretin (SecreFlo, ChiRhoClin, Silver Springs, MD, USA) at a dosage of 0.2 mg/kg (after a 0.2-mg test dose) can stimulate pancreatic secretion and may assist identification of the ductal disruption (Fig. 91.1b).

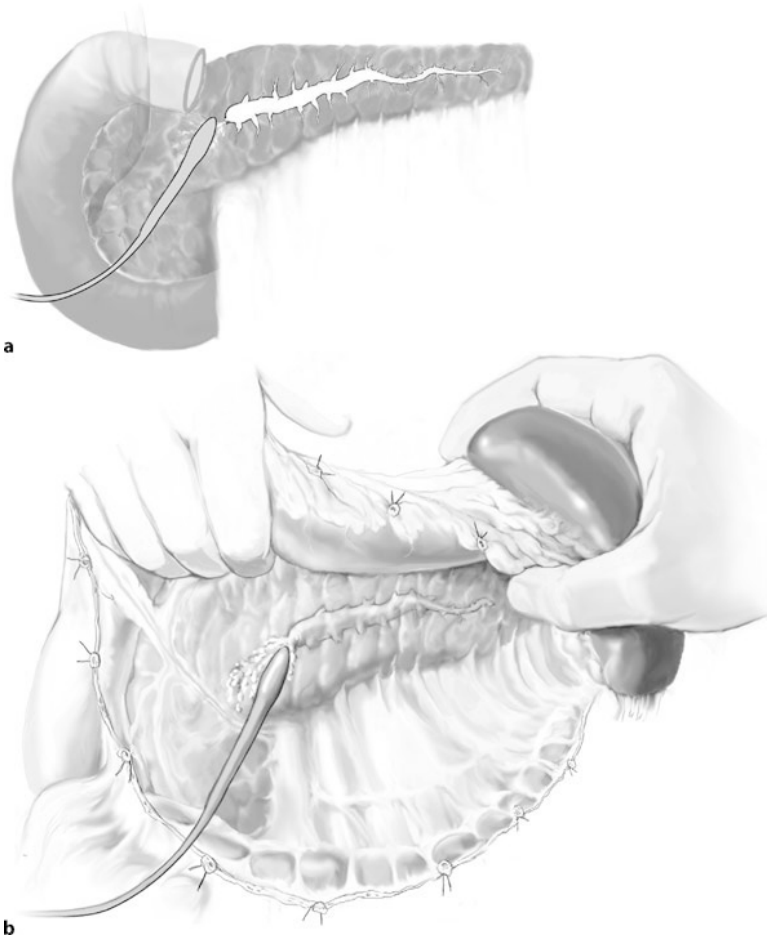
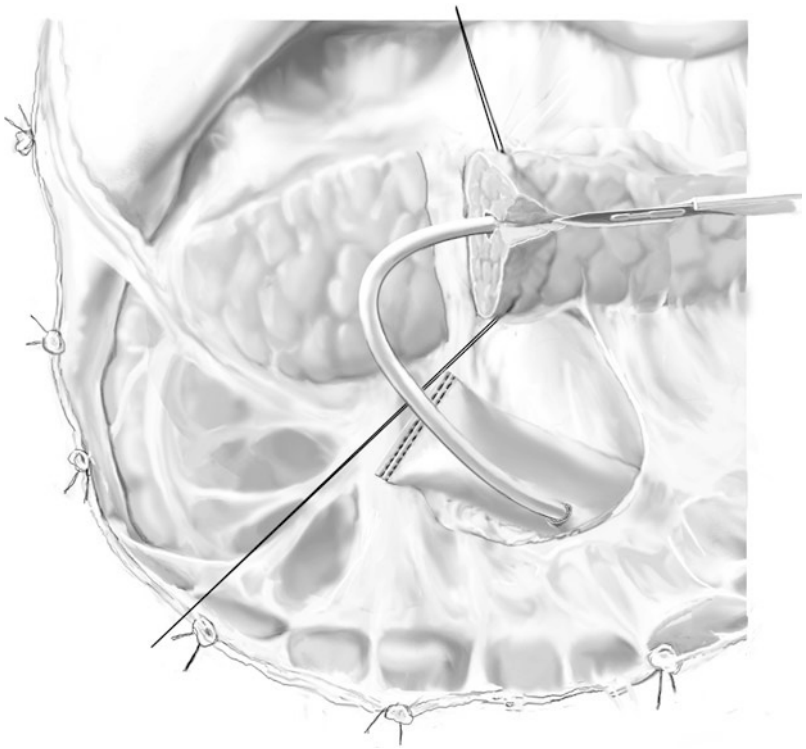


Fig. 91.1

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Step 2

- If possible, a catheter or probe is passed through the fistulous tract into the pancreatic duct.
- If the pancreatic duct is identified, opening the anterior wall (spatulating the duct) increases the effective diameter of the anastomosis and facilitates the conduct of the anastomosis.
- Pancreatography can be obtained if not done already.
- The pancreatic duct should be imaged proximally and distally.
- The jejunum is transected about 15 cm distal to the ligament of Treitz.
- The blind end of the jejunum is closed by a stapling device or sutures.
- Enteric continuity is reestablished by end-to-side jejunojejunostomy at least 60 cm from the closed end of the Roux limb. The Roux limb can be passed through a controlled defect created in the transverse mesocolon.
- The anastomosis is constructed by suturing the side of the jejunum to the pancreatic duct or the rim of scarred tissue at the fistulous tract at its point of origin on the pancreas (◘ Fig. 91.2). For details of construction of the Roux-en-Y limb, see Part II, ▶ Chap. 20, "Subtotal Gastrectomy, Antrectomy, Billroth II, and Roux-en-Y Reconstruction and Local Excision in Complicated Gastric Ulcers."



◘ Fig. 91.2

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Step 3

- A posterior row of Lembert-type sutures is placed using 4-0 silk.
- Next, a row of absorbable sutures (4-0 or 5-0 polyglycolic acid) are placed full thickness through the pancreatic duct and the jejunum.
- A catheter can be left as a stent through the anastomosis and brought out of the anterior abdominal wall, allowing the anastomosis to be studied postoperatively through the catheter if indicated (Fig. 91.3).

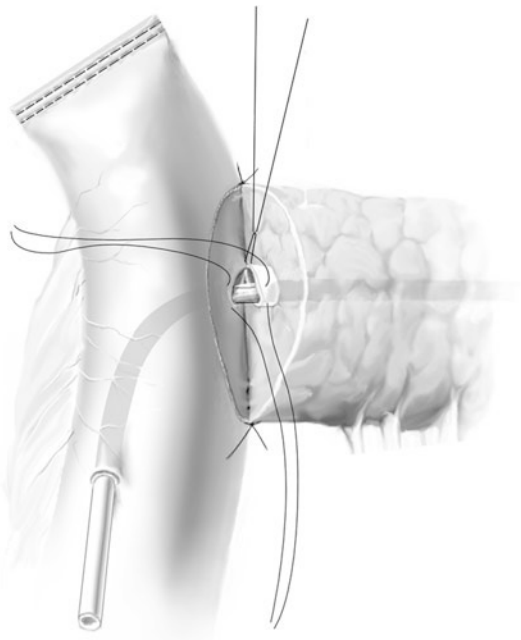


Fig. 91.3

- If the pancreatic duct cannot be identified definitively, the jejunum can be sewn over the fistulous tract as an onlay anastomosis to the pancreatic parenchyma; it would be optimal to keep a stent across this onlay anastomosis.

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Step 4

- A soft closed suction drain is placed adjacent to the anastomosis (Fig. 91.4).

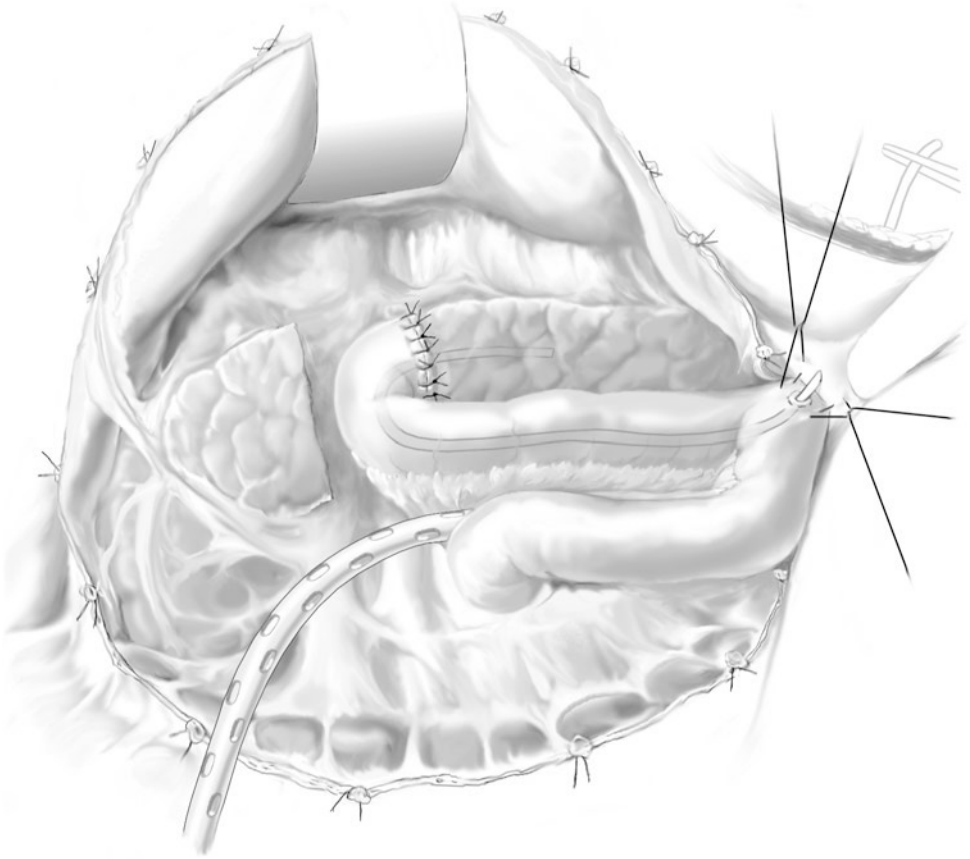


Fig. 91.4

Postoperative Tests

- Hemodynamic and respiratory monitoring in an intensive or intermediate care unit.
- Measure daily drain output; note changes after beginning oral intake. Drains are removed when output is less than 50 mL per day after resumption of oral intake.
- Measure drain amylase if output persists at more than 50 mL per day. If fluid is amylase-rich, convert drains from closed suction drains to passive drains after 7 days and then advance the drains 1 to 2 cm per day.

Local Postoperative Complications

- Anastomotic leak, possible recurrent fistula
- Abscess
- Pancreatitis
- Pancreatic pseudocyst
- Intra-abdominal hemorrhage

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Tricks of the Senior Surgeon

- Patience, adequate drainage, and complete preoperative or intraoperative imaging are paramount for definition of the fistula and associated ductal anatomy; should marked disease remain in the duct, an alternative procedure, such as resection or lateral pancreaticojejunostomy, might be a better choice.
- One goal of fistula drainage is to preserve pancreatic endocrine and exocrine function. If the fistula arises from the tail of the pancreas, resection of the distal pancreas may be a better option, if minimal loss of functional pancreatic tissue is anticipated.
- A fistula arising from the left pancreas associated with splenic vein thrombosis, sinistral portal hypertension, or both may be best managed with pancreatic resection and splenectomy.
- Spontaneous closure of the pancreatic fistula can be aided with a somatostatin analogue. The likelihood of success may be predicted on the basis of radiographic evaluation: fistulae that arise from a divided duct will not resolve.
- Closure of fistulae that connect radiographically to the GI tract may be facilitated by transpapillary pancreatic stents and by ensuring that strictures and obstructing calculi are addressed.
- Internal drainage of the fistulous tract into the stomach is not suggested; instead, a defunctionalized Roux limb of jejunum is preferred when resection is not the best option.
- Sew to the pancreatic parenchyma at the point of origin of the fistula and not to the fistulous tract; the parenchyma at this site is usually thickened and scarred.
- If internal drainage is not possible because of high operative risk or anatomic considerations, chronic external drainage is the best option.
- Amylase-rich fluid in the drain signifies breakdown of the anastomosis; management is considerably easier if a stent is placed across the anastomosis at operation. The anastomosis can be evaluated radiographically; as the output decreases, the stent is converted from closed suction to passive drainage and then is advanced 1 cm per day.
- Early intra-abdominal hemorrhage is best treated by reoperation and direct vessel ligation. Late hemorrhage may be a sentinel bleed from a pseudoaneurysm; immediate angiography and vessel embolization are indicated.

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Sphincteroplasty for Pancreas Divisum

Andrew L. Warshaw

Indications and Contraindications

Indications

- *Strong:* recurrent episodes of documented acute pancreatitis (typical pain, increased serum amylase) in patients with congenital pancreas divisum or other variants of a dominant dorsal duct (absent duct of Wirsung, filamentous communication to duct of Wirsung).
- *Weak:* patients with pancreas divisum and episodic "obstructive pancreatic pain" (pain with characteristics and location attributable to a pancreatic origin but without objective substantiation by hyperamylasemia or pancreatic edema).

Contraindications

- Chronic pancreatitis (fibrosis, major duct dilation, pseudocyst, segmental duct obstruction, calcification)
- Pancreatitis from alcoholism, hypercalcemia, hyperlipidemia, gallstones, or trauma
- Recent severe acute pancreatitis, significant residual inflammation or swelling

Preoperative Investigation and Preparation for the Procedure

- *History:* Recurrent episodes of epigastric pain, especially with radiation through to the mid back; pain starts sporadically, with bouts months apart, but may become frequent and even constant; attacks are usually mild. Attacks are more common in young women; mean onset is at 34 years but can occur in childhood; onset is uncommon after age 50 years.
- *Clinical evaluation:* May have tenderness over the pancreas.
- *Laboratory tests:* Serum amylase and/or lipase.
- *Imaging:* ERCP or MRCP to elucidate pancreatic ductal anatomy; ERCP must include opacification of the dominant dorsal duct via accessory papilla. Caution: acquired obstruction of the duct of Wirsung by tumor in the pancreatic head can mimic pancreas divisum.
- *Functional tests:* Transabdominal ultrasonography, endoscopic ultrasonography, or MRCP, demonstrating abnormally delayed return of the principal pancreatic duct to normal size after hyperstimulation of pancreatic secretion. Impaired emptying through stenotic accessory papilla results in persistent duct dilation (15–30 min).

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Procedure

Step 1

Exposure of minor papilla

- An upper midline or right subcostal incision depends on patient habitus.
- Extensive mobilization of the duodenum and the head of the pancreas (extended Kocher maneuver) facilitates exposure.
- Cholecystectomy is performed if the gallbladder is still present; passage of a biliary Fogarty catheter via the cystic duct or common duct through the major ampulla into the duodenum aids localization of the accessory papilla, which is proximal and slightly anterior to the papilla of Vater.
- A transverse duodenotomy is made just proximal to the papilla of Vater, which can usually be felt transduodenally or with the aid of the biliary Fogarty catheter (Fig. 92.1).

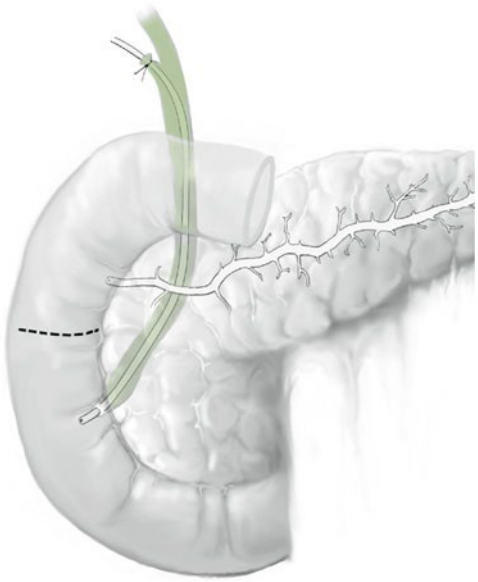


Fig. 92.1

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Step 2

Location of minor papilla intraduodenally

- Locate the accessory (minor) papilla 2 to 3 cm proximal and anteromedial to the papilla of Vater; minimize trauma to the duodenal mucosa.
- Secretin (1 U/kg intravenously) helps locate the papilla by inducing visible flow of pancreatic juice and sometimes by ballooning out the papilla.
- Grasp the duodenal mucosa just distal to the minor papilla to fix its position; insert a fine probe or Angiocath (Becton, Dickinson; Franklin Lakes, NJ, USA) into the orifice. (It may be necessary to pierce the membranous tip of the papilla if the orifice is miniscule.) (Fig. 92.2.)

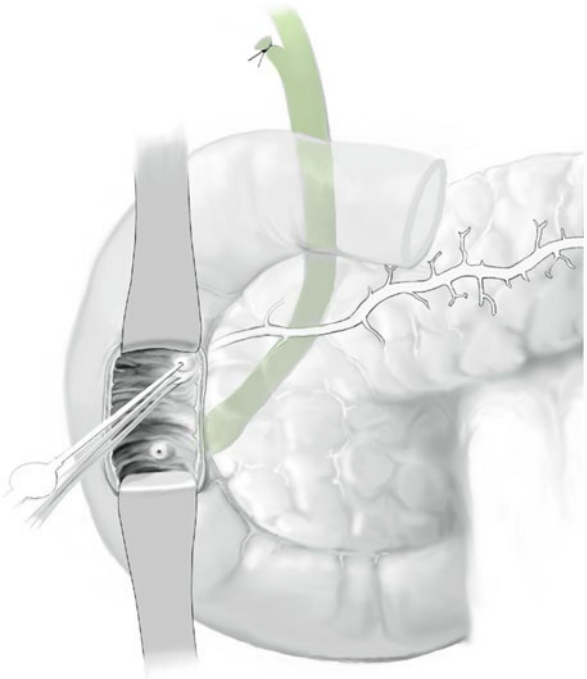


Fig. 92.2

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Step 3

Sphincterotomy of minor duct

- Fine traction sutures are placed at the distal margins of the accessory papilla; the papilla is incised over a probe in the duct. Pancreatic juice should gush forth, and a dilated vestibule proximal to the papillary membrane should be immediately apparent. The smooth, light pink mucosa lining the pancreatic duct is easily distinguished from the duodenal mucosa.
- The incision is extended about 1 cm, only as far as necessary to lay the duct vestibule widely open (Fig. 92.3).

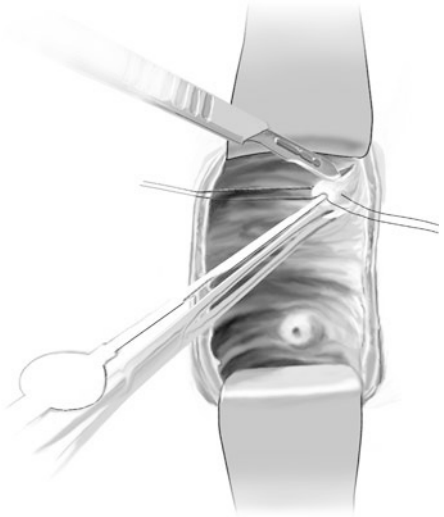


Fig. 92.3

Step 4

Sphincteroplasty of minor duct

- The duodenal mucosa and the pancreatic duct epithelium are approximated with fine, absorbable, synthetic sutures for hemostasis and to facilitate healing without re-stenosis (Fig. 92.4).



Fig. 92.4

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Step 5

Duct drainage and duodenal closure

- A small catheter (e. g., a 5-French pediatric feeding tube) is passed through the duodenal wall and into the pancreatic duct to insure against postoperative duct obstruction. The catheter is inserted within the duodenal wall through a 14-gauge needle or commercial catheter fitted on a trocar, tunneled within the duodenal wall, and closed with a double-purse-string absorbable suture (Fig. 92.5a). The catheter is brought out through the abdominal wall for postoperative drainage and remains in place for 2 to 3 weeks before removal (Figs. 92.5b and 92.6).
- The duodenotomy is closed transversely in two layers; no right upper quadrant drain is needed.

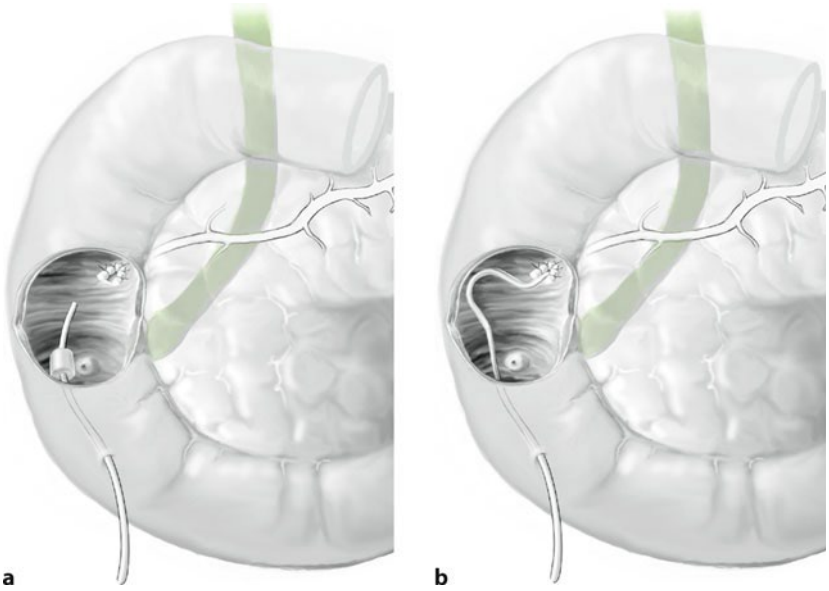


Fig. 92.5

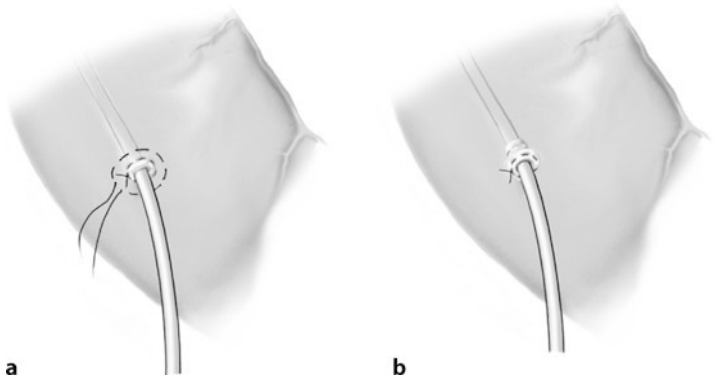


Fig. 92.6

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Postoperative Tests

- Routine postoperative surveillance
- Serum amylase testing only if there is a specific clinical indication

Local Postoperative Complications

- **Short-term:**
  - Acute pancreatitis
  - Duodenal obstruction
  - Duodenal leak
- **Long-term:**
  - Recurrent papillary stenosis
  - Recurrent symptoms, pancreatitis
  - Failure to cure preoperative pain syndrome

Tricks of the Senior Surgeon

- The major papilla (ampulla) of Vater is often palpable through the duodenal wall even without a transcholedochal catheter (i.e., catheter via cystic duct) through the ampulla of Vater.
- The accessory papilla is proximal in the duodenum, perhaps only 2 or 3 cm from the pylorus; a prominent vessel on the lateral duodenal wall is often noted at this point.
- The transverse duodenotomy provides adequate exposure and is less likely to cause postoperative duodenal stenosis than a longitudinal suture line.
- The accessory papilla may be difficult to find by visual inspection, as it is often small and protrudes minimally from the duodenal surface; it is located more easily by gentle palpation of the medial wall of the duodenum, where it feels like a small bump or nipple.
- Application of methylene blue to the duodenal mucosa may help to locate the pancreatic duct orifice; pancreatic secretions wash off the blue dye at the orifice, especially after the use of secretin.
- After cannulating the orifice, do not remove the probing instrument until the incision into the papilla has been completed. Local trauma may make rediscovery of a small, traumatized orifice very difficult.
- The dorsal duct of Santorini follows a perpendicular course through the duodenal wall (in contrast to the oblique path of the duct of Wirsung); the sphincteroplasty is therefore necessarily short. Going past the thin membrane of the first centimeter makes the apex of the sphincteroplasty difficult to suture.

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Sphincterotomy/Sphincteroplasty for Papillary Dysfunction: Stenosing Papillitis

Craig P. Fischer, Michael G. Sarr

Simple division (5 mm) of the anterior surface of the sphincter of Oddi (sphincterotomy) was utilized in the mid 20th century for presumed biliary-pancreatic pain from sphincter of Oddi dysfunction (biliary dyskinesia). Lack of success led to a longer (2–3 cm) division of the sphincter with formal sphincteroplasty, but the improvement in outcome was only marginal. Most groups currently perform a generous sphincteroplasty with division of the transampullary septum to include division of the pancreatic component of the sphincter, and with this extended approach, have achieved good to excellent results in appropriately selected patients. This procedure allows free egress of bile and pancreatic juice into the duodenum after stimulation from ingestion of a meal. Stenting of the pancreatic duct of even the septotomy when needed can now be accomplished after endoscopic sphincteroplasty in experienced hands.

Indications and Contraindications

Indications

- Persistence or recurrence of severe episodes of right upper quadrant or epigastric pain after cholecystectomy

Contraindications

- *Absolute contraindications:* active alcoholism, chronic pancreatitis
- *Relative contraindications:* unwillingness to pursue a trial of supervised detoxification (chemical withdrawal) from narcotics

Preoperative Investigations and Preparation for Procedure

- *Clinical:* Episodic, midepigastric pain, often in young women (25–40 years old), usually after cholecystectomy which failed to relieve their biliary-type pain
- *Physical examination:* Lack of jaundice or epigastric tenderness; otherwise normal abdominal examination
- *Laboratory evaluation:* Hemoglobin, amylase/lipase; one third of patients with papillary stenosis have a transient increase in biliary or pancreatic enzymes during the episode of pain; cardiorespiratory evaluation as indicated
- *Imaging:* Ultrasonography to exclude cholecystolithiasis and choledocholithiasis; ERCP probably should be attempted in all patients; deformity of papilla or dilation of bile or pancreatic ducts is present in 25 % and cannulation of the pancreatic duct is possible in only 50 %
- *Other:* Transpapillary manometry, if performed, shows high resting pressures in the pancreatic and biliary ducts
- *Psychologic/psychiatric consultation:* A viable preoperative attempt at narcotic detoxification should be entertained for all candidates for an operative approach preoperatively if they are an alcoholic, though these attempts are almost never successful
- Preoperative preparation:
  - A serious discussion with the narcotic-addicted patient regarding a commitment to postoperative narcotic detoxification is strongly suggested
  - Perioperative antibiotics (clean-contaminated procedure)
  - Perioperative prophylactic heparin and sequential compression devices (SCDs) to minimize venous thrombosis

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Procedure: Transduodenal Sphincteroplasty with Transampullary Septectomy

Step 1

- The abdomen is entered through the incision for prior cholecystectomy or through a midline incision.
- Exposure is optimized by a Thompson retractor or other mechanical retractor.
- After exploration, the duodenum and head of the pancreas are mobilized by a wide Kocher maneuver; the hepatic flexure of the colon is mobilized inferiorly. The head of the pancreas is mobilized from the underlying vena cava and the aorta in the avascular plane behind the duodenum.
- Such wide mobilization allows access to the cystic duct remnant, the common bile duct, and the anterior surface of the junction of the middle and lower third of the second part of the duodenum, where the papilla of Vater resides; the papilla is usually palpable by depressing the lateral duodenal wall against the medial wall (Fig. 93.1).

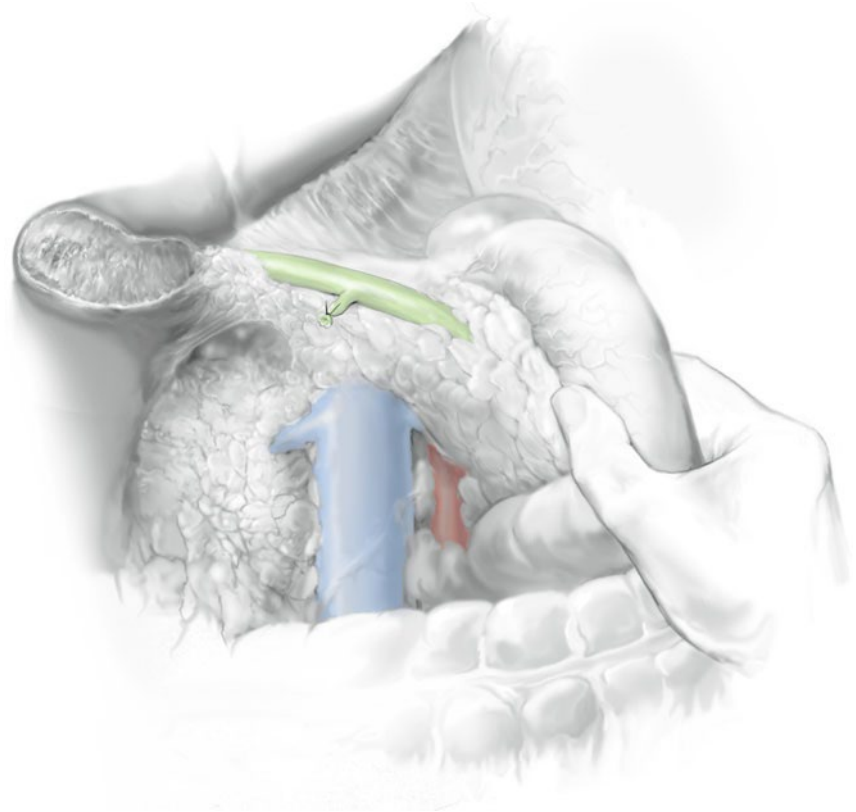


Fig. 93.1

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Step 2

- The biliary tree is intubated to accurately locate the papilla.
- Access to the biliary tree is gained through a small opening in the cystic duct remnant or, if necessary, the common bile duct; the latter access can be avoided if you can confidently locate the ampulla by transduodenal palpation.
- A 3-Fr. tapered, urethral filiform probe (or a small biliary Fogarty catheter) is passed through the common bile duct and into the duodenum to locate the papilla.
- Suspicion of a common bile duct stone may require formal bile duct exploration. Rigid probes (e. g., Bakes dilators) should not be used, because the bile duct is more vulnerable to perforation when papillary stenosis is present. Note the operator's left hand supporting the intrapancreatic portion of the common bile duct as the filiform passes through the papilla (Fig. 93.2).

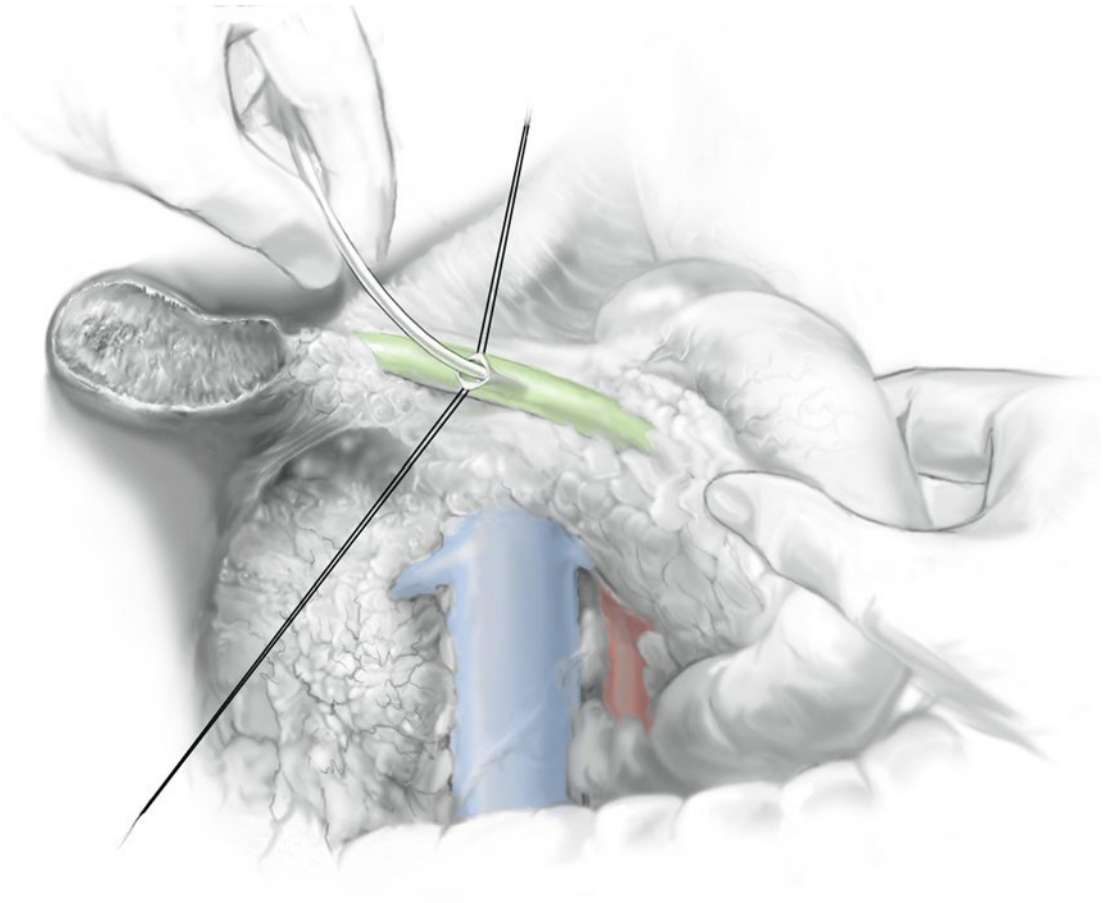


Fig. 93.2

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Step 3

- With the duodenum elevated anteromedially, a 2-cm lateral duodenotomy is made directly over where the filiform leaves the papilla.
- Stay sutures are placed at the 2 o'clock and 8 o'clock positions to elevate the papilla up to the level of the duodenotomy.
- An incision is made along an 11 o'clock plane on the anterior surface of the papilla. Use of small iris scissors facilitates transection of the sphincter; cautery should be avoided because it obscures recognition of the mucosal edges.
- Approximating the bile duct epithelium to the duodenal mucosa is carried out in sequential fashion with 5-0 polyglycolic acid sutures. The length of the sphincteroplasty (2–3 cm) should be determined by a point where the bile duct separates from the duodenal wall. Care must be taken to approximate the bile duct epithelium and duodenal mucosa precisely in this area (Fig. 93.3).



Fig. 93.3

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Step 4

- Papillary stenosis often is associated with marked deformity of the transampullary septum (the tissue that separates the intrapancreatic bile duct from the pancreatic duct within the papilla of Vater).
- The ostia of the duct of Wirsung can be difficult to visualize; it may be necessary to gently probe the inferior lip of the papilla with the smallest of lacrimal probes.
- Once cannulated, the ostia should be dilated with one or two larger probes.
- The septum can then be divided safely by a sharp, scalpel incision (11 blade) for at least 1 cm or to the point where the pancreatic duct measures at least 3 mm; deformity or scarring in this region may make this difficult and bloody.
- A pancreatogram should be obtained at this point if not already done if there is any concern (Fig. 93.4).

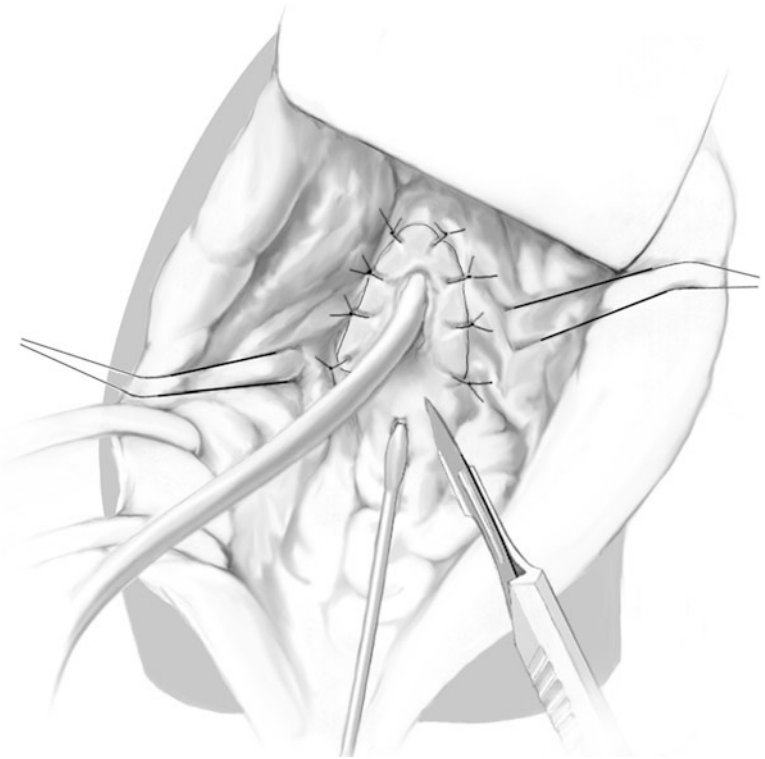


Fig. 93.4

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Step 5

The mucosa of the pancreatic duct is approximated to the bile duct epithelium with interrupted 7-0 polyglycolic acid suture, using a small ophthalmic needle. Figure 93.5 illustrates what the papilla should look like at the completion of the operation. Note that the anterior surface of the papilla has been effaced, and that the bile duct and duct of Wirsung enter the duodenum through separate openings.



Fig. 93.5

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Step 6

- The duodenum is closed in two layers with an inner row of absorbable suture; we prefer a running Connell, mucosa-inverting fashion; the outer layer of interrupted seromuscular nonabsorbable sutures is placed in interrupted Lembert fashion.
- A Jackson-Pratt or similar type of silicon, closed suction drain is usually unnecessary but can be positioned in the retroperitoneal bed of the duodenum, and a tag of omentum is sutured over the duodenotomy (Fig. 93.6).

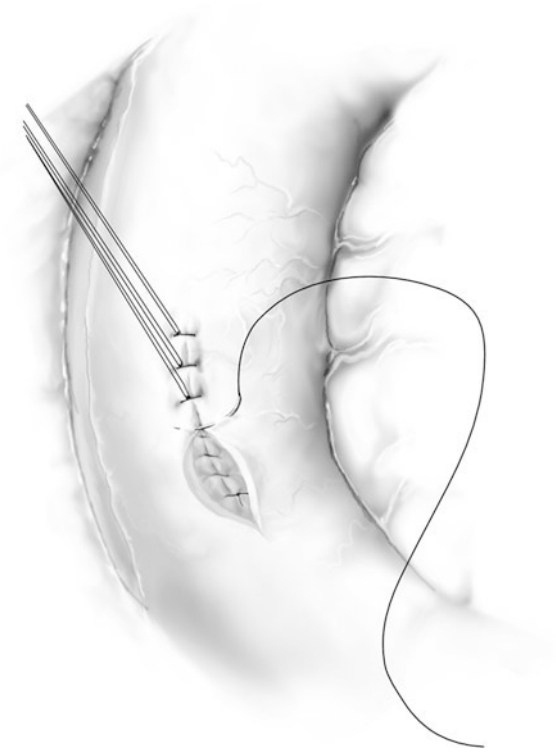


Fig. 93.6

Postoperative Tests

- Hemogram, WBC, serum amylase
- Monitor drain output
- Cholangiogram if T-tube is present on postoperative day 6
- No need for a nasogastric tube
- Resumption of oral intake as soon as tolerated

Local Postoperative Complications

- **Early:**
  - Pancreatitis (usually postoperative day 1): fever, abdominal pain, increased serum amylase
  - Cholangitis (usually postoperative day 3): fever, jaundice
  - Bilious drainage (usually postoperative days 3–7): duodenal leak
  - Wound infection (postoperative days 4–7): fever; increased WBC; tender, red wound
  - Gastrointestinal bleeding can occur from the sphincteroplasty site

- **Late:**
  - Recurrent pain
  - Recurrent stenosis of bile or pancreatic duct (with or without pancreatitis)
  - Persistent narcotic dependence

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Tricks of the Senior Surgeon

- Select your patients carefully.
- Wear a headlight and use optimal magnification.
- Rotate the duodenum anteromedially and make the duodenotomy on the lateral wall, not the anterior wall of duodenum; this way the exposure of the ampulla is optimal.
- Handle the papilla gently and with great respect.
- Insist on postoperative narcotic detoxification.
- Be kind and empathetic toward the patient with this form of addictive postcholecystectomy pain.

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Pancreatic Enucleation

Geoffrey B. Thompson, Michel Gagner

Enucleation of functioning neuroendocrine neoplasms (insulinomas, selected gastrinomas) and nonfunctioning, well-circumscribed neuroendocrine neoplasms smaller than 2 cm has been shown to be appropriate therapy for these neoplasms. Overtly malignant neuroendocrine neoplasms require a formal anatomic pancreatic resection.

Indications and Contraindications

Indications

- Insulinomas
- Selected gastrinomas, somatostatinomas
- Nonfunctional neuroendocrine neoplasms, usually smaller than 2 cm, well-circumscribed, no signs of malignancy

Contraindications

- Glucagonoma (usually malignant and requires a formal pancreatic resection)
- Recent acute pancreatitis
- Uncontrolled coagulopathy or severe thrombocytopenia
- Comorbidities dramatically limiting life expectancy
- Active peptic ulceration (gastrinoma patients)
- Signs of malignancy (multiple enlarged lymph nodes, liver metastases)

Preoperative Investigations and Preparation for Procedure

- History:
  - *Insulinoma:* "spells" associated with neuroglycopenia, Whipple's triad
  - *Gastrinoma:* peptic symptoms, gastroesophageal reflux disease (GERD), diarrhea, unusual location of duodenal ulcers (distal to first portion of duodenum)
- Clinical history:
  - *Insulinoma:* documented neuroglycopenic episodes (confusion, amnesia, double vision, blurred vision, seizures, coma), symptoms relieved by glucose administration (Whipple's triad)
  - *Gastrinoma:* increased serum gastrin and gastric acid secretion
- Laboratory tests:
  - *Insulinoma:* supervised 72-hour fast (endpoint-neuroglycopenia and plasma glucose < 45 mg/dL); increased C-peptide level (> 200 pmol/L); increased insulin level (≥ 3, immunochemiluminometric assay [ICMA]); increased proinsulin level; negative sulfonylurea screen in blood; negative insulin antibodies
  - *Gastrinoma (off antisecretory medication):* increased serum gastrin (> 500 pg/mL); gastric pH persistently < 1; positive secretin provocative test (when available) or calcium stimulation test
- Localization:
  - Spiral CT with triple-phase contrast
  - MRI
  - Transabdominal ultrasonography
  - Endoscopic ultrasonography with or without fine-needle aspiration
  - Selective arterial calcium stimulation test (insulinomas, gastrinomas)
  - Selective use of octreotide scintigraphy

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Procedures

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Open enucleation

Geoffrey B. Thompson

Step 1

Setup, Positioning, Incision, Exposure

- Setup, transverse epigastric incision, exploration, entry into lesser sac.
- Plasma glucose concentrations should be checked every 20 to 30 min with the patient off all glucose-containing fluids (insulinoma patients only).
- The patient is best positioned supine with arms tucked at sides.
- A transverse epigastric incision is best. A third-arm mechanical retractor facilitates the exposure and allows a thorough abdominal/pelvic exploration to be carried out.
- First, the gastrocolic omentum is mobilized off the transverse colon from left to right, entering the lesser sac; the stomach and the omentum are held cephalad by the second assistant, and the transverse colon is retracted caudad, exposing the pancreas (Fig. 94.1).

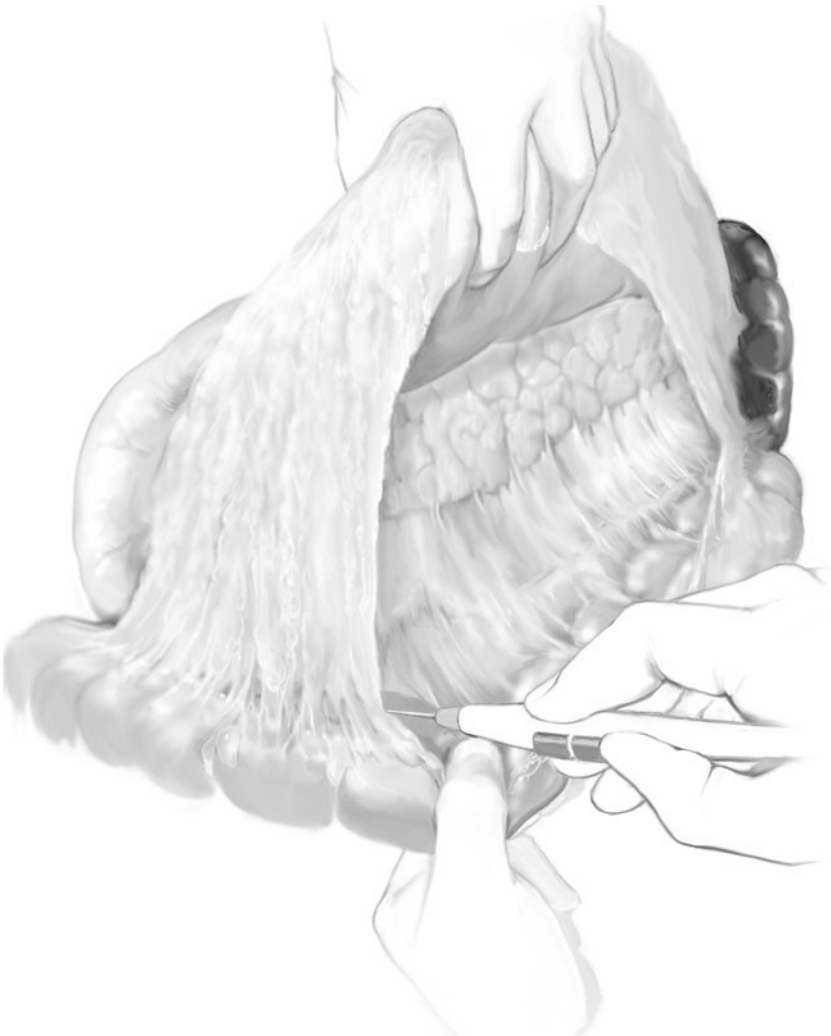


Fig. 94.1

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Step 2

Kocherization, mobilization of body and tail, inspection, and palpation

- Before further mobilization, the pancreas is inspected and palpated carefully. If the tumor is readily apparent on the surface or edge of the gland and its location is consistent with preoperative localization studies, further mobilization may be limited to the involved portion of the pancreas, unless there is a familial syndrome or other concerns predisposing the patient to multiple neoplasms.
- For tumors in the head and uncinate region, the duodenum is widely Kocherized out to and including the ligament of Treitz; division of the right gastroepiploic vessels on the anterior surface of the pancreatic head and the anterior inferior pancreatoduodenal vein to the uncinate facilitates exposure of the head and uncinate and reduces the risk of inadvertent vascular injury and bleeding during dissection; transpancreatic palpation of the head and uncinate allows localization of tumors in this region (Fig. 94.2).

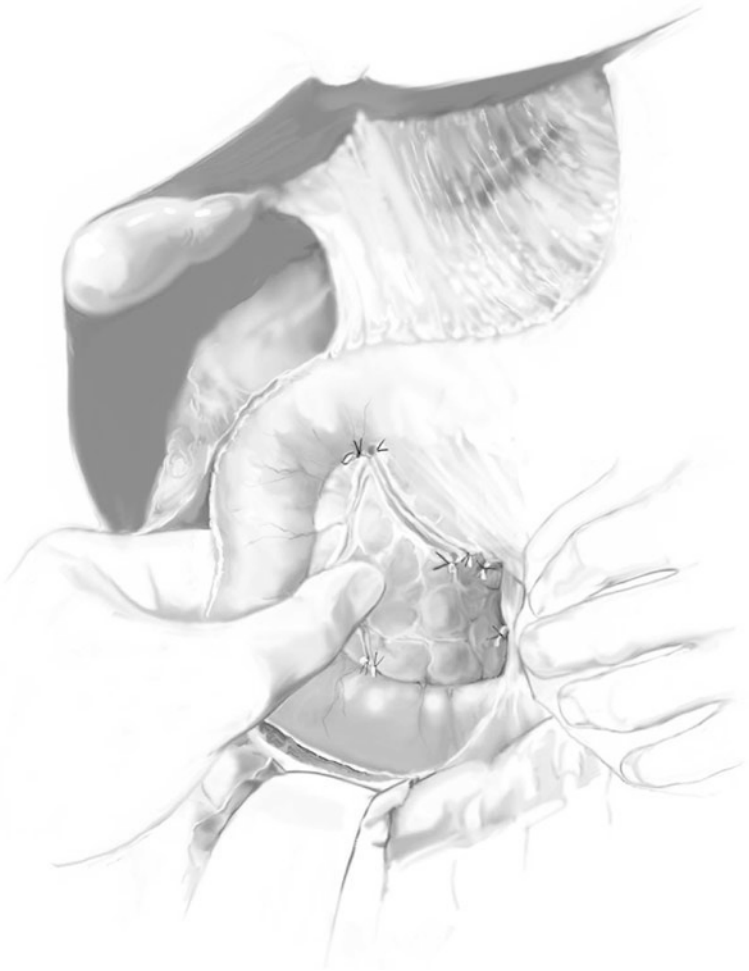


Fig. 94.2

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Step 3

Exposure of superior mesenteric vein and uncinate

- A plane is often developed between the underside of the neck of the gland and the underlying portal vein at the superior mesenteric vein junction. After exposing the superior mesenteric vein at the inferior edge of the neck of the pancreas, gentle blunt dissection with an index finger or a small peanut dissector completes the dissection under direct vision; care is taken to stay directly on top of the vein throughout the dissection to avoid injury to lateral venous tributaries to the uncinate. In patients with insulinoma, this is usually an easy dissection (Fig. 94.3). This step is not always necessary but facilitates exposure of the uncinate.

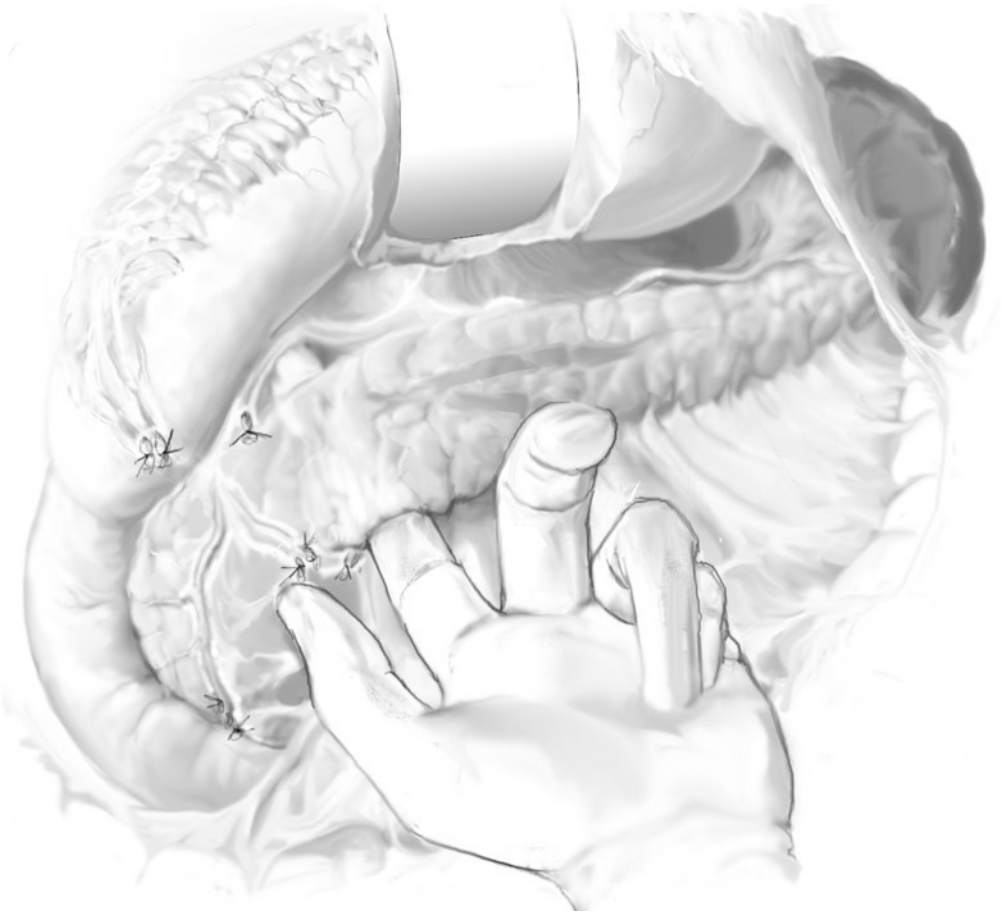


Fig. 94.3

Step 4

Mobilization of the pancreatic body and tail, intraoperative ultrasound

- When the tumor is in the body of the pancreas, dissection continues along the avascular inferior border of the body of the gland. After incising this plane, the body of the pancreas is mobilized from the inferior border to the superior border (Fig. 94.4a).
- When the tumor is in the tail of the pancreas, mobilization of the spleen by incising its lateral peritoneal attachments to the kidney and diaphragm usually allows best exposure. Short gastric vessels are not divided until the decision is made regarding splenic preservation (Fig. 94.4b).
- When the tumor is occult, all these maneuvers should be performed prior to intraoperative ultrasonography (IOUS); bimanual and bidigital palpation allow the gland to be examined from head to tail; suspicious lymph nodes are excised for frozen section analysis (Fig. 94.4c).
- Real-time IOUS is next performed using a 6-mHz transducer in the longitudinal and transverse axes. Islet cell neoplasms appear as hypoechoic masses within the pancreatic parenchyma, are firmer in texture than the surrounding parenchyma, and are tan to reddish-brown.

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Step 4 ***(continued)***

- Islet cell neoplasms typically have a rim of vascular enhancement not seen with lymph nodes on color-flow Doppler examination.
- Further palpation of lesions seen on ultrasonography often reveals subtle thickening within the pancreas not appreciated during the initial exploration.
- If doubt of the findings exists, ultrasonography-guided fine-needle aspiration provides immediate cytologic evaluation; this is especially important for occult islet cell neoplasms deep within the head of gland abutting the pancreatic and/or bile ducts; this situation may require pancreatoduodenectomy, and absolute cytologic confirmation of an islet cell neoplasms is essential.

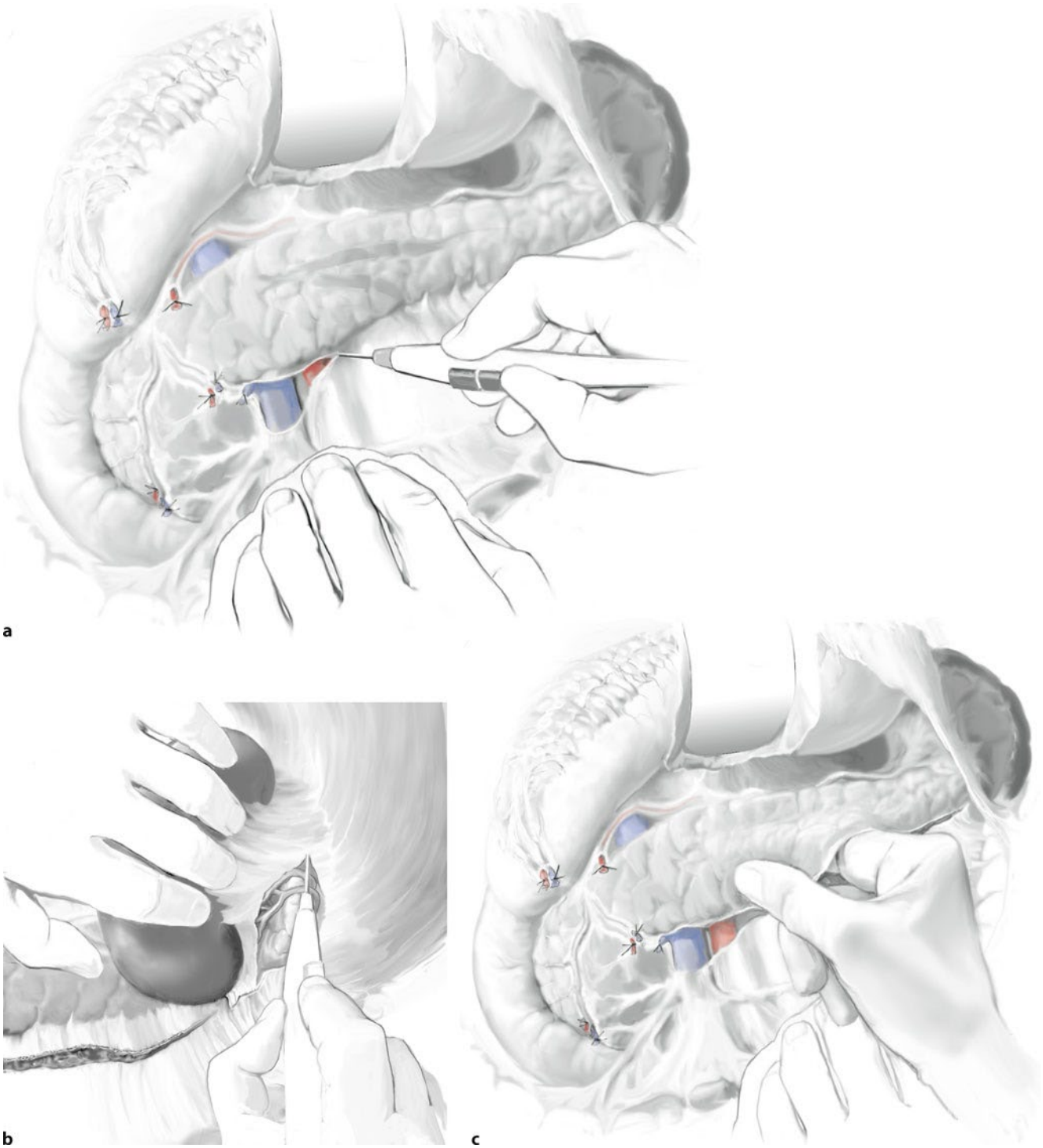


Fig. 94.4

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Step 5

Enucleation

- Once the site of the tumor is ascertained and no other abnormalities are noted, a decision must be made regarding enucleation versus resection; over two thirds of insulinomas can be enucleated safely with attention to detail.
- For palpable tumors on the edge of the gland, anterior surface, or posterior surface, the very thin operculum of pancreatic tissue overlying the tumor is carefully incised using a combination of bipolar cautery and a fine-tipped hemostat, the underlying insulinoma is exposed, and a traction suture is placed deep into the tumor in figure-of-eight fashion to avoid fracture. Constant gentle elevation of the traction suture allows direct visualization of the small feeding vascular tributaries, which can be managed with bipolar cautery but infrequently require fine metallic clips. The pancreatic parenchyma is dissected away from the tumor using a fine endarterectomy spatula. Near the base of the enucleation, the endarterectomy spatula really helps to push the parenchyma away from the adenoma, especially when enucleating tumors that abut the pancreatic duct (Fig. 94.5).
- All malignant islet cell neoplasms require maintenance of oncologic principles with distal pancreatectomy and splenectomy or pancreatoduodenectomy including regional lymphadenectomy.
- For tumors in the tail of the gland, it is usually easy to separate the splenic artery and vein from the gland, and the pancreatic tail is removed using a stapling device; the staple line is reinforced with a row of absorbable horizontal mattress sutures that incorporate the pancreatic duct. Drains are placed.
- When the spleen is small or the patient is thin, the splenic artery and vein can be freed from the pancreas by individually dividing venous and arterial tributaries with fine metal clips, a harmonic scalpel, or both. Concern regarding patency of the splenic vein should lead to splenectomy (essential for a larger spleen). This avoids future development of left-sided portal hypertension and gastric varices.
- For larger tumors in the body of the pancreas, splenic preservation can be accomplished in two ways. In obese patients, the splenic artery and vein are divided 1 to 1.5 cm outside the splenic hilum, leaving the spleen based on the short gastric vessels, provided that the spleen is not enlarged. Once the spleen and blood supply are separated from the pancreas, the splenic artery is redivided and ligated at its origin. The splenic vein is also redivided and ligated at its junction with the superior mesenteric/portal vein junction, and the body and tail are removed with a stapler.

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Step 6

Completion of operation

- Once enucleation is complete, ultrasonography confirms the integrity of the main pancreatic duct. Secretin is administered to dilate the pancreatic duct and to demonstrate major leaks from the enucleation site. Dilation of the pancreatic duct aids in post-enucleation IOUS to ensure ductal continuity and completeness of resection (Fig. 94.5).
- After enucleation or resection, the abdomen is irrigated and hemostasis is assured.
- The stomach and greater omentum are draped over the colon and the abdomen closed.
- Major ductal disruption in the body and tail of the gland is best managed with immediate distal pancreatectomy.
- A major ductal injury in the head of the pancreas is managed in one of three ways (with external drainage strongly suggested for all patients):
  - Suture closure of the duct with fine absorbable suture and drainage
  - Closure of the hole over a tiny Silastic stent passed across the papilla with placement of the Roux limb over the enucleation site
  - Pancreatoduodenectomy (< 2 % of patients).
- Once the insulinoma is removed, plasma glucose concentrations are drawn every 15 min; increases in serum glucose concentration by 20 mg/dL in the first 30 min after excision usually indicate a cure, but false positive and false negative studies are possible; in some centers, rapid insulin assays are available.
- The enucleation site is left open and drains are placed nearby.
- Tumors larger than 2 cm centralized within the body or tail of the pancreas are probably best managed by distal pancreatic resection with or without splenectomy, unless they are located eccentrically in which case enucleation may be possible.

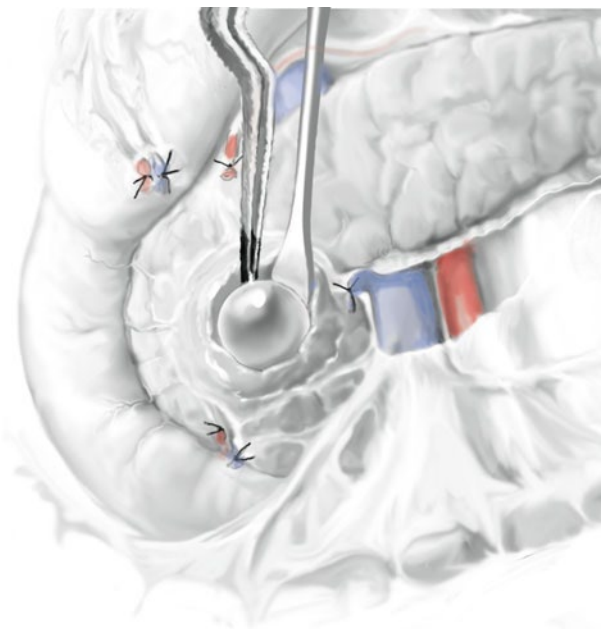


Fig. 94.5

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Laparoscopic enucleation

Michel Gagner

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Step 1

Operative room positioning and trocar placement

- The patient is placed under general anesthesia with orotracheal intubation.
- A nasogastric tube and Foley urinary catheter are inserted.
- Prophylactic parenteral antibiotics are given.
- The patient is positioned in the lithotomy position with a wedge under the left flank (45° of elevation).
- The surgeon stands between the patient's legs, the first assistant to patient's right, and the scrub nurse to the patient's left.
- Two monitors are positioned at each of the patient's shoulders.
- A five-trocar technique is used. A 10-mm trocar is placed at the umbilicus for insertion of a 10-mm, 30° laparoscope; the size and position of the other four trocars vary with patient habitus, but a 12-mm trocar in the left midaxillary line is used to introduce the linear stapler if necessary (Fig. 94.6).

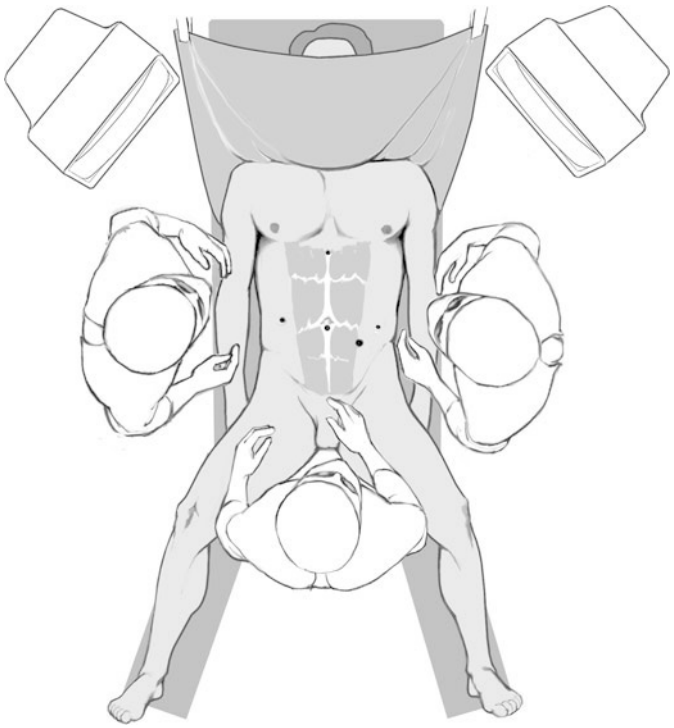


Fig. 94.6

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Step 2

Pancreatic exposure and mobilization

- Exploratory laparoscopy is performed first to exclude local or distant extension of the neoplasm.
- The small bowel is moved from the operative field and the table is rotated/inclined with the left side up and in reverse Trendelenburg to obtain the best exposure.
- The lesser sac is exposed by opening the gastrocolic ligament widely inferior to the gastroepiploic arcade using an ultrasonic scalpel (Harmonic; Ethicon, Cincinnati, Ohio, CT, USA) or electrothermal bipolar vessel-sealing device (LigaSure; Covidien; Mansfield, MA, USA). The splenic flexure of the colon is mobilized inferiorly to expose the pancreatic tail; if further exposure is needed, the short gastric vessels are transected.
- The retroperitoneum is incised along the inferior and superior border of the body/tail of the pancreas; the mesenteric vessels are identified at the uncinate process and the splenic artery, at the superior border of the pancreas (Fig. 94.7).

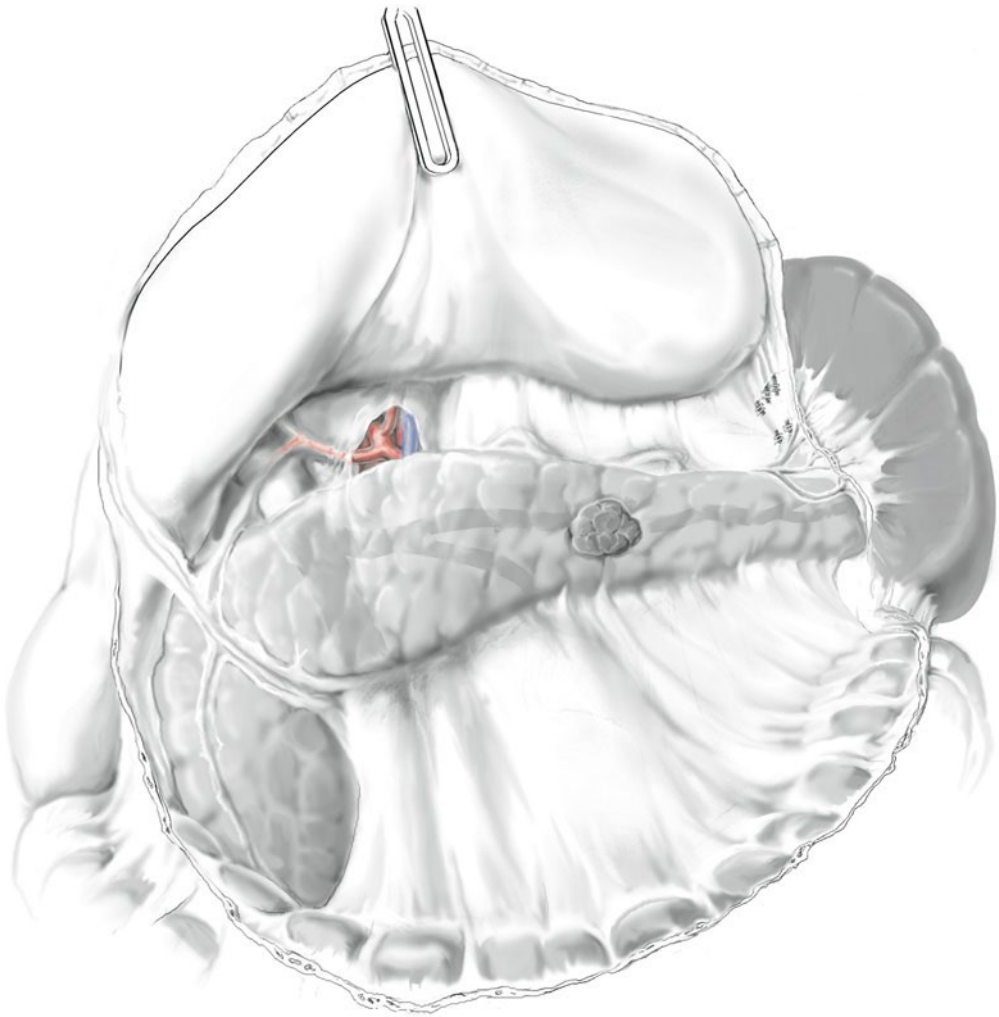


Fig. 94.7

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Step 3

Ultrasonography

- Laparoscopic ultrasonography is performed routinely; the aim is to localize the tumor, define the resection margin, exclude any secondary lesions (both hepatic or pancreatic), and define the relationship with the main vessels and pancreatic duct.
- The probe we use fits through a 10-mm trocar; its tip can be angulated for maximal surface contact. For small lesions, a water balloon is placed between the probe and the pancreatic body to improve resolution.
- The ideal treatment for these selected neuroendocrine neoplasms is enucleation; but if the tumor is large, deep, or located too close to the main vessels or pancreatic duct, a pancreatic tail resection, with or without splenectomy, is preferred (Fig. 94.8).

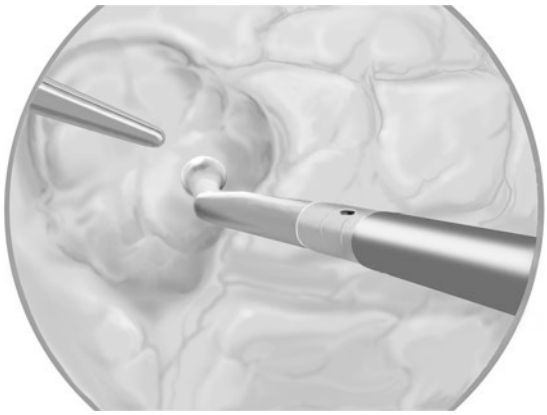


Fig. 94.8

Step 4

Mobilization of tumor for enucleation of pancreatic neoplasm

- A pancreatotomy is performed in a circle a few millimeters from the edge of the tumor.
- An ultrasonic scalpel is used to dissect the tumor from the normal parenchyma.
- As the plane of dissection goes deeper, small vessels are cauterized or ligated with ultrasonic energy.
- An irrigation-suction cannula keeps the field free of blood; if hemorrhage occurs, pressure is applied for several minutes (Fig. 94.9).



Fig. 94.9

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Step 5

Enucleation of pancreatic neoplasm

- Larger vessels feeding the tumor are controlled using 5-mm or 10-mm vascular clips.
- The resected tumor is placed in a retrieval bag and extracted through the 12-mm trocar.
- Frozen sections confirm the histology and assess resection margins.
- Intraoperative insulin assays are obtained before and after enucleating the insulinoma (Fig. 94.10).

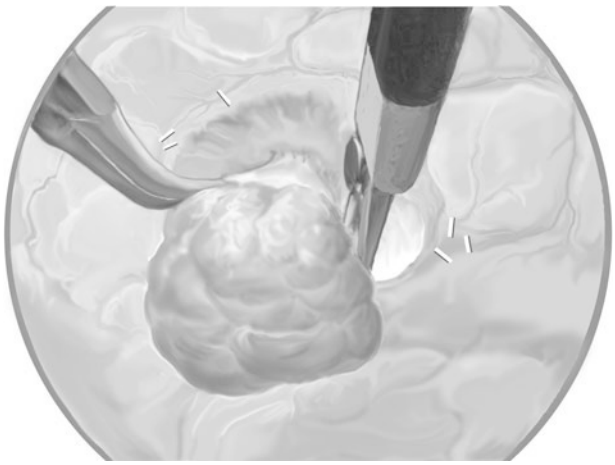


Fig. 94.10

Step 6

Hemostasis and drainage

- The bed of the tumor is covered with fibrin glue in an attempt to prevent pancreatic exocrine leakage.
- A closed suction drain is left in the lesser sac near the resection site (Fig. 94.11).

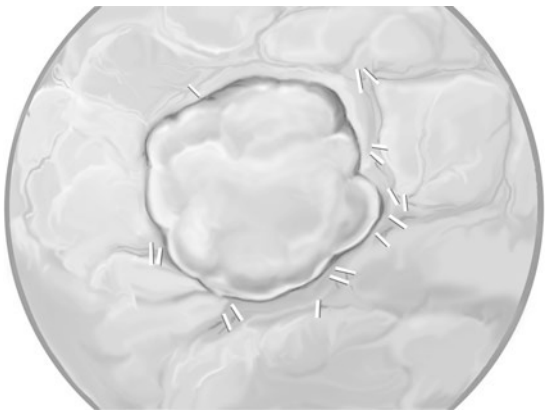


Fig. 94.11

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Postoperative Tests

- Hold all glucose for 24 h (insulinoma)
- Test plasma glucose every 6 to 8 h for 48 h, then twice daily until oral intake resumes (insulinoma)
- Every other day, CBC, electrolytes, amylase
- Test drain fluid for amylase if the fluid becomes cloudy

Local Postoperative Complications

- **Short-term:**
  - Pancreatic leak
  - Acute pancreatitis
  - Bleeding
  - Intra-abdominal abscess
  - Wound infection
  - Persistent hypoglycemia, hypergastrinemia
- **Long-term:**
  - Chronic pancreaticocutaneous fistula
  - Pancreatic ascites (internal fistula)
  - Pancreatic pseudocyst
  - Diabetes mellitus
  - Recurrent peptic ulcer disease (gastrinoma)
  - Recurrent hypoglycemia secondary to missed insulinoma, unrecognized factitious hypoglycemia, nesidioblastosis, or multiple endocrine neoplasia syndrome

Tricks of the Senior Surgeon

Open enucleation

- Minimize mobilization of the pancreas if the tumor is readily apparent (use IOUS to look for multiple tumors).
- IOUS guides tumor removal (enucleation *vs* resection); use IOUS to check the continuity of the main pancreatic duct after enucleation.
- Avoid sutures and unipolar electrocautery; utilize a traction suture, bipolar cautery, fine clips, and an endarterectomy spatula during enucleation to avoid major ductal injury.
- Leave the enucleation sites open.
- Fibrin glue and octreotide do not prevent pancreatic fistulas.
- Always leave one or more drains.

Laparoscopic enucleation

- A 5-mm hook cautery can be very useful to dissect the deep plane between the pancreas and insulinoma.
- Reuse the laparoscopic ultrasound probe used to monitor enucleation.
- If the enucleation plane is difficult, perform a laparoscopic or open distal pancreatectomy.
- Clip the last deeper posterior centimeter of the pancreatic parenchyma to control posterior vessels feeding the tumor, as well as possible pancreatic ductules.

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Transduodenal Resection of Periampullary Villous Neoplasms

Michael L. Kendrick, Michael B. Farnell

Halsted reported the first ampullary resection of a periampullary carcinoma in 1899.

Compared with more radical procedures, this approach offers a potential decrease in operative risk and complications, but there is a high incidence of recurrence, and ongoing endoscopic surveillance is needed.

Indications and Contraindications

Indications

- Benign periampullary villous neoplasm
- Prohibitive operative risk for pancreatoduodenectomy
- Patient preference or refusal of pancreatoduodenectomy

Contraindications

- Presence or suspicion of malignancy
- Extension of the tumor more than 1.5 cm into the pancreatic or common bile duct
- Large tumor (> 2.5 cm), precluding adequate margins for reconstruction and closure

Preoperative Investigations and Preparation for Procedure

Endoscopy with biopsy

- Mandatory in all patients
- With high suspicion of malignancy, or biopsy-proven malignancy (especially with tissue invasion), very strong consideration should be given to radical resection
- Findings suggesting malignancy include dilation of the bile duct, pancreatic duct, or both; hard or ulcerated tumor; or high-grade dysplasia
- Cautionary notes: Endoscopic biopsy misses a diagnosis of malignancy in 40 % of cases; the most accurate diagnostic method for invasion is complete excision with pathologic analysis
- Endoscopic retrograde cholangiopancreatography (ERCP): The gold standard, ERCP determines ductal extension
- CT excludes evidence of local complications (ductal dilation, pancreatitis, etc.) or metastatic disease
- Endoscopic ultrasonography can (in experienced hands) delineate transmural invasion, ductal extension, or nodal involvement, but it is very operator-dependent

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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Procedure: Transduodenal Resection of Periampullary Neoplasm

Open approach

Step 1

Access and exposure

- *Incision:* A right subcostal incision is usually preferable in most patients.
- *Exploration:* First, one must exclude metastatic disease to the liver, nodes, or peritoneum. (These are extremely rare.)
- *Exposure:* A fixed mechanical, upper abdominal retractor markedly facilitates operation.
- After mobilization of the hepatic flexure inferiorly, a wide Kocher maneuver is performed, mobilizing the duodenum medially (Fig. 95.1a).
- Next, assessment of the posterior duodenum is performed (Fig. 95.1b).
- The lesion and ampulla are localized by palpation medially from the lateral duodenal wall (Fig. 95.1c).

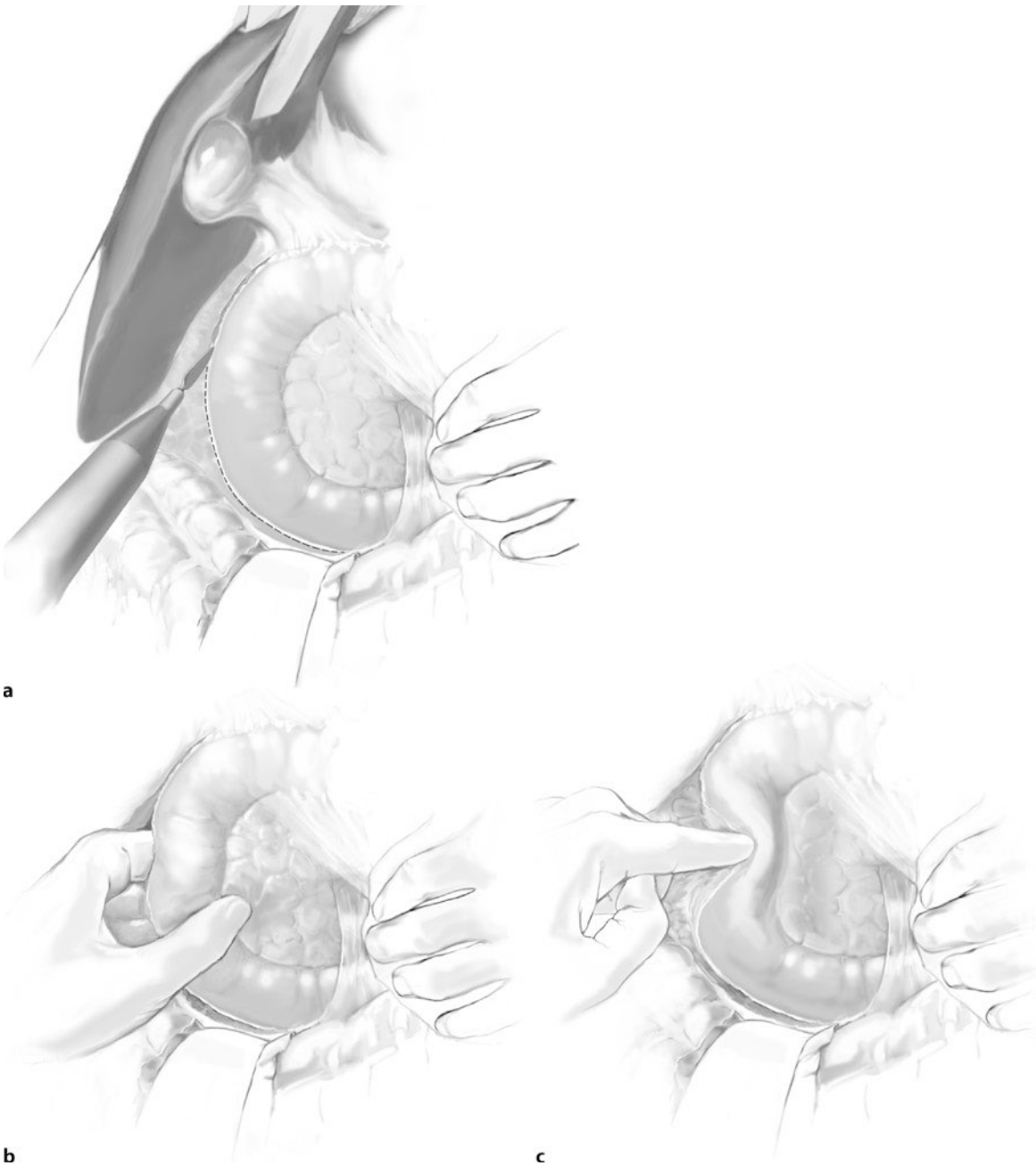


Fig. 95.1

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Step 2

Duodenotomy and setup

- An anterolateral oblique duodenotomy is made (Fig. 95.2a).
- Cholecystectomy is performed in routine fashion. A flexible catheter (e.g., biliary Fogarty catheter) is placed antegrade from the cystic duct distally through the papilla into the duodenum, to assist localization of the ampulla.
- A margin of 5 to 10 mm is scored circumferentially in the mucosa around the adenoma with electrocautery. Sutures placed at the margins assist with retraction. A mixture of saline and epinephrine (1:100,000) is injected submucosally to elevate the mucosa and the tumor, facilitating resection (Fig. 95.2b).



Fig. 95.2

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Step 3

Resection

- The extent and depth of the excision are based on the preoperative and intraoperative assessment; submucosal excision may be adequate for superficial lesions not involving the ducts (Fig. 95.3a; 1). Full-thickness "ampullectomy" is necessary for lesions with transmural invasion or ductal extension (Fig. 95.3a; 2 and 3).
- "Needle-point" electrocautery is used to excise the lesion with a rim of normal tissue (Fig. 95.3b). More extensive resection, including the pancreatic margin of the pancreas and the pancreatic and common bile ducts, is necessary to ensure adequate resection; the specimen is examined carefully, oriented, and margins marked for frozen section. Optical magnification assists this step as well as the reconstruction (Fig. 95.3c).
- If carcinoma in situ or invasive carcinoma is identified, conversion to a formal pancreatoduodenectomy is best in patients with acceptable risk.

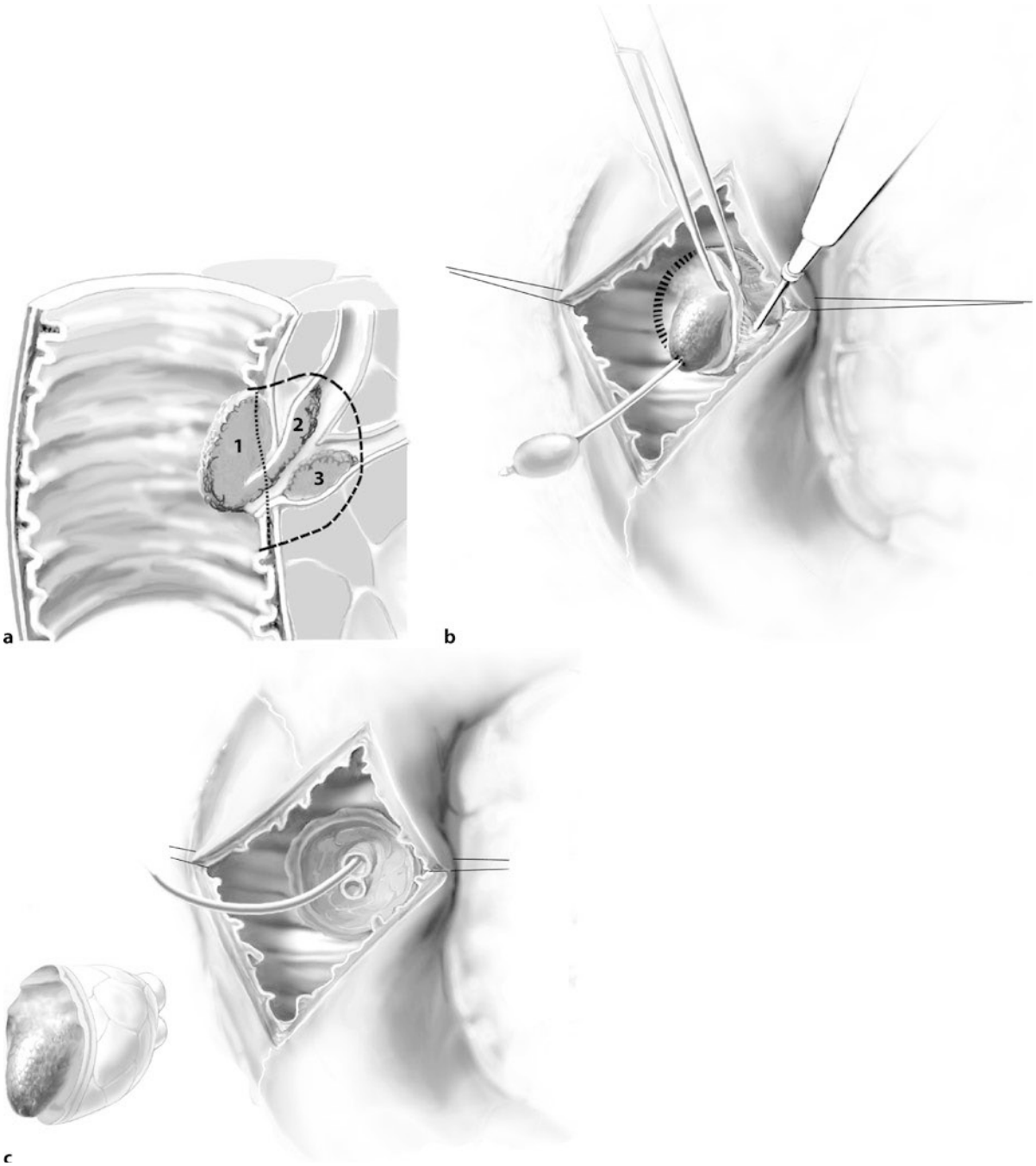


Fig. 95.3

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Step 4

Reconstruction

- Once the lesion is confirmed to be benign, local reconstruction is initiated. The method of reconstruction depends on the extent of resection and ductal anatomy.
- Submucosal excisions are reconstructed using interrupted absorbable suture to approximate the mucosa of the ampulla to that of the duodenum. Care is taken not to obliterate the orifice of the pancreatic duct located at the caudal aspect of the transected ampulla. Intravenous secretin (0.25 mg/kg) is used to identify the pancreatic duct if the orifice is uncertain (Fig. 95.4a).
- Ampullectomy is reconstructed by approximating the adjacent portion of the pancreatic and bile duct (Fig. 95.4b; inset) with interrupted 5-0 or 6-0 absorbable suture, followed by reconstruction of the entire complex to duodenal mucosa, as for submucosal excisions (Fig. 95.4b; inset).
- Ampullectomy or more extensive resection of the pancreatic and bile ducts may require separate reconstruction of each duct (Fig. 95.4c).
- Assessment of ductal patency is imperative and is done with a small probe.
- The lateral duodenotomy is closed in a two-layer fashion.
- A paraduodenal drain is placed in Morison's pouch and brought out through the right lateral abdominal wall.

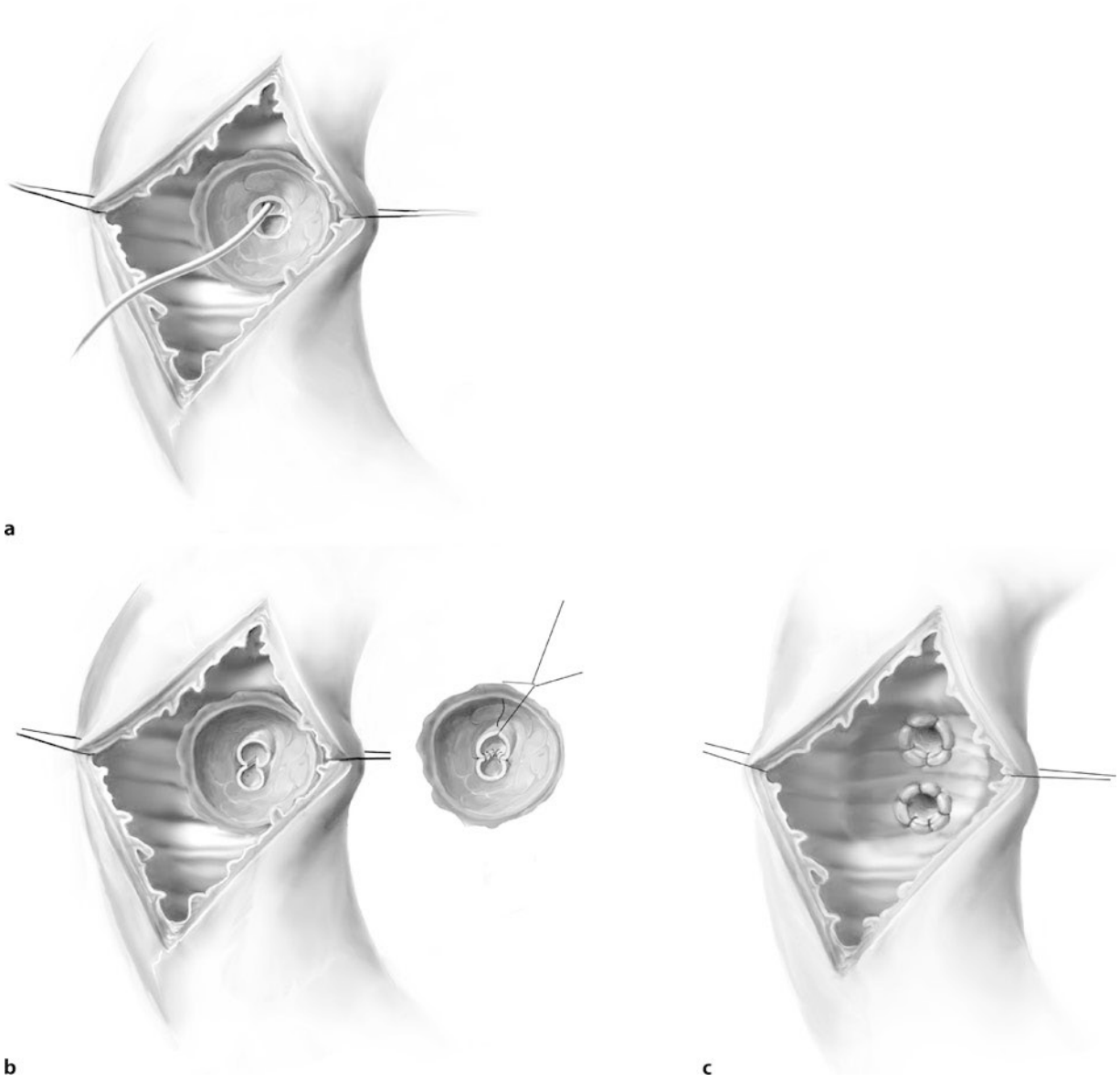


Fig. 95.4

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95

Minimally invasive approach

- Laparoscopic transduodenal resection of a periampullary neoplasm is feasible but should be reserved for surgeons experienced in both advanced laparoscopy and hepatopancreatobiliary surgery.
- Correct trocar placement (Fig. 95.5) is critical to allow optimal exposure and access for the resection and reconstruction.
- Procedural steps are followed as for the open approach.

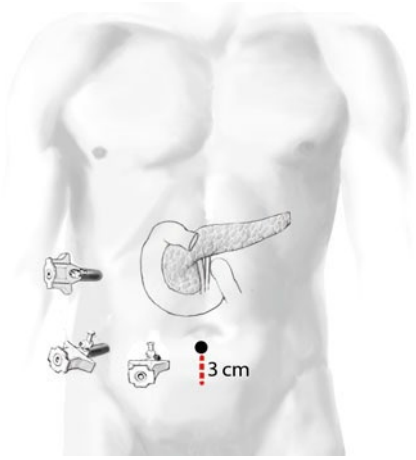


Fig. 95.5

Postoperative Care

- If a nasogastric tube is used, it is removed the night of the operation or the next morning.
- Routine postoperative tests and imaging are unnecessary.
- The drain is removed when the patient tolerates oral intake and is without evidence of any complications.

Local Postoperative Complications

Short-term:

- Transient increases in serum liver function studies and pancreatic enzymes (infrequently clinically important)
- Duodenal, pancreatic, or biliary leak
- Intraduodenal hemorrhage
- Pancreatitis

Long-term:

- Stricture of the common bile duct or pancreatic duct
- Duodenal stricture
- Recurrent villous adenoma (estimated to occur in about 40 % at 10 years of follow-up)
- Development of ampullary carcinoma (malignant recurrence) is possible, requiring regular endoscopic surveillance

Postoperative Surveillance

- Endoscopic gastroduodenoscopy with a side-viewing instrument should be performed 6 months after the operation, biannually for 2 years, and then annually.
- Strictures are interrogated for recurrent neoplasm and ideally should be treated with pancreatoduodenectomy.

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Tricks of the Senior Surgeon

Open approach

- A subcostal incision provides excellent lateral exposure, greatly facilitating access for the dissection.
- An anterolateral oblique duodenotomy gives ideal exposure and allows further extension if needed; a two-layer closure does not compromise the duodenal lumen.
- An extended Kocher maneuver is imperative.
- A folded laparotomy pad placed behind the duodenum displaces the operative field anteriorly.
- A catheter placed antegrade via the cystic duct provides assurance in locating and protecting the retroduodenal common bile duct, especially when a full-thickness excision is performed.
- Placement of sutures at the margin of the specimen assists exposure and dissection.
- Optical magnification is very helpful for resection and reconstruction.

Minimally invasive approach

- After duodenotomy, a retraction suture is placed on the anterior and posterior edge to facilitate exposure by the assistant.
- Use of a trans-cystic duct biliary catheter is especially critical.
- L-shaped electrocautery allows more precise dissection than the traditional J-shape.
- Sutures are placed to orient the specimen prior to completion of the resection, to avoid disorientation during port site retrieval.

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Pancreas Transplantation

Nicolas Demartines, Hans Sollinger

The aim of pancreas transplantation is to restore normal glycemia in diabetics and to attempt to stop the vascular pathophysiology of diabetes (i. e., microangiopathy) and, whenever possible, to reverse established renal, ophthalmologic, and neurologic complications of microangiopathy. Pancreas transplantation can be performed either simultaneously with a kidney transplant, sometimes after a previous kidney transplant, or less commonly, as a primary procedure alone.

The operative technique of pancreas transplantation has evolved from a segmental organ transplantation to a complete (pancreatoduodenal) transplantation. Similarly, the original method of drainage of the exocrine pancreas into the bladder has also evolved into enteric drainage. In many centers, enteric drainage has been shown to be safe and efficient and has largely replaced bladder drainage.

The question about the benefit of portal venous drainage versus caval (systemic) drainage remains unresolved, and both techniques are described.

Indications and Contraindications

Indications

- **For pancreas transplantation:**
  - Type 1 diabetes mellitus
  - Indications for simultaneous pancreas and kidney transplantation
  - Diabetic nephropathy
  - End-stage renal disease
- **For pancreas transplantation after kidney transplantation**
  - Functioning kidney graft
- **For pancreas transplantation alone (severe complications of diabetes)**
  - Instability of glycemia: unstable, "brittle", insulin-dependent diabetes
  - Progressive retinopathy
  - Progressive neuropathy

Contraindications

- Coexistent cancer (excluding squamous or basal cell carcinoma of the skin)
- Severe infection
- Psychiatric disease (psychosis)
- Peripheral arteriopathy with infection
- Symptomatic coronary artery disease

Preoperative Investigations and Preparation for the Procedure

- Routine evaluation for transplantation with appropriate serum cross-match
- Evaluation of renal function unless on preoperative hemodialysis
- Clinical cardiovascular evaluation, further cardiac workup if clinically indicated
- Clinical exclusion of concurrent infection

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Procedure

Step 1

Back-table preparation

- We prefer to completely prepare the pancreas for transplantation during cold ischemia. All connective tissues around the pancreas are divided with 2-0 or 4-0 silk ligatures placed close to the pancreas. The spleen is resected and the splenic vessels carefully ligated with 0 silk. The superior mesenteric artery and vein distal to the pancreatic vessels are divided in one of two ways: either with a vascular stapler close to the pancreas or by ligating the vessels with 0 silk and oversewing them with polypropylene running sutures.
- A 12-cm segment of the second portion of the duodenum containing the entrance of the pancreatic duct is isolated using a gastrointestinal stapler. The staple lines are oversewn for hemostasis with a running suture of resorbable suture.
- The portal vein is usually left short at the procurement; this permits a very short portal anastomosis, which decreases the risk of venous thrombosis. The mesenteric and splenic arteries are connected with use of a Y-graft from the donor iliac bifurcation with running sutures of 6-0 polypropylene. The graft is now ready for implantation (Fig. 96.1).

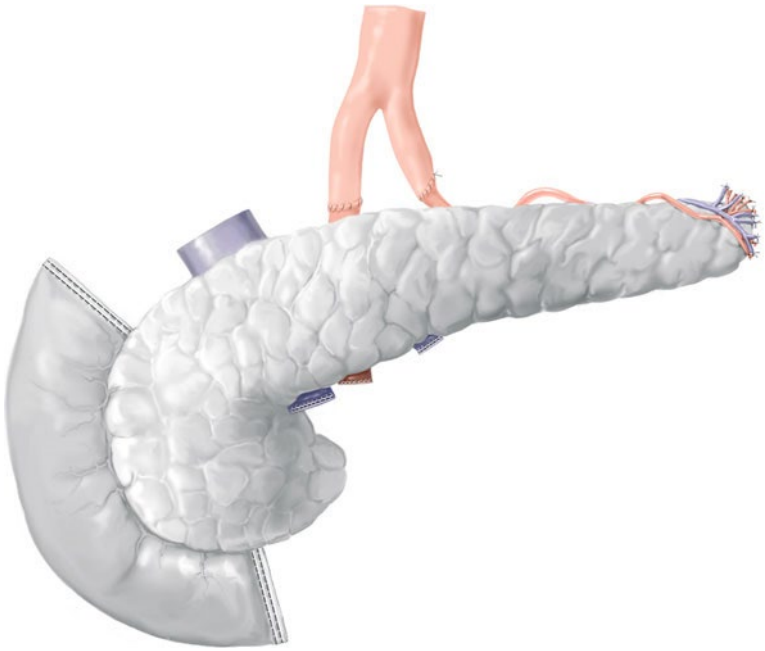


Fig. 96.1

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Step 2

Access (Fig. 96.2)

- Access to the retroperitoneum for portocaval anastomosis is obtained with a midline incision. An Omnitract (Omni-Tract Surgical; St. Paul, MN, USA) or Octopus (Medtronic; Minneapolis; MN, USA) retractor aids exposure.
- The cecum and right colon are mobilized medially to expose the vena cava. Care should be taken to avoid injury to the right ureter, which may cross the iliac vessels on the right side at several different levels, either at the caval bifurcation or more laterally. The ureter is retracted laterally.
- During preparation of the vena cava for anastomosis (about 5 cm is needed), the surgeon must remember the sacral vein located posteriorly, usually just cephalad to the iliac bifurcation. The right common iliac artery is prepared similarly.
- Lymphatic vessels should be ligated to avoid formation of a lymphocele.

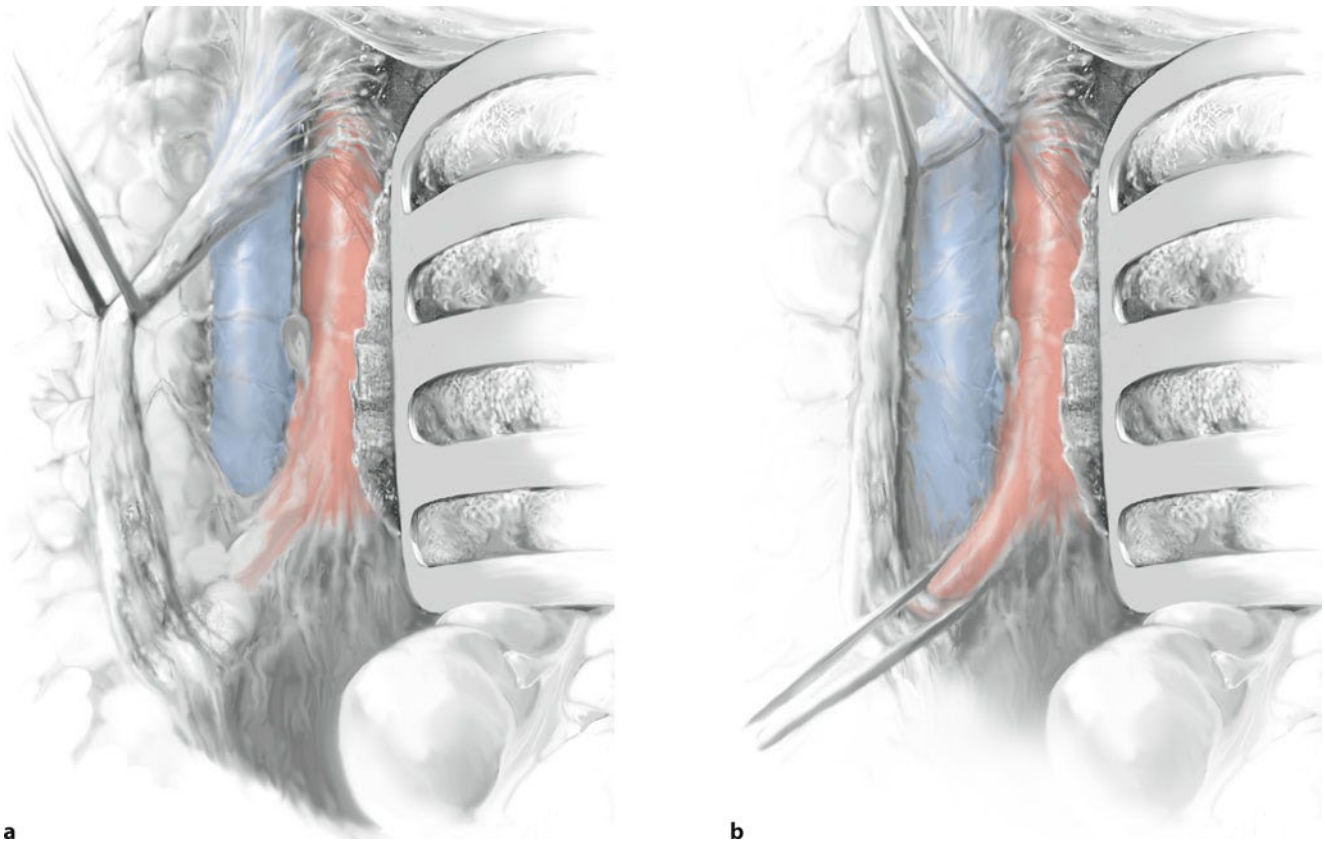


Fig. 96.2

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Step 3

Venous anastomosis (Fig. 96.3)

- A Satinsky vascular clamp is placed on the vena cava for the venous anastomosis.
- The type of clamp used on the common iliac artery depends on the site for anastomosis and the presence or absence of arteriosclerosis: either a Satinsky clamp or two right-angle vascular clamps.
- For the posterior aspect of the venous anastomosis, the cava is opened longitudinally for 20 to 30 mm, corresponding to the size of the portal vein of the graft. A stay suture on the left side of the opened vena cava maximizes exposure. After irrigating the lumen with a heparin/saline solution, a 6-0 polypropylene running suture starts on the right side of the cava and is carried around the posterior circumference. The technique for the vascular anastomosis is also used for a portomesenteric venous anastomosis.
- The anterior part of the anastomosis is performed next with the same running suture, taking care not to include the posterior wall with the anterior suture layer. Before completing the anastomosis by tying the two ends of the suture, a bulldog clamp is placed on the portal vein and the anastomosis is tested by filling and distending the cava and portal vein with a heparin/saline solution through a cannula. The bulldog clamp should remain in place while the vascular clamp on the cava is removed.

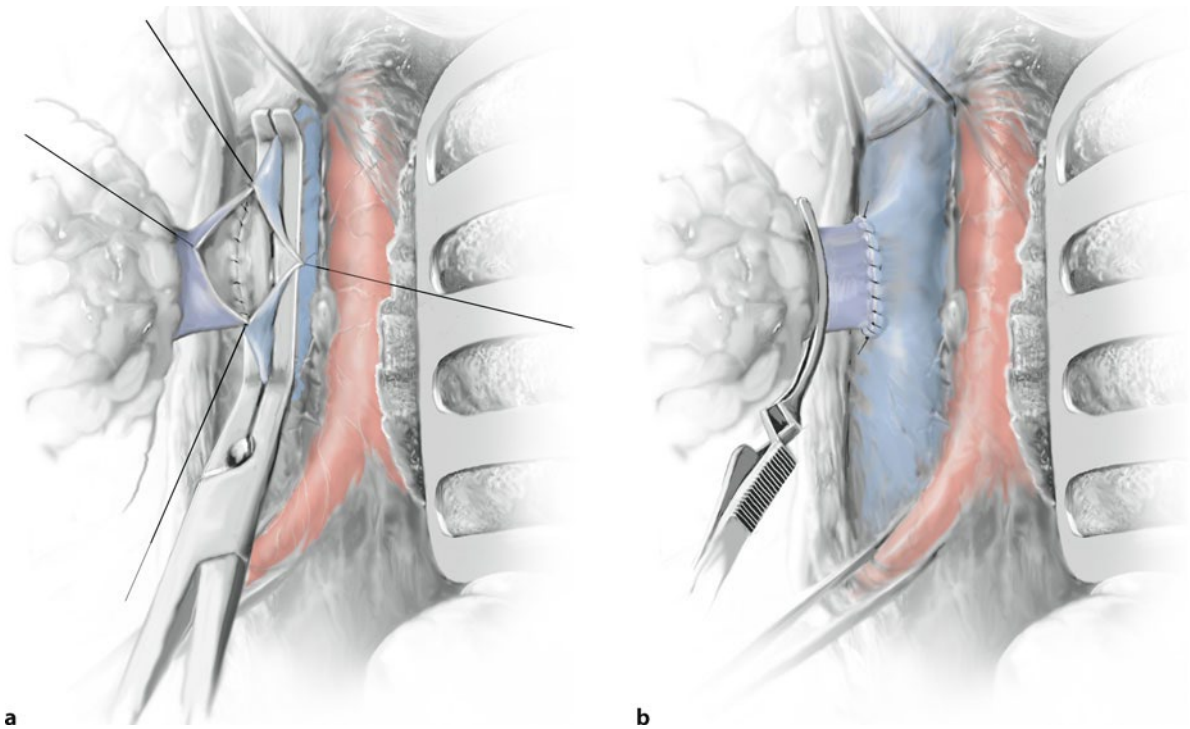


Fig. 96.3

۰۲۱-۶۶۱۹۸۵۱۴ www.myuptodate.com دریافت آخرین نسخه آپتودیت آفلاین

Step 4

Arterial anastomosis (Fig. 96.4)

- The right common iliac artery is opened, and a patch corresponding to the diameter of the graft artery is resected. The vascular anastomosis is performed with two running sutures of 6-0 polypropylene. A bulldog vascular clamp is placed on the arterial graft, and the anastomosis is filled with heparin/saline solution.
- After testing the arterial anastomosis for leak, the pancreas graft is ready to be perfused. First, the venous clamp is removed and then the arterial one. The anesthesiologist should be warned about the possibility of cardiac dysrhythmias or hypotension when the graft is first perfused. Also, it is not unusual for small vessels not ligated during the back-table preparation to bleed during reperfusion; careful hemostasis is mandatory.
- Intraoperative glycemia monitoring usually shows normalization without additional insulin within 1 to 2 h after the graft reperfusion.

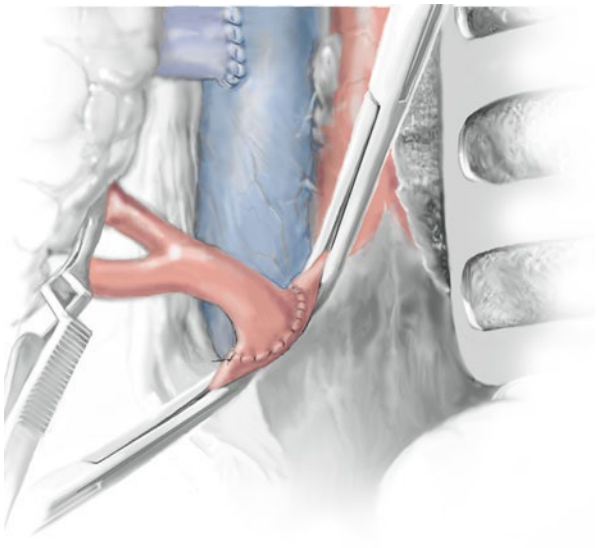


Fig. 96.4

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Step 5

Portomesenteric anastomosis

- Whenever possible, the venous anastomosis should be performed without an additional venous graft, to decrease the risk of venous thrombosis. For this procedure, the colon is not mobilized. The small intestine is retracted to the left, and the superior mesenteric vein is located caudal to the transverse mesocolon. An incision is made about 20 mm lateral of the vein to allow better control of this vein while positioning the pancreas graft.
- The venous anastomosis is performed with the same technique described above. For the arterial anastomosis, the common iliac artery is palpated medial to the ileocolic artery through the mesocolon, and the mesentery is opened for 4 to 5 cm to expose the common iliac artery. The anastomosis is performed through the mesentery using the same technique as above.
- This approach speeds the procedure and avoids complete mobilization of the right colon. The retroperitoneum is not opened, decreasing the risk of postoperative hemorrhage. Whether benefit is achieved through a portomesenteric versus systemic venous drainage is still debated (Fig. 96.5).

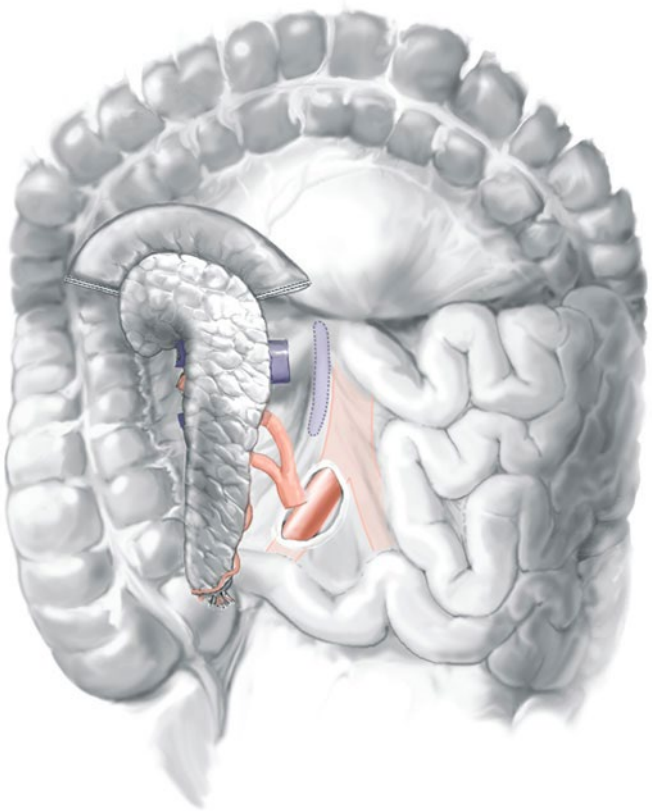


Fig. 96.5

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Step 6

Duodenojejunostomy (Fig. 96.6)

- Exocrine drainage of the pancreas graft remains a major unsolved problem. The jejunum 40 to 50 cm distal to the ligament of Treitz is selected for a side-to-side duodenojejunostomy. With portomesenteric venous drainage, the entire graft is intraperitoneal. The anastomosis should be about 30 to 50 mm in length.
- The anastomosis is performed in two layers, with the inner layer as a running 4-0 absorbable suture, including all layers of the gut wall. The outer layer is performed with interrupted 0 silk seromuscular sutures. Once the running suture is achieved, the second layer of interrupted stitches of silk is performed. As an alternative, the second layer may be a running suture.

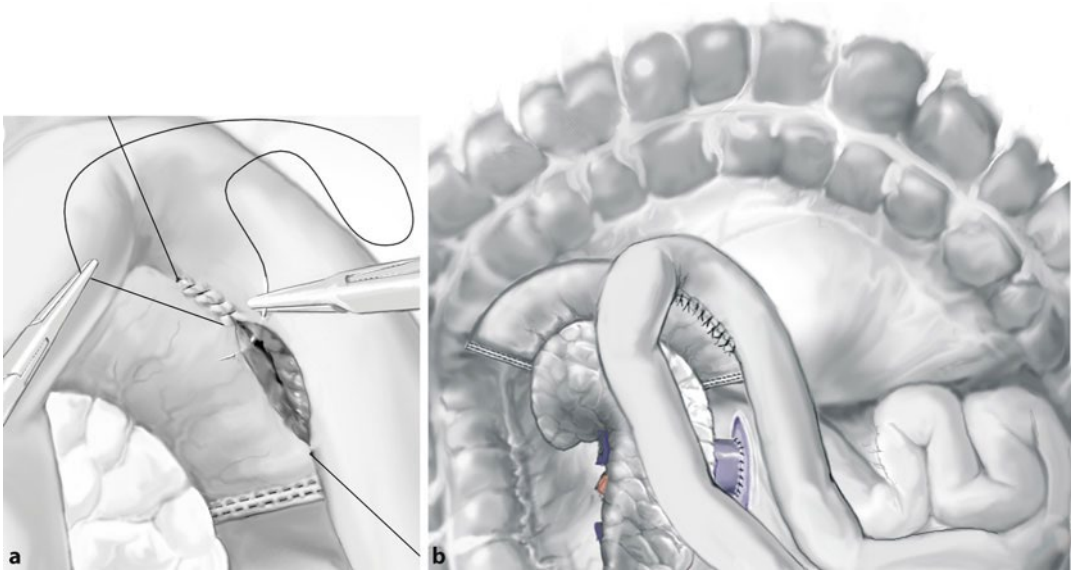


Fig. 96.6

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Step 7

Drainage and duodenal fixation

- An 18-Fr. closed suction drain is placed alongside the pancreas graft. The cecum is usually pexed or reperitonealized with either running or interrupted polypropylene sutures to avoid later cecal volvulus. Such lateral refixation is not necessary for portomesenteric venous drainage.
- If simultaneous kidney transplantation is to be done, the same intra-abdominal access can be used to expose the iliac vessels transperitoneally; a separate, contralateral retroperitoneal approach is an alternative (Fig. 96.7).

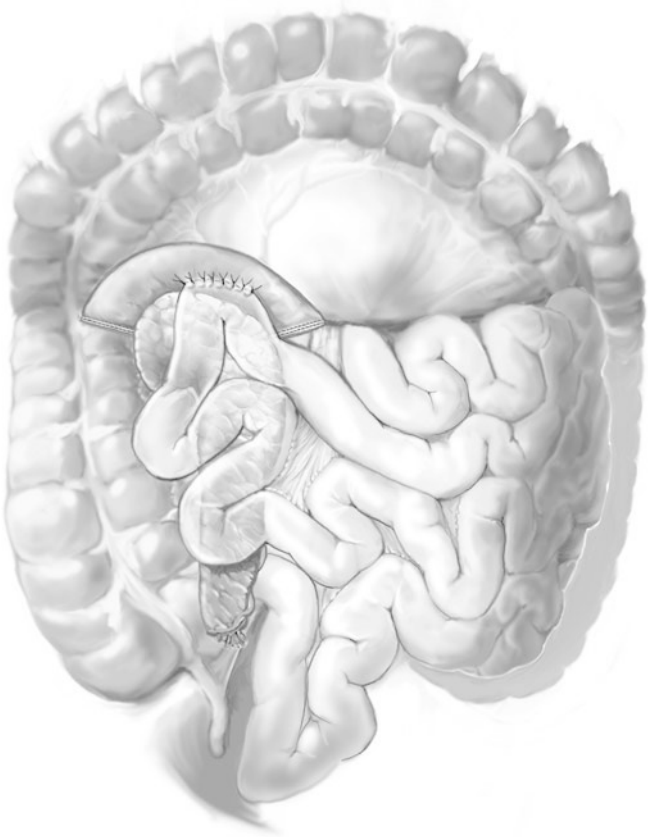


Fig. 96.7

Postoperative Tests

- Close postoperative management in an intensive-care or intermediate-care unit
- Daily hemoglobin and kidney function tests
- Blood sugar determination every 4 h

Local Postoperative Complications

- **Short-term:**
- Postoperative bleeding
- Duodenal anastomotic leak
- Ascites (rule out pancreatic ascites/anastomotic leak)
- Portal vein graft thrombosis
- Hypoglycemia
- Acute rejection
- Mild pancreatitis

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- **Long-term:**
  - Chronic pancreas rejection
  - Adhesive small bowel obstruction

Tricks of the Senior Surgeon

- Whenever possible, avoid the use of a venous graft on the donor portal vein.
- Meticulous hemostasis at the end of the procedure is imperative to prevent delayed hemorrhage up to 2 hours after reperfusion.
- The exocrine drainage must be tension-free, and the drainage catheter must be kept away from the anastomosis to avoid catheter erosion.

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Chronic Pancreatitis

*L. William Traverso, Joshua G. Barton, Nicholas J. Zyromski, Kathrin Mayer, Hans G. Beger, Bettina M. Rau, Wolfgang Schlosser**

As our knowledge of the pathogenesis of pancreatitis-associated pain has matured and as experience with formal operative pancreatectomies has grown, the emphasis on operative treatment of patients with symptomatic chronic pancreatitis has switched from distal-based resections (60 % → 80 % → 95 % pancreatectomies) to proximal-based resections (pancreatoduodenectomy) and more recently, to nonanatomic, duodenum-preserving subtotal resections. No one specific operation fits all patients with this heterogeneous disease, so the surgeon operating on patients with chronic pancreatitis should be well versed in several operative techniques. Proper patient selection is paramount to achieving optimal outcomes. The following two sections address proximal and distal resections.

Proximal Pancreatectomy

L. William Traverso, Joshua G. Barton

The goals of a pylorus-preserving Whipple procedure for chronic pancreatitis are twofold. The first goal is to remove the head of the pancreas (what Longmire referred to as the "pacemaker of pancreatitis"), which serves as the source of chronic pain. Relief of pain will occur in almost every properly selected patient, and 75 % of these patients will remain pain-free. In the remaining patients, the pain relief achieved yields substantial improvement that allows the patient to reenter daily life patterns. It is uncommon that distal pancreatectomy should be performed for true chronic changes. As above, it is the author's contention that chronic pancreatitis is almost always driven by pathology within the proximal portion of the pancreas.

The other goal is to minimize gastrointestinal dysfunction. The senior author has observed patients for over two decades to determine that these goals have been achieved using the techniques described in this chapter.

The anatomic approach is to preserve a functioning pylorus, the entire stomach, and the first 3 to 5 cm of the duodenum. Therefore, the neurovascular supply to the pylorus is protected and preserved by wide dissection; maintaining intact vagal innervation to the distal stomach appears to be mandatory for a functioning pylorus.

Indications and contraindications

Indications (must have all of these)

- Disabling abdominal pain
- Chronic pancreatitis: residual pancreatic damage, anatomic or functional, that persists even if the primary cause or other factors are eliminated
- Chronic pancreatitis of "severe" grade on the Cambridge Classification of Image Severity; i. e., main pancreatic duct stricture in head of gland (with or without stones, biliary stricture, or duodenal stenosis) or intrapancreatic head pseudocyst (with or without pseudoaneurysm)
- Etiology (gallstones or alcohol) has been remedied
- Endotherapy failed, with or without extracorporeal lithotripsy

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery*,
DOI 10.1007/978-3-662-46546-2_97, © Springer-Verlag Berlin Heidelberg 2016

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Contraindications for pylorus preservation

- Previous vagotomy and nonfunctional pylorus
- Pancreatic cancer discovered intraoperatively in the area of the anterior superior head of the gland, such that preservation of the pylorus would not achieve a negative oncologic margin
- History of severe peptic ulcer disease
- Occluded portal vein or superior mesenteric vein (SMV) (look for large collaterals in the hepatoduodenal ligament on CT)

Relative contraindications for resection of the pancreatic head in chronic pancreatitis

- Active inflammation; always wait for the acute inflammation to subside
- Unaddressed peripancreatic fluid collection
- Multidrug and/or recreational drug addiction

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Preoperative investigations and preparation for the procedure

- The goal of imaging studies is to picture the anatomy (i. e., a "composite pancreas" from images of pancreas-protocol CT, endoscopic retrograde cholangiopancreatography [ERCP], and, if necessary, intraoperative pancreatography); if jaundiced, biliary decompression is usually indicated until bilirubin is almost normal.
- Allow acute inflammation or infection to subside, with minimally invasive drainage as necessary.
- If CT shows an intrapancreatic pseudocyst in the head of the gland, arteriography is often indicated to investigate the presence of a pseudoaneurysm. If present, then preoperative embolization is needed.
- Preoperative mechanical bowel preparation is used, as are intravenous perioperative antibiotics.

Procedure: Pancreatoduodenectomy

Step 1

Incision and mobilization of duodenum, pylorus, antrum (◘ Figs. 97.1 and 97.2)

- An upper midline incision from the xiphoid to just below the umbilicus gives optimal exposure.
- A mechanical retractor elevates and retracts the costal margins (Fowler retractor, Pilling Surgical, Horsham, PA) and an articulating Martin Arm retractor (Elmed, Addison, IL) retracts the liver off the hepatoduodenal ligament.
- Division of the round ligament with excision of the abdominal portion optimizes exposure.
- The duodenum is mobilized with a wide Kocher maneuver around to the superior mesenteric artery.
- Next, the lesser sac is opened by dissecting the omentum rostrally off the transverse colon, leaving it attached to the stomach.
- Wide dissection frees the cephalad superior surface of the duodenal bulb and pylorus from the hepatoduodenal ligament and the dorsal inferior surface from the head of the pancreas, right gastroepiploic artery, and the nest of veins entering the right gastroepiploic vein on the surface of the SMV. The neurovascular supply to the pylorus rostral and caudal to the duodenal bulb is carefully protected and preserved.
- The following blood vessels are divided at their origins away from the pylorus: right gastric artery (if present, usually not one major vessel), superior duodenal vessels of Wilkie, and the gastroepiploic artery and vein at the inferior border of the pancreas.
- Dissection of the duodenal bulb is continued for 3 to 5 cm to the junction of the first portion of the duodenum and the area where the duodenum and pancreas merge, to form an "angle"; distal to the angle, tiny shared blood vessels are encountered between the pancreas and duodenum.
- The duodenum is divided with a stapling device at this angle; the stomach and stapled first part of the duodenum are now mobile and are retracted toward the left upper quadrant.

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Step 1 *(continued)*

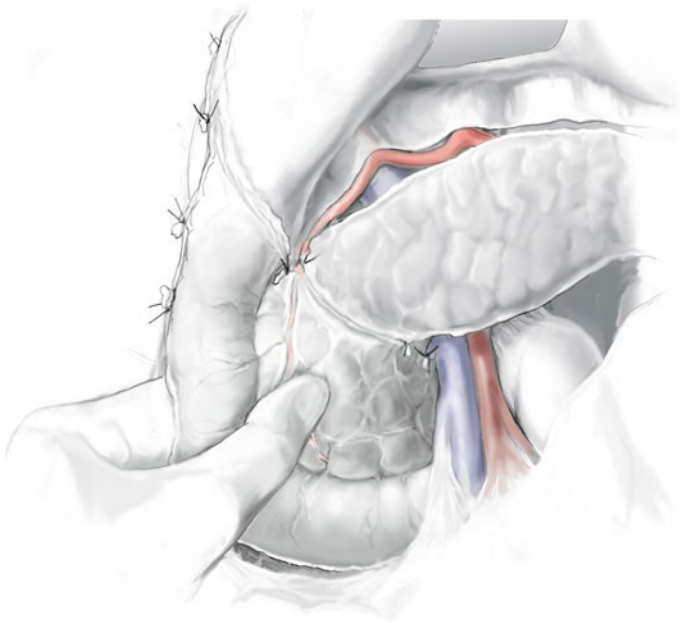


Fig. 97.1

- After placing stay-sutures along the superior and inferior edges of the neck of the pancreas, a plane is developed carefully behind the neck of the pancreas but anterior to the superior mesenteric portal venous confluence. The neck of the pancreas is then divided carefully. In a vast majority of patients with severe chronic inflammation, this maneuver may be very difficult.

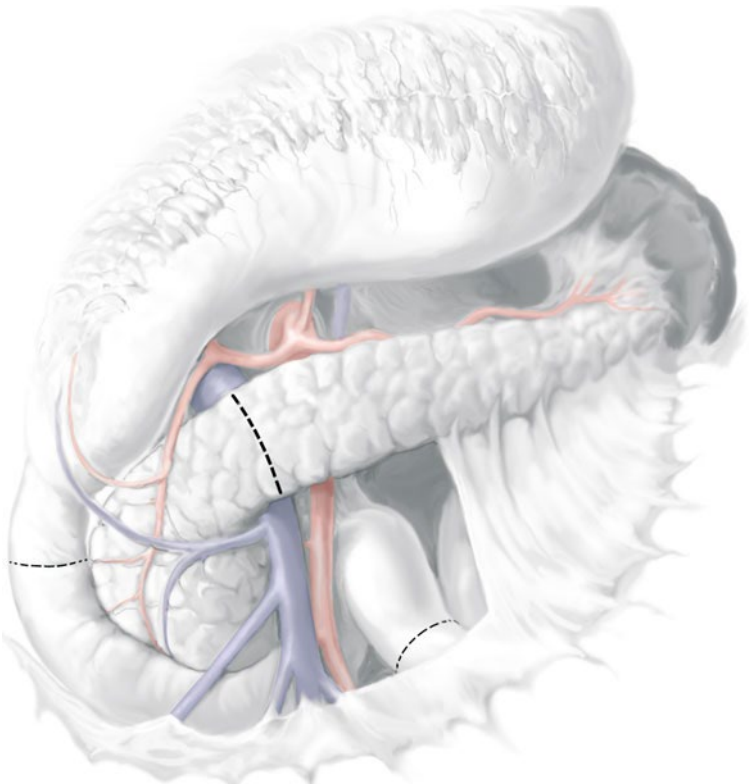


Fig. 97.2

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Step 2

Excision of pancreatic head, remaining duodenum, and distal common bile duct

- This resection is no different from resection for cancer except that nodal tissue along the right side of the superior mesenteric artery is not necessarily removed with the specimen. To decrease blood loss, the surgeon on the left side of the patient compresses the pancreatic head and uncinate process between the fingers of the left hand to control vessels in lymphatic attachments to the superior mesenteric artery behind the portal vein.
- Electrocautery is avoided when dividing the main pancreatic duct over the portal vein; cautery, harmonic scalpel, or another energy-based sealing-ligating device is useful in dividing the parenchyma (Fig. 97.3).

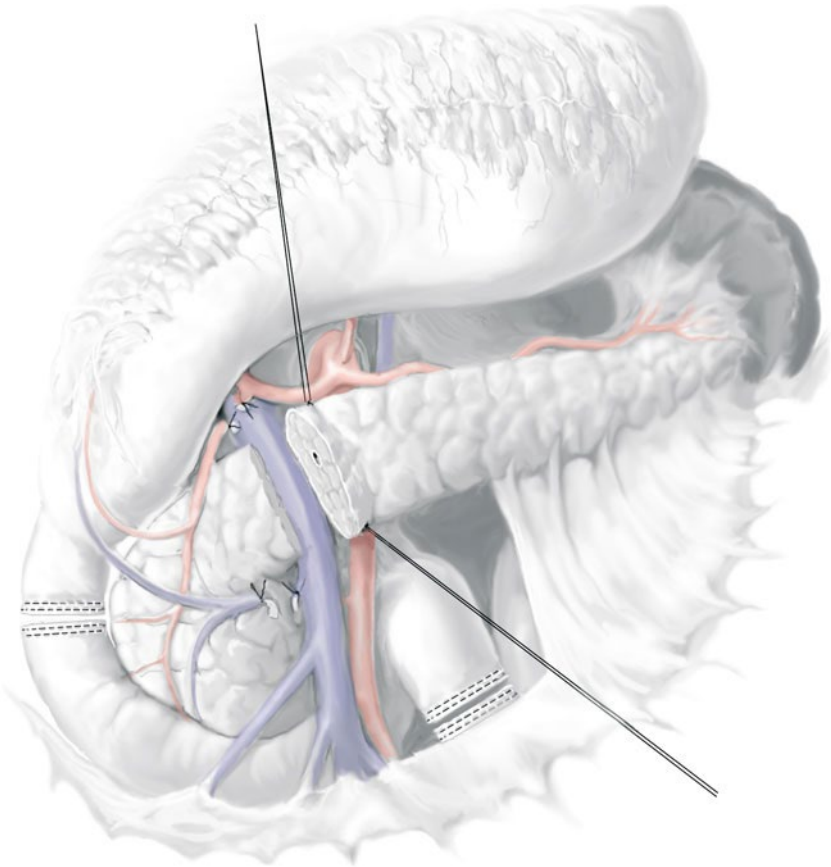


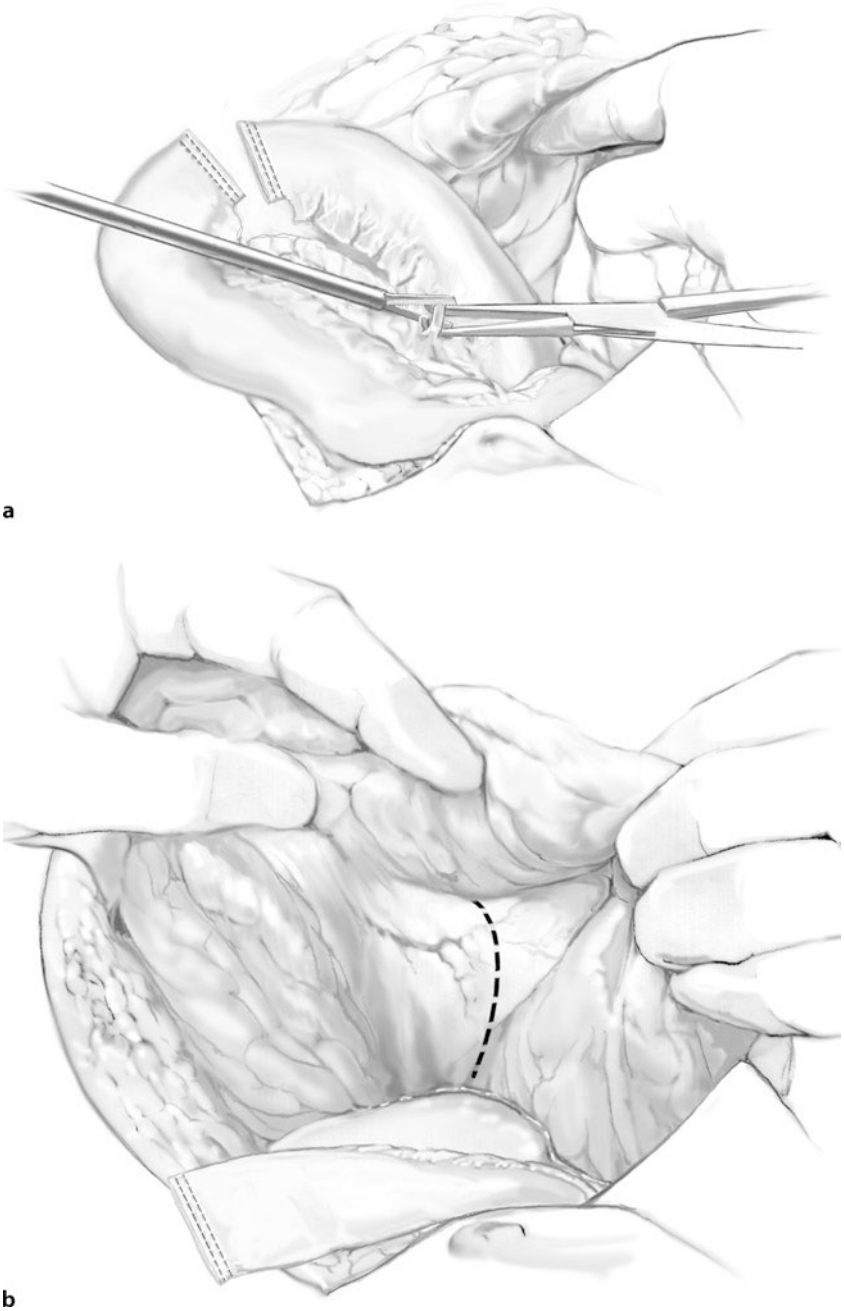
Fig. 97.3

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Step 3

Preparation of neoduodenum (■ Fig. 97.4)

- Using an energy-based sealing-ligating device, the mesenteric vascular attachments to the proximal jejunum are divided; the jejunum is divided with a stapler 6 to 8 cm distal to the ligament of Treitz.
- The avascular portion of the transverse mesocolon is opened just to the left of the middle colic vein.
- The defect in the ligament of Treitz is closed to avoid internal hernia.
- An intraoperative fluoroscopic pancreatogram of the pancreatic remnant is obtained if this area of the duct was not visualized by preoperative ERCP. If pancreatography shows chain-of-lake strictures, a partial longitudinal incision to the body and tail of the gland with lateral pancreaticojejunostomy may be indicated.



■ Fig. 97.4

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Step 4

Reconstruction: pancreatic anastomosis

- Pancreatic and biliary anastomoses are routed retrocolic via the defect created in the transverse mesocolon described in step 3; the duodenojejunostomy is antecolic; anastomoses are positioned to isolate potential leakage of bile, and pancreatic anastomoses, i. e., positioned away from the duodenojejunostomy to minimize delayed gastric emptying (8 % in the senior author's last 215 resections).
- The stump of the proximal jejunum is delivered into the supracolic space through the retrocolic defect in the mesocolon for pancreatic and biliary connections; the stomach with the preserved pylorus and duodenal bulb is brought antecolic over the left transverse colon, allowing for an anatomically remote duodenojejunostomy.
- Patients with a normal 2-mm to 3-mm duct in the pancreatic remnant are more prone to anastomotic leak at the pancreaticojejunostomy (Fig. 97.5).

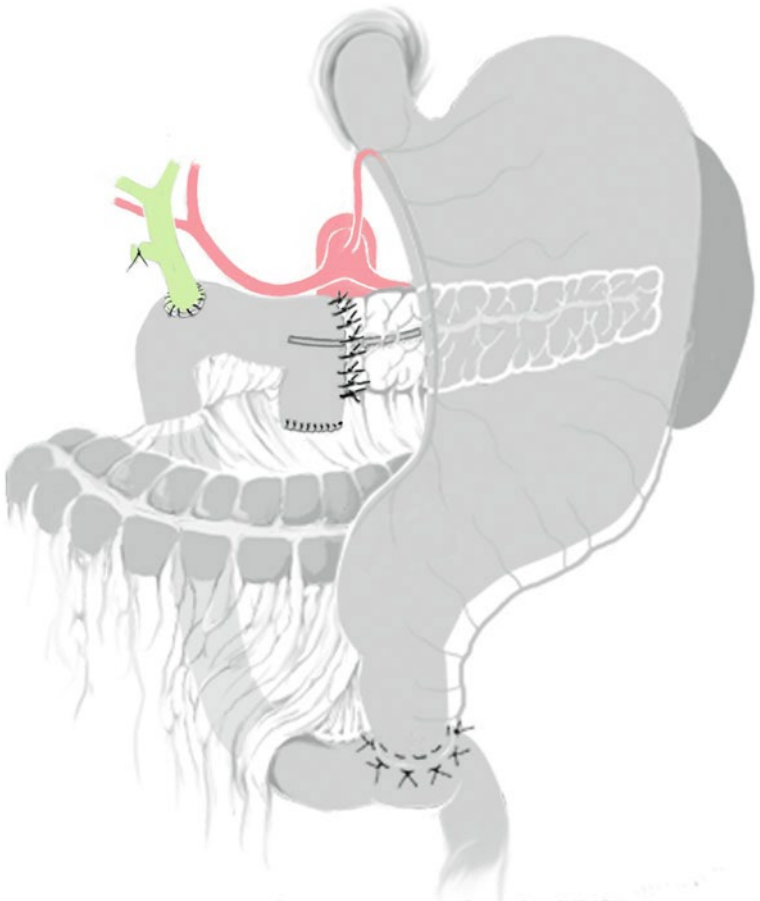


Fig. 97.5

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Step 5

Pancreaticojejunostomy

- The technique of the pancreaticojejunostomy involves a seromuscular envelope containing a stented, end-to-side, duct-to-mucosa anastomosis created using optical magnification.
- First, the back wall of the outer 3/0 silk sutures is placed and tied with the knots placed anteriorly. A small enterotomy is made in the jejunal mucosa opposite the pancreatic duct (Fig. 97.6a,b).
- The mucosa-to-mucosa anastomosis is created with interrupted 6-0 polyglycolic suture with the knots tied on the outside of the new lumen (the inner layer). Exact placement of the mucosal suture is key and is performed using 12.5 power through a surgical microscope (Fig. 97.6c). A 4-cm-long, 3-Fr. polytetrafluoroethylene, radiodense stent with multiple holes throughout it (Zimmon stent, Wilson-Cook Medical, Winston-Salem, NC) is inserted into the duct just before placing the last (anterior) mucosa-to-mucosa stitch. Using 6-0 polyglycolic acid suture, the stent is attached loosely in its mid portion to the jejunal mucosa near the last anterior stitch. This stent, which insures apposition of mucosa and decompresses the pancreatic duct upstream from the mucosal sutures, passes spontaneously in about 2 weeks and can be checked for position with an abdominal X-ray. An anterior outer layer of 3-0 silk completes the anastomosis (Fig. 97.6d). The Zimmon stent is prevented from migrating into the biliary tree downstream during spontaneous passage, as its distal tip (the end residing in the jejunum) has a pigtail.
- If chain-of-lakes ductal dilation is present in the remnant pancreas, then a longitudinal side-to-side technique is used (Fig. 97.6e).

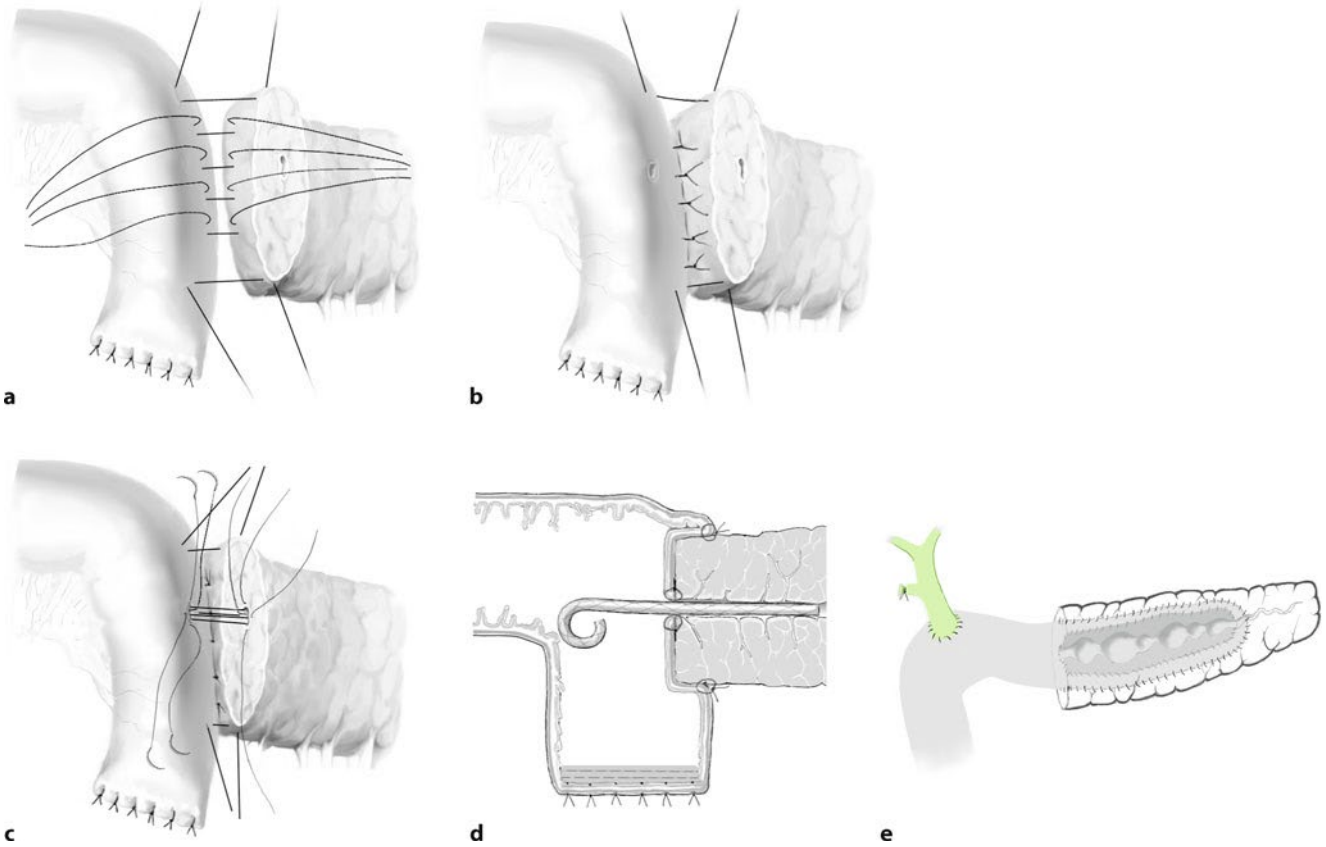


Fig. 97.6

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Step 6

Biliary anastomosis

- A single-layer anastomosis (end-choledochus to side jejunum) is performed with interrupted 5-0 polydioxone with knots tied on the outside (to prevent stone formation on knots of delayed absorbable suture); no tube choledochostomy is needed (Fig. 97.7).
- To prevent intussusception of the jejunal limb back through the mesocolon window, it is essential to tack the jejunum to the transverse mesocolon exit site, using 3/0 silk sutures to also close the mesenteric defect (Fig. 97.7).

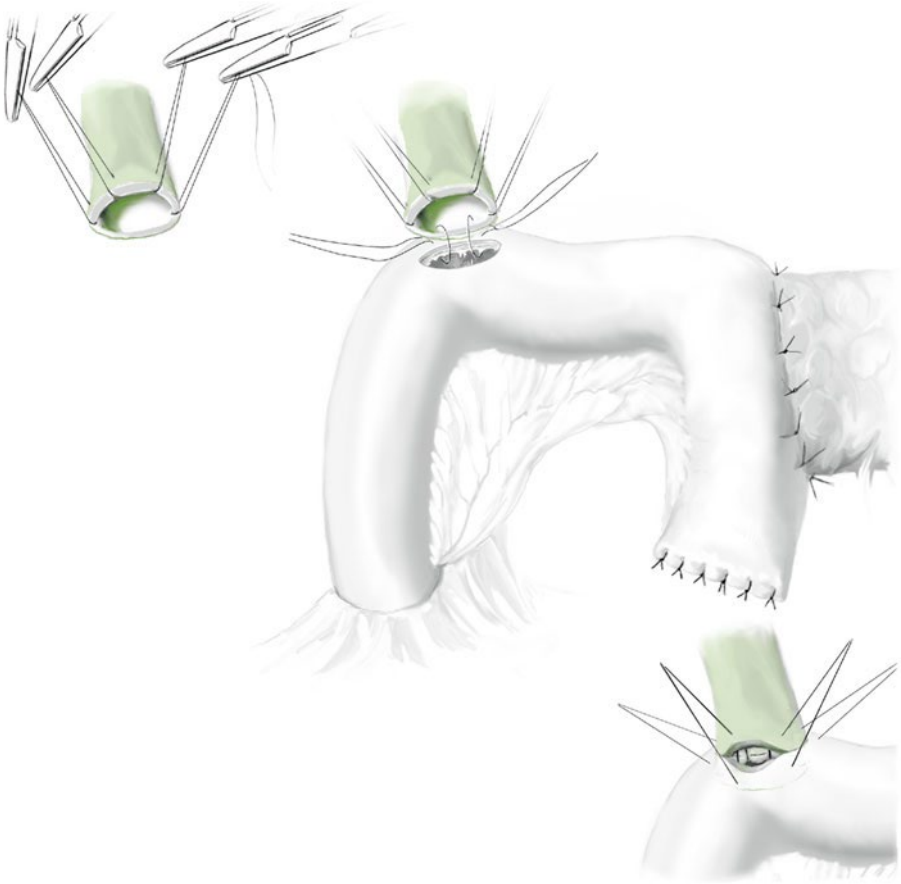


Fig. 97.7

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Step 7

Antecolic duodenojejunostomy

- The intact stomach, the first part of the duodenum, and omentum are brought over the left transverse colon. The jejunal limb (after it exits the transverse mesocolon downstream from the biliary and pancreatic anastomoses) is brought up to the end of the stapled duodenum, and an anastomosis (end duodenum to side jejunum) is performed in two layers 10 cm distal to the exit site of the jejunum from the transverse mesocolon. An inner layer of running 3-0 polyglycolic acid sutures and an outer layer of interrupted 3-0 silk are put in place (Fig. 97.8).
- A 15-Fr. drainage catheter is placed under the biliary and pancreatic anastomoses from the right upper quadrant.
- The midline fascia is closed with an interrupted figure-of-eight 0 polyglyconate suture.

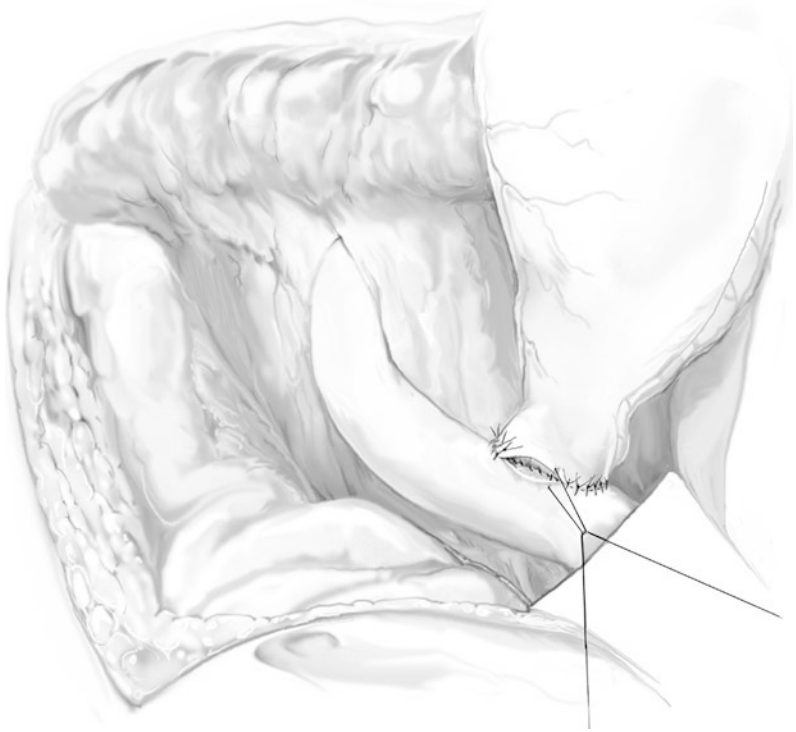


Fig. 97.8

Postoperative care

- The nasogastric tube is removed 1 to 3 days postoperatively.
- Drains are removed when drainage volume is less than 30 to 50 mL per day and when amylase values are less than three times the normal value of serum amylase.
- Oral intake is allowed when tolerated, on or after the fourth postoperative day.

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Local postoperative complications

- **Early:**
  - Intra-abdominal hemorrhage: explore or angiographically examine specifically ligatures of named arteries for pseudoaneurysms and pancreatic remnant
  - Gastrointestinal hemorrhage: Be cautious, as early hemorrhage is a hallmark for pseudoaneurysm bleeding as the blood travels to the place of least resistance, usually the biliary anastomosis apposed to the stump of gastroduodenal artery. Less commonly, the bleeding could be from the pancreaticojejunostomy or duodenojejunostomy
  - Delayed gastric emptying
  - Anastomotic leak, most likely at the pancreaticojejunostomy but possible at the choledochojejunostomy or duodenojejunostomy
  - Intra-abdominal abscess, usually related to transient or persistent anastomotic leak or a nonfunctioning drain
  - Wound infection
  - Intestinal obstruction (exclude internal hernia)

- **Late:**
  - Recurrent epigastric pain
  - Extrahepatic jaundice secondary to stricture at the choledochojejunostomy
  - Pancreatic insufficiency from either progression of disease (chronic pancreatitis) or stricture at pancreaticojejunostomy
  - Adhesive intestinal obstruction
  - Stomal or duodenal ulcer at or near duodenojejunostomy
  - Pancreatic adenocarcinoma (risk estimated to be up to 1 % per year)

Tricks of the Senior Surgeon

- The key to pain relief for chronic pancreatitis is pancreatic resection performed when the strict anatomic selection criteria described in this section are met (i. e., the presence of a demonstrable stricture of the pancreatic duct within the head of the pancreas or meeting the "marked" or most severe grade of the Cambridge Classification).
- Excess blood loss increases morbidity. All named vessels should be triply ligated with nonabsorbable suture. The ultrasonic scissors are used to divide small veins, particularly those around the right gastroepiploic and supraduodenal vessels. This technique is also handy when separating the mesenteric vascular attachments to the proximal jejunum removed with the specimen in the area of the ligament of Treitz.
- The left hand of the surgeon standing on the left side of the patient can minimize blood loss during division of the attachments of the vascular lymphatics from the dorsal head of the pancreas to the area around the superior mesenteric artery. Pedicles of tissue are divided as the dissection proceeds along the superior mesenteric artery. Only one clamp is used for each pedicle on the patient side of the divided pedicle; the specimen side is not clamped and is compressed by the left hand.
- Preserve all of the greater omentum, as this "watchdog" of the abdomen decreases postoperative infection.
- Use intraoperative fluoroscopic pancreatography to ensure that the pancreatic remnant is adequately drained. A cholangiocatheter with a balloon tip is useful.
- When a small pancreatic duct is used for the pancreaticojejunostomy, the anastomosis is best done with magnification to avoid crossing the sutures. The duct-to-mucosa anastomoses can be done in a more exact fashion by seeing the needle pass in and out of a small pancreatic duct. We have found the surgical microscope at 12.5 power to be useful in minimizing pancreaticojejunostomy leak.
- The choledochojejunostomy should have all of the knots tied on the outside, and only absorbable suture should be used on biliary anastomoses to prevent stone and debris formation. We use a single closed suction drain made of silicone rubber.
- An antecolic duodenojejunostomy markedly reduces delayed gastric emptying, compared with the retrocolic method.

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Nonanatomic Resections: The Beger and Frey Procedures

*Nicholas J. Zyromski, Kathrin Mayer, Hans G. Beger, Bettina Rau, Wolfgang Schlosser**

Local (nonanatomic) resections of the head of the pancreas with longitudinal pancreaticojejunostomy (LR-LPY or Frey procedure) and the duodenum-preserving (anatomic) subtotal head resection (Beger procedure) share similar goals: the relief of pain and the management of local pancreatic complications (biliary, duodenal, or venous obstruction; provision of pancreatic ductal drainage; subtotal resection of inflammatory mass in the head of the pancreas). The rationale for this approach is that the pain of chronic pancreatitis is believed to arise from either a ductal or pancreatic parenchymal hypertensive "compartment" syndrome or from inflammatory neural "irritation" (or both). The head of the pancreas is thought to be the driver or "pacemaker" of the pain. Pancreatic subtotal resections can accomplish removal of this pain pacemaker region of the gland with less operative morbidity and also preserve gastroduodenal continuity, including the important duodenal hormonal and absorptive milieu.

Indications and contraindications

Indications

- Incapacitating abdominal pain, usually continuous; but also, in selected patients, intermittent and frequent or associated with recurrent attacks of acute pancreatitis
- Resolution of extrapancreatic and pancreatic structural complications associated with chronic pancreatitis
  - *Extrapancreatic:* common bile duct (CBD) obstruction, duodenal obstruction, selected patients with compression of portal vein, SMV, or both
  - *Pancreatic parenchymal:* scarring, multiple fibrous strictures of duct ("chain of lakes") with calcification, ductal hypertension, retention cysts, ductal stones, also for an inflammatory mass in the head of the pancreas
  - *Pancreatic ductal disruptions:* contained (pseudocyst), uncontained (ascites), or pleural or pericardial fistula
- Inadequate pain relief after ductal drainage procedure or distal pancreatectomy
- Pancreas divisum causing chronic pancreatitis

Contraindications

- Absolute contraindications:
  - Findings that raise concern of potential malignancy: absence of history of alcoholism, hyperlipidemia, hyperparathyroidism, recent history of onset of pain, (especially back pain) with biliary obstruction, and increased serum CA 19–9 level.
  - If cancer cannot be excluded, a resective operation (pancreatoduodenectomy or distal pancreatectomy) is suggested. The resected "chips" from the pancreatic head after these nonanatomic resections should be sent for intraoperative frozen section analysis to exclude malignant change.
- Relative contraindications:
  - Disease limited to the body and tail of the gland (infrequent)
  - Unrelenting narcotic addiction; patient refuses the concept of postoperative detoxification
  - Inability to manage possible postoperative diabetes mellitus because of anticipated poor compliance
  - Obstruction of SMV/portal vein junction with mild to moderate portal hypertension
  - Complete thrombosis of SMV/portal venous junction with peripancreatic varices (cavernous transformation); in this circumstance, pancreatectomy should be attempted only by the most experienced pancreatic surgeons

Other Considerations

- The "small" pancreatic duct (< 3–4 mm) in the head, body, or tail of the pancreas is not a contraindication.
- Ducts in the pancreatic head (body or tail) are either resected or unroofed and thereby decompressed; a jejunal Roux limb can be sewn to the pancreatic capsule.

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Preoperative investigations and preparation for the procedure

- Exclude nonpancreatic pain.
- Maximize medical treatment, including nutrition, enzyme replacement, and cessation of alcohol intake. Patient's willingness to commit to preoperative smoking cessation is a useful barometer for their investment in their personal health.
- Assess the extent of chemical dependency (narcotics, alcohol).
- Strive for a preoperative commitment to undergo postoperative alcohol and/or drug rehabilitation.

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Preoperative investigation

- **History:**
  - Exclude alcohol or drug addiction, gallstones, pancreatitis-inducing medications, hyperparathyroidism, hypercalcemia, and hyperlipidemia
  - Evaluate hereditary chronic pancreatitis markers (*SPINK*, *CFTR*)
  - Evaluate for steatorrhea and diabetes mellitus (glucose intolerance), especially the need for insulin
  - Severity of pain (Likert visual analog pain scale completed by patient)
  - Psychosocial stability
  - Quality of life survey (optional): European Organization for Research and Treatment of Cancer QLQ-C30 (EORTC) or Medical Outcomes Trust Short-Form 36 (MOS SF-36)
  - Impact of pain on employment, family support, daily activities

- **Clinical evaluation:**
  - Jaundice, ascites, nutritional status, weight, physiologic health, comorbidities
  - Baseline pancreatic exocrine and endocrine function, if indicated

- **Laboratory tests:**
  - CA 19–9 (will be falsely increased in the setting of jaundice), LFTs, HbA1c, glucose tolerance test
  - Fecal fat and secretin studies (rarely required)

- **Imaging:**
  - Triphasic helical CT to evaluate for pancreatic masses, portal and left-sided hypertension or thrombosis of the splenic vein, involvement of adjacent organs, extrapancreatic causes of pancreatitis (cholelithiasis), MRCP is also an option for totoal imaging
  - ERCP to evaluate pancreatic and biliary ductal systems and esophagogastroduodenoscopy to exclude peptic ulcer disease
  - Endoscopic ultrasonography to biopsy suspicious mass lesions, if indicated

Preparation for the procedure

- Broad-spectrum, perioperative prophylactic antibiotics
- Full bowel preparation is not prescribed routinely

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Procedure: Local resection of the head of the pancreas with longitudinal pancreaticojejunostomy (Frey procedure)

Nicholas J. Zyromski

Step 1

Exposure and exploration; assessment and mobilization of pancreas; entering the lesser sac

- Either a bilateral subcostal incision or a midline incision from xiphoid to umbilicus provides adequate exposure.
- The ligamentum teres is preserved as a vascular pedicle to buttress ligated visceral arteries (if necessary).
- Dividing the gastrocolic ligament between the hepatic and splenic flexures exposes the lesser sac; alternatively, the omentum may be elevated from the transverse colon.
- The right gastroepiploic artery and vein are ligated and divided to expose the anterior surface of the head and neck of the pancreas.
- Cephalad retraction of the stomach and caudad retraction of the transverse colon expose the body and tail of the pancreas.
- The inferior border of the body and tail of the pancreas are mobilized to expose completely the anterior surface of the pancreas (Fig. 97.9).

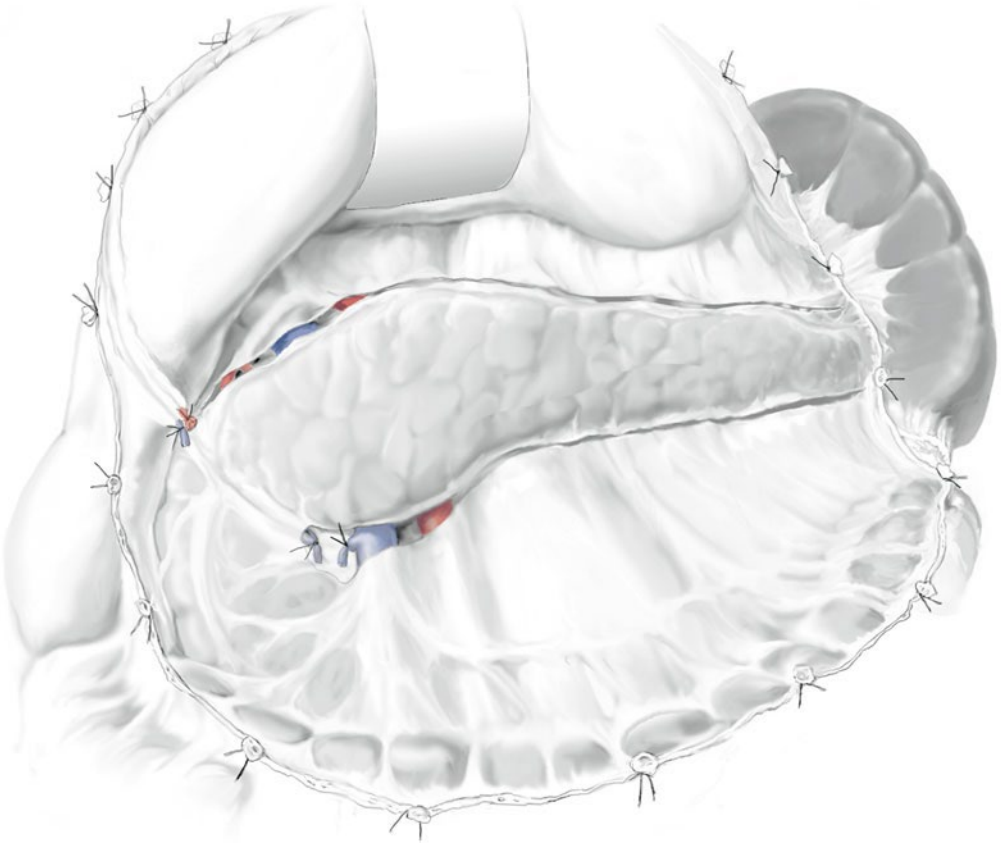


Fig. 97.9

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Step 2

Exposure of the head of pancreas

- The duodenum and head of the pancreas are mobilized by an extended Kocher maneuver; this maneuver allows manual palpation of both sides of the pancreatic head to determine the thickness and consistency. A wide Kocher maneuver also facilitates hemorrhage control should portal/SMV bleeding be encountered. (Placing the surgeon's left hand behind the pancreatic head and elevating the pancreas ventrally often slows even severe bleeding enough to allow direct suture repair.)
- The gastroduodenal artery may be encircled with a vessel loop should ligation be necessary for hemostasis (rare) during resection of the head of the gland (Fig. 97.10).

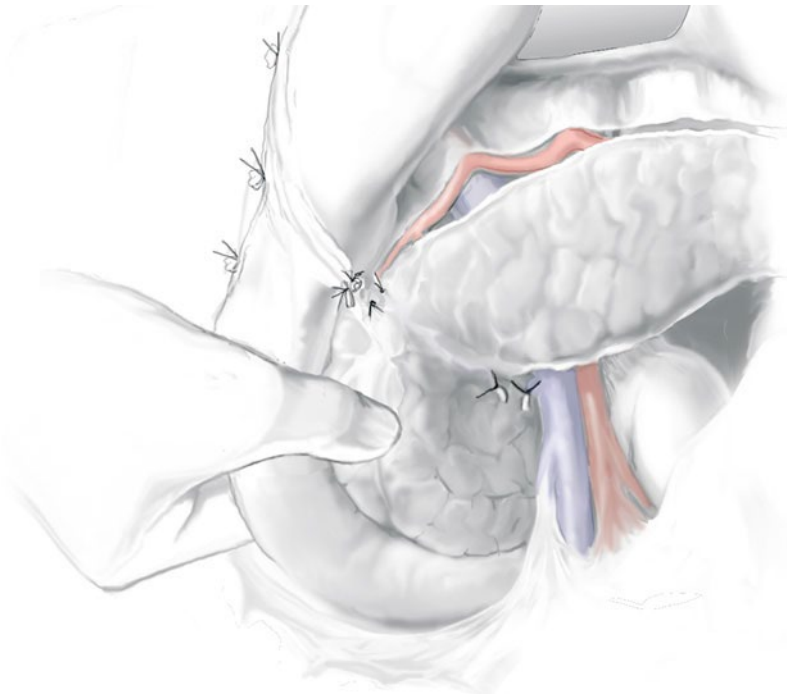


Fig. 97.10

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Step 3

Exposure of the SMV alongside the head of the pancreas

- Importantly, it is not necessary to free the portal vein beneath the neck of the pancreas.
- The SMV should be exposed caudally adjacent to the head and uncinate process of the pancreas to provide optimal exposure.
- Exposing the head and uncinate process is important not only for the coring out process, but also to provide an adequate rim of pancreatic tissue to which the Roux-en-Y jejunal limb is to be sewn.
- Free up the small veins and arteries from the head side of the SMV (arteriovenous tributaries).
- Divide the venous tributaries to the SMV from the third portion of the duodenum inferiorly; note that the inferior pancreatoduodenal artery on occasion may run anterior rather than posterior to the SMV (Fig. 97.11).

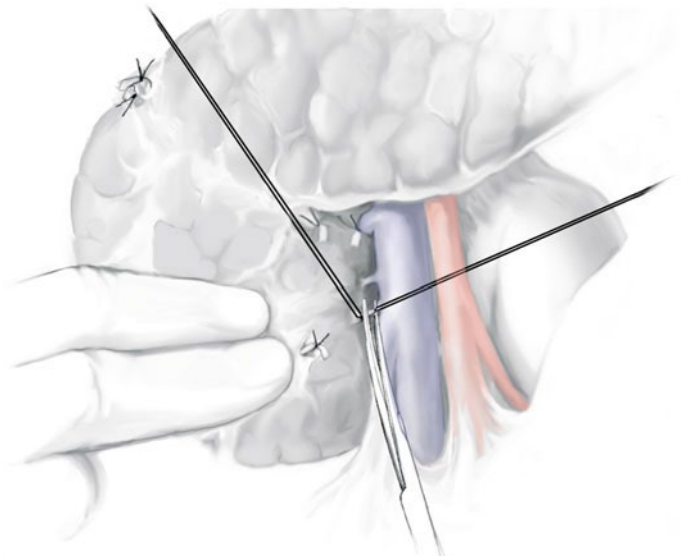


Fig. 97.11

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Step 4

Locating the main pancreatic duct (Fig. 97.12)

- To find the pancreatic duct, the main duct in the body of the pancreas is usually located eccentrically, closer to the superior border and deeper toward the posterior surface of the gland.
- Intraoperative ultrasonography can be a useful tool with which to locate the pancreatic duct, if needed.
- If the duct is large, it may bulge from the anterior aspect of the gland; if it is smaller, it is usually easily palpated or balloted as a "groove" along the long axis of the gland.
- To identify a small duct, we connect a 10-mL syringe to a 23-gauge butterfly needle, aiming obliquely and posteriorly in the suspected direction of the duct; avoid the neck of the pancreas when searching and aspirating to minimize injury to the underlying SMV; aspiration of clear fluid is an indication that the duct has been located.
- Measure duct pressure by connecting the needle to the manometer; in our experience, average pancreatic ductal pressure in patients with chronic pancreatitis is 33 cm H_2O (range: 20–47 cm H_2O), in contrast to a normal ductal pressure of 10 cm H_2O.
- Leave the needle in the duct.
- The duct of Wirsung in the neck of the pancreas is usually eccentric and slightly superior and posterior (closer to the SMV/portal vein).

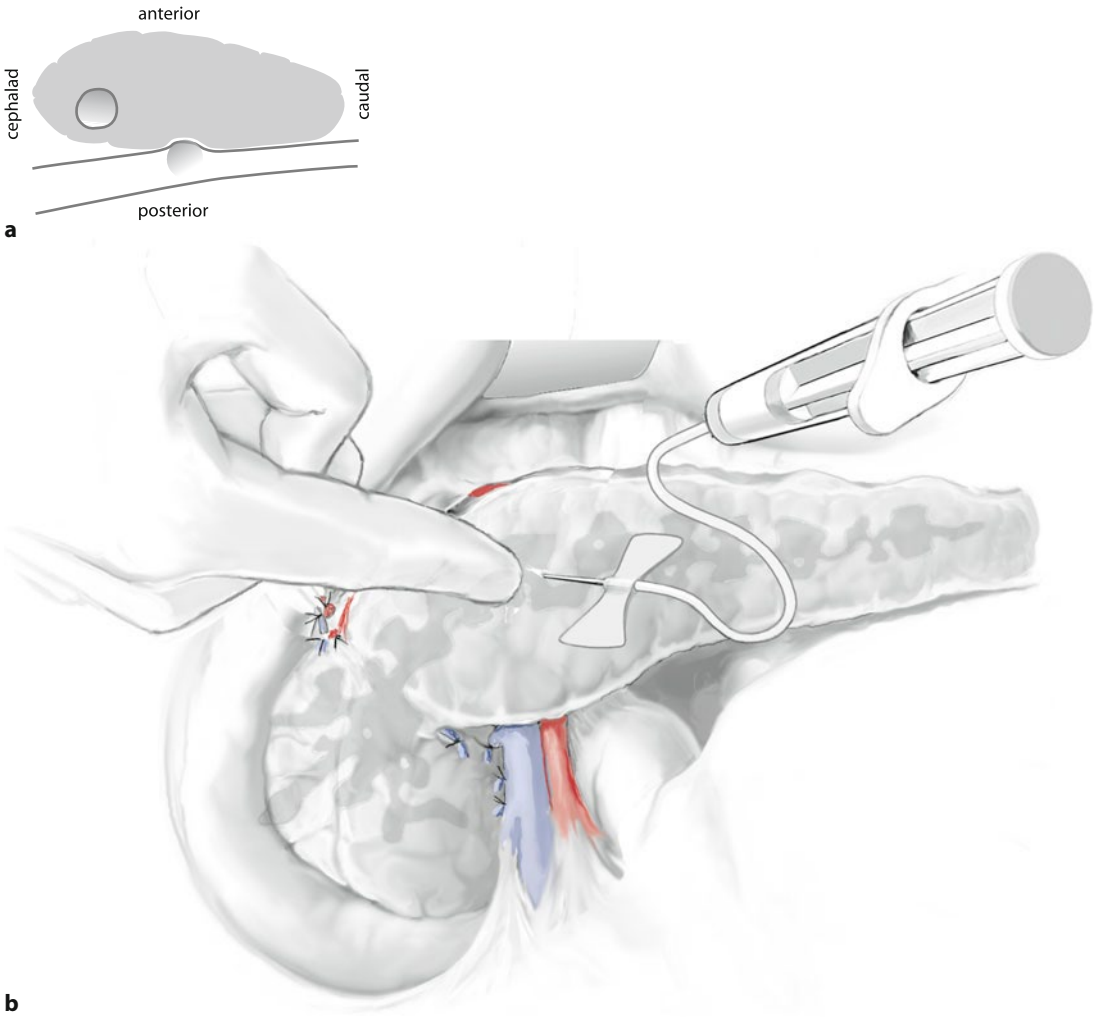


Fig. 97.12

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Step 5

Opening the pancreatic ductal system

- The anterior capsule of the pancreas is incised directly over the guide needle using electrocautery; a right-angle clamp is used to probe and define the direction of the duct.
- The anterior aspect of the duct is opened to within 1.5 cm of the tail of the gland; the duct is opened in the opposite direction toward the duodenal wall, along the duct of Wirsung, and extended to within 0.5 to 1 cm of the ampulla of Vater (Fig. 97.13a).
- The duct, after it crosses the portal vein, plunges posteriorly and then inferolaterally, coursing in the head close to the posterior capsule of the gland.
- The duct to the uncinate process from the duct of Wirsung (mid head) also runs close to the posterior capsule of the gland and is opened using a right-angle clamp to define the direction of the duct (Fig. 97.13b).
- Pancreatic calculi in side branches are searched for, and all encountered in any ductal systems are removed.
- To assess ampullary patency and the adequacy of head resection, the surgeon places a probe (a 2–3 mm Bakes dilator or the tip of the curved clamp) in the opened duct of Wirsung and pushes it against a finger indenting the duodenum.

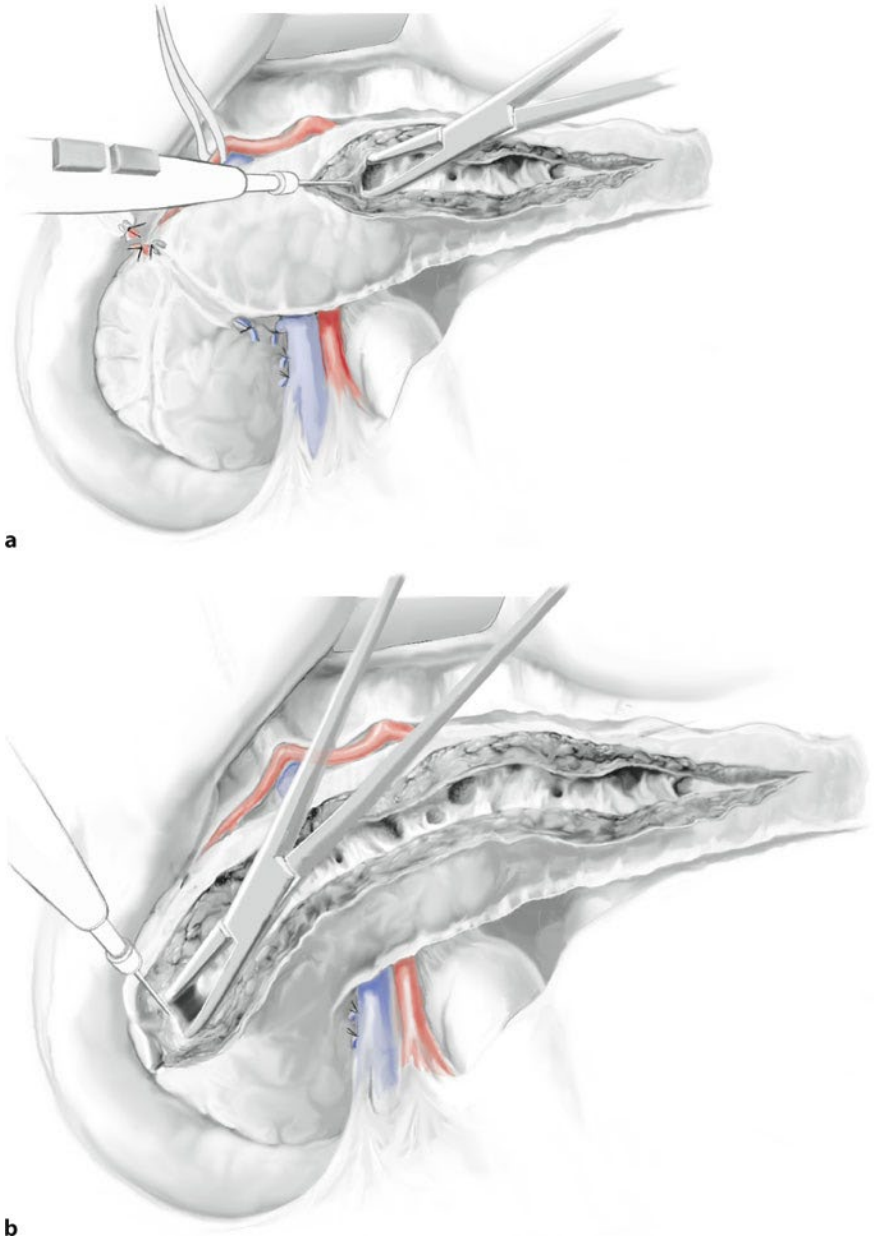
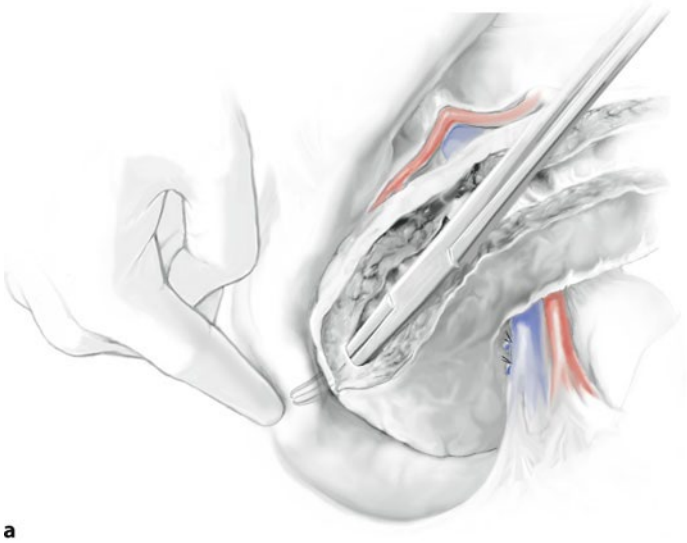


Fig. 97.13

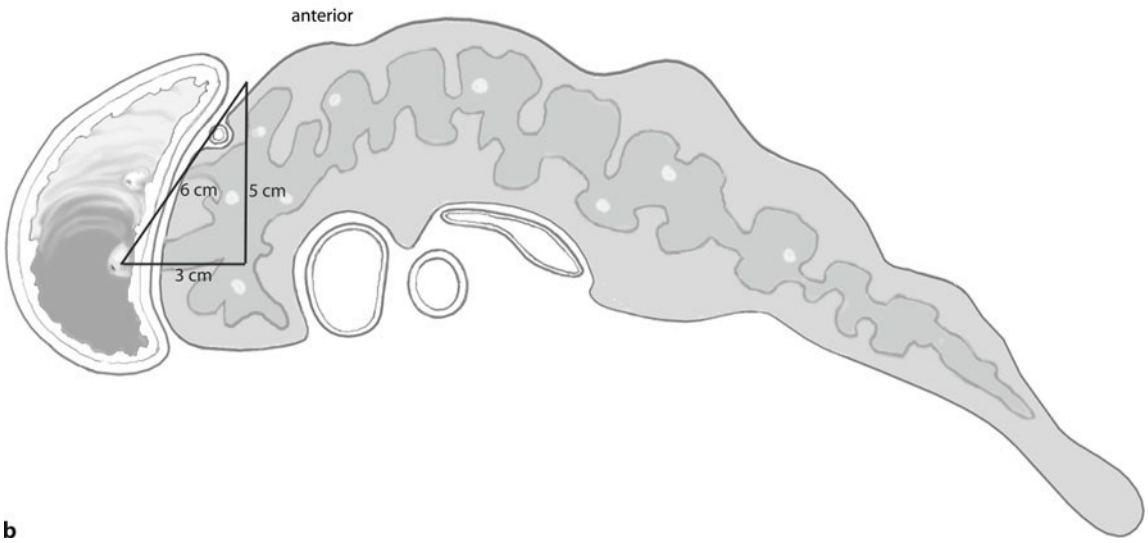
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Step 5 ***(continued)***

- The clamp should pass through the ampulla into the duodenum (Fig. 97.14a).
- The pancreatic head containing the ampullary portion of the pancreatic duct invaginates into the duodenum; looking down from above on the anterior surface of the gland, the pancreaticoduodenal junction is not a guide to locating the ampulla.
- The ampulla is 2 to 3 cm more lateral and posterior, owing to invagination of the pancreatic head into the duodenum. This consideration is important, because failure to the open main pancreatic duct down to the duodenum will leave a significant portion of the main pancreatic duct of Wirsung in the head of the pancreas undrained, along with its tributary ducts; the thicker the head of the pancreas, the longer the undrained portion of pancreatic duct. This situation occurs when the anterior surface of the pancreatoduodenal junction is used as a guide to the position of the ampulla; unexcised small retention cysts associated with tributary ducts located deep within the fibrotic head of the pancreas may be a source of persistent pain (Fig. 97.14b).



a



b

Fig. 97.14

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Step 6

Local resection of the head of the pancreas

- Working onward from the opened pancreatic duct, full-thickness slices of pancreatic tissue are excised to remove the anterior capsule of the gland and all intervening parenchyma down to the duct of Wirsung; the thickness of the remaining shell of the head of the pancreas is assessed carefully after each slice to determine the amount of tissue that needs to be removed.
- The posterior wall of the pancreatic duct of Wirsung in the head of pancreas marks the posterior extension of resection, because it is within a few millimeters of the posterior capsule of the gland.
- The duct of Santorini and its tributaries are located anteriorly in the pancreatic head; these ducts and tissue anteriorly are excised. In contrast, the duct to the uncinate process and its tributaries and the duct of Wirsung lie posterior; these systems should be unroofed but not excised, as the posterior capsule of the pancreas might be breached and the retroperitoneum exposed.
- Careful palpation of the cored-out head of the pancreas helps identify retention cysts or impacted calculi in tributary ducts, which should be removed.
- Only a rim of pancreatic tissue should be left anteriorly along the inner aspect of the duodenal curve, with a margin of 5 to 10 mm of pancreatic tissue to the right of the SMV to avoid vascular injury; care should be taken to preserve the pancreatoduodenal arcade.
- Based on the weight of excised tissue, approximately 4 to 12 g of fibrotic tissue should be removed. This is an underestimate of the total tissue removed; additional tissue is vaporized when taking multiple slices.
- Should there be concern about possible malignancy, tissue should be submitted for frozen section and histopathologic examination; if positive, pancreatoduodenectomy should be performed (Fig. 97.15).

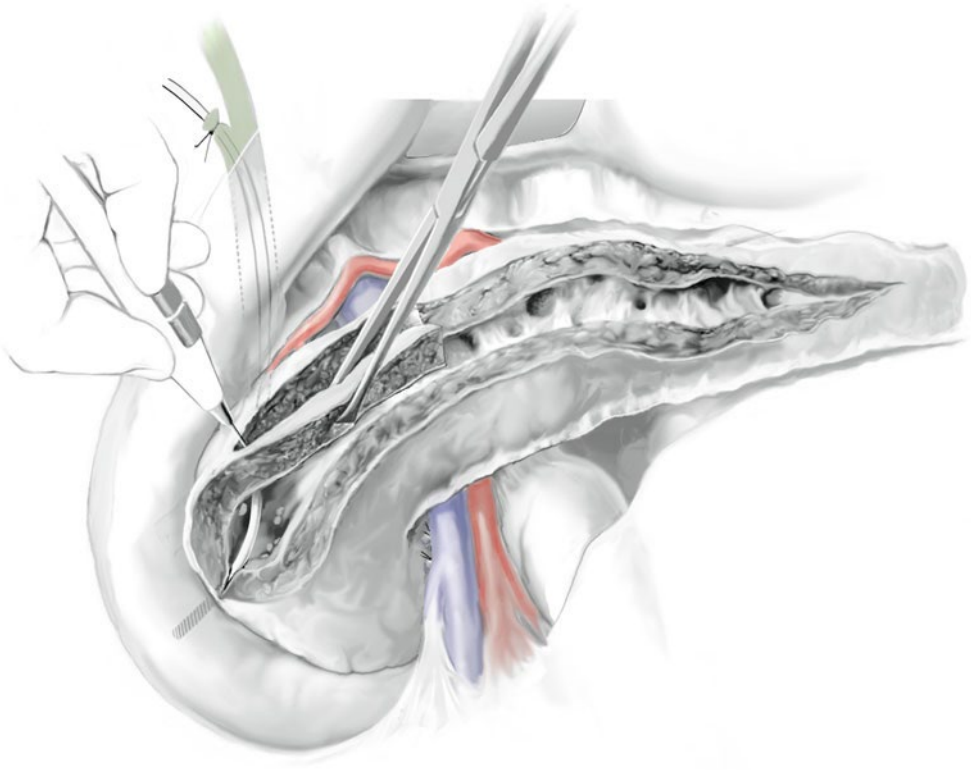


Fig. 97.15

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Step 7

Managing and avoiding injury to the common bile duct (CBD)

- About 50 % of patients with chronic pancreatitis have radiographic evidence of anatomic tortuosity, kinking, and narrowing of the CBD; with substantial stricturing, 10 % of patients undergoing head resection have preoperative findings of CBD obstruction (biochemical or clinical jaundice).
- During the coring-out process, it is important to identify and free the intrapancreatic portion of the CBD from the inflamed, fibrotic periductal tissue.
- The position of the CBD in the posterior pancreas varies; it may be posterior to the pancreas, indenting the pancreas (on palpation a "groove" may be discerned), or it may traverse the pancreatic parenchyma (the site most commonly associated with stricturing).
- In patients with anatomic obstruction, a 3-mm Bakes dilator or biliary Fogarty catheter is passed antegrade (from the cystic duct stump or an anterior choledochotomy) into the CBD to guide and protect the CBD during pancreatic resection.
- The CBD may be injured inadvertently during the coring process, or it may be severely strictured by pancreatitis. In these patients, some surgeons suggest performing choledochoplasty into the excavated pancreatic head. Our preference for durable biliary drainage is to perform either choledochojejunostomy into the Roux limb or choledochoduodenostomy.
- An alternative method for coring out the head of the pancreas is excavation of the head with total resection of the main and secondary ducts. The ductal system is followed to the level of the ampulla or to where the pancreatic duct meets the intrapancreatic CBD; the pancreatic duct is divided, and the proximal duct margin is sewn closed with a 4-0 nylon suture. Use of the Cavitron R Ultrasonic Aspirator (CUSA) System 200 (Valleylab, Norwalk, CT) facilitates conical removal of parenchyma in conjunction with electrocautery; the high-energy hand-piece at a setting of 70 % to 80 % power permits clear visualization of tissue, ducts, and vessels in the head of the pancreas. The proximal pancreatic duct is removed in total by transecting the dorsal duct at the pancreatic neck (Fig. 97.16).

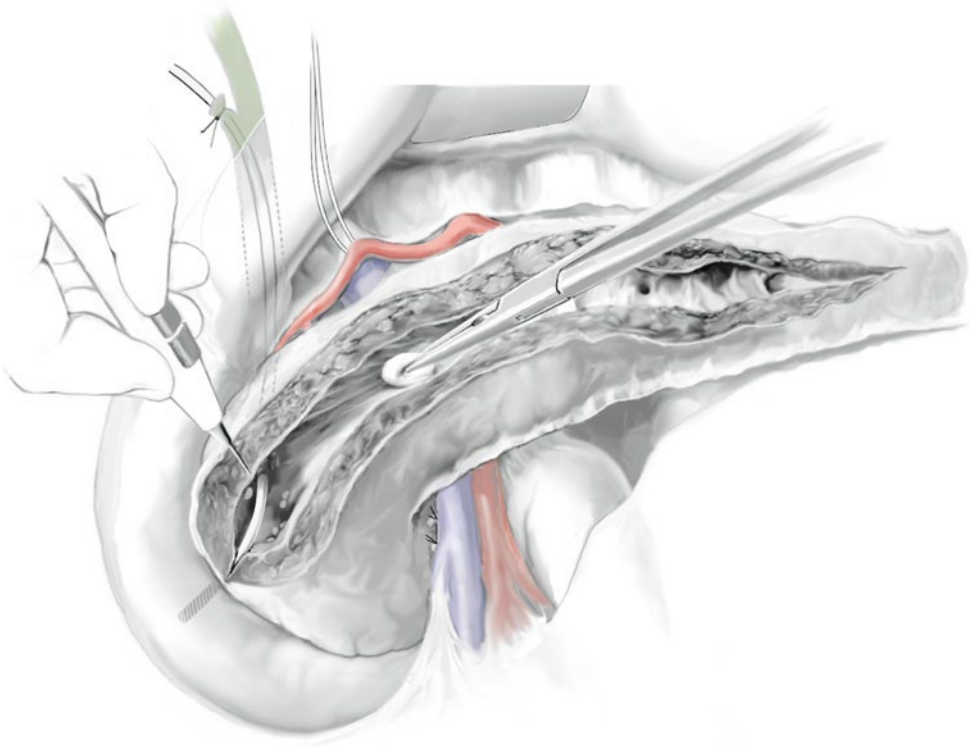


Fig. 97.16

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Step 8

Thumb-index measurement for depth

- The duct of Wirsung guides the proper depth of excavation/resection. Ducts of Wirsung and the uncinate process are adjacent to the posterior capsule and are opened (decompressed); the duct of Santorini is excised.
- A limited cuff of pancreatic tissue may be left between the cored-out head of the pancreas and the duodenum. Sufficient pancreatic tissue usually remains to preserve the important pancreatoduodenal arcade, which maintains the viability of the mid duodenum (Fig. 97.17).

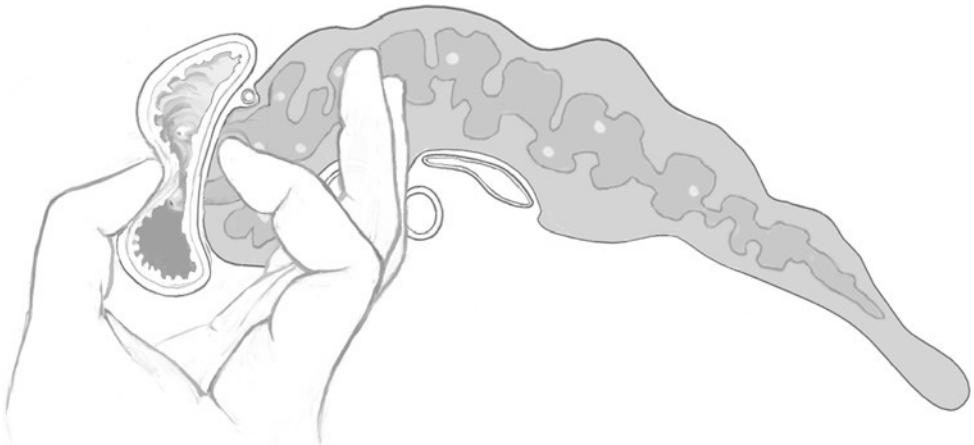


Fig. 97.17

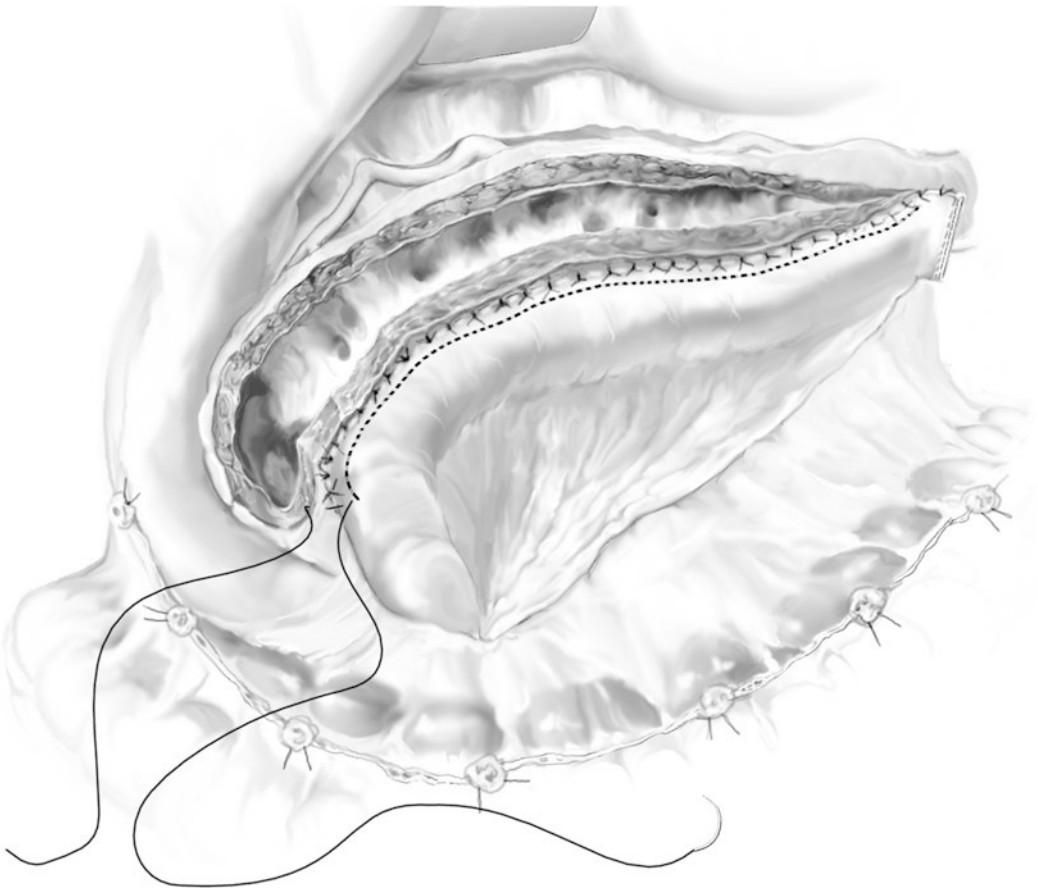
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Step 9

Reconstruction with Roux-en-Y drainage of the head of the pancreas with pancreaticojejunostomy (the outer layer of the anastomosis)

- The Roux limb is brought through the transverse mesocolon to lie over the entire pancreas. Bringing the limb to the patient's left of the middle colic vessels facilitates pancreatic head dissection should reoperation be required in the future. The end of the Roux limb can also be positioned at the head of the pancreas rather than at the tail of the gland as shown in ◘ Fig. 97.19.
- A two-layer pancreaticojejunostomy is performed with an outer layer of interrupted, Lembert 3-0 silk sutures, approximating the jejunal serosa to the capsule of the pancreas; the wall of the duodenum may be included with the pancreas in this layer. Inflammation and edema may render the distinction between the duodenum and the pancreas less well-defined (◘ Fig. 97.18).



◘ Fig. 97.18

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Step 10

Pancreaticojejunostomy (the inner layer of the anastomosis)

- Running, 3-0 absorbable sutures attach the full thickness of the jejunum to the cut surface of the pancreas along the capsule, continuing along the cored-out head of the pancreas; a formal anastomosis between the pancreatic duct and jejunum is not necessary.
- Sewing the jejunum to the capsule of the pancreas rather than to the pancreatic duct allows decompression of ducts as small as 2 to 3 mm in diameter (relief of the pancreatic compartment syndrome).
- If only the pancreatic head is diseased, or if the patient has had a distal pancreatectomy, then only a coring out of the head is necessary, with the head drained into the Roux limb.
- The jejunal Roux limb is anchored to the transverse mesocolon to prevent internal herniation.
- Continuity of the gastrointestinal tract is reestablished by end-to-side jejunojejunostomy 60 to 70 cm distal to the pancreaticojejunostomy; all mesenteric defects are closed.
- No drain is needed unless a choledochotomy has been performed (Fig. 97.19).

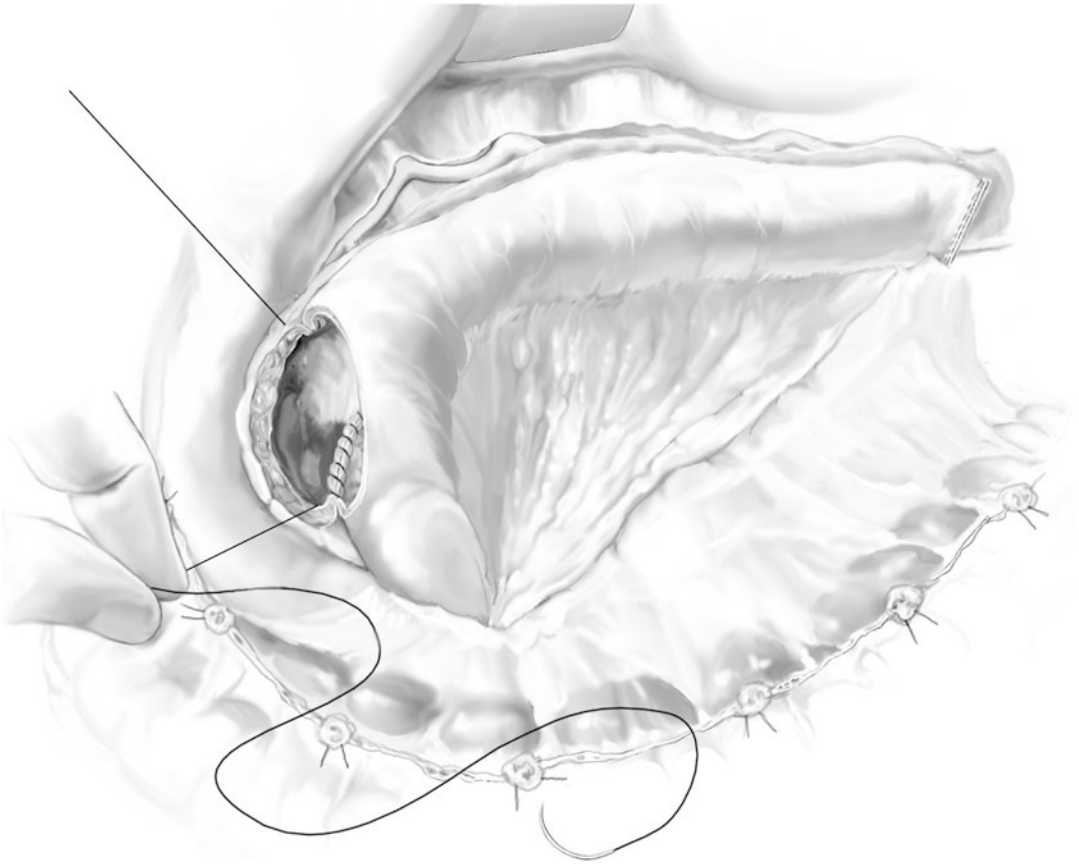


Fig. 97.19

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Duodenum-preserving head resection (Beger procedure)

Kathrin Mayer, Hans G. Beger, Bettina M. Rau, Wolfgang Schlosser

Duodenum-preserving pancreatic head resection was first described by Beger in 1979. The aim of the operation is a subtotal resection of the pancreatic head with removal of the inflammatory mass while preserving the duodenum, extrahepatic common bile duct, gallbladder, and stomach, as well as preserving a portion of the pancreatic parenchyma of the head of the gland.

Step 1

Exposure

- The head of the pancreas is exposed by dividing the gastrocolic ligament, taking care to avoid injury to the gastroepiploic vessels. The duodenocolic ligament is transected and the transverse colon is handled carefully.
- Subsequently, a Kocher maneuver is performed. Exposure of the portal vein and the SMV at the inferior margin of the pancreas follows (Fig. 97.20).

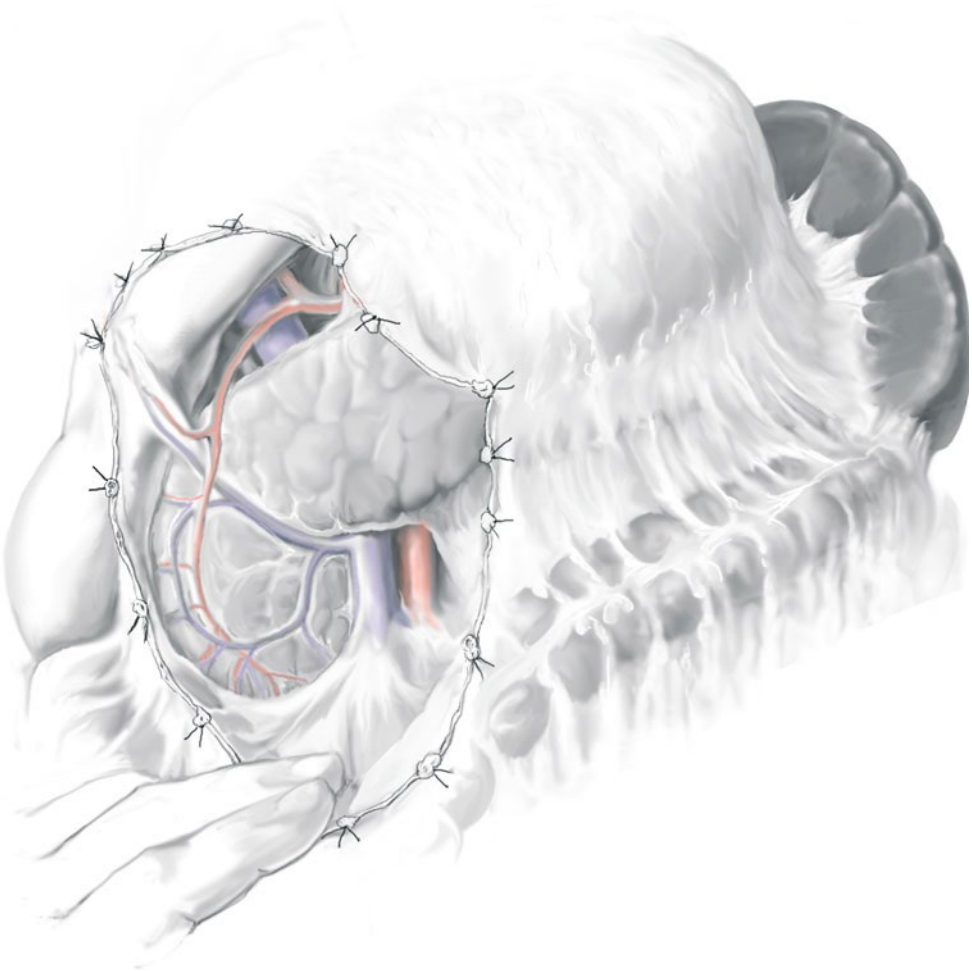


Fig. 97.20

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Step 2

Ligation of feeding vessels

The gastroduodenal artery is ligated at the upper margin of the body of the pancreas. The common hepatic artery is prepared and controlled with a loop. The common bile duct (CBD) is exposed circumferentially at the upper margin of the pancreas in the hepatoduodenal ligament. Next, the plane between the anterior surface of the portal vein and the posterior aspect of the pancreatic head is developed. either from above the neck of the gland starting at the portal vein or, more commonly, starting from below the neck of the gland at the superior mesenteric vein (SMV). This maneuver can be quite difficult, especially in cases of inflammatory and edematous reaction in the head of the pancreas (Fig. 97.21).

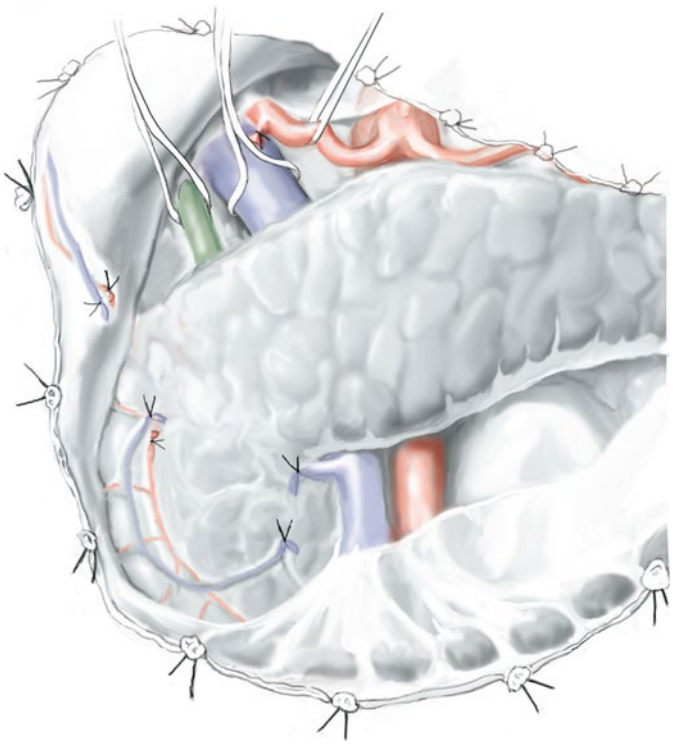


Fig. 97.21

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Step 3

Transection of the neck of the pancreas

The subtotal resection of the pancreatic head is begun by transecting the neck of the gland, starting near the duodenal edge of the portal vein in a sagittal plane as shown. At the cut surface of the left pancreas, meticulous hemostasis using nonabsorbable 5-0 or 6-0 monofilament sutures is mandatory; alternatively, energy-based sealing/ligating devices may facilitate this maneuver and those that follow (Fig. 97.22).

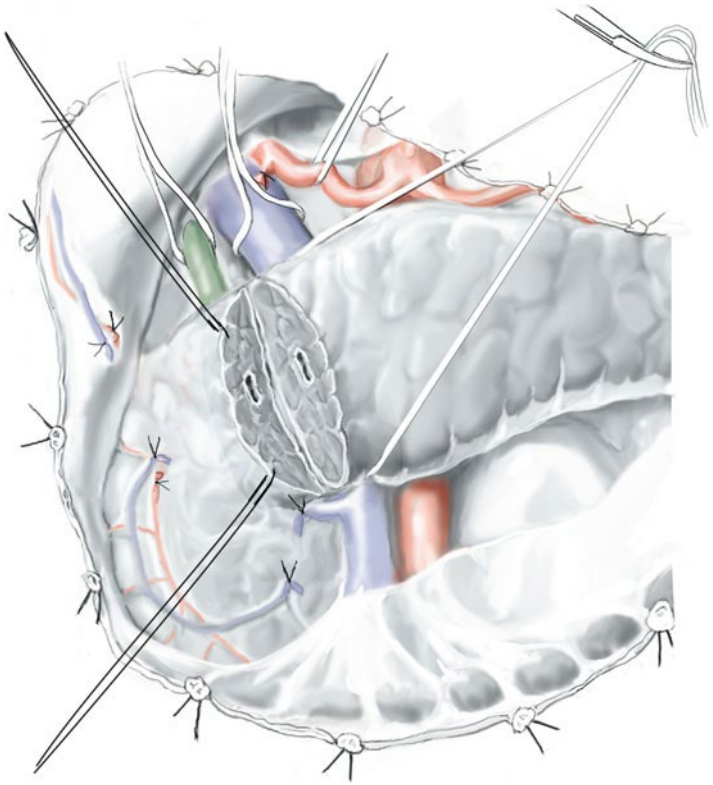


Fig. 97.22

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Step 4

Subtotal excision of the head of the gland

- The head of the pancreas is rotated ventroinferiorly. This rotation can be achieved by bluntly freeing the head of the pancreas from the portal vein. Small branches entering the portal vein directly must be ligated and divided. The head of the pancreas is released from the retroportal region with little technical difficulty as long as individual dissection of the vessels entering into the portal vein proceeds meticulously. Also, the pancreatic parenchyma is transected along the left lateral wall of the intrapancreatic portion of the distal CBD toward the papilla (Fig. 97.23).

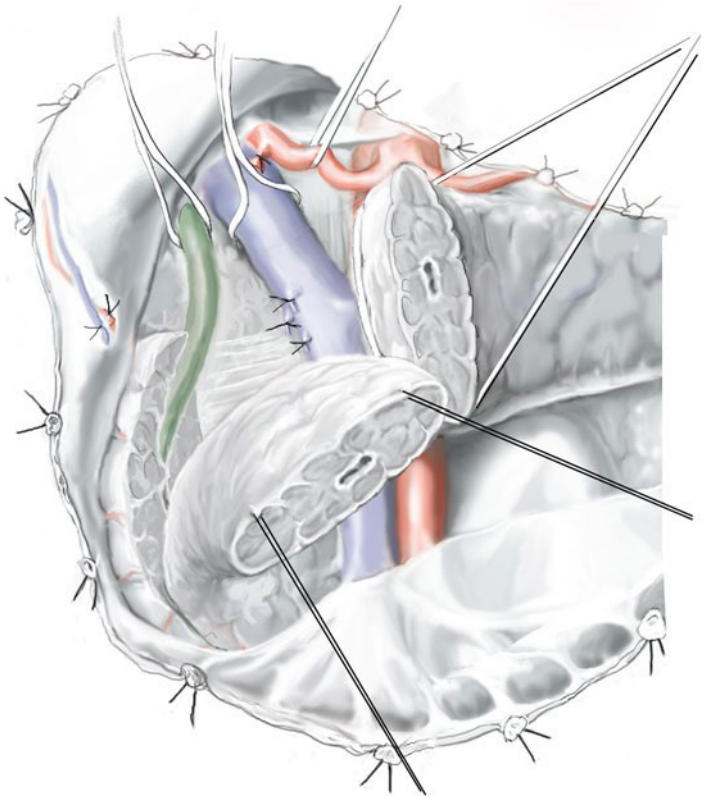


Fig. 97.23

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Step 5

Completion of subtotal resection

Subtotal resection of the pancreatic head is completed by including the tissue of the uncinate process. It is not necessary to preserve the gastroduodenal artery for adequate blood supply to the duodenum because the supraduodenal vessels, as well as duodenal vessels arising from the superior mesenteric artery, maintain sufficient perfusion of the duodenal wall. In most patients, it is not difficult to dissect the pancreatic tissue along the wall of the intrapancreatic portion of the CBD towards the papilla and further down, including the uncinate process. Removal of fibrotic tissue along the CBD decompresses the duct in most patients. In patients with inflammation in the wall of the CBD, the duct is opened by an incision in the lateral wall for an internal biliary bypass. After subtotal resection of the pancreatic head, a 5-mm to 8-mm shell-like remnant of the pancreatic head remains between the CBD and the duodenal wall (Fig. 97.24).

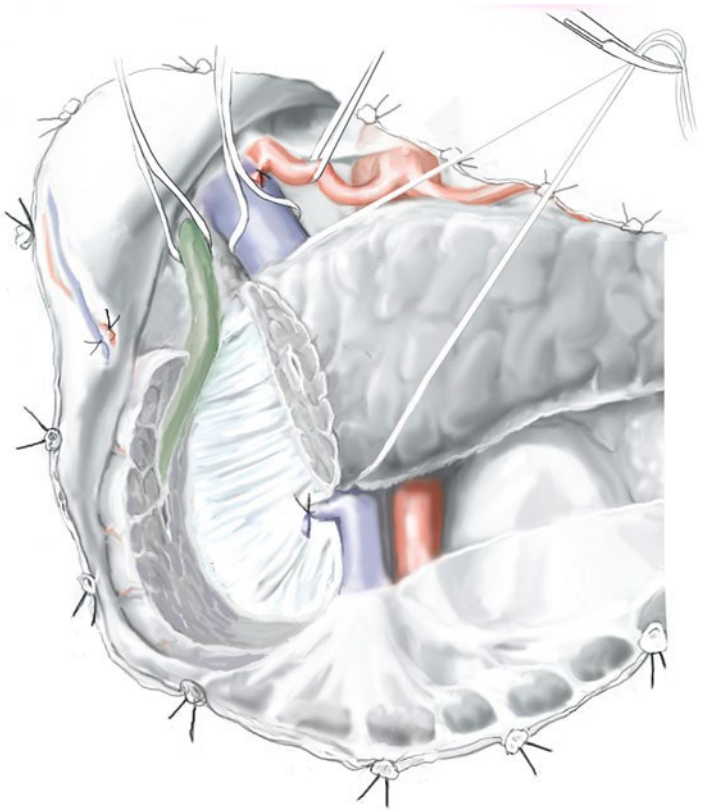


Fig. 97.24

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Step 6

Pancreaticojejunostomy

- Reconstruction after subtotal resection of the head of the pancreas is initiated by transecting the upper jejunum 40 cm distal to the ligament of Treitz. The Roux-en-Y jejunal limb is brought through a retrocolic mesenteric defect. An end-to-side anastomosis between the left pancreas and the jejunum is performed (Warren-Cattell). In this instance, a duct-to-mucosa anastomosis between the pancreatic duct and the jejunal mucosa is performed first. The anastomosis is completed with a single-layer seromuscular suture between the jejunum and the capsule of the left pancreas.
- A side-to-side anastomosis is made between the jejunal limb and the remnant of the pancreatic head for 5 to 8 cm. The jejunal incision for this anastomosis is 4 to 8 cm long. A single-layer anastomosis between the jejunum and the pancreas along the incision line serves as the inner layer; the outer layer is performed between the pancreatic capsule and the seromuscularis of the jejunum. For restoration of intestinal continuity, an enteroenterostomy is carried out 40 cm distal to the pancreaticojejunal anastomosis (Fig. 97.25).

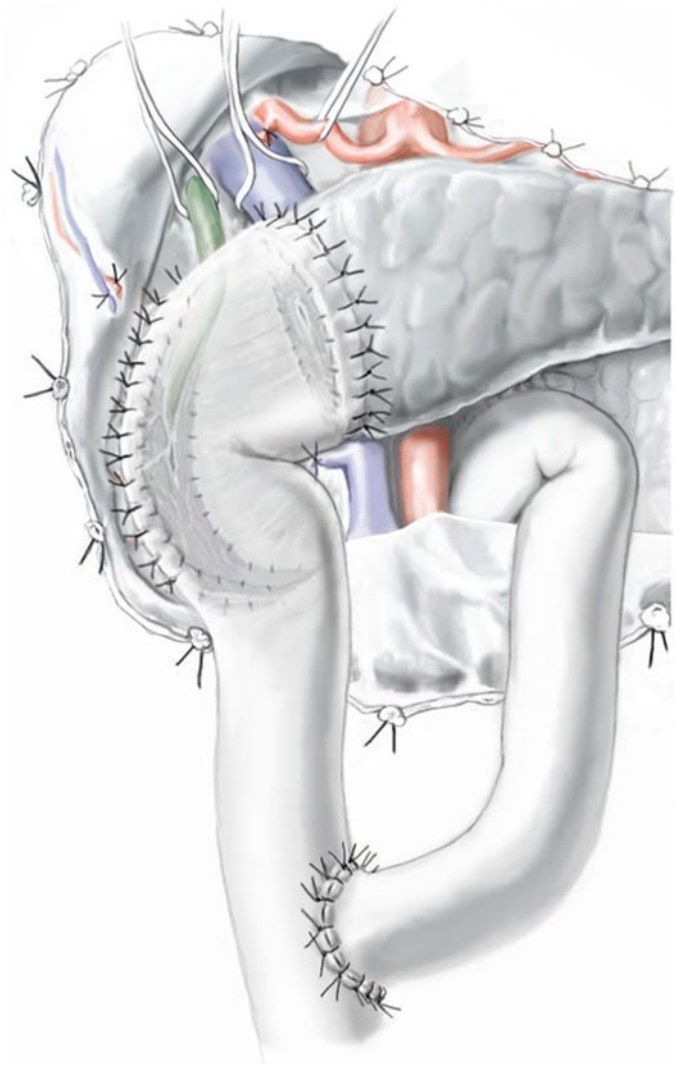


Fig. 97.25

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Step 7

Choledochojejunostomy

- For patients with a wide distal pancreatic body/tail remnant, an end-to-side pancreatojejunostomy may be better. Similarly, the intrapancreatic portion of the CBD can be opened in the proximal pancreatic head remnant and included in the proximal side-to-side pancreatojejunostomy.
- An additional anastomosis between the suprastenotic portion of the CBD and the jejunal limb is can be carried out in patients in whom the subtotal resection of the head of the pancreas has not resulted in complete decompression of the intrapancreatic CBD, and also when intraoperative examination reveals fibrotic involvement of the CBD proximal to the papilla. The side-to-side anastomosis between the CBD and the jejunum is sutured using a single-layer technique. In these patients, cholecystectomy is suggested (Fig. 97.26).
- After completing the anastomoses, a closed suction drain is placed near the anastomoses.

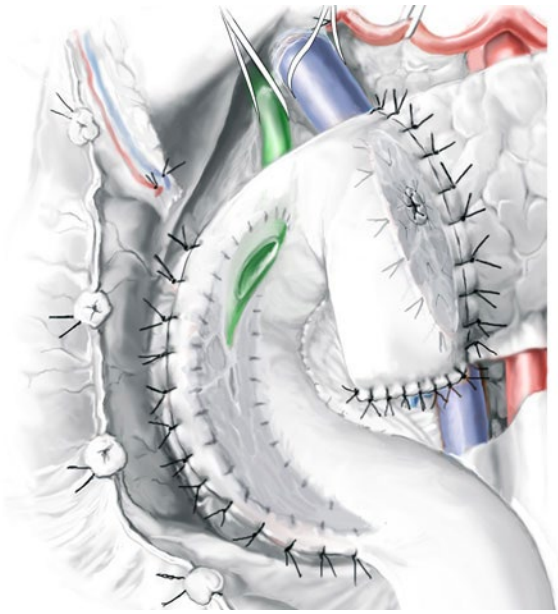


Fig. 97.26

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Step 8

Modification of pancreaticojejunostomy

- In patients with a dilated pancreatic duct or stenosis, the main pancreatic duct is incised longitudinally on its anterior surface, extending toward the tail. In these patients, a side-to-side anastomosis is made between the jejunum and the longitudinally incised pancreas, similar to the Partington-Rochelle procedure (Fig. 97.27).

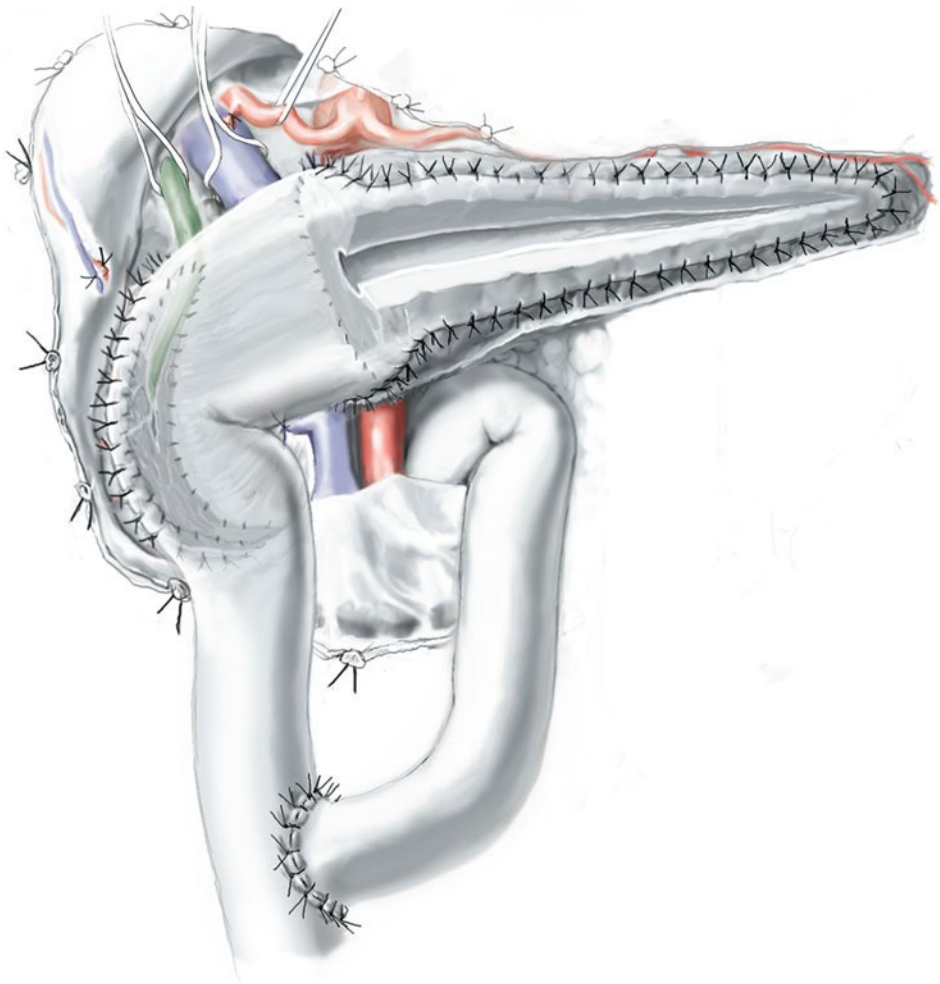


Fig. 97.27

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Postoperative management

- Postoperative monitoring in an intensive care unit is required only rarely and is based on nonpancreatic comorbidities
- Close monitoring of vital signs, fluid balance, and serum glucose concentrations
- Temporary nasogastric decompression
- No somatostatin analogue is recommended

Local postoperative complications

- **Short-term:**
  - Pancreatic leak: ascites, fistula, local collection. Pancreatic leaks should be drained externally. Total parenteral nutrition and bowel rest are indicated only for a very high-volume fistula; most leaks close spontaneously. CT-guided percutaneous drainage is recommended for fluid collections; if a fistula is not controlled, reoperation may be indicated
  - Bile leak (uncommon)
  - Obstructive jaundice (e.g., due to operative injury to the CBD or perioperative inflammation and edema) (uncommon)
  - Jejunal leak
  - Intra-abdominal bleeding

- **Long-term:**
  - Pseudocyst
  - Biliary stricture
  - Recurrence of pain
  - Pancreatic endocrine and/or exocrine insufficiency
  - Pseudoaneurysm of splenic or pancreatoduodenal artery (usually manifests as gastrointestinal bleed 3 to 4 weeks postoperatively)

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Tricks of the Senior Surgeon

The Frey procedure

- Don't try to "talk" the patient into an operation:
  - Explain the magnitude of the operation in detail, with all long-term and short-term complications, including failure to relieve pain.
  - Explain the natural history of chronic pancreatitis, including the possibility of endocrine or exocrine pancreatic insufficiency in the future.
- Technical tips:
  - Open the duct of Wirsung in the head of the pancreas down to the ampulla, creating a road map of the duct before resecting parenchyma. If the duct is impacted with calculi, a small bone curette, stone forceps, or a right-angle clamp may be helpful in removing them.
  - The pancreatic duct must be opened as far to the tail as possible to avoid obstructed tail parenchyma with postoperative "left-sided" pancreatitis flares. Left upper quadrant exposure may be challenging.
  - In patients with CBD obstruction, the surgeon must free up inflamed fibrotic tissue obstructing the duct; a groove can often be felt posteriorly in the location where the CBD traverses the pancreas. To avoid injury to the CBD, a Bakes dilator is placed into the CBD through a cystic or common bile ductotomy. The dilator within the duct is palpated between the index finger behind the CBD and the thumb in front of it, through the surrounding inflamed, fibrotic tissue as the duct is freed up.
  - Because of inflammation and edema, it may be impossible to distinguish the exact margin between the duodenal wall and the pancreas when suturing the Roux-en-Y jejunal limb to the cored-out pancreas. We have encountered no adverse effects aside from including some duodenal wall with pancreatic sutures.
- Patient follow-up: Continue to follow patients yourself postoperatively; patients look to you (the surgeon) for physical and emotional support, rather than to the gastroenterologist or primary care physician.

The Beger procedure

- Tunneling of the pancreatic head along the portal vein groove starts with the preparation of the SMV on the caudal border of the pancreatic neck. Blunt dissection begins in front of and along the mesenteric aspect of the portal vein toward the cranial border of the pancreatic neck. To facilitate this step, a suture at this level in the lower border of the pancreas allows lifting of the pancreatic neck segment anteriorly. If severe bleeding should occur, compression of the pancreas toward the spinal column interrupts the blood flow from the splenic vein. Transection of the head anterior to the portal vein exposes the portal vein for repair of the vessel wall.
- Placing a hand behind the head of the pancreas when the subtotal excision of the pancreatic head is to be performed helps to minimize blood loss.
- If the intrapancreatic wall of the CBD is not palpable or visible, a Kehr-Sonde or a biliary Fogarty catheter can be passed via a choledochotomy (or preferably through the cystic duct) to help palpate the intrapancreatic CBD.
- Frozen section of the inflammatory mass is necessary, because about 5 % of patients with an inflammatory mass have pancreatic cancer.
- Accidental incision of the intrapancreatic wall of the CBD need not be sutured; this part can be included into the anastomosis between the shell of the pancreatic head remnant and the jejunal limb (side-to-side anastomosis).
- If there is marked stenosis of the intrapancreatic CBD, an additional biliary anastomosis is necessary. A single-layer anastomosis between the jejunal limb and the CBD using absorbable suture material should suffice.
- Use of an energy-based sealing/ligating device may aid in dissection and hemostasis.

■ *Acknowledgments

Charles F. Frey contributed to this chapter in the first edition.

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Exploration of the Gastrinoma Triangle

Geoffrey W. Krampitz, Jeffrey A. Norton

Zollinger and Ellison first described gastrin-secreting neoplasms in 1955. These unusual neoplasms are malignant. Diagnosis of the Zollinger-Ellison syndrome (ZES) depends on measurement of an increased fasting serum gastrin concentration (> 250 pg/mL), increased basal acid output (> 10 mEq/L, or > 5 mEq/L in patients with prior acid-reduction surgery), and an abnormal secretin test (increase of > 200 pg/mL in serum gastrin concentration after 2 U/kg of intravenous secretin).

Although gastrinomas originally were believed to be primarily neoplasms of the pancreas, today we know that most gastrinomas arise in the wall of the duodenum. Gastrinomas can occur as sporadic (nonfamilial) neoplasms or as one of the manifestations of multiple endocrine neoplasia type 1 (MEN1) syndrome; MEN1 includes pituitary neoplasms (most commonly prolactinomas), parathyroid hyperplasia, and neuroendocrine neoplasms of the duodenum and pancreas. In addition, patients with MEN1 may manifest benign thyroid neoplasms, benign and malignant adrenocortical neoplasms, lipomas, and cutaneous angiofibromas, as well as other neuroendocrine neoplasms of the foregut and midgut.

Most gastrinomas (especially the occult neoplasms) arise in the proximal duodenum, but gastrinomas also occur in the pancreas, especially in association with MEN syndrome. Sporadic gastrinomas are usually solitary, whereas gastrinomas associated with MEN1 are frequently multiple. Several ostensibly "primary" lymph node gastrinomas have been reported to occur within the gastrinoma triangle, with long-term cure after lymphadenectomy alone.

Approximately 50 % to 80 % of gastrinomas have metastasized to lymph nodes and about one quarter have liver metastases at the time of operation. Gastrinomas found in the pancreas have a greater incidence of liver metastases than duodenal tumors, whereas duodenal gastrinomas have a higher incidence of lymph node metastases. Although the presence and extent of liver metastases are the primary determinants of subsequent patient survival, recent evidence suggests that lymph node metastases decrease disease-related survival on long-term follow-up.

Indications and Contraindications

Indications

- ZES without evidence of unresectable metastatic disease

Contraindications

- "Falsely" increased serum gastrin concentration secondary to:
  - Pernicious anemia (achlorhydria)
  - Medications that inhibit acid production, such as H_2 receptor inhibitors or proton pump inhibitors
- G-cell hyperplasia
- Tumor size smaller than 2 cm on radiologic localization studies in a patient with a confirmed diagnosis of MEN1

Preoperative Investigations and Preparation for the Procedure

- History:
  - Peptic ulcer disease (PUD), watery diarrhea, gastroesophageal reflux disease (GERD), and possibly a family history of the associated endocrinopathies, primary hyperparathyroidism, nephrolithiasis, prolactinoma, insulinoma, Cushing's syndrome, neuroendocrine neoplasms, or carcinoid syndrome

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- Clinical evaluation:
  - Upper gastrointestinal endoscopy with or without endoscopic ultrasonography
- Laboratory tests:
  - Fasting serum concentration of gastrin, basal acid output after ceasing all acid secretory inhibitors for at least 3 to 7 days, secretin test
  - When indicated, serum concentrations of intact parathyroid hormone (PTH), total or ionized calcium, prolactin, fasting glucose, pancreatic polypeptide, chromogranin A, serotonin, 24-h urine excretion of free cortisol, and 5-hydroxyindoleacetic acid (5-HIAA)
- Medical management
  - Appropriately high doses of proton pump inhibitor to stop acid hypersecretion and control of PUD, GERD, and diarrhea (often up to 80–120 mg pantoprazole two or three times a day or 20–40 mg omeprazole). Pantoprazole can be given at the same dose either intravenously or orally and is indicated in the perioperative period.
- Radiologic localization studies
  - CT or MRI to image pancreas, duodenum, and liver, and to exclude liver metastases.
  - Somatostatin receptor scintigraphy (either octreoscan or DOTA-TATE scan) is the best imaging study, imaging 90 % of gastrinomas; although it will detect distant metastases, they may miss small duodenal gastrinomas.
  - Endoscopic ultrasound can detect small tumors within the pancreas but may miss duodenal gastrinomas.
- Exclusion of MEN1 with ZES
  - Of patients with ZES, 20 % have a familial form associated with MEN1. Because hypercalcemia exacerbates the symptoms of ZES and alters surgical management, all patients should undergo screening for hyperparathyroidism associated with MEN1. The initial screen should include a serum calcium measurement and, if it is increased, an intact PTH level to confirm the diagnosis.

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Procedure: Exploration of the Gastrinoma Triangle

Step 1

Exposure of the pancreas

- The apices of the gastrinoma triangle are defined by the confluence of the cystic and common bile ducts superiorly, the junction of the second and third portions of the duodenum laterally, and the neck of the pancreas medially. The gastrinoma triangle includes the head of the pancreas and the duodenum and encompasses an anatomic area from which over 80 % of gastrinomas arise (Fig. 98.1).
- Duodenal gastrinomas are often smaller than pancreatic gastrinomas. Consequently, duodenal gastrinomas are missed frequently on preoperative imaging and intraoperative exploration, so opening the duodenum for intraluminal transmural palpation is critical for their operative detection.
- Access is best obtained via a bilateral subcostal incision, division of the falciform ligament, and installation of a mechanical retractor (either Thompson or Bookwalter retractor).
- Next, the surgeon opens the lesser sac widely by dividing the gastrocolic ligament from the hepatic flexure to the splenic flexure, thereby exposing the entire head, neck, body, and tail of the pancreas. The tissue along the inferior border of the pancreas is opened to allow the surgeon to palpate tumors within the pancreas between the thumb and forefingers.

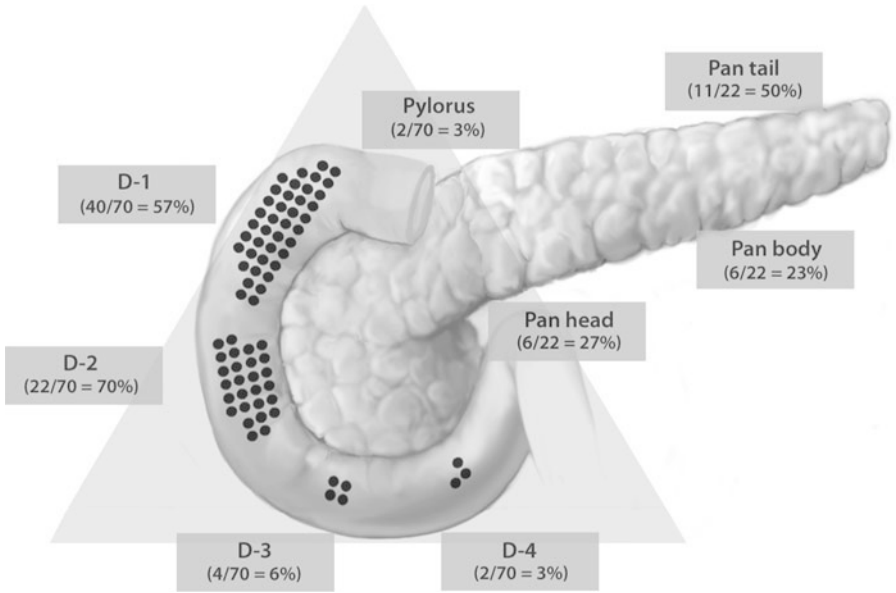


Fig. 98.1

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Step 2

Extended Kocher maneuver

- The next step involves an extended Kocher maneuver by mobilizing the entire right colon and the proximal as well as distal duodenum; this maneuver allows palpation of the head of the pancreas and, equally important, the wall of the duodenum (Fig. 98.2).
- Intraoperative ultrasonography is performed in a systematic fashion with a near-field, high-resolution 10 MgH2 transducer. Small neoplasms within the pancreas are identified by their sonolucent nature, compared with the more echo-dense pancreas. Although intraoperative ultrasonography of the duodenum is also performed, this procedure often misses duodenal gastrinomas if they are small. Finally, the liver is also evaluated for metastases.

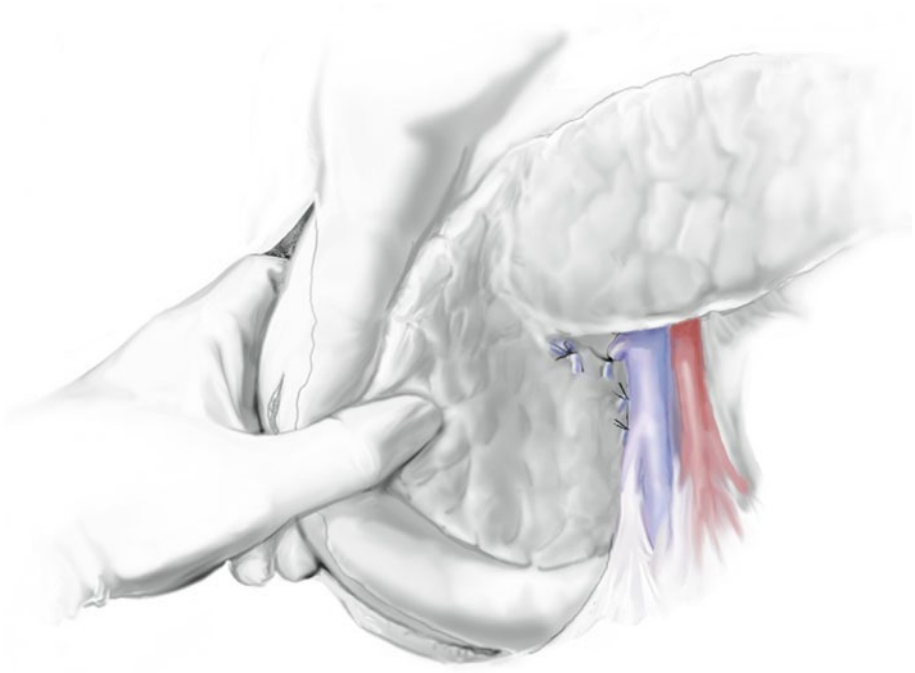


Fig. 98.2

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Step 3

Lymphadenectomy of gastrinoma triangle

- All lymph nodes within the gastrinoma triangle are excised in a systematic fashion, starting with a lymphadenectomy of the hepatoduodenal ligament. Lymph nodes from the porta hepatis to the duodenum are excised, labeled, and sent for pathologic analysis, as are nodes from both the anterior and posterior border of the head of the pancreas (Fig. 98.3).
- Neuroendocrine neoplasms identified within the head of the pancreas are enucleated with palpation or via ultrasonographic control. When a tumor is enucleated from the head of the pancreas, we apply 5 mL of fibrin glue to the site of enucleation, and a closed suction drain is placed nearby.

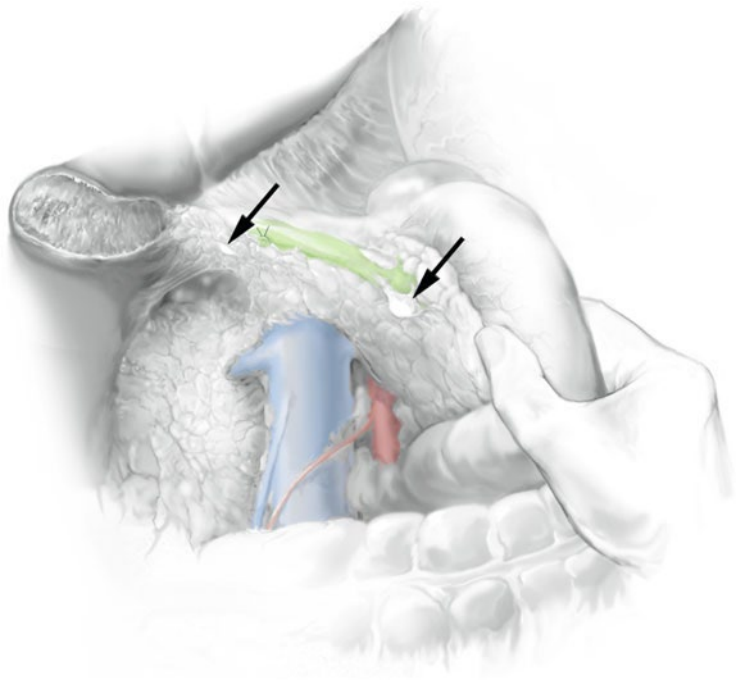


Fig. 98.3

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Step 4

Opening the duodenum to identify and remove duodenal gastrinomas (Fig. 98.4)

- If the location of the tumor is not known, a duodenotomy is essential, because this maneuver is often the only way to detect occult duodenal gastrinomas. The surgeon can palpate the tumor within the wall of the duodenum between the index finger (within the duodenal lumen) and the thumb (on the serosal side). If a duodenal tumor has been identified, the incision used to excise the duodenal gastrinoma can be extended to explore the remainder of the duodenum (Fig. 98.4a).
- Because the neoplasm arises from the submucosa and can invade the mucosa, the gastrinoma should be excised via a full-thickness specimen with a rim of normal duodenal wall around the tumor. In patients with MEN1, multiple duodenal neoplasms may be present, and the surgeon must palpate and inspect carefully the remainder of the inner surface of the duodenum after it is open, to exclude the presence of other neoplasms. Do not confuse the ampulla of Vater or the entrance of the minor pancreatic duct with a gastrinoma. When in doubt, administer secretin (2 U/kg) intravenously to elicit pancreatic secretions to identify the orifices of the pancreatic ducts.
- After excising a duodenal gastrinoma, the duodenum is closed with a single-layer, full-thickness, monofilament absorbable suture in a transverse direction so as not to narrow the lumen. If a long duodenotomy is necessary, a longitudinal closure is performed. For bulky tumors in the pancreatic head, tumors involving the pancreatic duct, or duodenal tumors involving the ampulla of Vater, a pylorus-preserving pancreatoduodenectomy may be necessary. A periduodenal or peripancreatic closed suction drain is left.

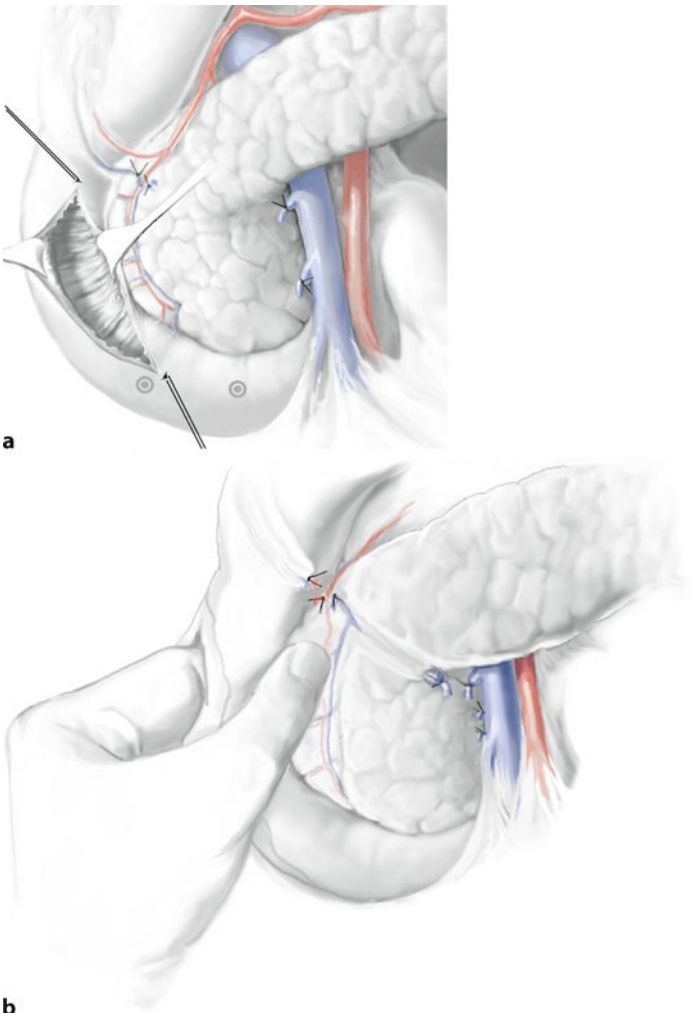


Fig. 98.4

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Postoperative Tests

- After the operation, the patient is kept on the same preoperative dose of proton pump inhibitor for 1 to 3 months; parietal cell hypertrophy that occurs with ZES may take 3 to 6 months to involute.
- A postoperative fasting serum gastrin measurement should be compared with the preoperative level. For selected patients to assess biochemical care, fasting serum gastrin, basal acid output, and secretin-stimulated gastrin are measured 3 to 6 months postoperatively.
- On occasion, we obtain a CT scan with oral contrast on postoperative day 5 to rule out a duodenal leak and a peripancreatic fluid collection.
- The drain is removed when the patient is eating a regular diet, the drainage fluid is low in amylase concentration, and the volume is less than 20 mL per day for 2 consecutive days. We may discharge the patient with a drain in place to be removed later.

Local Postoperative Complications

- **Short-term:**
  - Duodenal leak
  - Pancreatic leak and/or abscess
  - Pancreatic fistula
  - Intra-abdominal bleeding
  - Pancreatitis
  - Duodenal ulcer bleeding
- **Long-term:**
  - Duodenal stricture
  - Recurrent hypergastrinemia
  - Other manifestations of MEN1 (hypothalamic, parathyroid, carcinoid)

Tricks of the Senior Surgeon

- Do not cut corners; do the same operation every time regardless of the preoperative localization studies.
- Develop a dedicated team approach; an ultrasonographer willing to take the time and effort to find the gastrinoma is crucial.
- Beware of the ampulla and pancreatic duct on the medial wall of the duodenum, because these strictures can feel like nodules and have been mistaken for duodenal gastrinomas; I remove the gallbladder and pass a catheter through the cystic duct into the duodenum if there is any question about the location of the ampulla. On occasion, secretin given intraoperatively to stimulate pancreatic secretion can be helpful if there is any question about identifying the pancreatic duct orifice.
- Exclude MEN1 preoperatively by screening for other endocrinopathies and questioning family history.
- Remember that patients with both ZES and MEN1 generally have multiple pancreatic and duodenal neuroendocrine neoplasms, so the cure rate is very low. If a patient also has primary hyperparathyroidism, perform the parathyroid operation first, because it may ameliorate the manifestations of ZES.
- Be sure to maintain the patient on an aggressive regimen of acid-suppressive medication during the perioperative period and postoperatively for 3 to 6 months.

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Necrosectomy

*Oliver Strobel, Markus W. Büchler, Carlos Fernández-del Castillo, Gregory G. Tsiotos, Michael G. Sarr, C. Ross Carter, Euan J. Dickson, Hjalmar C. van Santvoort, Karen D. Horvath**

Severe acute pancreatitis remains a life-threatening disease. The first phase (about 7 days) is characterized by formation of pancreatic and peripancreatic necrosis and development of a systemic inflammatory response syndrome. This systemic response to the pancreatic inflammation and necrosis causes early organ failure, which necessitates intensive care therapy. In the second phase (after the first week), the leading cause of morbidity and mortality is superinfection of necrosis with development of septic multiple organ failure. In the past two decades, treatment has evolved considerably with improved aggressive initial resuscitation and intensive care management. There is a worldwide trend toward a more conservative strategy of delayed operative intervention. Treatment is initiated primarily because of the local and systemic manifestations of infected necrosis and less so for sterile necrosis. Nevertheless, septic complications caused by pancreatic infection account for 80 % of the mortality, so infected necrosis usually remains an absolute indication for some form of invasive intervention.

The goals of operative necrosectomy are to remove the necrotic and infected tissue and to minimize injury to viable tissues. Each technique described below also aims to minimize the accumulation of exudative fluid and extravasated pancreatic exocrine secretions from the operative bed; if these are not drained, infection invariably occurs.

This chapter discusses five operative techniques of necrosectomy and drainage. All have similarities in their ultimate goal of débridement of necrotic tissue, but all tend to achieve this goal differently. Indeed, individual patients may be best treated with a customized approach.

Indications and Contraindications

Indications

- Pancreatic and/or peripancreatic necrosis (based on contrast-enhanced dynamic CT scan) complicated by documented infection (guided fine needle aspiration culture or extraluminal retroperitoneal gas) unresponsive to antibiotics and percutaneous drainage alone.
- Sterile necrosis with progressive clinical deterioration despite maximal medical treatment. (An aggressive operative approach in the absence of documented infection is controversial.)
- Timing: Necrosectomy should be undertaken at least 4 weeks after onset of disease, when the ongoing necrotic process has ceased, viable and nonviable tissues are well demarcated, and the infected necrotic tissues are better organized and "walled off."
- Controversy remains about whether operative necrosectomy is indicated for patients who are not improving and cannot eat more than 3 or 4 weeks after the onset of disease but who have documented "sterile necrosis." Some groups maintain that recovery is speeded with necrosectomy; others maintain that a nonoperative approach ultimately proves safer.
- Massive hemorrhage or bowel perforation (colon, duodenum).

Contraindications

- Pancreatic and/or peripancreatic necrosis without evidence of infection or clinical deterioration.
- Less than 1 week elapsed from onset of acute pancreatitis; the systemic inflammatory response syndrome (SIRS) has not yet subsided and maximal intensive medical treatment is still necessary. Hemodynamic and metabolic instability early after necrotizing pancreatitis is secondary to SIRS and not to bacterial sepsis.

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Preoperative Investigation and Preparation for Procedure

- The early diagnosis of severe acute pancreatitis is one of exclusion (excluding other surgical conditions) based on history, physical examination, and biochemistry.
- Initial assessment and continuous intensive care unit monitoring of severity (APACHE-II score).
- Laboratory assessment: CBC and electrolytes, liver function tests, and coagulation profile; some groups utilize serum C-reactive protein as a diagnostic and prognostic guide.
- Aggressive cardiovascular, respiratory, and metabolic resuscitation; aggressive management of SIRS for the first 7 days of acute pancreatitis.
- Contrast-enhanced dynamic CT scans about 1 week from the onset of severe acute pancreatitis to assess the presence and extent of pancreatic and/or peripancreatic tissue necrosis, as well as extraluminal retroperitoneal gas.
- Early "prophylactic" administration of appropriate antibiotics (imipenem) to prevent pancreatic superinfection from the gut is no longer supported by available evidence and consensus guidelines; use of oral antifungal agents is favored. This concept of antibiotic prophylaxis remains controversial.
- Initiation of parenteral nutrition with early conversion to intrajejunal feeding (using a nasojejunal tube with its tip distal to the fourth portion of the duodenum); if necessary, intragastric feeding may be effective. Enteral nutrition is preferred whenever possible due to reduced infections and mortality rates as compared to parenteral nutrition.
- In severe gallstone pancreatitis, if choledocholithiasis with biliary obstruction is present, early endoscopic sphincterotomy and stone removal decreases morbidity and may reduce mortality.
- When operation is planned, the preoperative CT images serve as the "road map" for necrosectomy, to delineate all fluid collections in areas remote from the pancreas, especially for the retroperitoneal paracolic gutters and perinephric spaces.

Procedure: Open Necrosectomy with Closed Postoperative Lavage

Oliver Strobel, Markus W. Büchler

Our technique of necrosectomy involves a primary, organ-preserving local débridement of necrotic tissue, accompanied by continuous postoperative removal of infected necrotic debris, ongoing necrosis, peripancreatic exudate, and extravasated pancreatic exocrine fluid by continuous peripancreatic lavage. We believe that our technique represents a less invasive strategy with results comparable to other techniques.

Step 1

Exposure

- Midline vertical incision allows assessment of the entire abdominal cavity, generalized irrigation, and diverting ileostomy when the necrotic process involves the mesocolon and mesenteric area.
- The lesser sac is opened by dividing the duodenocolic and gastrocolic ligaments close to the greater curvature of the stomach inferior to the gastroepiploic vessels; this approach avoids injury to the colonic vessels and transverse mesocolon (Fig. 99.1).

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Step 1 *(continued)*

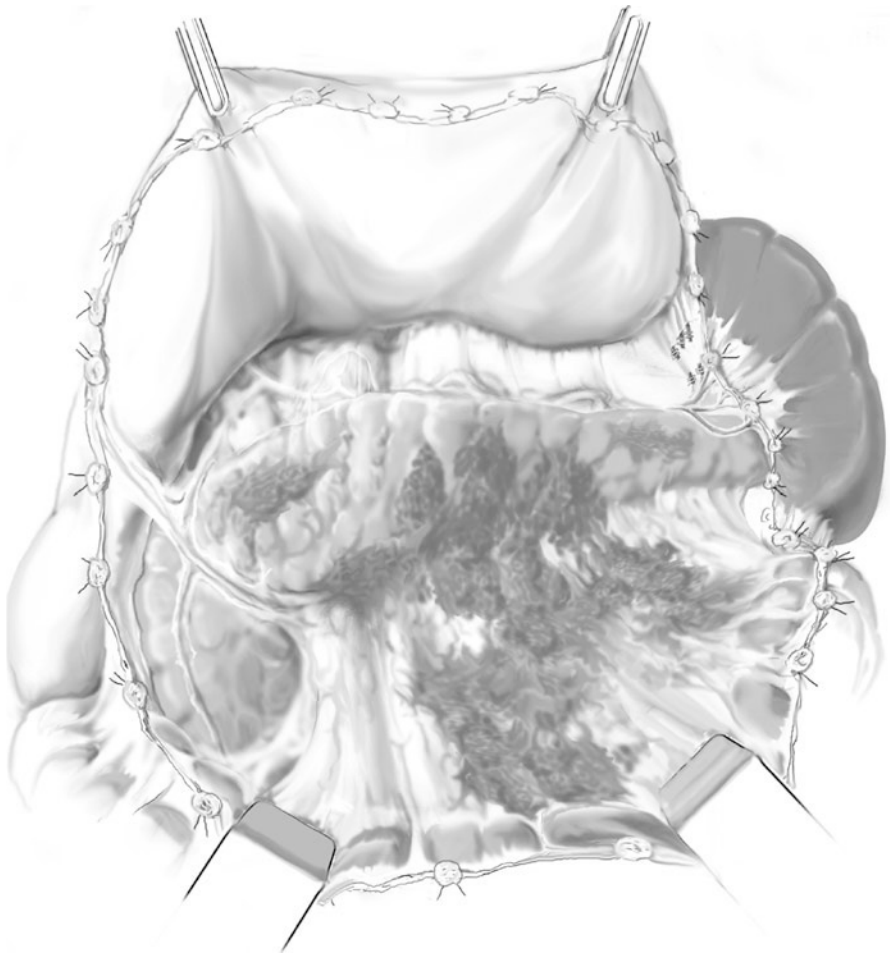


Fig. 99.1

- Caution is necessary because of inflammatory adhesions between the pancreas, transverse mesocolon, and posterior wall of the stomach.
- The pancreatic area is fully exposed; necrotic areas are darker and more woody-feeling than viable tissue.
- Necrosis is usually not limited to the pancreas but also involves the peripancreatic and retroperitoneal fatty tissue; pancreatic parenchymal necrosis is usually patchy and superficial, with deeper parts of the pancreas still perfused and viable (Fig. 99.2).

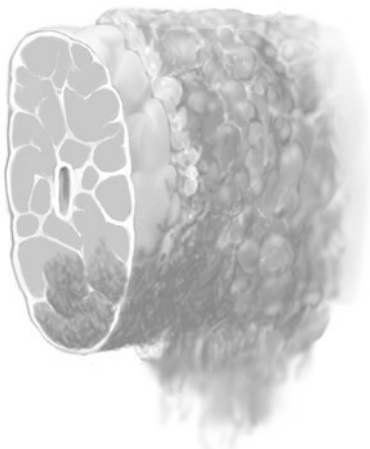


Fig. 99.2

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Step 2

Blunt dissection of necrotic tissue

- All fluid collections (defined by CT images) must be opened and evacuated by suction.
- Removal of necrotic pancreatic and peripancreatic fatty tissue, accomplished by blunt digital dissection or careful use of instruments and irrigation, is the goal; sharp dissection is specifically avoided to prevent devascularization of viable tissue and uncontrollable hemorrhage (Fig. 99.3).
- Necrotic tissue is systematically sought in the retroperitoneum behind the transverse, ascending, and descending colon, and down to Gerota's fascia; all areas of necrosis are removed by blunt dissection.
- Necrotic tissue and fluid from the operation room are sent for culture.
- After necrosectomy, the pancreatic area and the retroperitoneal cavity are irrigated generously with 4 to 10 L of normal saline.

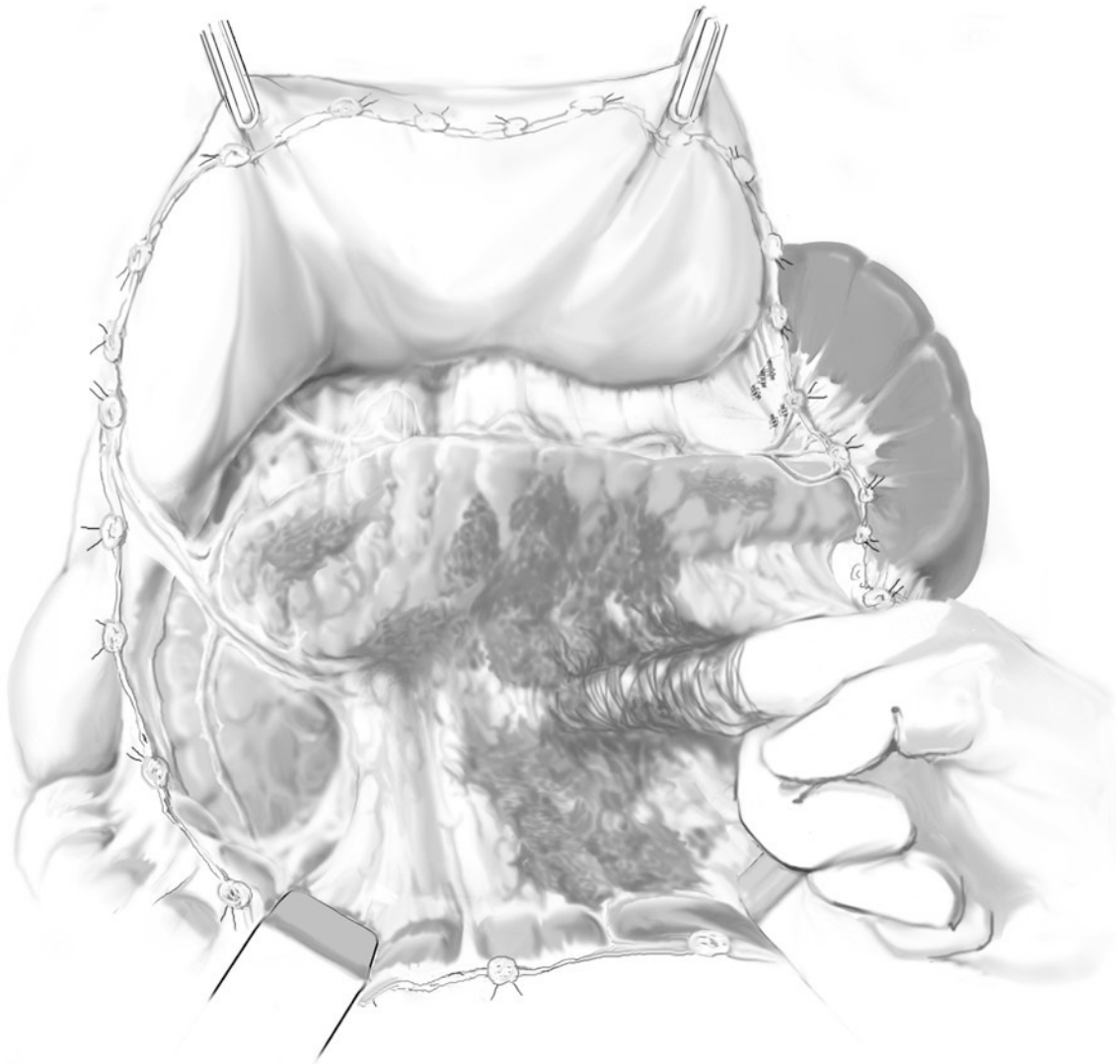


Fig. 99.3

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Step 3

Hemostasis after necrosectomy

- A careful blunt technique removes devitalized tissue and preserves the viable pancreatic parenchyma.
- Bleeding from the pancreas is controlled by transfixion sutures using nonabsorbable, monofilament suture material (Fig. 99.4).
- The spleen is usually not specifically involved in the necrotic process, so splenectomy is usually not required.

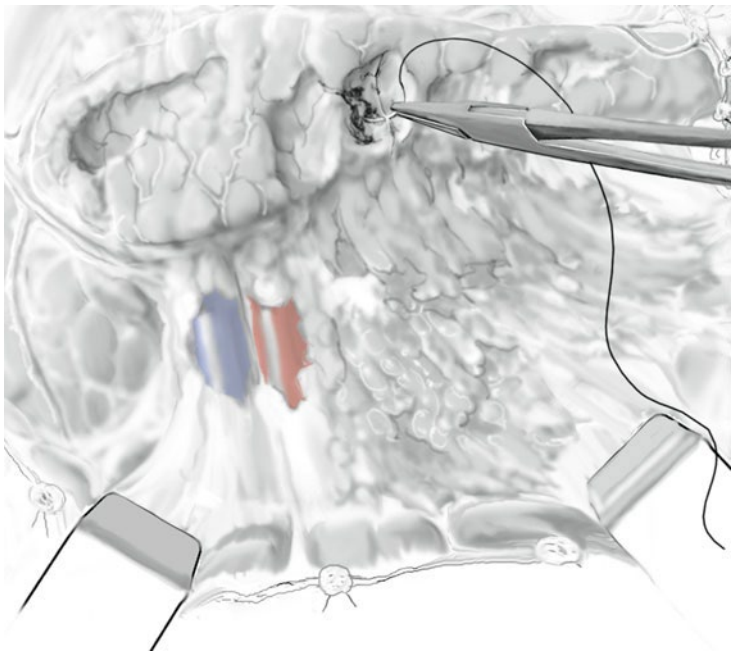


Fig. 99.4

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Step 4

Placement of catheters for postoperative closed lavage

- Four drainage catheters (two from each side) are directed to the contralateral side of the peripancreatic space and placed with the tip of the catheter at the head and tail of the pancreas and behind the ascending and descending colon. Two of these four catheters (sump-like tubes, 20–24 Fr.) have two lumens: a smaller one for inflow of lavage fluid and a wider one for outflow. The other two drains (silicon tubes, 28–32 Fr.) have one lumen of larger diameter to allow evacuation of both fluid and necrotic debris (Fig. 99.5).

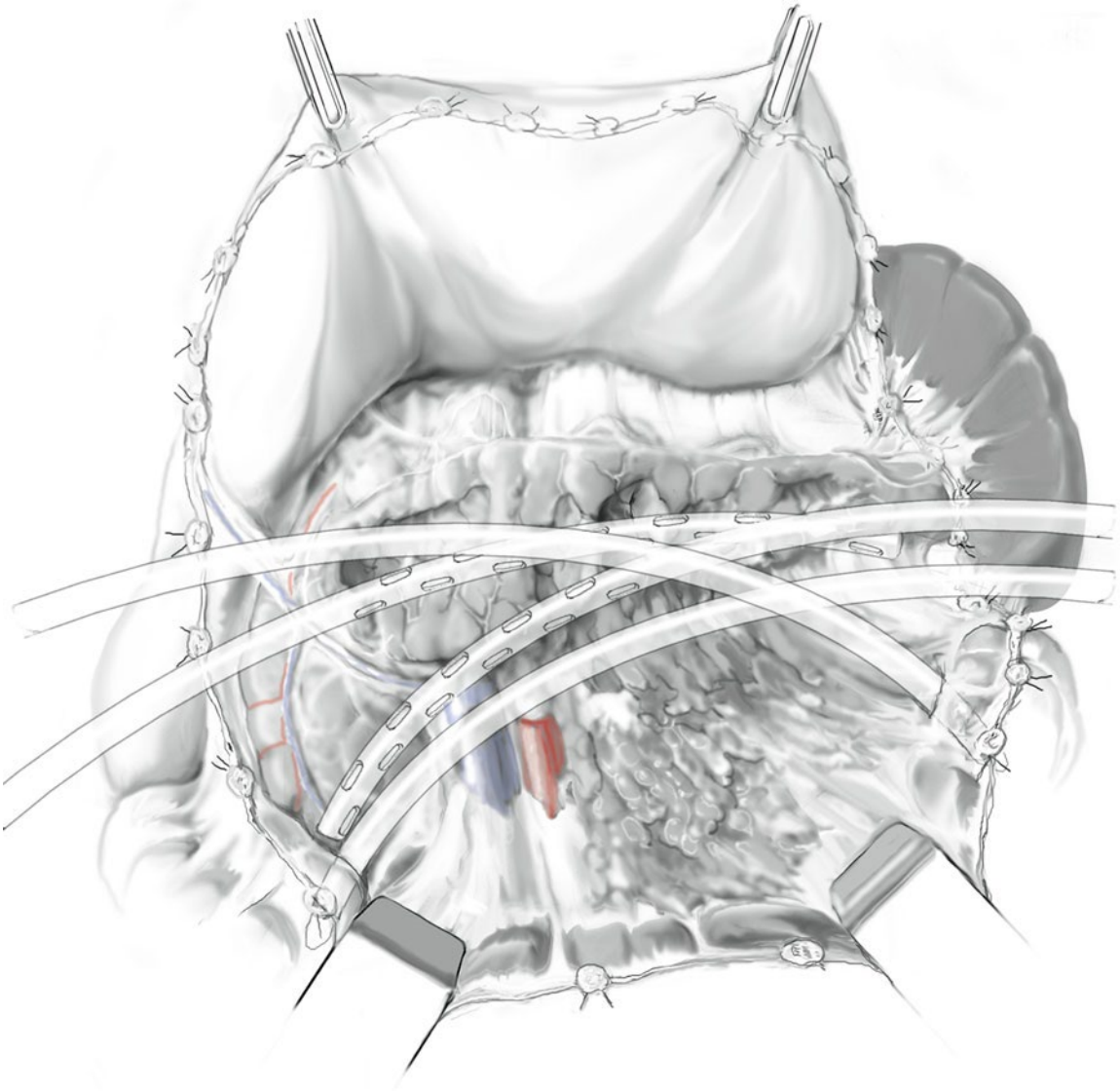


Fig. 99.5

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Step 5

Closure

- Gastrocolic and duodenocolic ligaments are resutured together to create a closed peripancreatic compartment to allow for contained postoperative lavage of the lesser sac and involved retroperitoneum.
- Cases of marked mesocolic and retrocolic necrosis present a risk of colonic perforation or fistula, so a diverting ileostomy is created in the right lower quadrant (Fig. 99.6).

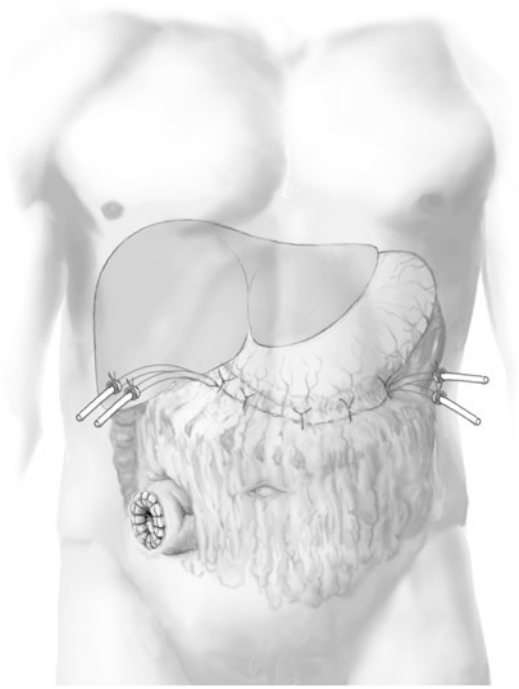


Fig. 99.6

Procedure: Necrosectomy and Closed Packing

Carlos Fernández-del Castillo

In any surgical approach to necrotizing pancreatitis, the goal is to remove the necrotic tissue and to minimize accumulation of exudative fluid and extravasated pancreatic exocrine secretions. Reoperation in this setting can be difficult and can lead to increased morbidity. The principle of necrosectomy and "closed packing" is to perform a single operation, with thorough débridement and removal of necrotic and infected tissue, while minimizing the need for reoperation or subsequent pancreatic drainage.

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99

Step 1

Exposure and entry into the lesser sac

- For most patients, a midline incision allows better exposure and optimal placement of drains.
- The transverse colon is elevated anteriorly and access to the lesser sac is gained via the left mesocolon. When necrosis is extensive, often there is bulging of the necrotic process at this site and entry should be made bluntly with a clamp or finger. Fluid is evacuated and sent for culture.
- The opening is enlarged, and the cavity is explored with two fingers. Depending on the extent and location of necrosis, an incision can also be made in the right mesocolon and, if necessary, the middle colic vessels are clamped and ligated (Fig. 99.7). All attempts at preserving the middle colic vessels should be undertaken.

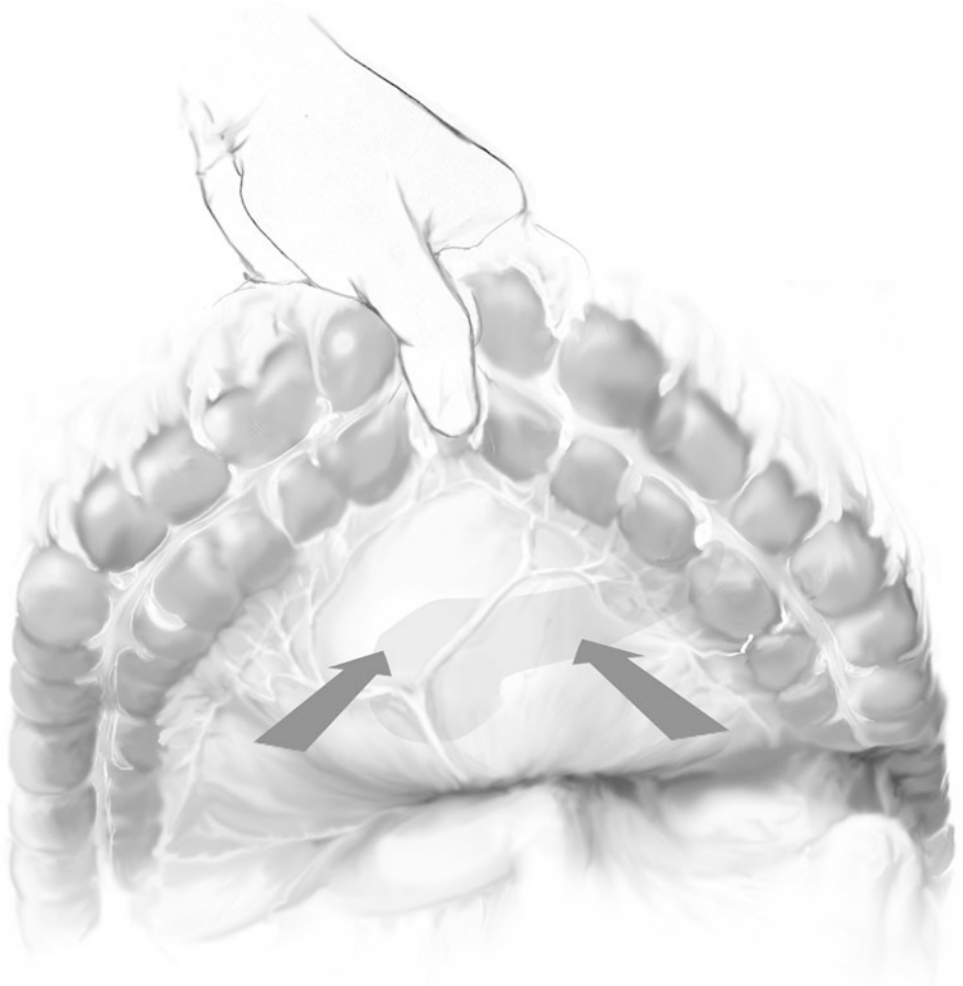


Fig. 99.7

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Step 2

Pancreatic and peripancreatic necrosectomy and débridement

- Débridement and removal of the necrotic tissue (necrosectomy) is done bluntly with the fingers or with a sponge. It is important to break into all the recesses of the cavity, as guided by the CT imaging, to thoroughly remove the debris and necrotic material, a sample of which should also be sent to bacteriology. Any firm attachments should be clamped and tied or left alone.
- The pancreas often can be discerned from peripancreatic tissues only on the basis of its location and consistency. Resection of the pancreas should be done carefully and only if the CT scan shows pancreatic parenchymal necrosis.
- If necrosis extends deep into the perirenal spaces and this area cannot be accessed through the mesocolon, the respective paracolic gutters are opened to remove the debris and necrosis.
- After completing the necrosectomy and débridement, the pancreatic bed is irrigated with several liters of normal saline (Fig. 99.8).

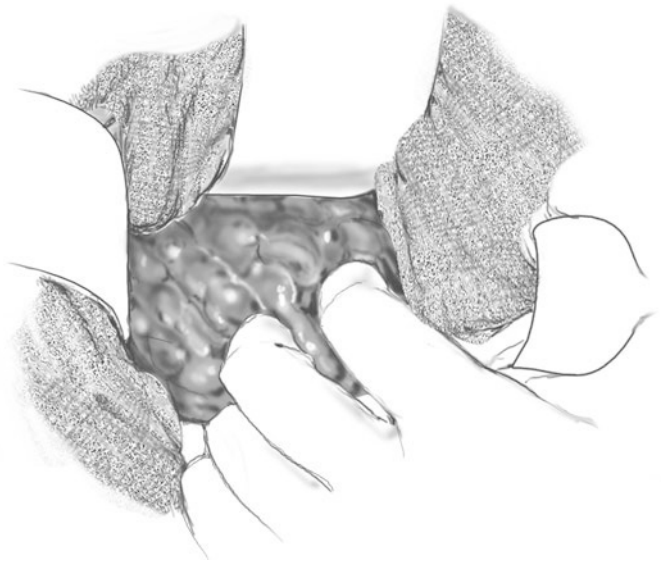


Fig. 99.8

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Step 3

Drain placement (Fig. 99.9)

- Stuffed Penrose drains (often called cigarette drains), made using 3/4-inch Penrose drains stuffed with two gauze sponges, are used for packing the large, stiff cavity that results after débridement. These drains are introduced into the abdomen through separate stab wounds to the side of the midline incision. The intent of this drain is to fill the cavity and provide compression, rather than strictly to drain the area. The number of drains varies depending on the size of the cavity; in our experience, the number of these drains has ranged from 2 to 12.
- In addition, we leave the soft, round Jackson-Pratt closed suction silicone drains, usually one into each major locale of the débridement cavity.
- The stuffed Penrose drains are removed 5 to 7 days postoperatively. We typically remove one every other day, which allows the cavity to close gradually. The Jackson-Pratt drains are removed last, when they have no output.
- A gastrostomy tube placed at the time of the débridement proves useful in many patients. It prevents the need for a nasogastric tube and can be used eventually for enteric feeding. We do not place jejunostomy tubes routinely .
- In patients with cholecystitis, a cholecystectomy can be done at this time if the patient is stable and the degree of inflammation in the right upper quadrant makes it safe. Otherwise, cholecystectomy is better left for a later stage.
- The abdomen is closed primarily in routine fashion.

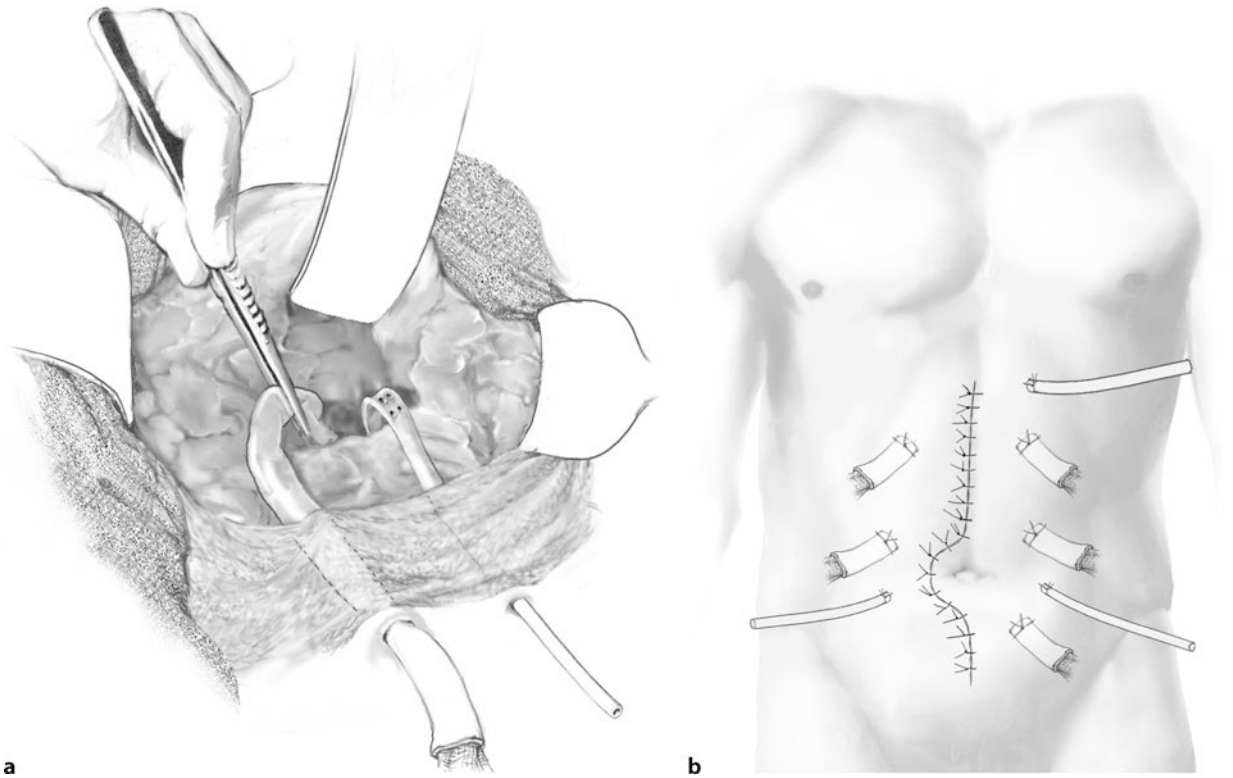


Fig. 99.9

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Procedure: Planned Repeated Necrosectomy

Gregory G. Tsiotos, Michael G. Sarr

Step 1

Exposure and exploration

- The operation begins with a systematic, comprehensive, manual and visual exploration of the entire pancreas as well as an exploration to delineate the extent of necrosis in both paracolic gutters, the root of the small bowel mesentery below the transverse mesocolon, and the suprapancreatic retroperitoneal tissues. CT imaging is the guide to locating all areas of necrosis.
- Entrance into the lesser omental sac is through the gastrocolic ligament whenever possible, rather than through the transverse mesocolon, because this approach provides superior access to the pancreatic bed, not hindered by risking injury to the middle colic or right colic vessels. Although necrosis often presents through the left mesocolon when the pancreatic body and tail are involved, or through the right mesocolon when the head and uncinate are involved, any approach from below the mesocolon for a complete pancreatic necrosectomy offers suboptimal exposure and risks inadvertent surgical trauma and incomplete necrosectomy. We believe that exposure via the gastrocolic ligament is especially important for necrosis of the body and tail, except when the necrotizing process involves predominantly the head and uncinate process of the pancreas or when previous pancreatic surgery has obliterated the lesser sac.
- Probing the gastrocolic ligament bluntly with a finger will usually identify the cavity containing the necrosis in the lesser sac. Once the finger finds the cavity, the space is unroofed in a controlled fashion, with care to protect the gastroepiploic arcade and vessels in the transverse mesocolon (Fig. 99.10).



Fig. 99.10

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Step 2

Access for necrosectomy

- The actual necrosectomy should be carried out by manual, blunt dissection as the technique of choice. Gentle "scooping out" of the putty-like necrosis is sufficient in most cases. Sharp necrosectomy (using knife or scissors) is specifically condemned, especially in the vicinity of the splenic and superior mesenteric veins and in the area of the middle colic vessels. All devitalized tissue amenable to blunt débridement should be removed. The initial necrosectomy offers the best possible exposure, and thus every attempt at a complete and safe necrosectomy should be pursued at this time (Fig. 99.11).

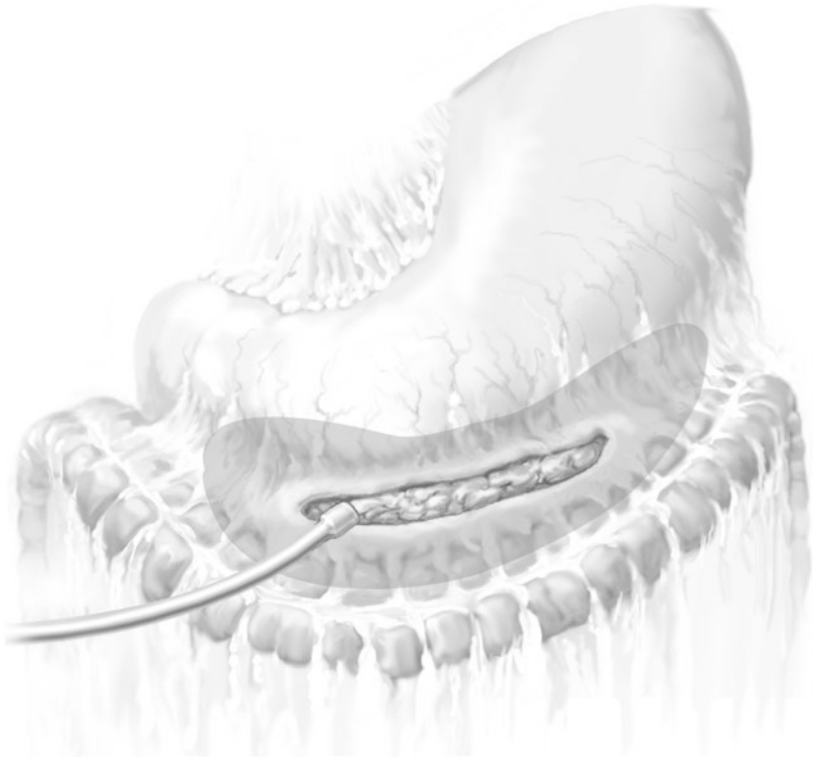


Fig. 99.11

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Step 3

Necrosectomy technique

- When the necrotic material must be accessed through the gastrocolic ligament, extreme care should be taken to avoid injury to the transverse colon and its mesentery, which is often shrunken, thickened, less immobile, and involved in the obliterated lesser sac region.
- When necrotic tissue remains adherent to viable tissue, blunt avulsion or sharp dissection away from the viable tissue may cause bleeding that is difficult to control. These areas will separate themselves from the viable tissue at the time of planned reexploration 2 or more days later. Similarly, viable tissues that are inflamed, friable, or hypervascular are not disturbed, to minimize blood loss.
- During removal of a piece of necrosis, a band or bridge of tissue may span the now-defined cavity. Although the tendency is to avulse this persistent bridge of tissue, the surgeon should avoid the urge to do so, because this bridge usually represents a blood vessel, often with persistent flow. Any uncontrolled, active bleeding during necrosectomy may be difficult to control in this inflamed peripancreatic space. Similarly, ligation or suture closure of a major blood vessel will then be subject to pseudoaneurysm formation. The overall goal of the necrosectomy should be to evacuate all necrosis without inducing hemorrhage (Fig. 99.12).



Fig. 99.12

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Step 4

Extended necrosectomy

- The peritoneum overlying both paracolic gutters should be incised to visualize and expose the retroperitoneal tissues, especially if the CT scan shows extension of the "inflammation" in these regions; simple palpation with the peritoneum intact can be deceiving as to the presence or absence of peripancreatic fat necrosis, especially in the obese patient. These spaces, if involved, should be unroofed, either medially to their colonic mesenteries or, if more extensive, via a lateral approach with medial mobilization of the colon (Fig. 99.13).
- The root of the small bowel mesentery and the suprapancreatic area (e.g., periesophageal and periaortic regions) are other locations where the necrotizing process can be concealed as it dissects along the superior mesenteric vessels.
- After the necrosectomy, we irrigate the débrided areas extensively to remove devitalized tissue, inflammatory exudate, and residual bacteria. We have used the pressurized water irrigator (SurgiLav, Model 201; Stryker, Kalamazoo, MI, USA), because it provides a controlled pressure system of blunt, liquid débridement and irrigation.

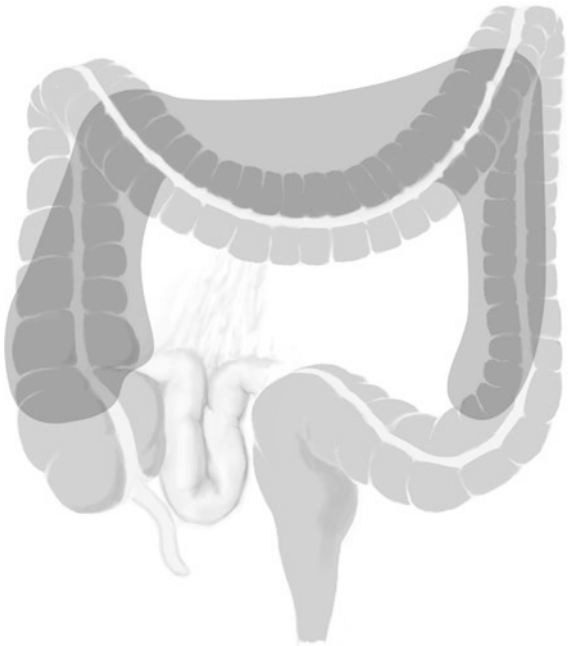


Fig. 99.13

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Step 5

Temporary closure with a zipper

- When areas of questionable viability are noted that remain adherent to viable areas, we return the patient to the operating room 2 days later for a repeat operative exploration and necrosectomy under general anesthesia. In these patients, after the initial necrosectomy, the débrided areas are packed with moistened sponges. If exposed, the splenic or superior mesenteric vessels are protected by interposition of a layer of nonadhesive dressing such as Adaptic (Systagenix; Gargrave, UK) or a thin layer of Silastic sheeting. Soft, closed-suction drains are positioned on top of the gauze packing to evacuate free fluid that might otherwise accumulate and increase intra-abdominal pressure.
- Abdominal wall closure proceeds with a zipper sewn to the fascia, which not only speeds opening and closure during any planned operative redébridement but also maintains the abdominal domain between débridements, facilitating delayed primary wound closure and pulmonary ventilation. We specifically avoid sewing the zipper to the skin, because doing so allows the fascia to retract laterally, making later fascia closure more difficult or impossible. Reoperation is planned for 48 hours after the current procedure and proceeds as described above. The zipper is opened, and the abdomen fully reexplored in a systematic fashion. Additional necrosectomy and blunt débridement are performed as needed. The process is repeated at 48-hour intervals until the necrotizing process has been arrested, as evident by cessation of suppuration and absence of necrosis.
- If the first necrosectomy is complete, as is usually possible when the necrosectomy occurs more than 21 days after the onset of pancreatitis, then the abdomen is closed without planned reexploration (Fig. 99.14).

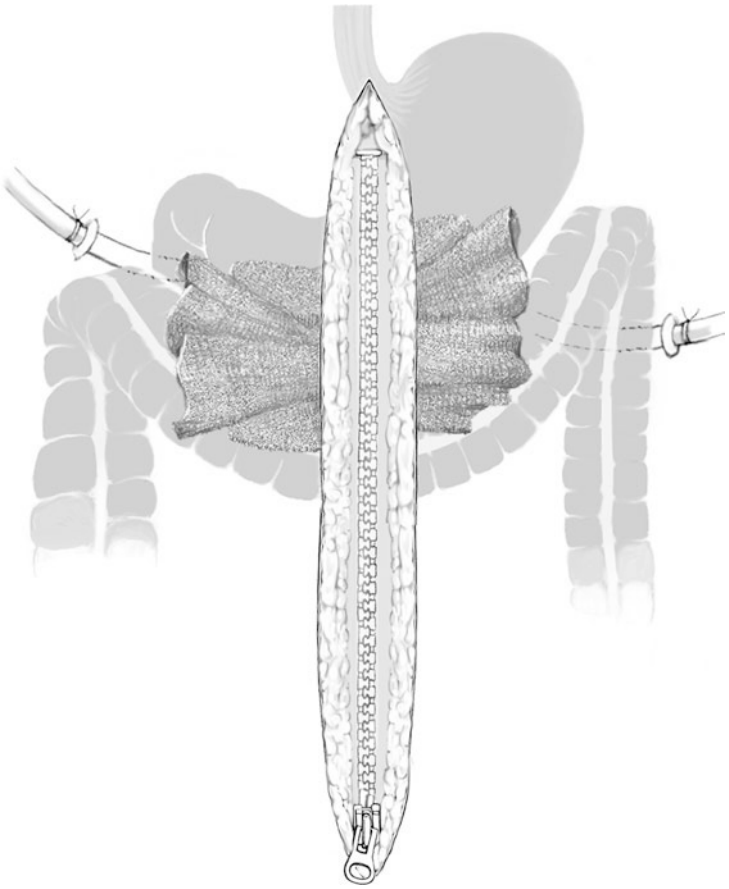


Fig. 99.14

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Step 6

Definitive abdominal closure

- When convinced that all necrotic debris has been removed, the abdomen is closed over drains. We prefer soft, closed-suction Silastic drains, which minimize risk of pressure necrosis of adjacent structures. We avoid large, stiff "sump" drains with large holes, because with our technique of late (rather than early) first necrosectomy followed by planned reoperations, only minimal particulate matter remains in the region and large bore drains are unnecessary.
- The drains should be positioned away from major vessels and from direct contact with the colon or small bowel. We are very liberal in the number of drains placed, with at least one drain in each anatomic area of necrosis. Drains are routed below the liver and posterior to the hepatic flexure on the right and posterior to the splenic flexure inferior to the lower pole of the spleen on the left. A gastrostomy tube for gastric decompression and a needle catheter jejunostomy for eventual enteral feeding are usually inserted.
- At final closure, the zipper is removed and the abdominal wall is closed with nonabsorbable suture. The skin remains packed open (Fig. 99.15).

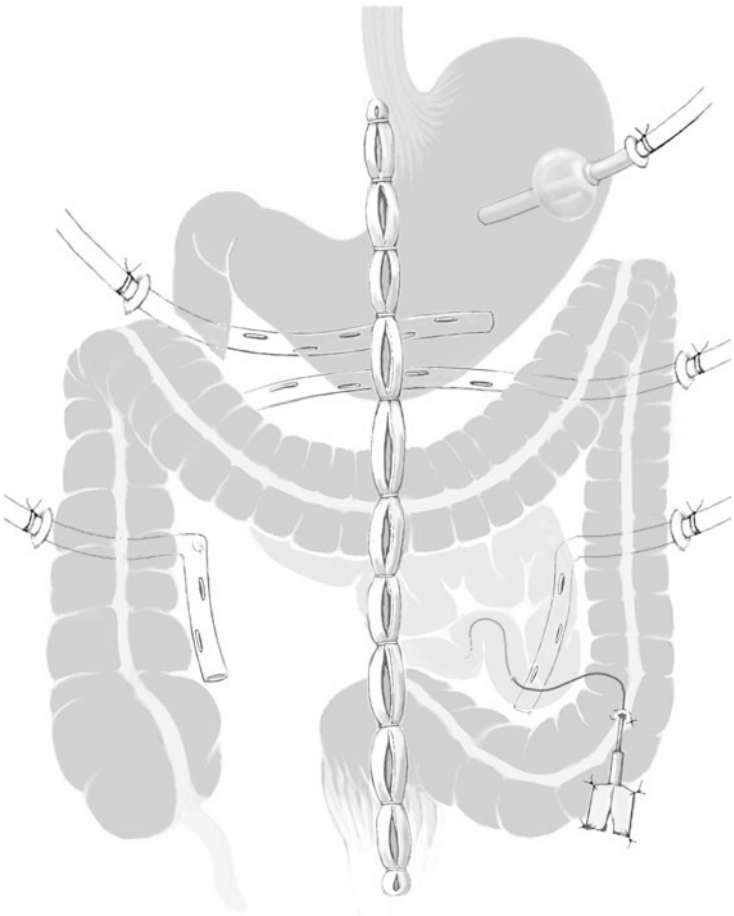


Fig. 99.15

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Procedure: Percutaneous Necrosectomy

C. Ross Carter, Euan J. Dickson

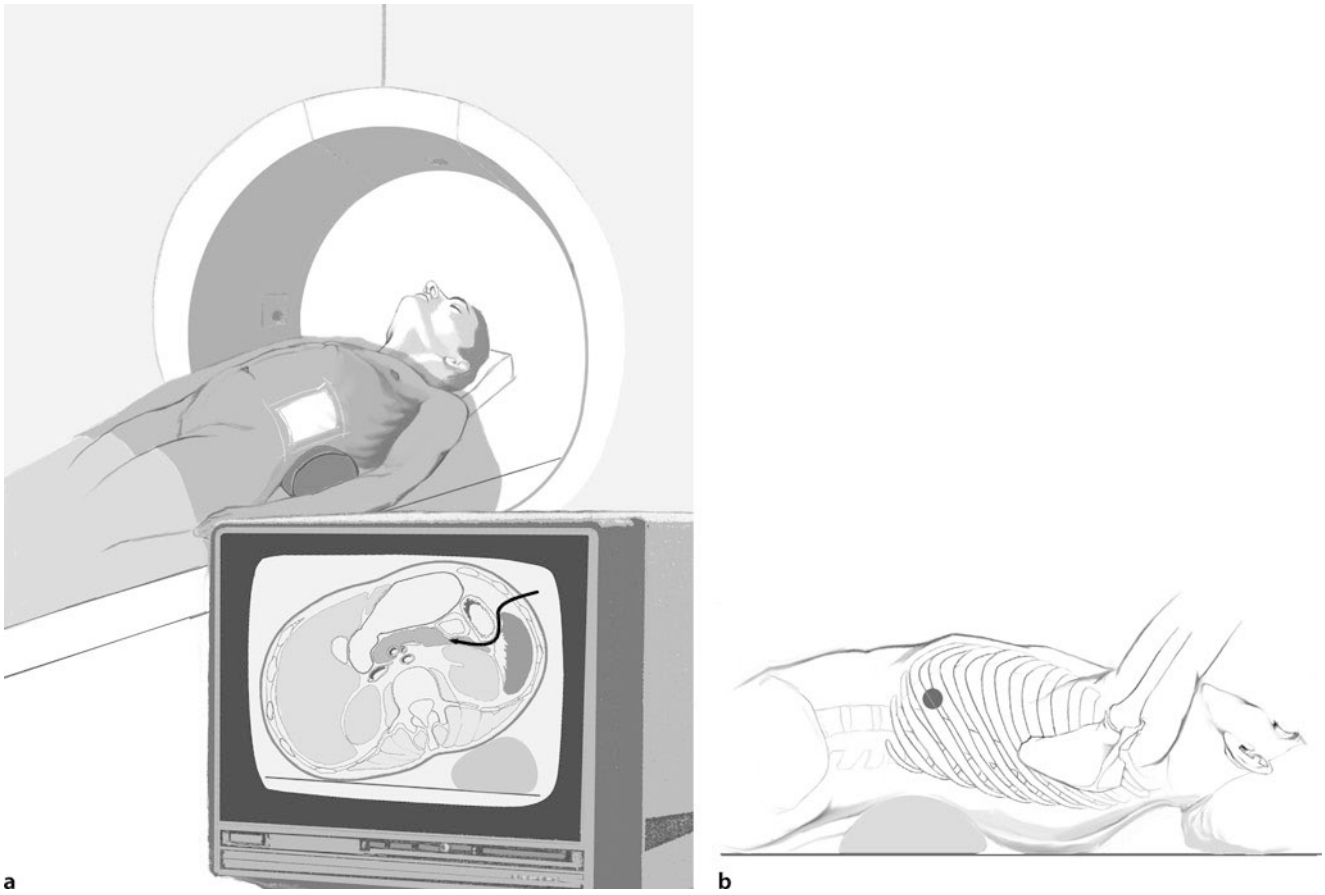
The development of minimal access techniques to surgical problems has been limited by technical difficulties. The goal of percutaneous necrosectomy is simply to achieve adequate control of sepsis, so we aim to remove only sufficient necrotic or infected tissues to maintain drainage and prevent catheter blockage.

This operative approach has several specific indications and contraindications. One specific indication is that the area of necrosectomy must be accessible to percutaneous puncture allowing dilatation of the needle tract. Specific contraindications include bowel ischemia, perforated viscus (not late fistula), or significant preoperative hemorrhage.

Step 1

Access (Fig. 99.16)

- Transfer the patient to the Radiology Department for a dual contrast CT scan of the abdomen with CT-guided puncture and insertion of an 8-Fr. drainage catheter.
- Sedation versus general anesthetic depends on the degree of organ dysfunction, site of access, and patient selection.
- Transfer the patient to the operating room.



a b

Fig. 99.16

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Step 2

Preparation of the nephroscope (necrosectoscope) (Fig. 99.17)

- Attach the suction to a three-way tap.
- Use a pressurized irrigation system with warmed fluid only.
- The patient should be positioned supine on the operating table. A sandbag is used to raise the side of the abdomen with the drain to allow horizontal access along the puncture tract.
- Use of a "barrier" nephrolithotomy theater drape to collect irrigant fluid is beneficial.
- General anesthesia is usually necessary.
- Pass a 0.035-mm wire along the 8-Fr. drainage catheter into the cavity.
- Exchange the 8-Fr. drainage catheter for a stiffener.
- Pass the dilatation balloon along the access tract or dilate the tract using a 10-mm balloon dilator.
- Insert a 34-Fr. Amplatz sheath over the largest dilator.

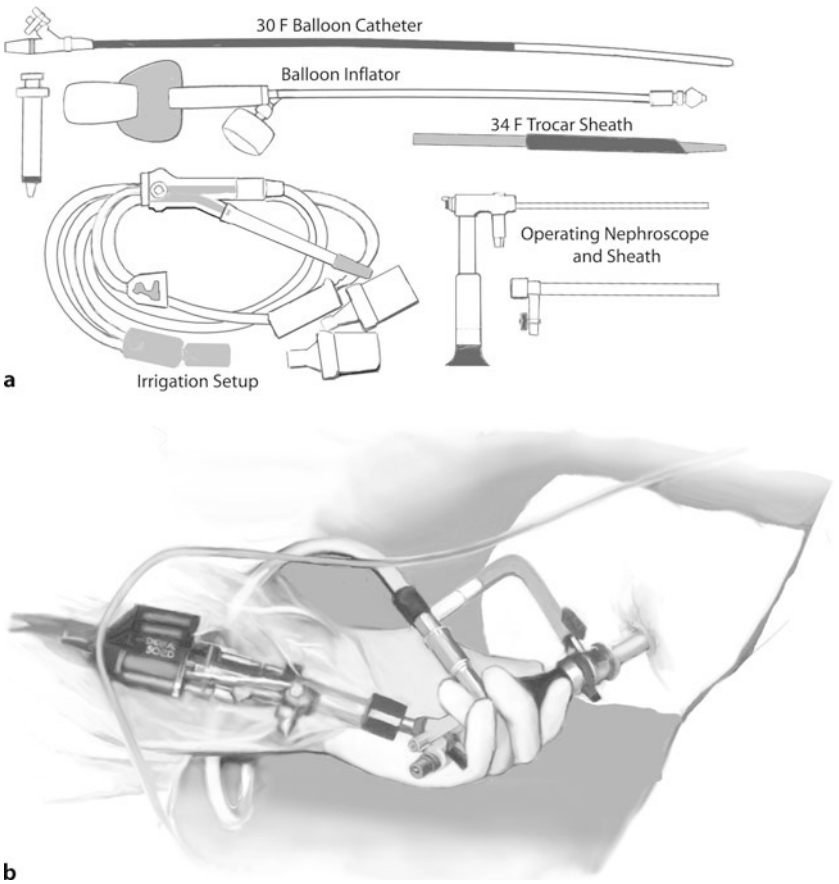


Fig. 99.17

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Step 3

Visualization and débridement of necrosis

- Gently insert the nephroscope along the Amplatz sheath to enter the cavity.
- The initial step is to lavage/aspirate the cavity to allow the pus-filled cavity to run clear. The goal at the first procedure is to achieve adequate drainage. No attempt is made to perform a necrosectomy, in an effort to avoid the risks associated with a prolonged procedure, including hemorrhage. At subsequent procedures, devitalized tissue is identified, and loose material is removed carefully with forceps.
- Use soft grasping forceps to avoid trauma.
- Adherent material is left in situ for removal at a subsequent exploration; overzealous débridement may result in major hemorrhage (Fig. 99.18).

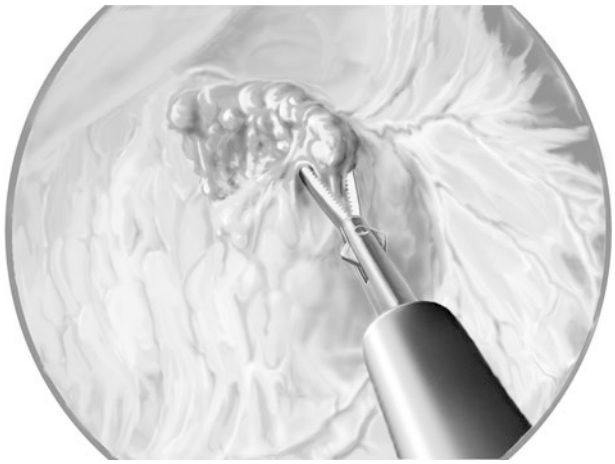


Fig. 99.18

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Step 4

Postoperative management of cavity

- Having removed all loose necrotic material, the guide wire stiffener is again passed along the dilated tract.
- A 32-Fr. soft tube drain is passed over the stiffener.
- An 8-Fr. umbilical catheter is sutured to the larger drain to allow continuous cavity lavage postoperatively.
- Cavity lavage is started at 250 mL per hour using dialysis fluid via a blood warmer.
- A median of three procedures per patient will be required prior to resolution. Steps 1 and 3 are omitted in later procedures, as the dilatation/access is not required. The Amplatz sheath is again not required (Fig. 99.19).

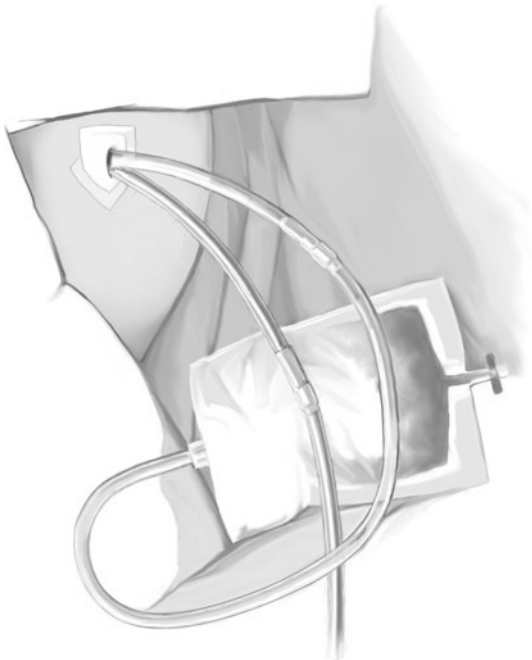


Fig. 99.19

Postoperative Considerations

- Close monitoring of physiology with organ support as indicated
- Appropriate antibiotic and antifungal therapy guided by cultures and clinical conditions
- Adequate nutritional support, preferably by the enteral route

Local Postoperative Complications

- **Short-term:**
- Pancreatic and gastrointestinal fistulae
- Recurrent peripancreatic abscess
- Colonic necrosis (abscess or fistula)
- Intra-abdominal hemorrhage
- Sepsis syndrome

- **Long-term:**
- Endocrine pancreatic insufficiency
- Exocrine pancreatic insufficiency

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- Pseudocyst (if present, usually from an isolated remnant or disconnected duct syndrome secondary to complete necrosis of the neck of the pancreas)
- Recurrent pancreatitis (rare)

Procedure: Step-Up Approach With Video-Assisted Retroperitoneal Necrosectomy

Hjalmar C. van Santvoort, Karen D. Horvath

Step 1

Retroperitoneal percutaneous catheter drainage

- A percutaneous catheter drain is placed in the peripancreatic collection of infected fluid and necrosis under CT guidance in the Radiology department (Fig. 99.20). The drain should be positioned via the patient's left flank through the retroperitoneum. The minimum drain size required is 12 to 14 Fr. Upsizing to larger-bore drains of 18 to 22 Fr may be associated with higher success rates of preventing the need for necrosectomy. Drains should be flushed every 8 h with at least 50 mL of saline to promote gentle lavage of the collection, in addition to just keeping the drain patent. The effect of percutaneous drainage is awaited in the next 1 to 2 weeks, as approximately 30 % of patients will improve clinically and will not need further operative necrosectomy. If the patient's clinical condition does not improve (i. e., resolution of fever, decrease in white blood cell count, subsidence of organ failure), a second percutaneous catheter drainage procedure can be performed. If additional drainage is not feasible or does not lead to clinical improvement, the patient is prepared for a video-assisted retroperitoneal débridement (VARD) in the operating room (OR), the "step-up" concept.

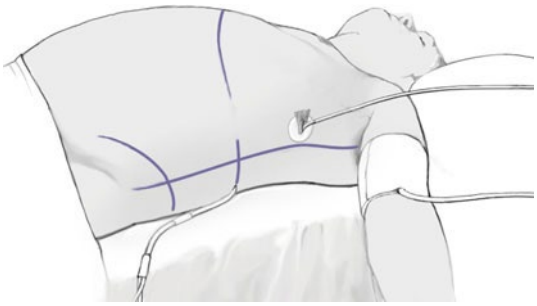


Fig. 99.20

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Step 2

Video-assisted retroperitoneal débridement

Positioning and incision

- A recent CT scan is displayed in the OR and is used as a road map during this procedure.
- The patient is positioned supine with the left side elevated 30 to 40 degrees using a bean bag or a roll; the left arm is draped medially and strapped into an airplane device (Fig. 99.21). The xiphoid, bilateral costal margins, anterior superior iliac spine, midaxillary line, and planned incision site are marked. The incision should be approximately 5 cm transversely centered over the midaxillary line near the exit point of the drain, ideally one finger breadth below the left costal margin. The entire abdomen and flank are prepared and draped so that conversion to laparotomy is possible if necessary.



Fig. 99.21

First débridement under direct vision

- After the incision, the lateral abdominal wall muscles are divided separately with electrocautery. The retroperitoneum is entered with the forefinger, and the drain is located and used as a guide to the peripancreatic collection (Fig. 99.22). Care should be taken not to go into the peritoneum, because the colon may be just anterior to the drain track. It may take several minutes of careful blunt dissection to reach the peripancreatic collection, which is opened by palpation with the finger staying right on top of the catheter drain. Purulent or "dirty" fluid and necrotic material are released from the cavity, which can be cleared using Yankauer suction. The cavity is then palpated gently; after blunt dissection with the finger, all visible necrosis is removed carefully with a ring-forceps under direct vision. Débridement at this stage should only be performed under direct vision, because any aggressive "blind" necrosectomy may result in injury of blood vessels or perforation of the overlying colon. A retractor can help to improve vision into the collection.

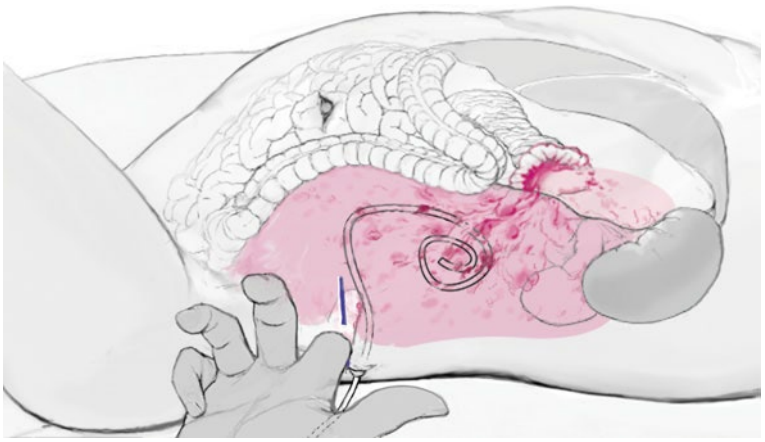


Fig. 99.22

Additional debridement under video assistance

- Once débridement under direct vision is no longer possible, a 10-mm, extra-long port without the trocar is placed into the wound under digital guidance. A 0-degree laparoscope

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Step 2 ***(continued)***

is used; a 30-degree laparoscope is not recommended because of the parallel arrangement of the laparoscope and the débridement and suction devices. Smudging of the laparoscope is minimized by keeping the lens of the scope inside the port and not in direct contact with fluid and necrosis in the cavity. Under video assistance, débridement is performed with a laparoscopic forceps introduced directly into the wound without the use of a port (Fig. 99.23). Frequent suction is performed with a Yankauer suction device held parallel to the forceps. Periodic use of a pulse lavage suction irrigator is helpful to facilitate hydrodissection of the necrotic cavity. It is important to correlate the location of débridement with the CT image and the tip of the percutaneous drain.

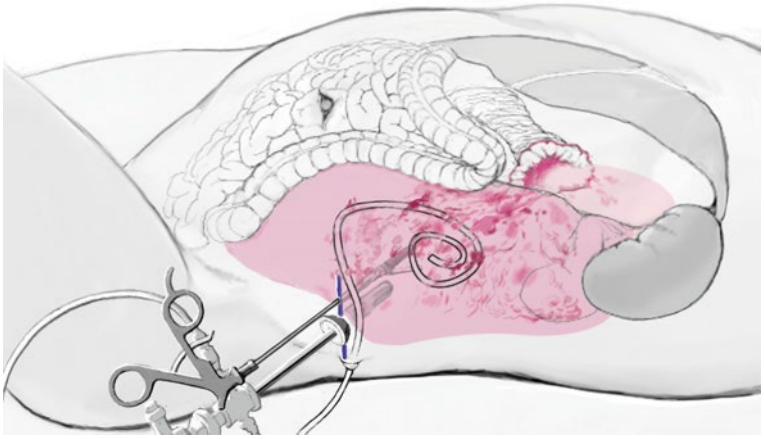


Fig. 99.23

Placement of drains for continuous postoperative lavage

- Once the débridement is finished, the loosely adherent necrosis is irrigated with several liters of saline. Final inspection with the laparoscope should exclude residual bleeding.
- Two 1-inch Penrose drains are inserted through the incision and positioned at different levels in the cavity. The percutaneous drain is left in place to deliver the postoperative lavage. The abdominal wall muscles are closed in separate layers with interrupted sutures to lessen risk of a flank incisional hernia, the skin is closed, and the Penrose drains are sutured in place. A urostomy appliance is placed over the wound and connected to a Foley urimeter.

Postoperative management

- A continuous lavage system is instituted postoperatively (Fig. 99.24). We infuse about 3 l of normal saline per 24 h on the first postoperative day, and increase to 6 l on day 2 and to 10 l on day 3 after the operation. Lavage is decreased and stopped eventually, when the clinical condition of the patient improves, the effluent is clear, or both.
- Most patients require only one débridement procedure. If the patient fails to improve by the second postoperative week, however, a CT scan can assess whether there is a remaining cavity with fluid and necrosis that requires additional débridement.

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Step 2 *(continued)*

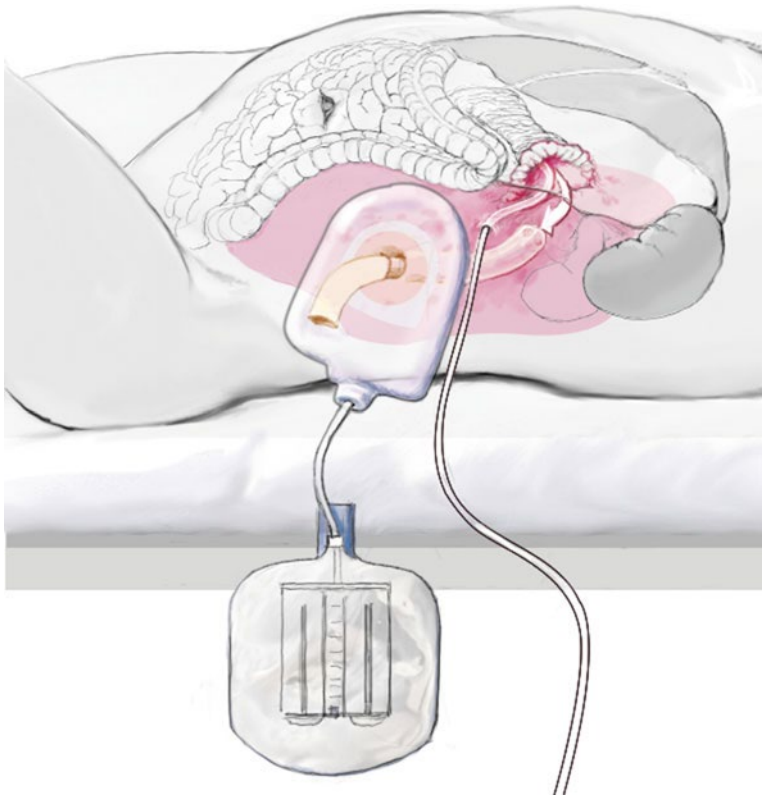


Fig. 99.24

Tricks of the Senior Surgeon

Open necrosectomy with closed postoperative lavage

- Blunt necrosectomy: Necrotic tissue is removed by blunt digital dissection without instruments; use of scissors increases the risk of excising tissue that is still viable; injuring portal, splenic, or mesocolic vessels; or causing difficult-to-control bleeding.
- Retroperitoneal necrosis: Even if the necrotic process in the retroperitoneum extends into the pelvis, blunt digital necrosectomy can be performed via an anterior, supracolic approach through the lesser sac, dissecting inferiorly, following the necrosis.
- Biliary pancreatitis: Endoscopic retrograde cholangiography (ERC) can be performed before necrosectomy in patients with gallstone pancreatitis, clearing the common duct of stones; thus only cholecystectomy is performed and exploration of the bile duct is omitted, reducing the risk of bile duct injury.
- Diverting ileostomy: With extension of the necrotic process behind the colon, we often perform a diverting ileostomy to reduce the risk of colonic fistula during the course of disease; intestinal continuity is restored 3 months after discharge.

Necrosectomy and closed packing

- Have the recent CT image in the operating room. It is your road map to be sure you do not leave collections of necrosis undrained.
- Bleeding inevitably ensues during the débridement. Unless it is copious, finish the débridement before attempting to stop it. It usually stops spontaneously or with the packing.

Planned repeated necrosectomy

- Resist operating early on patients with necrotizing pancreatitis, even if they have hemodynamic and metabolic instability. Make every effort to operate as late as possible, even with proof of infected necrosis, if the patient remains stable with maximal intensive medical therapy. The necrotizing process will have ceased and all viable and devitalized tissue will be defined. In such cases, a single complete necrosectomy and primary abdominal wall closure usually will be enough.

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- Operative planning based on the preoperative CT images is of paramount importance. All areas with fluid collections demonstrated on preoperative CT scans should be sought for, unroofed, and débrided. Do not rely solely on visual and manual exploration of the peritoneal cavity and the retroperitoneum.
- The initial necrosectomy offers the best possible exposure, so every attempt at a complete and safe necrosectomy should be pursued at this time.
- Resist the urge to "débride" a possible "bridge" of tissue traversing the lesser sac cavity after blunt necrosectomy, as this "bridge" probably represents the middle colic vessels.

Percutaneous necrosectomy

- Use of a "Level 1" fluid warmer provides pressurized warm fluid for intraoperative irrigation in order to obtain an adequate intracavitary view.
- Be prepared to come back another day rather than be overzealous with the initial or subsequent débridement.
- Clinically relevant arterial or venous bleeding may be encountered during débridement. This bleeding can usually be controlled by balloon tamponade while mesenteric angiography is arranged. The balloon should be deflated briefly during angiography in an effort to identify focal bleeding sites. Arterial hemorrhage is controlled with angiographic techniques. Venous bleeding is often managed by leaving the balloon inflated for 48 to 72 h. It may then be deflated under direct observation and monitoring. If no further bleeding is encountered, the balloon is removed after a further 24 h of inflation.
- Discontinue the procedure if the patient shows signs of cardiovascular instability: resuscitate the patient, lavage the cavity, and come back another day.

Step-up approach with video-assisted retroperitoneal necrosectomy

- Whenever possible, institution of the step-up approach, in which percutaneous drainage is followed if necessary by VARD, should be delayed to at least 3 to 4 weeks into the disease. This period allows for encapsulation of the peripancreatic collections with infected fluid and necrosis, facilitating necrosectomy and thereby decreasing the risk of complications such as bleeding and colon perforation.
- Correct positioning of the percutaneous catheter drain through the left retroperitoneum, with the entry point in the patient's flank just subcostally and the tip deep into the collection, is of paramount importance. This important point requires close communication with the radiologist, because the drain serves as a visible guide into the retroperitoneal collection during operation.
- A laparoscopy CO_2-insufflation line can be attached to the percutaneous catheter to create more working space in the cavity with a pressure at a maximum of 20 mm Hg.
- Complete débridement is not the aim of the initial necrosectomy procedure. Only loosely adherent necrosis should be removed, to prevent injury to adjacent blood vessels.
- If minor bleeding occurs during the procedure, visible vessels can be ligated with a laparoscopic clip applier. For major bleeding, the cavity should be promptly packed, and the patient transferred to the Radiology department for emergency angiography and possible coiling, or a celiotomy should be performed.

Acknowledgments

Waldemar Uhl and Clement W. Imrie contributed to this chapter in the first edition.

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Laparoscopic Staging of Periampullary Neoplasms

Kevin C. Conlon, Sean M. Johnston

The global concept of preoperative staging of malignancies is to select, as well as possible, those patients who are or are not candidates for operative resection. In the case of periampullary neoplasms, we have good, nonoperative palliation for patients with incurable neoplasms. A celiotomy for a periampullary neoplasm that proves to be nonresectable is not therapeutic and subjects the patient to a period of postoperative recuperation that can be considered unnecessary. Preoperative staging laparoscopy thus is valuable because it helps in selecting those patients who have the greatest chance for potentially curative resection while preventing celiotomy in most of those with unresectable disease.

Indications and Contraindications

Indications

- Assessment of resectability for:
  - Pancreatic cancer (adenocarcinoma): Head lesions larger than 3 cm or any head lesion with a CA 19-9 higher than 150 U/mL; all body and tail lesions
  - Distal bile duct cancer
  - Duodenal cancer
- Staging of locally advanced disease prior to chemoradiation
- Diagnosis of suspected metastatic disease
- Histologic confirmation of radiologically unresectable disease

Relative contraindications

- Patient unfit for general anesthesia
- Multiple previous upper abdominal operations
- Intra-abdominal sepsis
- Coagulopathy

Preoperative Investigation and Preparation for Procedure

- *History:* Jaundice, weight loss, abdominal pain, early satiety
- *Clinical evaluation:* Signs of jaundice, cachexia, epigastric mass, ascites
- *Laboratory tests:* Liver function tests (albumin, total protein, bilirubin, alkaline phosphatase, transaminases), coagulation parameters (PT, APTT), urea and electrolytes, full blood count, C-reactive protein, tumor markers (CA 19-9, CEA)
- *Radiologic assessment:* Ultrasonography; contrast-enhanced, dynamic, thin-cut CT imaging of the pancreas and liver in selected patients; endoscopic ultrasonography (EUS), endoscopic retrograde cholangiopancreatography (ERCP); magnetic resonance cholangiopancreatography (MRCP)
- *Instruments and laparoscopes:*
  - 30-degree angled laparoscope, either 10 mm or 5 mm
  - 5-mm laparoscopic instruments
  - Maryland dissector
  - Blunt tip dissecting forceps
  - Cup-biopsy forceps
  - Atraumatic grasping forceps
  - Liver retractor

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- Scissors
- 10-mm suction device
- Laparoscopic ultrasound probe (optional)

Procedure: Laparoscopic Staging

Step 1

Positioning

- The patient is positioned supine on the operating table. A warming blanket is placed beneath the patient, who is secured appropriately to the table (Fig. 100.1).
- Requirements:
  - General anesthesia
  - Orogastric tube for stomach decompression
  - Urinary catheter (optional)
  - Anesthetic equipment on boom or freestanding cart

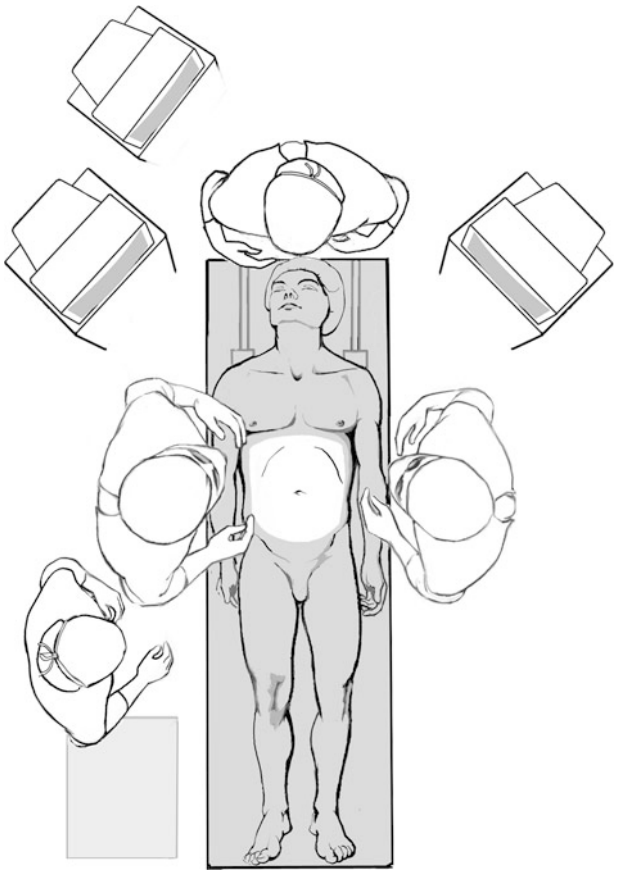


Fig. 100.1

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Step 2

Trocar placement

- A multiport technique is used. The initial trocar (10-mm blunt port) is placed using an open cutdown, usually in the infraumbilical area. After the skin and subcutaneous tissue are divided, the fascia is grasped between two forceps and incised with either a knife or cautery, opening the peritoneum under direct vision.
- Some form of blunt, Hassan-type port is inserted and secured in place; a pneumoperitoneum is established with CO_2 gas. An intraperitoneal pressure of 10 to 12 mm Hg is considered optimal.
- The laparoscope is inserted and an initial examination of the peritoneal cavity is performed. If no obvious metastases are seen, further ports are inserted in the right (10 mm and 5 mm) and left (5 mm) upper quadrant along the line of an intended incision.
- The 30° angled laparoscope is placed in the umbilical port, with the two 5-mm ports used for graspers, scissors, and liver retractor. The right lateral 10-mm port is used for the blunt suction irrigator. This instrument is particularly useful for retraction and "blunt" palpation. The lateral port is also used for the laparoscopic ultrasonography (Fig. 100.2).

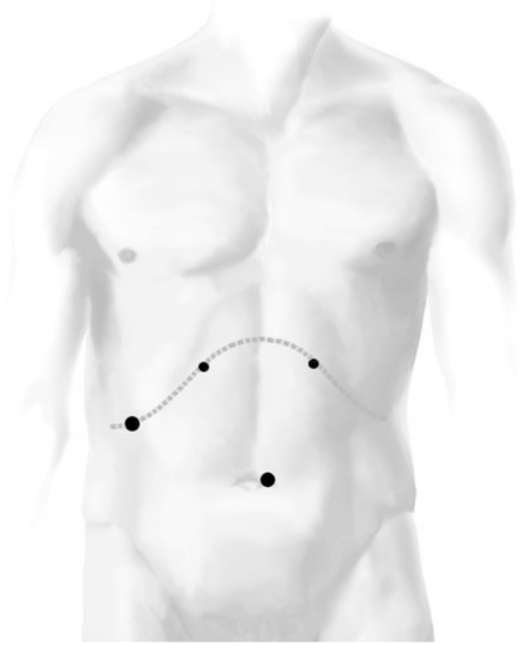


Fig. 100.2

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Step 3

Examination

- A systematic examination of the abdominal cavity is performed, which mimics that performed during open exploration. Adhesions, if present, are divided to facilitate examination. A cup biopsy forceps is used to take a specimen of any peritoneum-based mass.
- The sequence of examination is 1) peritoneal cavity; 2) left and right lobes of the liver; 3) duodenum and the foramen of Winslow; 4) colonic mesocolon and ligament of Treitz; and 5) gastrohepatic omentum, lesser sac, pancreas, gastric pillar, and hepatic artery (Fig. 100.3).

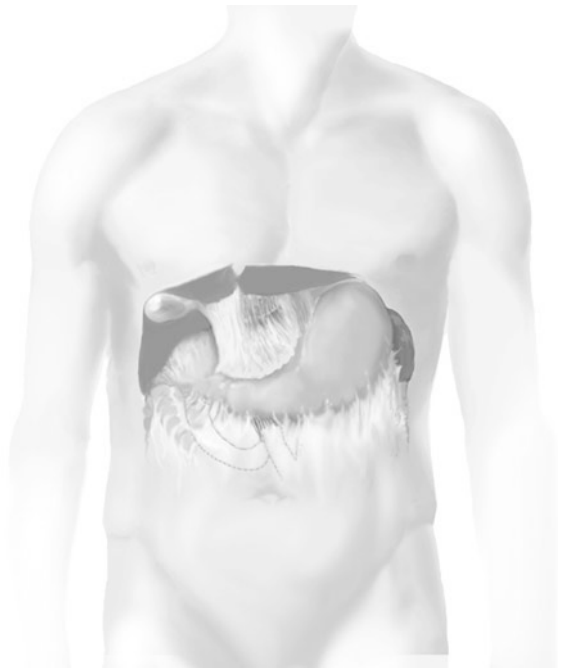


Fig. 100.3

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Step 4

Abdominal exploration (Fig. 100.4)

- After a general inspection of the peritoneal cavity, the patient is tilted approximately 10 degrees head up. Examination of the liver begins with the anterior aspect of the left lateral lobe (segments 2 and 3). Palpation is achieved with the 10-mm and 5-mm instruments. The posterior aspect of the left lateral lobe and the anterior and inferior aspects of the right hepatic lobe are then examined in turn.

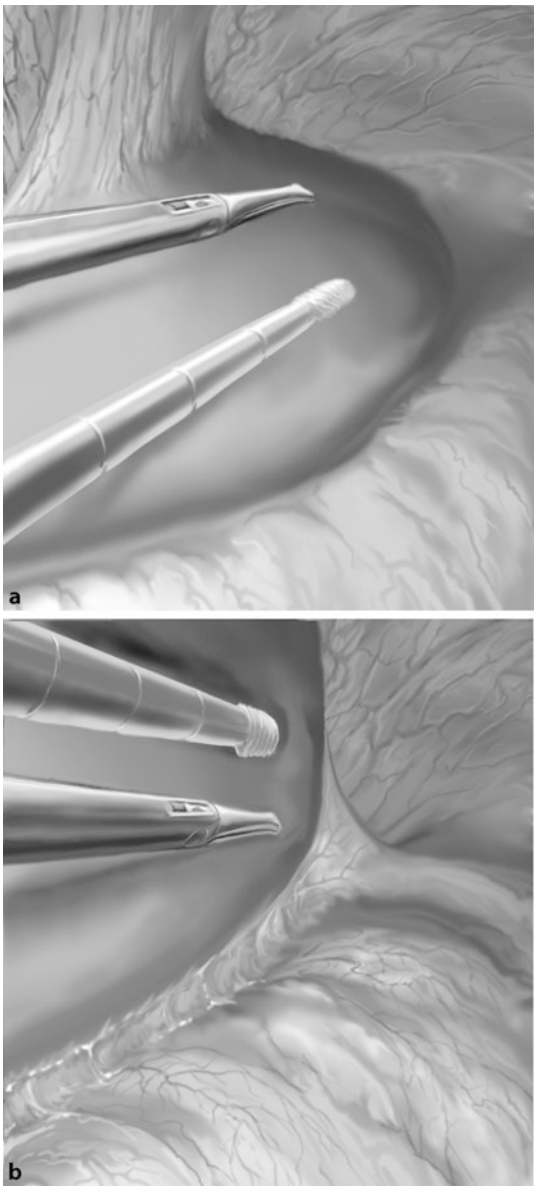


Fig. 100.4

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Step 5

Inspection of the liver hilus and foramen of Winslow

- The right lobe of the liver is elevated with the retractor placed through the left upper quadrant port. The structures of the hepatoduodenal ligament can be dissected out and a biopsy performed on suspicious nodes if indicated (Fig. 100.5).

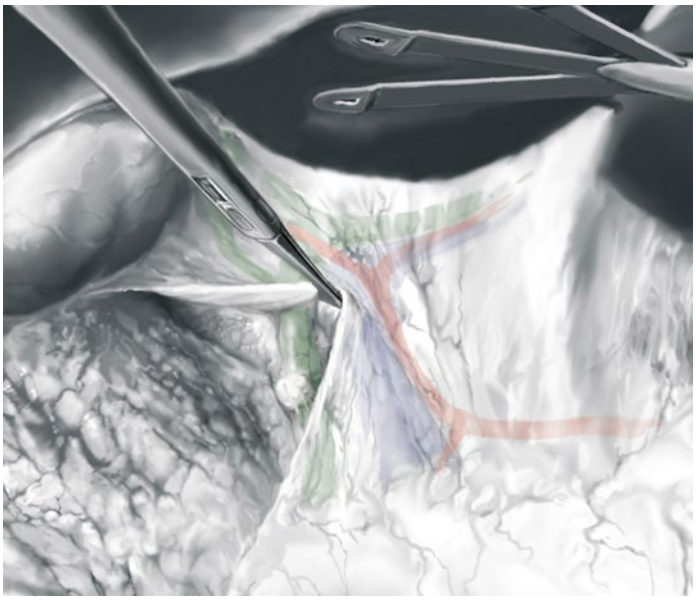
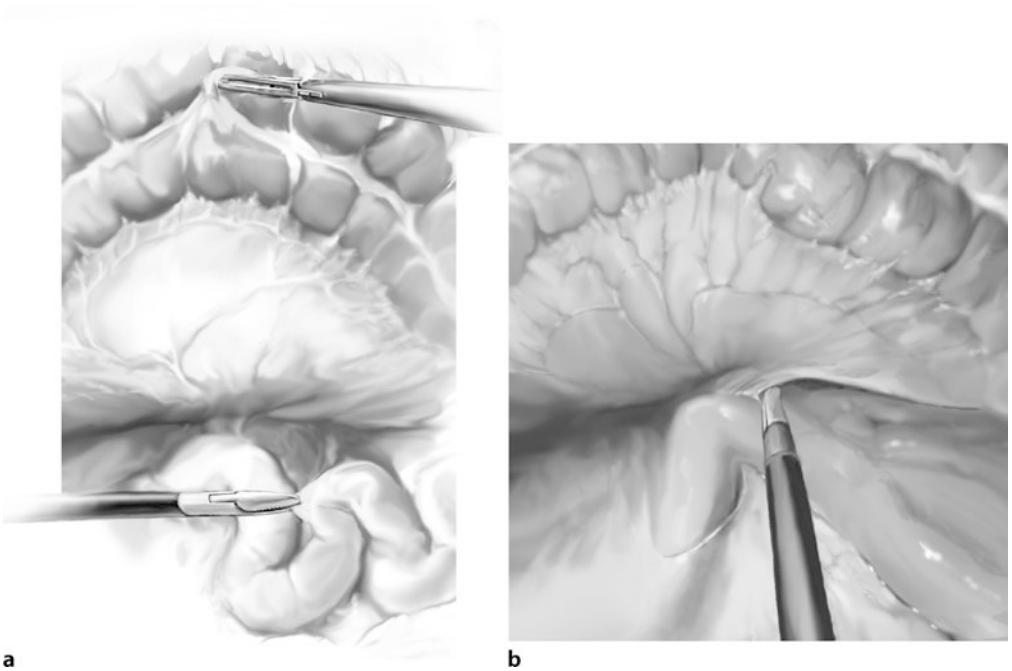


Fig. 100.5

Step 6

Examination of the colonic mesocolon (Fig. 100.6)

- The patient is now placed in 10 degrees of head down tilt. The omentum and transverse colon are retracted or pushed toward the left upper quadrant, which allows examination of the ligament of Treitz.



a b

Fig. 100.6

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Step 7

Examination of lesser sac

- The patient is now placed supine. The left lateral lobe of the liver is elevated with a 5-mm retractor placed through the left upper port. The gastrohepatic omentum is grasped, elevated, and incised. Care must be taken to identify and preserve an aberrant left hepatic artery if present (Fig. 100.7a).
- With the lesser sac opened, biopsies can be performed on suspicious nodes along the left gastric or hepatic arteries, if indicated. The neck and body of the pancreas can be examined (Fig. 100.7b).

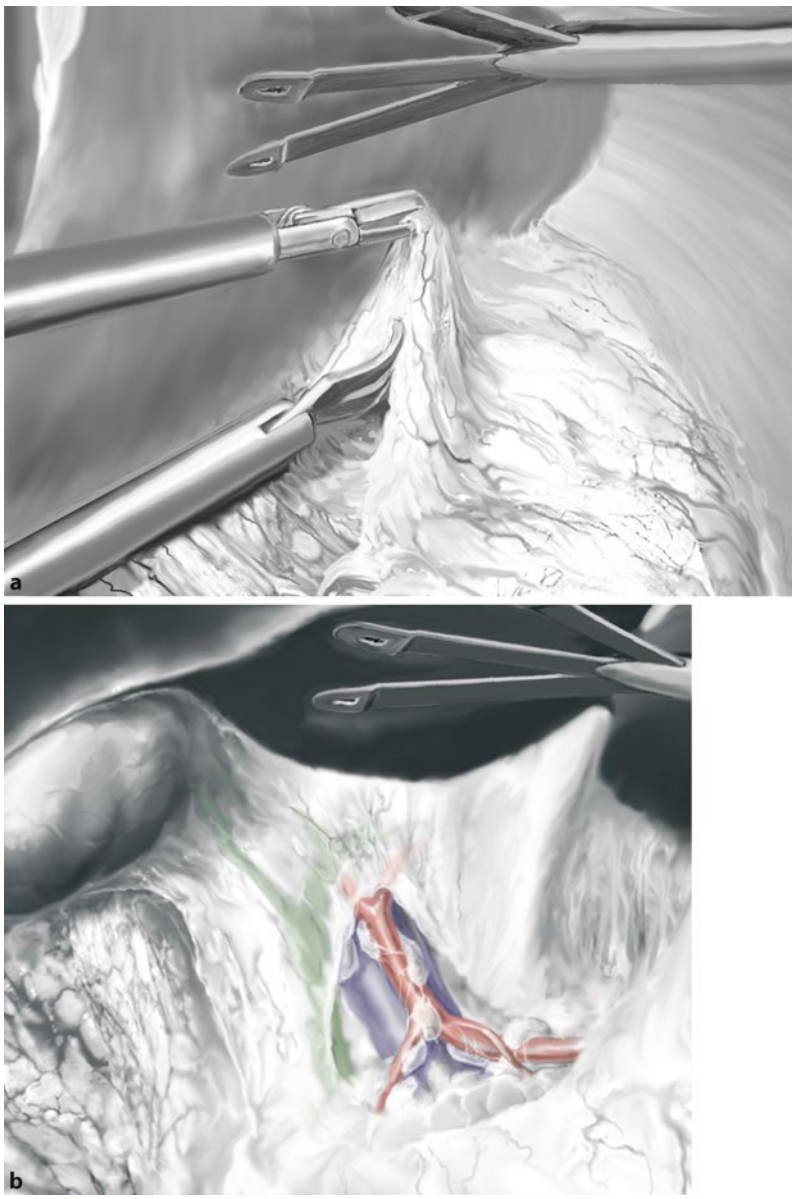


Fig. 100.7

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Step 8

Laparoscopic ultrasonography

- The laparoscopic ultrasound probe is inserted through the right lateral port. The examination starts with scanning of the left lateral lobe of the liver, examining segments I, II, and III in turn. Examination of the right lobe follows (Fig. 100.8a).
- The hepatoduodenal ligament is examined, with identification of the common hepatic duct, common bile duct, portal vein, and hepatic arteries (Fig. 100.8b). Visualization of these structures is aided by the use of color flow Doppler. The pancreas is then examined by slowly rotating the head of the transducer. The relationship of the tumor to the pancreatic duct and surrounding peripancreatic vessels (portal vein, superior mesenteric vein, superior mesenteric artery) can be determined.

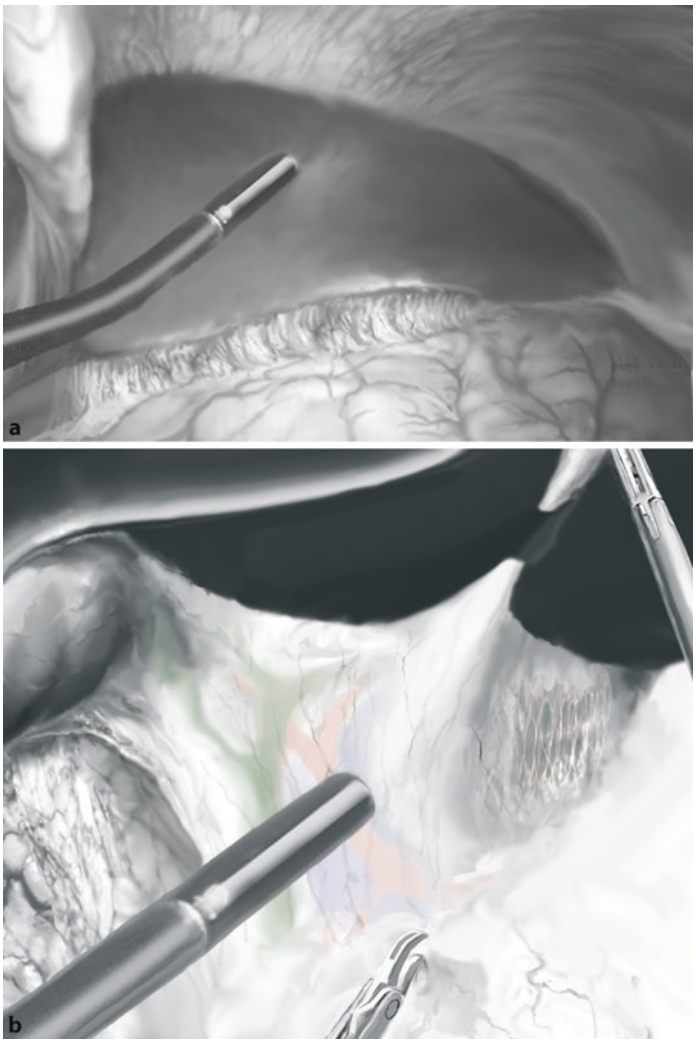


Fig. 100.8

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Postoperative Tests

- This should be an outpatient procedure.
- Laboratory investigation may be unnecessary.

Local Postoperative Complications

- Monitor for usual problems after laparoscopy: shoulder pain, infection or hernia at trocar sites.
- Severe pain or fever should not occur; if present, aggressive evaluation is required to look for inadvertent injury to an abdominal viscus during the laparoscopic procedure.

Tricks of the Senior Surgeon

- Be patient and move slowly. Metastases are often small and may be missed with a cursory examination.
- Maintain hemostasis; blood absorbs light and obscures the anatomy.
- A single-port examination is inadequate. Multiple ports are required for the appropriate exposure to be obtained.
- Mobilization of the duodenum is not required.
- Place the 10-mm port as lateral as possible in the right upper quadrant. Doing so will allow the ultrasound probe to be placed directly at right angles over the hepatoduodenal ligament, making identification of the bile duct and vessels easier.

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Distal Pancreatectomy

*Woody Denham, R. Matthew Walsh**

Although distal pancreatectomy for diffuse chronic pancreatitis has gone out of favor, there are still selected situations in which a localized, anatomic distal pancreatectomy is indicated. The following two procedures describe open and laparoscopic techniques, each of which may have selected indications or contraindications.

Indications and Contraindications

Indications

- Chronic abdominal pain due to chronic pancreatitis completely or predominantly confined to the body or tail of pancreas (e.g., due to posttraumatic or postnecrotic stricture of the main pancreatic duct)
- Adenocarcinoma arising from the tail of the pancreas
- Pancreatic ascites from ductal disruption of the body/tail region
- Pancreatic pseudocyst in the distal body/tail region

Contraindications

- Diffuse changes of chronic pancreatitis throughout the gland
- If diffuse changes are present in the gland with predominance of disease in the left gland (e.g., alcoholic pancreatitis with a left-dominant, midgland stricture or a complex pseudocyst in the mid or distal pancreas), distal pancreatectomy may occasionally be appropriate, but the results are variable
- For laparoscopic approach: left-sided sinistral portal hypertension, multiple previous intra-abdominal operations with multiple adhesions

Preoperative Investigation and Preparation for the Procedure

- *History:*
  - Search for a history of pancreatic trauma and previous or current alcohol abuse, chronic abdominal pain, steatorrhea, diabetes, family history of pancreatitis or pancreatic cancer, and use of narcotic pain medication.
  - If narcotic or alcohol dependency is active, encourage commitment to undergo postoperative detoxification in a controlled chemical dependency unit.
- *Clinical evaluation:* Abdominal tenderness or mass, splenomegaly (suspect splenic vein thrombosis)
- *Laboratory tests:* CBC, glucose, serum calcium, triglycerides
- *Imaging:*
  - CT, MRI or endoscopic ultrasound (EUS): Assess the extent of parenchymal disease (should be confined to body/tail); if splenomegaly or gastric varices are present, suspect splenic vein thrombosis.
  - ERCP: Evaluate for a midpancreatic ductal stricture and an intrapancreatic biliary stricture.
- *Preoperative considerations:*
  - If splenectomy is planned, immunize with pneumococcal vaccine, *Haemophilus influenzae* type b vaccine, and meningococcal vaccine 2 weeks preoperatively.

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- Entertain use of an epidural catheter for postoperative pain control. (Preoperative narcotic dependence is a relative contraindication, because the patient will need systemic levels of the narcotic.)
- Deep vein thrombosis (DVT) prophylaxis with sequential compression devices and/or subcutaneous heparin (check with anesthetist regarding policy on heparin in patients with postoperative epidural analgesia).
- Prophylactic intravenous antibiotics are given 30 min prior to incision.

Procedure: Distal Open Pancreatectomy with Splenectomy

Woody Denham

Step 1

Initial exposure, entering the lesser sac (Fig. 101.1)

- Selection of a bilateral subcostal or midline incision depends on the surgeon's preference.
- After full abdominal exploration, self-retaining retractor systems (e.g., the Buckwalter) aid by retracting the costal margin cephalad.
- The lesser sac is entered by dissecting the greater omentum off the transverse colon and retracting it rostrally with the stomach.
- Ligate and divide the more distal short gastric vessels between the stomach and splenic hilum; higher short gastric vessels are easier to manage once the spleen is mobilized (Step 5). These maneuvers expose the body and tail of the pancreas. The use of alternative energy sources may facilitate this and other parts of the resection.
- Subsequent dissection is facilitated if the splenic flexure of the colon is fully separated from the omentum and retracted inferiorly.

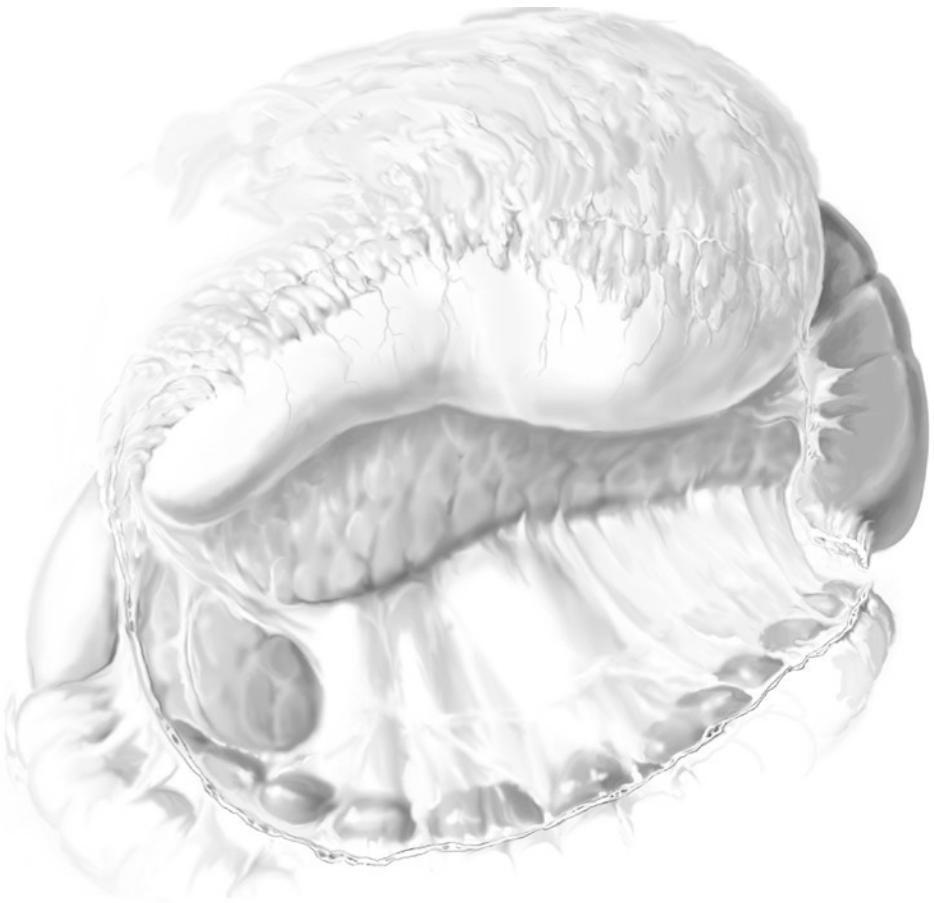


Fig. 101.1

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Step 2

Identification of the superior mesenteric vein, mobilization of the inferior edge of the pancreas

- The middle colic vein is followed downward to localize the superior mesenteric vein (SMV).
- The SMV should be freed below the edge of the pancreas and followed beneath the neck of the pancreas; this maneuver ensures easy division of the neck of the gland later.
- The peritoneum along the inferior border of the pancreas is incised; the body/tail of the pancreas is elevated by gentle sharp dissection behind the gland (Fig. 101.2).
- At this point, the decision to proceed with the resection from the patient's left to right or right to left is made. The following description is the classic prograde resection (left to right).



Fig. 101.2

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Step 3

Mobilization of the spleen (Fig. 101.3)

- The spleen is mobilized anteriorly by dividing the lateral peritoneal attachments.
- Splenic attachments to the colon (splenocolic ligament) and diaphragm are then divided.
- Residual short gastric vessels from the upper pole of the spleen to the stomach are divided; the stomach is retracted superiorly out of the field, fully exposing the distal pancreas.

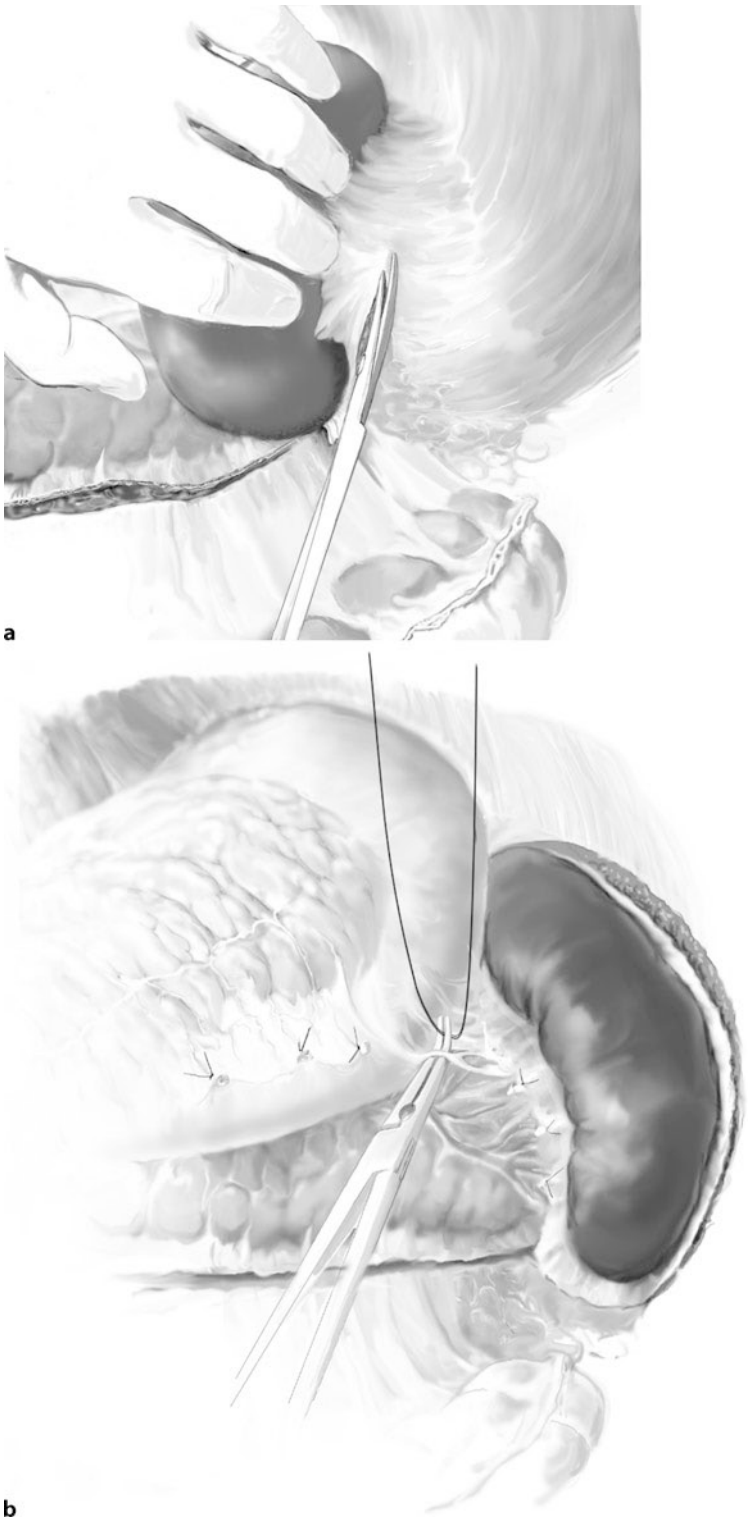


Fig. 101.3

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Step 4

Mobilization of the distal pancreas (Fig. 101.4)

- The spleen and distal pancreas are mobilized to the patient's right side; it is important to stay between the kidney and the tail of the pancreas, leaving Gerota's fascia undisturbed posteriorly.
- After initial mobilization, the hand enters the retropancreatic space created in Step 3.
- Retroperitoneal attachments along the upper border of the pancreas are ligated and divided until the origin of the splenic artery is reached; location of this artery is ascertained by palpation.
- The spleen and pancreas are held upward and to the patient's right, so the surgeon can visualize the posterior aspect of the gland and identify the splenic vein as it courses along the back of the gland.

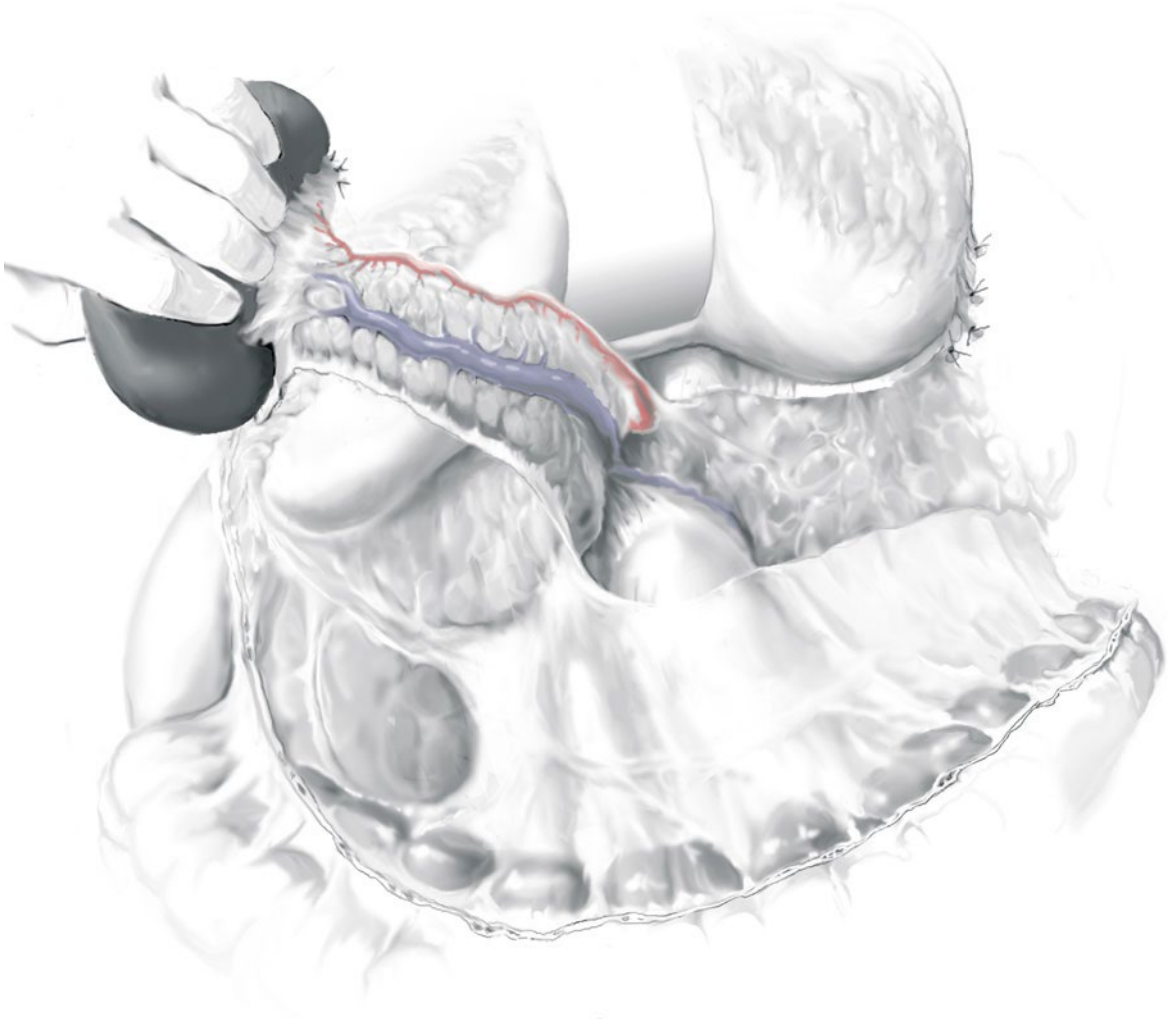


Fig. 101.4

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Step 5

Ligation of the splenic artery (Fig. 101.5)

- Along the upper border of the pancreas, the splenic artery is isolated near its origin from the celiac axis before it enters the pancreatic substance; here it is suture-ligated proximally with 2-0 suture, ligated distally, and divided. A vascular stapler can also be used. Be certain to fully identify the artery as the splenic artery and to clearly distinguish it from the common hepatic artery.

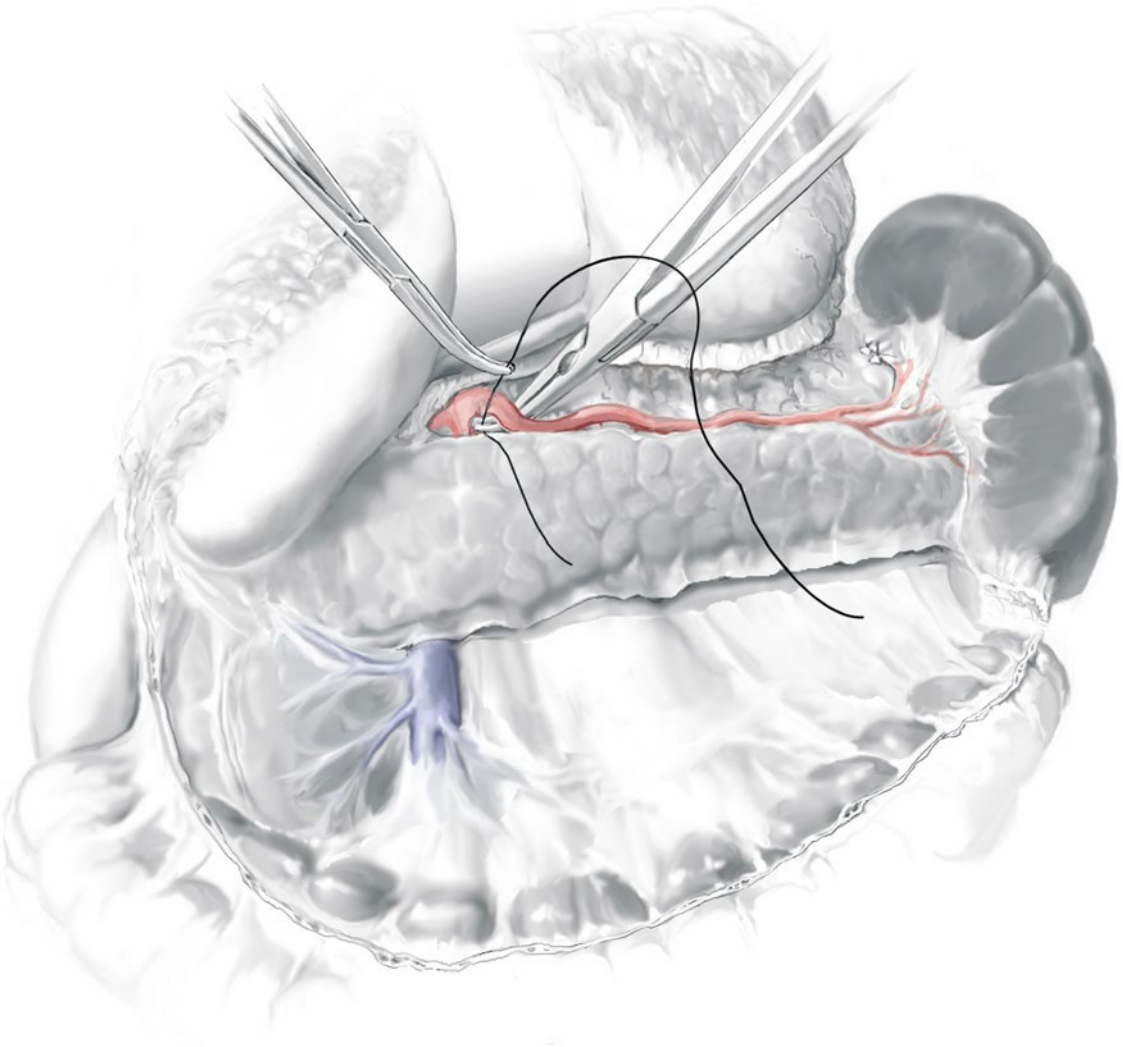


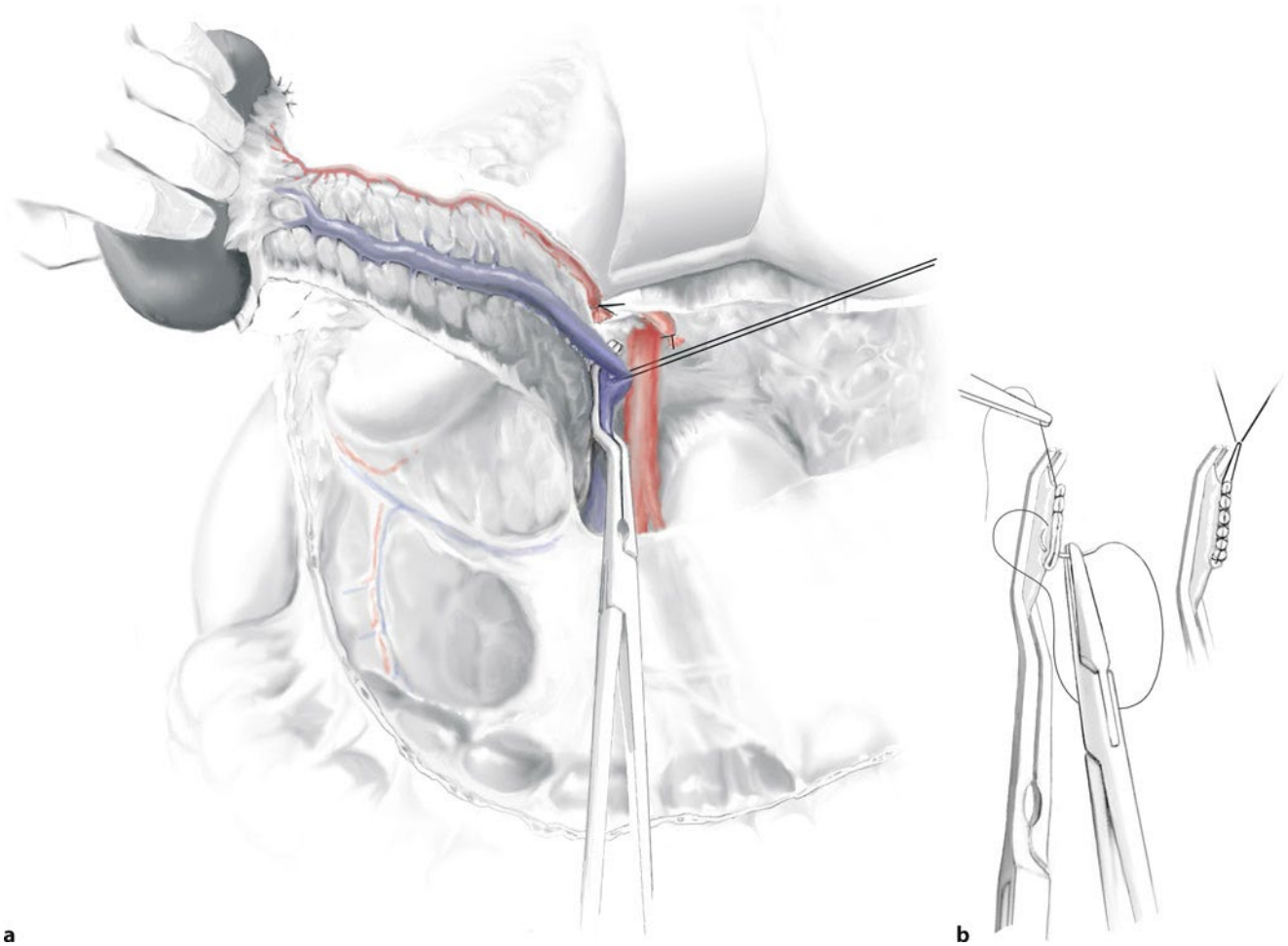
Fig. 101.5

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Step 6

Isolation/ligation of the splenic vein (Fig. 101.6)

- Moving to the inferior and posterior edge of the gland, dissection of the peripancreatic soft tissues continues until the confluence of the splenic vein and SMV is visualized.
- The inferior mesenteric vein (IMV) is ligated and divided if it joins the splenic vein directly or if it interferes with ligation of the splenic vein close to the origin with the SMV. (This is usually not the case.)
- Tissues around the entrance of the splenic vein into the SMV are carefully dissected off the vein. A Satinsky, side-biting vascular clamp is placed on the SMV–portal vein junction; the splenic end of the splenic vein is tied with 2-0 suture.
- The splenic vein is divided between ligature and clamp, being sure to leave the cuff of vein extending beyond the jaws of the clamp.
- The proximal end of the splenic vein is oversewn with continuous 5-0 polypropylene suture, and the vascular clamp is then removed.
- A vascular stapler may also be used.



a b

Fig. 101.6

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Step 7

Division of the pancreas (Fig. 101.7)

- The neck of the pancreas is divided over the SMV-portal vein using electrocautery; a large clamp behind the neck of the pancreas protects the vein. Alternatively, devices using radiofrequency energy for tissue coagulation are being utilized prior to dividing the gland.
- If a neoplasm is suspected, a margin of at least 1 cm to the left of any mass must be maintained and checked with frozen section of the transected margin.
- Marginal or intraparenchymal arteries supplying the pancreas that bleed after the parenchyma is divided are controlled with suture ligatures.
- Once the cut edge of the pancreas is hemostatic, the pancreatic duct orifice is identified and ligated with 3-0 polypropylene.
- The cut edge of the pancreas is closed with a continuous running suture of 3-0 polypropylene.
- Other methods to transect and "close" the cut edge of the pancreas include using a linear stapler or techniques of tissue welding. A soft, closed-suction drain is placed adjacent to the cut edge of the pancreas and brought out through the left lateral abdominal wall.
- The abdominal wall is closed in layers.

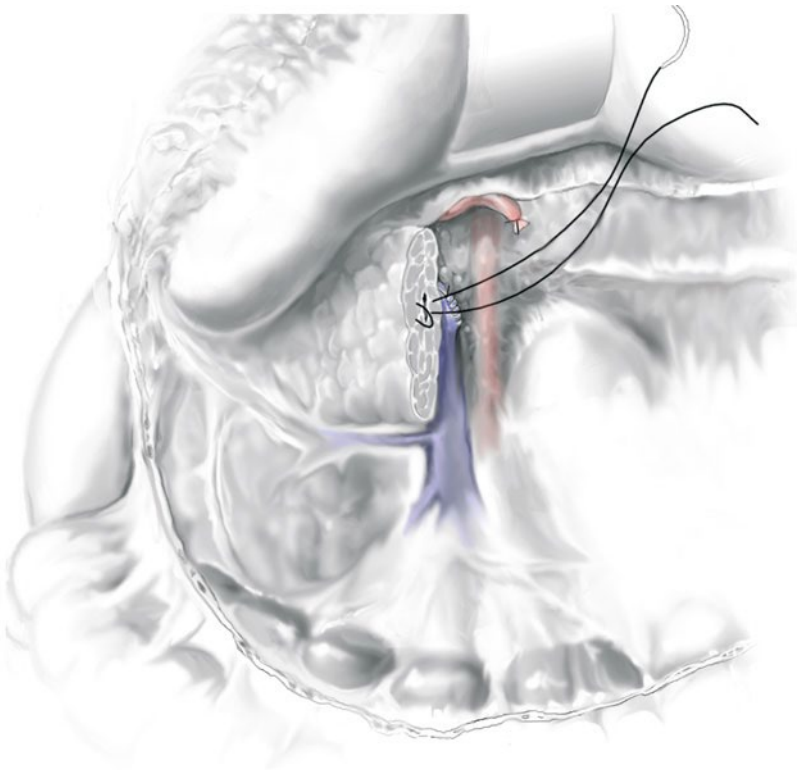


Fig. 101.7

Procedure: Distal Pancreatectomy with Splenic Preservation

Preserving the spleen during removal of the body or tail of the pancreas in patients with chronic pancreatitis is difficult; scarring around the splenic vein may make dissection and preservation of the vein difficult and even dangerous. If a malignant neoplasm is suspected, the spleen and splenic vessels should not be preserved, but if the distal pancreatectomy is for pain, there is no suspicion of malignancy, and the splenic vein is patent, an attempt to preserve the spleen is justified. The course of the operation is quite different when splenic preservation is the goal:

- After entering the lesser sac, the operation commences with division of the pancreatic neck over the isolated SMV-portal vein, and the mobilization proceeds from the patient's right to left.

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- The spleen is not mobilized; the body/tail of the pancreas is dissected from the point of division of the gland toward the spleen by dividing the multiple small branches entering the splenic vein from the pancreatic parenchyma.
- Branches of the splenic artery entering the pancreas are divided individually as dissection progresses to the patient's left.
- Before proceeding with dissection of the body/tail of the gland from the splenic vessels, it is wise to gain control of both the proximal splenic vein near its entrance to the SMV and the splenic artery near its origin; expeditious vascular control can be obtained if bleeding becomes excessive during subsequent dissection.
- Splenic venous branches are small, delicate, and easily torn; they are controlled best with fine vascular staples or fine ties of 4-0 or 5-0 silk or with use of alternative energy devices.
- The surgeon decides how much blood loss is acceptable when trying to preserve the spleen and should be willing to abandon this approach if necessary.

Procedure: Laparoscopic Distal Pancreatectomy

R. Matthew Walsh

The advent of minimally invasive techniques has now advanced to an era of minimally invasive approaches for all types of pancreatic surgery. Laparoscopic distal pancreatectomy has been the most widely applied of these procedures in pancreatic surgery and can be done with or without splenic preservation. There are variations to a minimally invasive approach, such as hand-assisted and robotic distal pancreatectomy, but a totally laparoscopic approach to pancreatectomy has the broadest applicability and is the most commonly performed. Requisites to successfully perform this procedure include advanced laparoscopic skills that include two-handed operative dexterity, facility at intraoperative suturing, familiarity with all manner of energy and stapling devices, knowledge of pancreatic anatomy, and experience with open pancreatic surgery.

Indications and contraindications

Indications

- Resectable pancreatic ductal carcinoma
- Functioning solitary neuroendocrine neoplasms
- Nonfunctioning pancreatic neuroendocrine neoplasms (PNEN) larger than 2 cm
- Symptomatic cystic pancreatic neoplasms or those with features suspicious for malignancy
- Symptomatic focal chronic pancreatitis

Contraindications

- Locally advanced pancreatic neoplasms that may require extended vascular or soft-tissue resection
- Extensive prior abdominal surgery with anticipated or known severe adhesions
- Severe complications of pancreatitis such as portal vein/SMV thrombosis or pseudocysts
- Untreated autoimmune pancreatitis
- Causes of diffuse pancreatitis (e.g., genetic abnormalities) that involve the entire gland

Preoperative Investigation and Preparation for the Procedure

- *History:* For suspected neoplasms, a history of extensive weight loss and back pain are important. For suspected PNEN, functional endocrine symptoms and family history of multiple endocrine neoplasia type 1 (MEN1) are important. Patients with suspected pancreatitis need to be assessed for the etiology of their disease, including genetic causes. Patients with alcohol as an etiology must have successfully completed a rehabilitation program, and the disease needs to be localized only to the distal gland.
- *Clinical evaluation:* Nutritional assessment, jaundice, hepatosplenomegaly, ascites, abdominal mass, supraclavicular lymphadenopathy.

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- *Laboratory tests:* CBC, liver function tests, albumin. Potentially important: serum IgG isoenzymes, CA 19-9, gastrin, chromogranin A, pancreatic polypeptide, insulin, genetic panel for pancreatitis.
- *Imaging:* CT, MRI/MRCP/EUS: to assess disease extent, pancreatic duct abnormality, metastatic disease, fine needle aspiration (FNA) for biopsy or cyst aspiration.
- *Preoperative considerations:*
  - All patients vaccinated for encapsulated organisms in anticipation that splenectomy may be required: *Haemophilus influenzae* type B, meningococcal, and polyvalent pneumococcal vaccines 2 weeks preoperatively.
  - DVT prophylaxis with pneumatic compression stockings and/or subcutaneous heparin.
  - Gentle bowel preparation
  - Prophylactic intravenous perioperative antibiotics

Procedure: Laparoscopic distal pancreatectomy

Step 1

Peritoneal access, port placement, entering lesser sac (Figs. 101.8 and 101.9)

- Nearly always, access to the peritoneal cavity is with use of a 5-mm optical trocar in the left upper quadrant. A 0-degree telescope is used for optical trocar entry, and it is important to place the trocar through the rectus abdominis to easily identify all abdominal wall landmarks. The entry site should be close to the costal margin and lateral enough to avoid the falciform ligament. This port site will eventually be replaced by a Nathanson retractor to retract the stomach.
- General inspection of the liver and peritoneum is performed to exclude metastatic disease. Four additional trocars (two 5-mm and two 10- or 12-mm) are then placed as outlined (Fig. 101.8). A 30-degree, angled 10-mm telescope is used thereafter. We do not use split-bed configuration but rather place the surgeon on the patient's left, with a single assistant on the right.
- The gastrocolic omentum is divided with an ultrasonic shears, sparing the gastroepiploic vessels. The omentum must be divided completely, including all short gastric vessels, and carried to the insertion of the right gastroepiploic vein into the SMV. Embryonic retroperitoneal attachments are divided medially. Both surgeon and assistant participate in this division depending on the angle approached. Retraction of the stomach and the omentum is achieved with locking graspers; this maneuver exposes the pancreas. When necessary, laparoscopic ultrasonography may be required to locate the lesion or investigate the extent of disease.

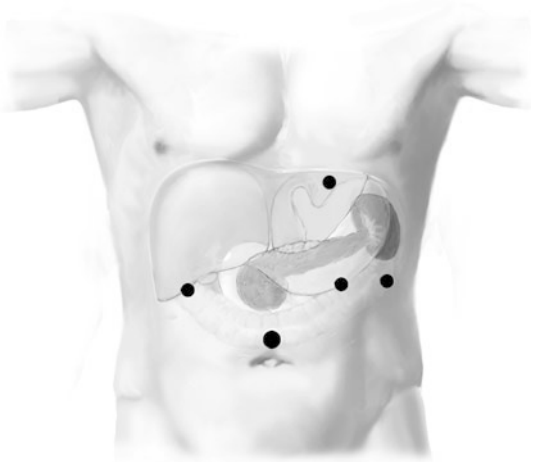


Fig. 101.8

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Step 1 *(continued)*



Fig. 101.9

Step 2

Identification of the SMV (Fig. 101.10)

- Nearly all neoplasms of the distal pancreas require division at the level of the pancreatic neck; this necessitates locating the SMV and developing a space between the neck and vein. This maneuver is best accomplished early in the operation, to assess resectability, and it is best achieved by identifying the junction of the right gastroepiploic vein and the SMV. This dissection is facilitated by retracting the antrum of the stomach anteriorly to place this vascular junction at a clear right angle. The SMV is then readily identified at the inferior margin of the pancreas; a blunt-tipped dissector develops the tunnel behind the pancreatic neck.

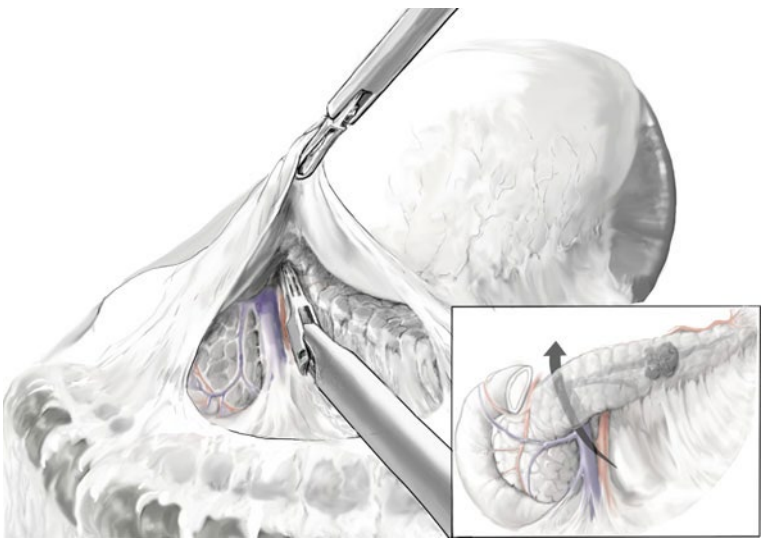


Fig. 101.10

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Step 3

Mobilization out to the splenic flexure (Fig. 101.11)

- The dissection then begins at the exposed SMV and is carried laterally along the inferior border of the gland, allowing elevation of the posterior margin of the pancreas out of the retroperitoneum. The ligament of Treitz should be identified, and typically the IMV can be divided between clips. Avoid progressing into the splenic hilum; rather, direct the dissection to the inferior pole of the spleen, which achieves initial mobilization of the spleen. Complete mobilization requires division of the lateral colon attachments.

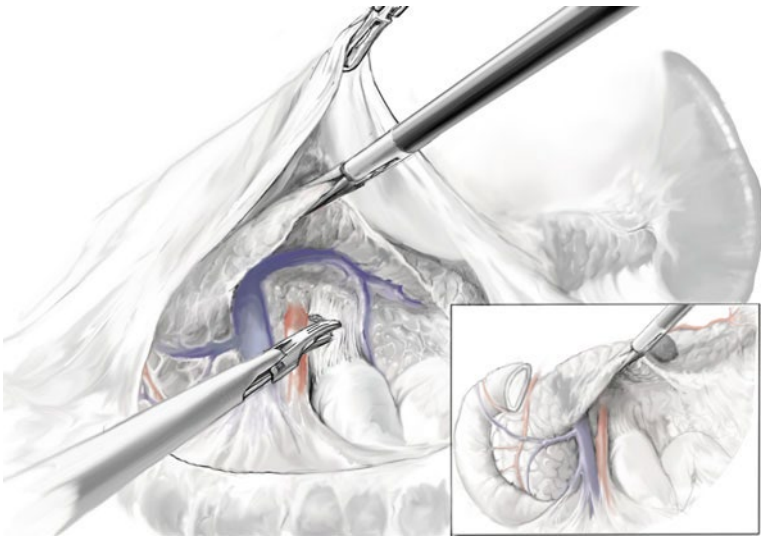


Fig. 101.11

Step 4

Division of the pancreatic neck (Fig. 101.12)

- To transect the pancreatic neck, the portal vein must be exposed at the superior margin of the pancreas by identifying the hepatic artery and excising its associated lymph node (Fig. 101.12a). This maneuver opens an avascular space where the portal vein can be identified; one must be wary of the inconsistent site of entry of the coronary vein into the portal system. After clearing a space superiorly and inferiorly, an Endo-GI stapler can be inserted (Fig. 101.12b). Selection of the correct stapler cartridge will depend on the gland thickness; the goal is not to fracture the gland with too short a staple length. Typically, the currently available maximal staple height is 4.3 mm, using a 60-cm stapler with Seamguard (W.L. Gore, Flagstaff, AZ, USA).

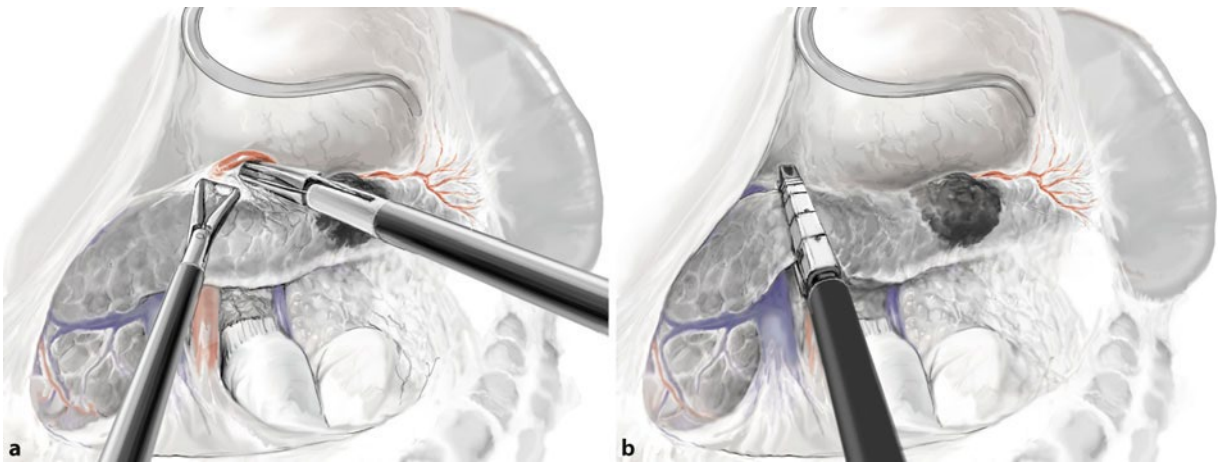


Fig. 101.12

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Step 5

Division of the splenic vessels (Fig. 101.13)

Dividing the pancreatic neck and retracting the neck inferiorly and laterally exposes the splenic artery and its origin. Circumferential dissection is achieved with a 10-mm angled dissector. The artery is divided usually with a vascular load Endo-GI, or on occasion between Weck clips. The artery transection precedes transection of the vein, to avoid splenic congestion and bleeding from the transected short gastrics. The splenic vein is then dissected circumferentially, with care taken to identify insertion of both the IMV and coronary veins. Division of the vein is similar to that of the artery.

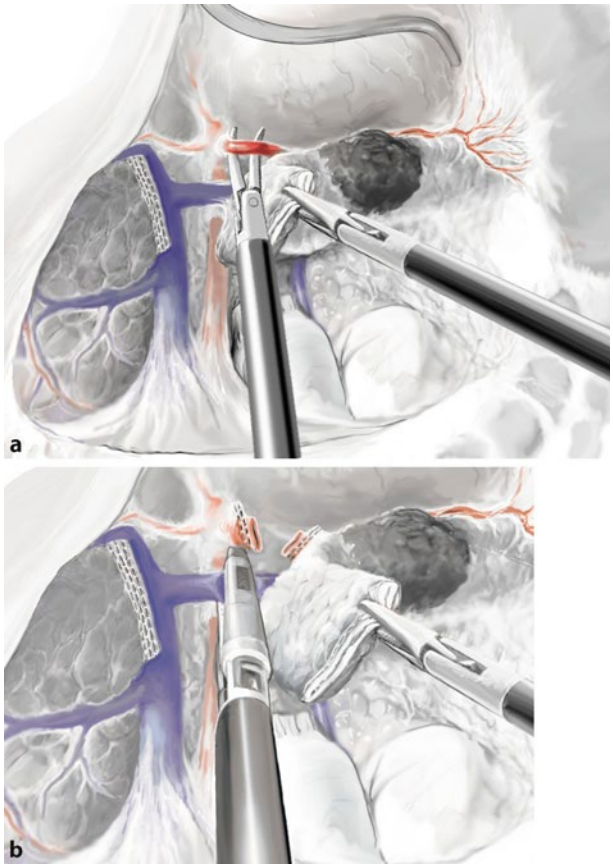


Fig. 101.13

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Step 6

Mobilization of body, tail, and spleen (Fig. 101.14)

- After division of the splenic vessels, the posterior retroperitoneal space can be dissected easily with the pancreas retracted anteriorly. The adrenal gland is avoided by its typical yellow color. The spleen is mobilized by continuing the posterior dissection laterally, although the most lateral diaphragmatic attachment may require rotating the spleen medially. This dissection is accomplished with ultrasonic shears.
- The spleen and pancreas are usually detached at the splenic hilum with the ultrasonic shears so that the pancreas can be delivered as an intact specimen and the spleen as a morcellated specimen. The pancreas is placed in a 10-mm endocatch bag and the spleen in a 15-mm endocatch bag (requiring removal of the trocar and direct placement of the device, or use of a 15-mm trocar). The pancreatic specimen should be inspected by the surgeon and the margin inked if necessary. Laparoscopic inspection should be done for bleeding, and a closed suction drain placed at the pancreatic margin. The orogastric tube is removed prior to emergence from anesthesia.

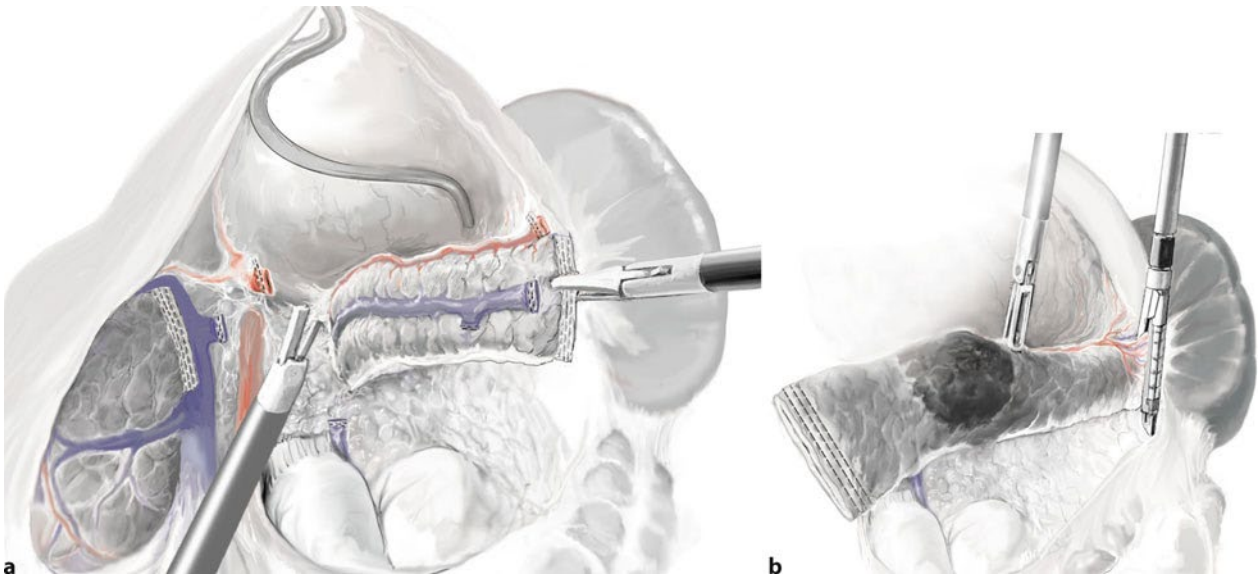


Fig. 101.14

Procedure: Splenic preservation

- Distal pancreatectomy with splenic preservation is possible in selected patients with benign disease. After transecting the neck of the pancreas, only the branches of the pancreas from the splenic artery and vein are controlled with the harmonic shears or clips. This can be a tedious and often impossible dissection if there is inflammation, but in the absence of inflammation, laparoscopic visualization is superior to an open approach.

Postoperative Care

- Patients are admitted to a regular surgical ward.
- Assessments are made for early bleeding.
- The Foley catheter is removed and oral diet initiated on the first postoperative day.
- Drain amylase is checked on post-op day 3 and drain is removed if there is no fistula.
- The patient can be discharged on the 3rd or 4th post-op day.

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Postoperative Complications

- **Short-term**
  - Intra-abdominal bleeding
  - Pancreatic fistula
  - Injury to the splenic flexure of the colon
  - Thrombocytosis

- **Long-term**
  - Diabetes mellitus
  - Pancreatic pseudocyst
  - Disease recurrence
  - Exocrine insufficiency
  - Postsplenectomy sepsis

Tricks of the Senior Surgeon

Open distal pancreatectomy

- The major intraoperative problems that occur during distal pancreatectomy are injuries to the major veins from excessive traction or incorrect dissection. Early identification of the SMV and development of the tunnel where the SMV passes beneath the pancreas is an important maneuver to be sure of the location of this major venous structure as the dissection proceeds, to allow rapid division of the pancreatic parenchyma over the vein if necessary to achieve vascular control.
- Because of the risk of vascular injury during distal pancreatectomy, an assortment of vascular clamps should be readily available on the back table; the surgeon should familiarize himself or herself with the selection of clamps before the operation begins.
- Sometimes, a posterior pseudocyst near the tail of the gland close to the splenic hilum or severe chronic inflammation will make it essentially impossible or inadvisable to mobilize the spleen safely from lateral to medial as suggested. In this case, it is sometimes more prudent to try to enter the retropancreatic space more medially, closer to the SMV. If possible, one can establish the proper plane of dissection there and move from medial to lateral behind the pancreas, remembering that the renal vein is at potential risk if the dissection goes too deep. It is important to stay close to the back of the pancreas.
- The spleen is sometimes injured during its mobilization, and it can be tempting to remove the spleen to reduce annoying bleeding. However, the spleen makes a nice "handle" for the distal pancreas, and it is best to leave it in situ for the remainder of the dissection. Bleeding can often be controlled with a laparotomy pad on the spleen and manual pressure. Another option is to locate and ligate the proximal splenic artery to diminish splenic arterial inflow.

Laparoscopic distal pancreatectomy

- Avoid mistaking the hepatic artery for the splenic artery by first dividing the pancreatic neck to expose the splenic artery correctly, test-clamping the artery, and visualizing the direction of blood flow.
- Be sure to completely mobilize the splenic flexure of the colon so that the colon does not require constant retraction to expose the pancreas. Mobilization of the splenic flexure is required to fully expose the lateral pancreas. This can be difficult in obese individuals, but when completed, gravity and the use of reverse Trendelenburg positioning will optimize exposure of the pancreatic tail and splenic hilum.
- Be sure to use a blunt dissector and gentle dissection of the pancreatic neck when dissecting the space anterior to the SMV, especially at the superior border.

- ***Acknowledgments**

Richard H. Bell, Jr., and Ronald A. Hinder contributed to this chapter in the first edition.

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Robot-Assisted Laparoscopic Distal Pancreatectomy and Splenectomy

Eric C.H. Lai, Chung Ngai Tang

In contrast to pancreatoduodenectomy, minimally invasive distal pancreatectomy is much easier technically, because there is no need for any anastomosis. Most surgeons agree that the conventional laparoscopic approach to distal pancreatectomy should be considered the standard approach for benign and borderline malignant tumors of the pancreas. A robot-assisted approach provides equivalent safety and similar outcomes, but with the advantage of a shorter learning curve for surgeons less experienced in minimally invasive distal pancreatectomy.

Indications and Contraindications

Indications

- The indications for robot-assisted laparoscopic distal pancreatectomy are the same as for open distal pancreatectomy: benign diseases or neoplasms of low-grade malignant potential occurring in the neck, body, or tail of the pancreas. Spleen preservation is not attempted in patients with lesions adherent to the splenic hilum or lesions that are malignant or potentially malignant.
- The role of robot-assisted laparoscopic distal pancreatectomy for adenocarcinoma is still not fully established.

Contraindications

- Distant extrapancreatic metastatic disease
- Tumor involvement or invasion of the superior mesenteric vein (SMV), portal vein (PV), celiac artery, or superior mesenteric artery (SMA) that precludes a safe, oncologic resection
- Bulky tumors that jeopardize a safe, oncologic resection by a laparoscopic approach
- Multiple adhesions that prevent safe laparoscopic procedures
- Intolerance to pneumoperitoneum
- Clinically relevant coagulopathy

Instruments

- Fenestrated bipolar forceps
- Prograsp × 2 (Intuitive Surgical; Sunnyvale, CA, USA)
- Cautery hook
- Monopolar curved scissors
- Large needle drivers × 2
- Surgical energy devices (LigaSure [Covidien, Boulder, CO, USA], Harmonic Scalpel [Ethicon, Johnson & Johnson, Cincinnati, OH, USA], Thunderbeat [Olympus, Japan], etc.)
- Vascular clip applier × 2
- Linear cutting staplers for bowel and vascular transection

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
DOI 10.1007/978-3-662-46546-2_102, © Springer-Verlag Berlin Heidelberg 2016

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Procedure: Robot-Assisted Laparoscopic Distal Pancreatectomy and Splenectomy

Step 1

Patient position, port sites, and pneumoperitoneum (Fig. 102.1)

- The patient is placed supine on a split-leg table with a nasogastric tube and Foley catheter. The left body trunk is raised about 30° to 50° with body support. Five ports are inserted.
- The first 12-mm trocar is inserted in the infraumbilical region to gain access to the abdomen by an open technique; pneumoperitoneum with low pressure CO_2 (12 mm Hg) is created. This trocar is used as the robotic camera port after docking of the robot.
- Three 8-mm robotic trocars and one additional 12-mm assistant trocar are inserted under direct vision. The assistant trocar is placed 7 to 8 cm to the right of the midline. One 8-mm robotic port is in the right anterior axillary line, and the other two 8-mm ports are placed in the left upper quadrant.
- Staging laparoscopy and laparoscopic ultrasonography are performed. If no contraindication to resection is found, the operating table is positioned with the left side up in reverse Trendelenburg position, and the da Vinci® S or Si Surgical System (Intuitive Surgical, Sunnyvale, CA, USA) is docked directly over the head of the table or over the left shoulder of the patient, depending on the tumor location. The robotic surgeon sits at the console, and the bedside surgeon, on the right side of the patient to exchange instruments, pass needles, and manage the suction irrigator, clip appliers, and various surgical energy devices.
- Teamwork between two experienced laparoscopic pancreatic surgeons is imperative.

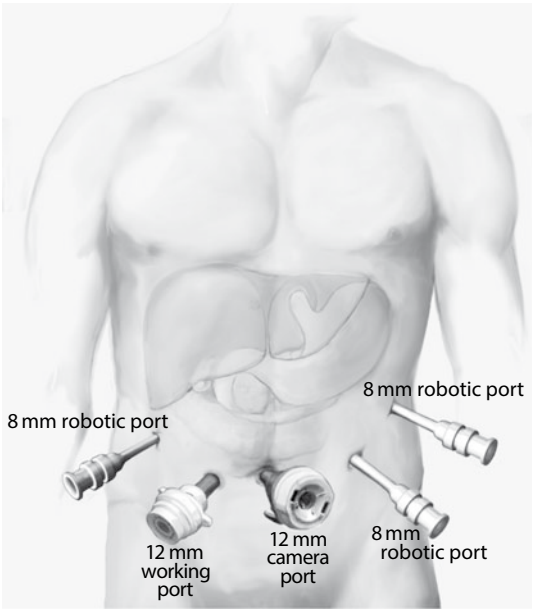


Fig. 102.1

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Step 2

Entering the lesser sac

- The gastrocolic ligament is divided over to the splenic flexure to obtain full access to the lesser sac.
- The splenocolic ligament is divided, and the splenic flexure of the colon is retracted inferiorly, as with the typical laparoscopic approach.

Step 3

Mobilization of pancreatic body and tail

- Pancreatic mobilization begins by incising the retroperitoneum along the caudal and cranial aspect of the pancreas proximal to the pancreatic lesion, to gain access to the space posterior to the pancreas.
- An umbilical tape is placed around the pancreas at the planned level of transection.
- When the lesion is in the proximal body of the pancreas, the mobilization may begin at the SMV, and the space posterior to the pancreatic neck is mobilized as with a robotic pancreatoduodenectomy.
- The anterior surface of the pancreas is then mobilized to the hilum of the spleen.
- These maneuvers are identical to a laparoscopic approach.

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Step 4

Control of the splenic vessels

- The splenic artery is dissected along the superior border of the pancreas (Fig. 102.2a), slinged, and secured with Hem-o-lok clips (Weck Closure Systems, Research Triangle Park, NC, USA). Double clips are applied to the proximal vascular stump before transection (Fig. 102.2b). An endoscopic vascular stapler can also be used.
- Next, beginning from the inferior side of the pancreas, the pancreas is elevated and the splenic vein is visualized on the posterior aspect of the pancreas. The splenic vein is dissected (Fig. 102.2b), slinged, and secured with Hem-o-lok clips (Fig. 102.2c). Double clips are applied to the proximal vascular stump before transection. Alternatively, a clip and a 3-0 monofilament transfixion suture are applied to the proximal vascular stump (Fig. 102.2c).

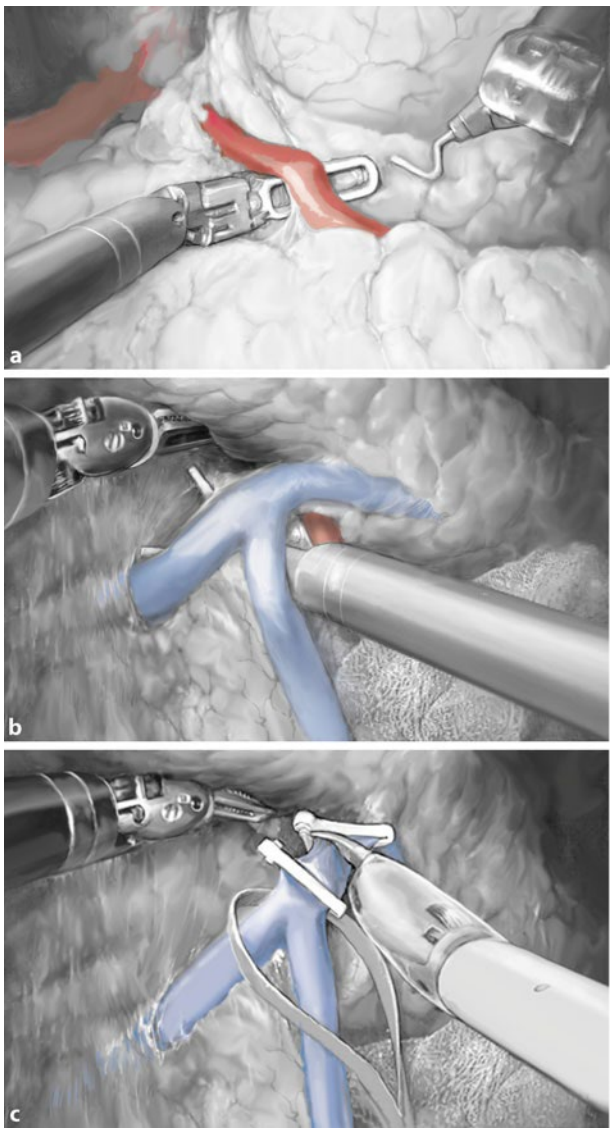


Fig. 102.2

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Step 5

Transection of the pancreas

- As with a laparoscopic distal pancreatectomy, an endoscopic linear stapler is passed to divide the pancreas.
- An alternative method to transect the pancreas is the use of monopolar scissors. This technique may be useful to prevent crushing injury in patients with thick pancreatic parenchyma. The pancreatic ductal opening in the remnant is located and oversewn with a 4-0 absorbable or nonabsorbable suture, placed in a mattress fashion. A row of 3-0 absorbable or nonabsorbable sutures is placed in figure-of-eight fashion over the end of the pancreas.
- The distal pancreas is then dissected free in a medial-to-lateral direction (Fig. 102.3).

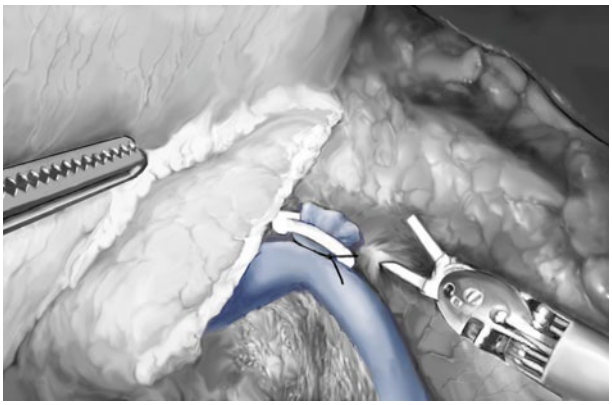


Fig. 102.3

Step 6

Splenic preservation

- When appropriate, the spleen can be preserved. The robot is ideal for visualization and the fine dissection and ligation of the diminutive branches from the splenic artery and vein to the pancreas.
- After transecting the pancreas, the distal pancreas is retracted anteriorly and the small branches to the gland are controlled with energy devices, being careful to protect the splenic artery and vein.
- This technique does not require mobilization of the spleen.

Step 7

Division of the short gastric vessels

- With surgical energy devices, the short gastric vessels are divided away from the gastric wall.

Step 8

Mobilization of the spleen

- The spleen is mobilized from its retroperitoneal attachments to the diaphragm and kidney by dividing the lienophrenic and lienorenal ligaments with the surgical energy devices.
- The distal pancreas and splenic vessels are elevated from the retroperitoneum and any residual attachments are divided.

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Step 9

Abdominal closure

- Prior to abdominal closure, the abdomen is carefully irrigated and hemostasis is checked.
- One closed suction drain is placed near the cut surface of the pancreas and exits the abdomen at the left 8-mm port site.
- The specimen is removed via the infraumbilical port in a retrieval bag or, if it is large and bulky, through a Pfannenstiel incision.

Tricks of the Senior Surgeon

- Robot-assisted laparoscopic distal pancreatectomy requires expertise in both pancreatic and laparoscopic surgery; cooperation of two surgeons facilitates the procedure.
- With persistent bleeding, insufficient exposure, or inadequate visualization compromising an oncologic resection, one should convert to an open procedure.
- Adequate adjustment and usage of the robotic third arm for retraction is important.
- A cautery hook can be a useful, effective dissecting tool.
- Because of the loss of effective feedback from tactile touch and tension, retraction using the robot must be gentle and controlled, highlighting the need for an experienced assistant.

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Robot-Assisted Laparoscopic Pancreatoduodenectomy

Eric C.H. Lai, Chung Ngai Tang

Minimally invasive approaches to pancreatoduodenectomy have been very difficult technically. Robotic systems offer many advantages, as use of the robot overcomes several of the obstacles of conventional laparoscopic surgery by increasing dexterity, restoring proper hand-eye coordination in an ergonomically comfortable position, and improving visualization. A robotic approach can facilitate several steps of the pancreatoduodenectomy, including dissection of the pancreas from major vascular structures, lymph node dissection, resection of the uncinate process, and construction of the pancreatobiliary anastomoses.

Robot-assisted laparoscopic pancreatoduodenectomy has been shown to be safe and feasible in selected patients. The current role of minimally invasive pancreatoduodenectomy remains unclear, and its oncologic outcome is unknown.

Indications and Contraindications

Indications

The indications for robot-assisted laparoscopic pancreatoduodenectomy are the same as for open pancreatoduodenectomy, including benign conditions and periampullary malignancy.

Benign conditions:

- Chronic pancreatitis
- Premalignant lesions:
  - Cystic neoplasms of the pancreas
  - Neuroendocrine tumors

Periampullary malignancy:

- Pancreatic head cancer
- Ampullary cancer
- Distal cholangiocarcinoma
- Duodenal cancer

Contraindications

- Distant extrapancreatic metastatic disease
- Tumor involvement or invasion of the superior mesenteric vein (SMV), portal vein (PV), or superior mesenteric artery (SMA) that precludes a safe oncologic resection
- Bulky tumors that jeopardize a safe oncologic resection by a laparoscopic approach
- Multiple adhesions that prevent safe laparoscopic procedures
- Intolerance to pneumoperitoneum
- Clinically relevant coagulopathy

Instruments

- Fenestrated bipolar forceps
- Prograsp × 2
- Cautery hook
- Monopolar curved scissors
- Large needle drivers × 2
- Surgical energy devices (LigaSure [Covidien, Boulder, CO, USA], Harmonic Scalpel [Ethicon, Johnson & Johnson. Cincinnati, OH, USA], Thunderbeat [Olympus, Japan] etc.)

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- Vascular clip applier × 2
- Linear cutting staplers for bowel and vascular transection

Procedures

Step 1

Patient position, port sites, and pneumoperitoneum

- The patient is placed supine on a split-leg table with a nasogastric tube and Foley catheter; five ports are inserted.
- The first 12-mm trocar is inserted in the infraumbilical region to gain access to the abdomen by an open technique. Pneumoperitoneum with low-pressure CO_2 (12 mm Hg) is created. This trocar is used as an assistant port after the docking of the robot.
- Three 8-mm trocars and one 12-mm camera trocar are inserted under direct vision. The robotic camera port is placed about 7 to 8 cm to the right of the midline (below the umbilicus) to improve exposure of the SMV-PV region and uncinate process. One of the 8-mm robotic ports is inserted in the right anterior axillary line; the other two 8-mm robotic ports are placed in the left upper quadrant (Fig. 103.1a).
- Staging laparoscopy and laparoscopic ultrasonography are performed. If no contraindication to resection is found, the patient is positioned right-side up in reverse Trendelenburg position, and the da Vinci® S or Si Surgical System (Intuitive Surgical Inc., Sunnyvale, CA) is docked directly over the head of the table (Fig. 103.1b).
- The robotic surgeon sits at the console, and the bedside surgeon sits between the legs of the patient to exchange instruments, pass needles, and manage various devices as needed. Teamwork between two experienced laparoscopic pancreatic surgeons is imperative.

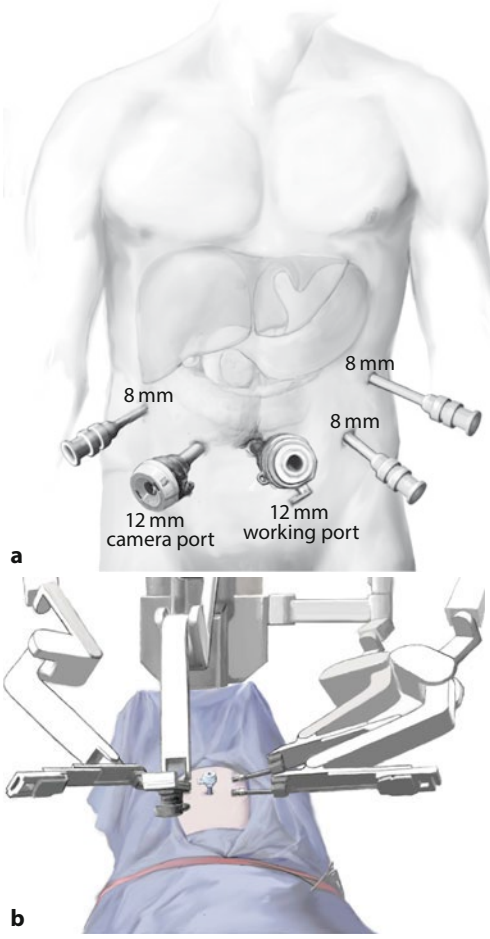


Fig. 103.1

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Step 2

Mobilization of hepatic flexure of colon, extended Kocher maneuver, and mobilization of the 3rd and 4th portions of the duodenum (Fig. 103.2)

- The hepatic flexure of the colon is mobilized from retroperitoneal attachments by robotic hook cautery.
- A Kocher maneuver is performed to fully mobilize the duodenum and head of the pancreas by exposing the inferior vena cava and part of the aorta.

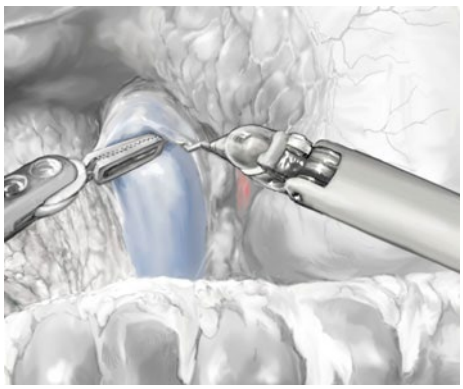


Fig. 103.2

Step 3

Entrance into the lesser sac and transection of the gastric antrum

- The lesser sac is entered by dividing the gastrocolic omentum and taking down adhesions between the posterior gastric wall and the anterior pancreas.
- The distal stomach is cleared of its mesentery along its greater and lesser curves by surgical energy devices, and the distal third of the stomach is divided using the linear cutting stapler.
- The staple line should be checked for hemostasis, and any bleeding should be controlled.

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Step 4

Dissection of the porta hepatis and division of the bile duct

- Cholecystectomy is then performed. The bile duct is dissected, the common hepatic duct (CHD) is transected at its junction with the cystic duct, and the margin is sent for frozen section analysis. The anterior surface of the PV is then easily identified. At this time, bile or endobiliary stents are sent for culture (Fig. 103.3a).
- Gauze is applied over the divided proximal CHD to collect bile leakage. The distal bile duct is sewn shut to prevent potential tumor spillage.
- The portal dissection is begun by exposing the common hepatic artery (CHA) proximal and distal to the right gastric artery and the gastroduodenal artery (GDA); the CHA is exposed by removing the lymph node that lies anterior to this vessel. The right gastric artery and the GDA are doubly ligated with Hem-o-lok® clips (Weck Closure Systems, Research Triangle Park, NC, USA) and divided (Fig. 103.3b).
- Anatomic variations in the hepatic artery should be recognized.
- Division of the GDA facilitates separation of the PV from the posterior aspect of the first part of the duodenum and the neck of the pancreas.

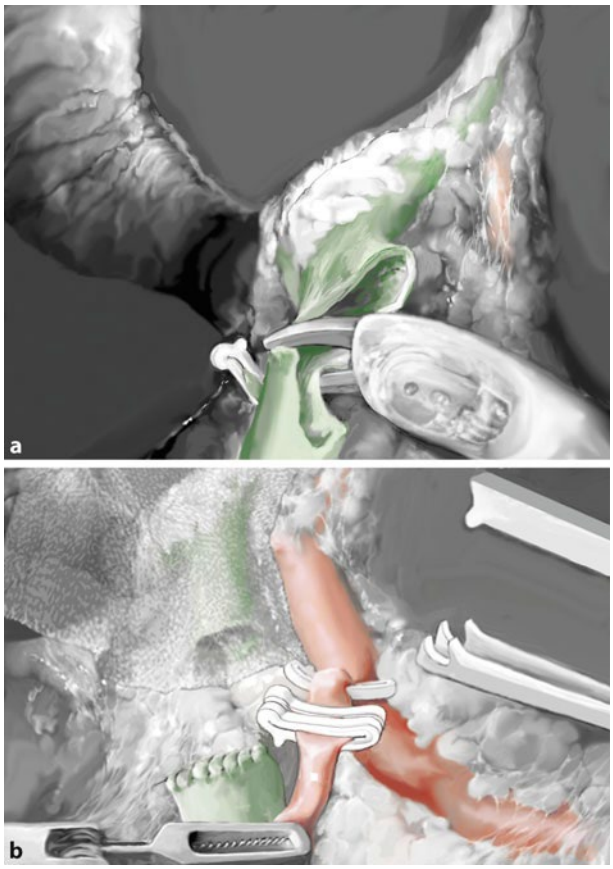


Fig. 103.3

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Step 5

Dissection of the SMV-PV and division of the neck of the pancreas

- The visceral peritoneum along the caudal border of the pancreas is transected to identify the middle colic vessels and expose the junction of the middle colic vein and SMV.
- The anterior surface of the SMV-PV can be dissected under direct vision by retracting the neck of the pancreas anteriorly (Fig. 103.4a). Once the tunnel behind the neck of the pancreas is made, an umbilical tape is passed around the neck of the pancreas (Fig. 103.4b).
- The neck of the pancreas is then divided from caudad to cranial with monopolar scissors, taking care not to injure the underlying SMV and PV. A frozen section of the pancreatic transection margin is sent for examination.
- Bleeding from the pancreatic parenchyma is controlled by bipolar diathermy coagulation.

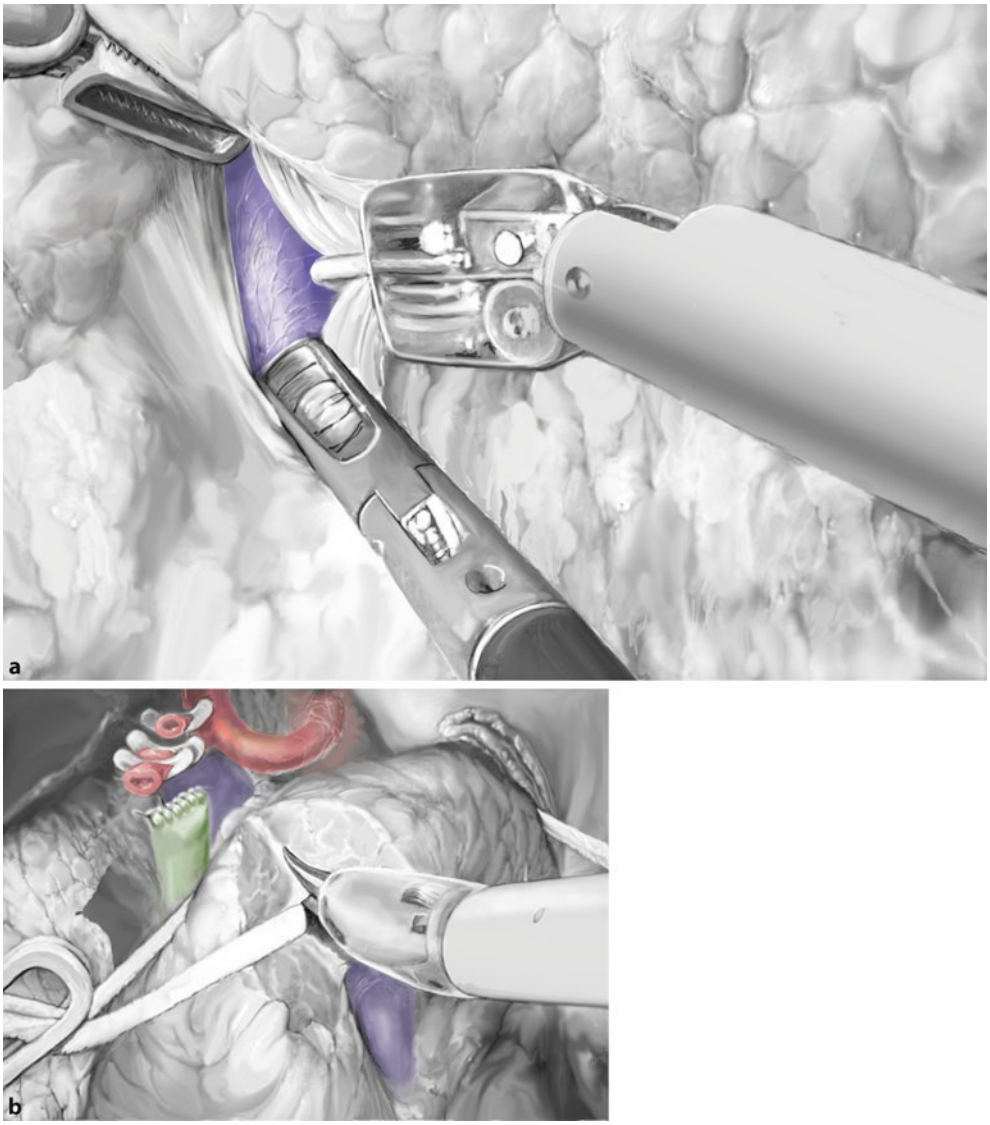


Fig. 103.4

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Step 6

Transection and detachment of the jejunum

- After dividing the proximal jejunum with the linear cutting stapler, the duodenojejunal flexure and the 4th part of the duodenum are dissected free. The dissection is continued along the inferior part of the 3rd part of the duodenum under the base of the small-intestine mesentery until the right-sided site of the duodenal mobilization is reached (Fig. 103.5).



Fig. 103.5

Step 7

Completion of the retroperitoneal dissection

- The uncinate and head of the pancreas are separated from caudal to cranial from the lateral margin of the SMV-PV. Venous tributaries are ligated individually with titanium clips, Hem-o-lok clips, or suture ligation (Fig. 103.6a)
- The uncinate process is then dissected from the SMA (Fig. 103.6b).

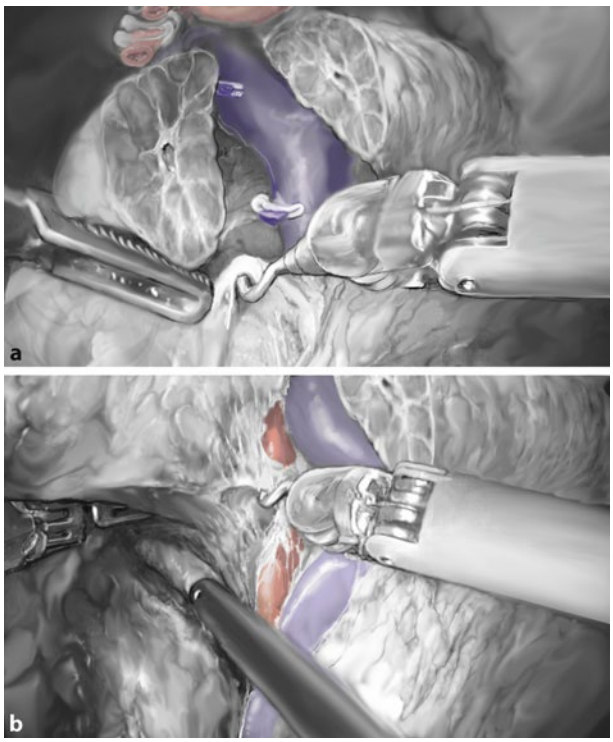


Fig. 103.6

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Step 8

Reconstruction

- Reconstruction includes a robotic pancreaticojejunostomy, hepaticojejunostomy, and gastrojejunostomy performed in the same sequence as an open reconstruction. The transected jejunum is brought through a wide incision in the right transverse mesocolon to the upper compartment.
- Pancreatic reconstruction (Fig. 103.7a)
  - The pancreatic remnant is mobilized anteriorly from the retroperitoneum and splenic vein for 2 to 2.5 cm. A two-layer, end-to-side, duct-to-mucosa pancreaticojejunostomy is performed.
  - After the posterior row of interrupted 3-0 or 4-0 absorbable seromuscular monofilament sutures, a small, transmural enterotomy is made. The anastomosis between the pancreatic duct and small-bowel mucosa is performed with interrupted 5-0 monofilament sutures, incorporating adequate bites of the pancreatic duct and full-thickness jejunum. The posterior knots are tied on the inside and the lateral and anterior knots are tied on the outside. An internal pancreatic stent is placed across the anastomosis. A 6.5 Fr pediatric feeding tube is cut to a length of about 6 to 8 cm, and multiple side holes are made in the tube to allow better drainage of pancreatic juice. The stent is positioned with half of the stent in the pancreatic duct and half in the jejunal lumen, and the anastomosis is completed with an anterior row of sutures.
- Biliary reconstruction (Fig. 103.7b)
  - A one-layer, end-to-side hepaticojejunostomy is performed with 3-0 or 4-0 absorbable sutures 10 to 15 cm away from the pancreaticojejunostomy, aligning the jejunum and bile duct to avoid tension between the pancreatic and biliary anastomoses.
- Gastric reconstruction
  - A stapled, side-to-side gastrojejunostomy is performed 50 cm distal to the hepaticojejunostomy.

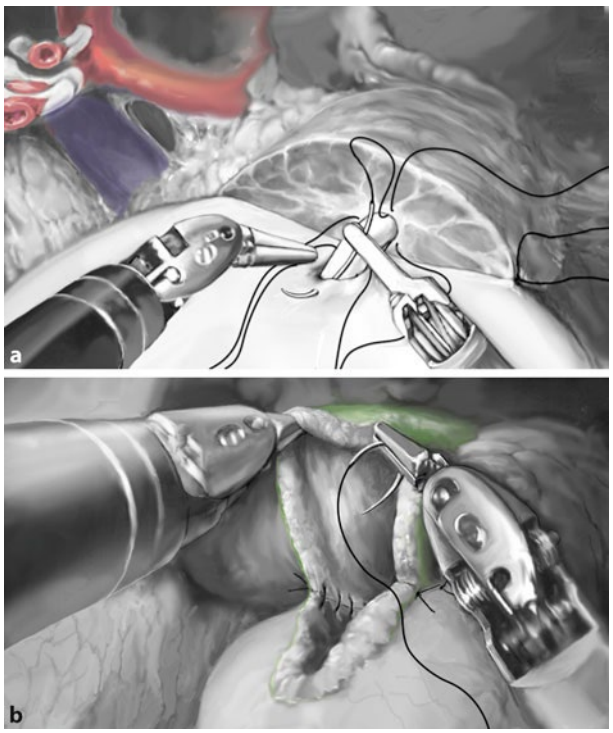


Fig. 103.7

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Step 9

Abdominal closure

- Two closed suction drains are placed near the pancreatic and biliary anastomoses, exiting the abdomen at the 8-mm port sites.
- The specimen is removed in a retrieval bag via the subumbilical port; if it is large and bulky, it can be removed via a Pfannenstiel incision.

Tricks of the Senior Surgeon

- Robot-assisted laparoscopic pancreatoduodenectomy is a difficult procedure that requires both pancreatic and advanced laparoscopic skills. The cooperation of two surgeons is ideal.
- Retraction using the robot must be gentle and controlled because of the lack of effective tactile touch and tension feedback, making the need for an experienced assistant even more important.
- Adequate adjustment and usage of the robotic third arm for retraction is important.
- A cautery hook can be a useful and effective dissecting tool.
- With persistent bleeding, insufficient exposure, or inadequate visualization that may compromise an oncologic resection, the procedure should be converted to an open procedure.

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Spleen

Robert Padbury

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Robert Padbury

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Chapter 109 Laparoscopic Unroofing of Splenic Cysts – 1059
Marco Decurtins, Duri Gianom

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Introduction: Spleen

Robert Padbury

Total splenectomy has been considered the appropriate management for splenic trauma, diseases, or disease processes that could be modified by splenectomy. This surgical truism has been supported by the belief that the spleen is not essential to life, that mortality is almost universal in non-operated splenic injury, and that delayed rupture is a significant danger.

The policy for total splenectomy has been progressively modified by a number of important observations; first, that splenectomy increases the risk of significant septic events and, second, that partial splenectomy or even splenic preservation is possible with low risk to the patient. Major advances in abdominal imaging have contributed significantly to the surgical developments.

Progress has continued with the development of laparoscopic surgery. Initially laparoscopic total splenectomy became a relatively standard procedure, particularly in the non-trauma patient. More recently the concept of partial splenectomy has been successfully implemented using laparoscopic access. As with other organ systems, laparoscopic surgery served as a stimulus for equipment development, and the benefits of this have been realized in both open and laparoscopic procedures. Particularly valuable in splenic surgery are the endovascular stapling devices and energy devices.

When considering a patient for splenectomy, decisions regarding the choice of access should take into account the experience and training of the surgeon, as well as the suitability of the patient. The size of the spleen, the nature of the problem, and previous abdominal surgery will be factors in the decision. Clearly, appropriate and specific informed consent is mandatory, including a discussion of total splenectomy when a partial procedure is planned.

In this part of the atlas a range of techniques for splenectomy, open and laparoscopic, total and partial, are discussed. Techniques for splenic preservation are described and finally some approaches for splenic cysts are presented.

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Open Splenectomy

John Paul Gonzalvo, Michel M. Murr

Indications and Contraindications

Indications

- Trauma
- Blood dyscrasias, e. g., idiopathic thrombocytopenic purpura
- Symptomatic relief, e. g., Gaucher's disease, chronic myeloid or lymphatic leukemia
- Splenic cysts and tumors

Contraindications

- No absolute contraindications for splenectomy
- Limited life expectancy and prohibitive operative risk

Contraindications to Laparoscopic Splenectomy

- Previous open upper abdominal surgery
- Uncontrolled coagulation disorder
- Massive splenic enlargement, i. e., spleen greater than four times normal size or larger
- Portal hypertension

Preoperative Investigation and Preparation

- Imaging studies to estimate the size of the spleen or extent of splenic injury and other abdominal injuries in trauma cases
- Interpretation of bone marrow biopsy, peripheral blood smear, and ferrokinetics in coordination with a hematologist
- Discontinue anticoagulants (such as aspirin, warfarin, clopidogrel, and vitamin E)
- Patients routinely given polyvalent pneumococcal vaccine, *Haemophilus influenzae* b conjugate vaccines and meningococcal vaccines on the same day at least 10–14 days prior to splenectomy (given postoperatively in trauma cases)
- Prophylactic antibiotics (cefazolin or cefotetan)
- Perioperative deep vein thrombosis prophylaxis as indicated
- Perioperative steroids should be administered to patients on long-term steroid therapy

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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Procedure

Step 1

Set-up approach

The standard supine position is employed with an optional small roll/bump under the left flank.

The patient should be well secured to the operating table should it become necessary to tilt the table to improve visualization of the operative field.

Mechanical retractors greatly enhance exposure and the primary surgeon should stand on the right side of the patient; the first assistant opposite the surgeon on the left side of the patient.

There are two standard incisions for open splenectomy: a supraumbilical midline or left subcostal with or without midline extension. A midline incision is usually employed in trauma cases.

Examine each patient following induction of anesthesia to estimate the location of the splenic hilum and the tip of the spleen, so the incision location optimizes exposure.

The principle of retraction is that of moving the incision over the operative field.

Two points of retraction include one retractor to gently hold the colon in the lower abdomen and counterretraction to lift the left portion of the incision superiorly and out of the operative field.

The standard order of steps is arranged to minimize blood loss, minimize the size of the spleen, and maintain adequate exposure while performing the deepest and most challenging dissection.

Identify the splenic artery near its origin from the celiac axis, which is accessed through the gastrohepatic ligament (Fig. 105.1).

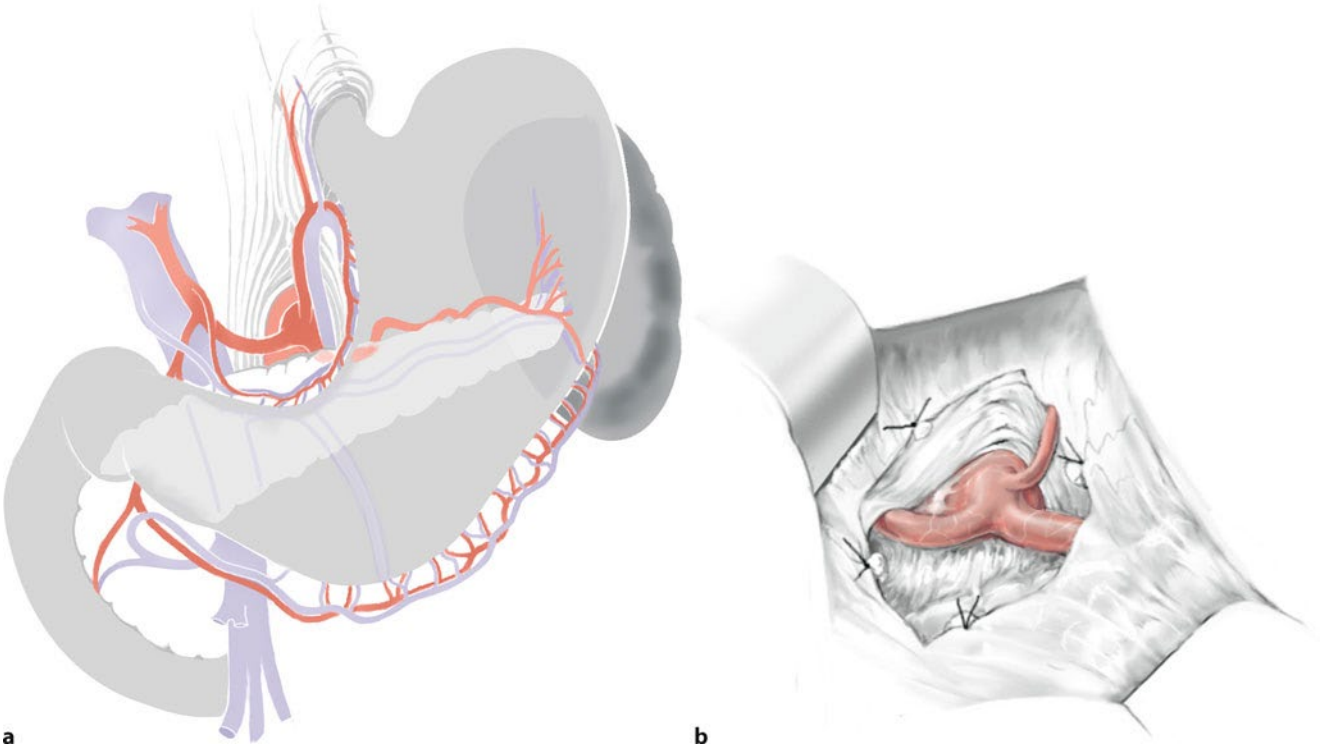


Fig. 105.1

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Step 2

Exposure of spleen

Upon entering the peritoneal cavity and again before closing, a thorough search for accessory spleens should be conducted, especially if the indication for splenectomy is hematological.

Open the gastrosplenic ligament through an avascular area and then proceed to dissect the short gastric vessels. These may be secured with hemoclips or ligatures.

The last several vessels in the gastrosplenic ligament are of particular note. These branches are often quite short, so care must be taken to utilize adequate tissue for hemostasis without injuring the greater curvature of the stomach. The LigaSure (R) device, the harmonic/ultrasonic scalpel, or a linear stapler can also be utilized for dividing the gastrosplenic ligament as is employed during laparoscopic splenectomy (Fig. 105.2).

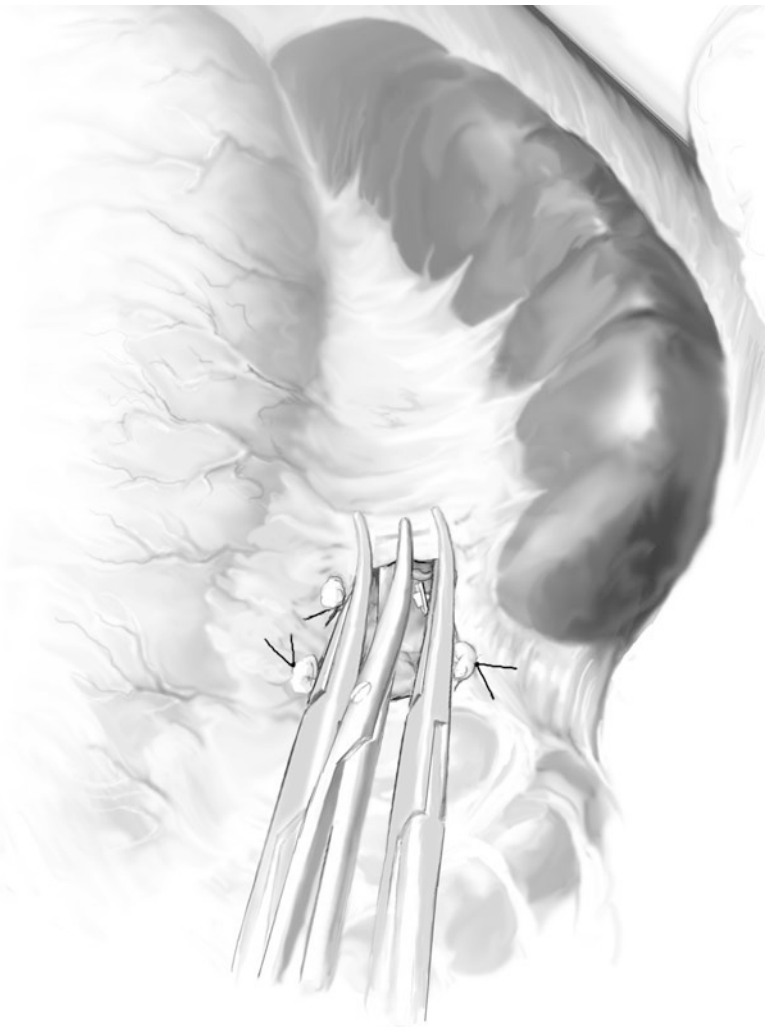


Fig. 105.2

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Step 3

Dividing the splenic attachments

While dividing splenic attachments, always attempt to stay closer to the spleen than to the opposite structure. Proceeding inferiorly along the gastrosplenic ligament typically includes dividing the left gastroepiploic artery. Taking down the splenic flexure and the splenocolic attachment usually facilitates this dissection (Fig. 105.3a).

The spleen is then gently and progressively retracted medially with the surgeon's left hand (Fig. 105.3b). Using a laparotomy pad under the retracting hand, it is a relatively simple maneuver for the surgeon to identify the peritoneal attachments and provide exposure with the left index finger. The attachments are divided with curved scissors proceeding from the inferior pole to the superior pole and then dividing the splenorenal ligament as the spleen is gradually rotated medially and anteriorly. Care should be taken with any blunt dissection as the splenic capsule is relatively thin and even small tears can result in moderate bleeding. Likewise, care should be taken as proceeding posteriorly around the inferior pole in order to avoid the adrenal gland.

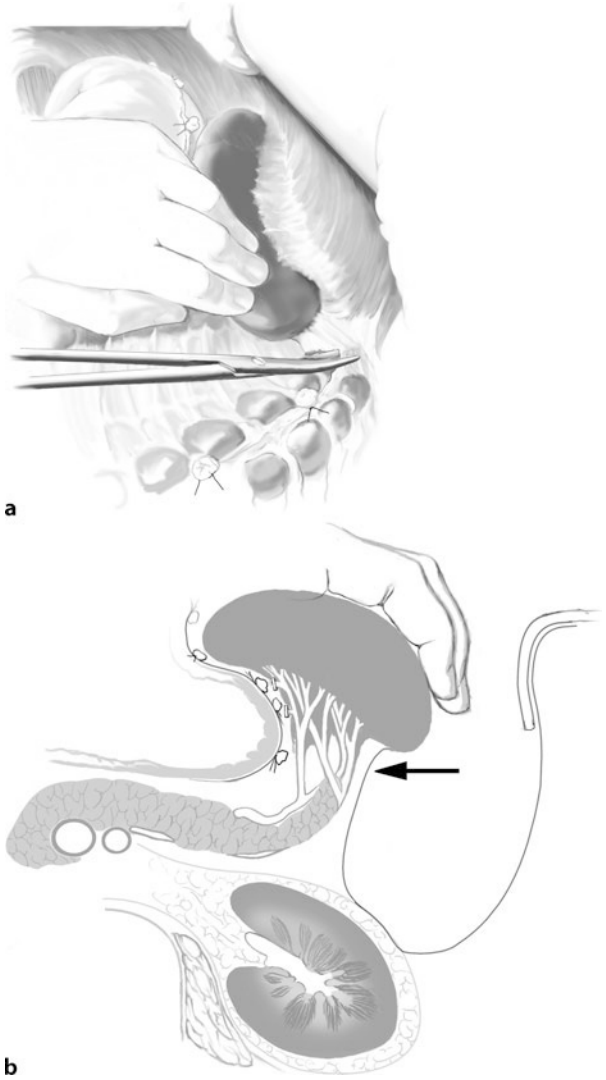


Fig. 105.3

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Step 4

Control of the splenic hilum

Once all of the splenic attachments have been divided the splenic hilum can be addressed definitively. Lift the spleen up and out of the retroperitoneum. This maneuver serves to clearly identify and separate the splenic vessels from the tail of the pancreas as shown. Laparotomy pads packed into the retroperitoneum can assist with elevating the spleen into the incision while controlling oozing in the retroperitoneum. With the assistant holding the spleen, the surgeon can separate the tail of the pancreas from the splenic vessels in order to protect the tail of the pancreas prior to dissecting and applying curved clamps. The surgeon divides the splenic artery and vein proximal to their bifurcation between clamps and applies a suture ligature to each after removing the spleen. We first clamp the artery, which is typically anterior to the splenic vein, and then squeeze the spleen in order to promote autotransfusion of splenic blood prior to clamping the vein.

Once the spleen is removed and all of the named vessels have been doubly ligated, the operative field can be inspected for hemostasis. The abdomen is closed with or without a closed suction drain (Fig. 105.4).

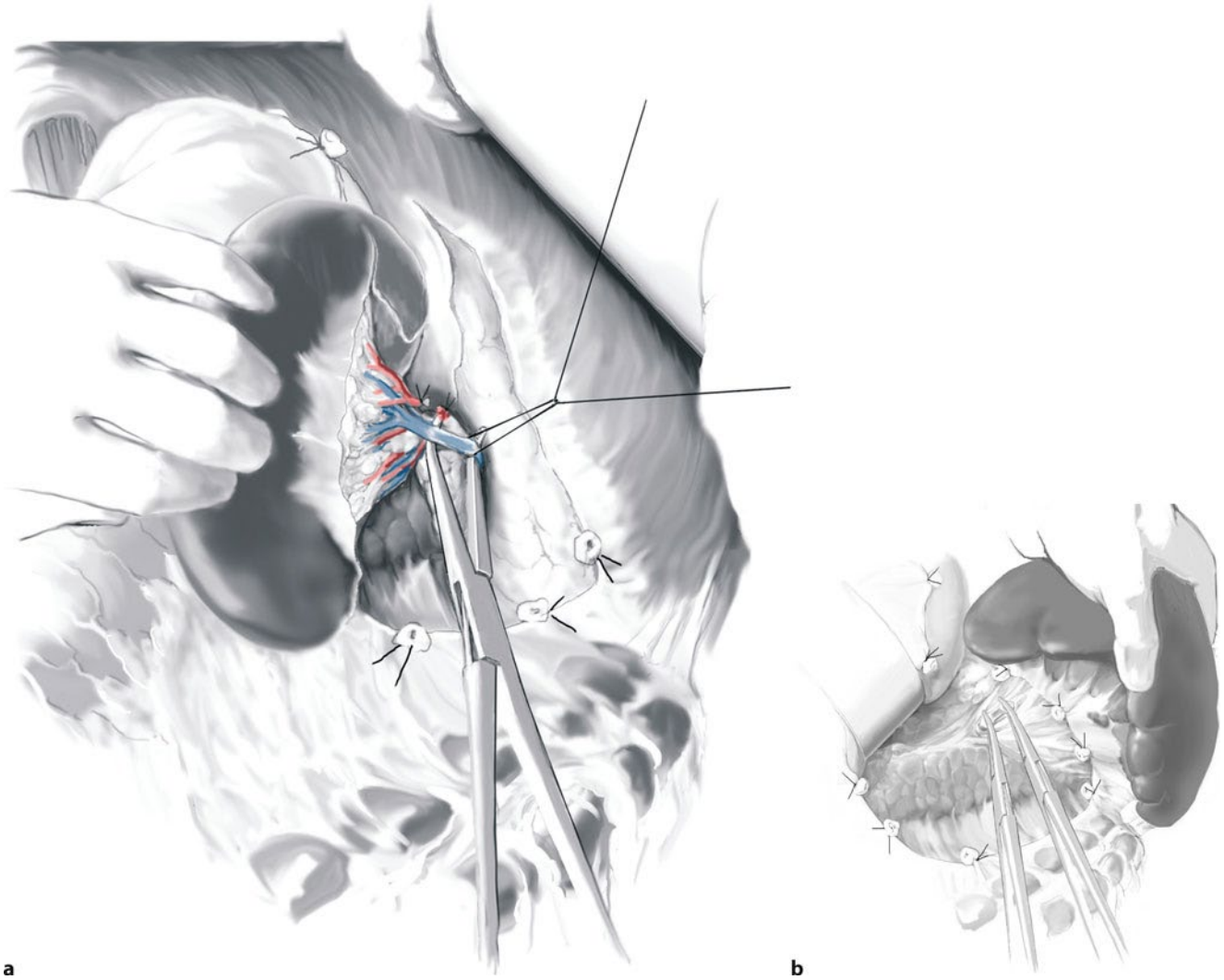


Fig. 105.4

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Postoperative Tests

- Monitor in high dependency unit
- Monitor platelets and hemoglobin

Complications

- Bleeding
- Pancreatitis
- Pancreatic fistula
- Colonic or gastric perforation
- Subphrenic abscess
- Wound infection
- Atelectasis
- Left pleural effusion
- Postsplenectomy sepsis
- Thrombocytosis

Tricks of the Senior Surgeon

- If bleeding is excessive and control of the splenic artery has not already been secured, or is not immediately feasible, the splenic artery and veins are easily controlled by gentle pressure applied between the second and the third fingers of the surgeon's right hand.
- Control of the splenic artery is most easily accomplished near its origin through the gastrohepatic ligament posterior to the lesser curvature of the stomach (*see* Step 1), which is particularly useful during splenorrhaphy.
- Another approach to the splenic hilum is anteriorly, which carries increased risk as the splenic vein is immediately posterior to the splenic artery near the hilum and the tail of the pancreas is also intimately associated to the splenic hilum.
- A linear stapler, as with laparoscopic splenectomy, is particularly useful when expeditious division of the hilum is necessary to control hemorrhage.
- For patients in whom difficulty gaining vascular control is anticipated, for those with enormous splenomegaly, or for those with portal hypertension, splenic artery embolization done immediately prior to the operation can reduce splenic sequestration, congestion, and bleeding.
- Early ligation of the splenic artery diminishes blood loss, maximizes the amount of blood in the spleen returning to the patient, decreases the size of the spleen, improves ease of handling, facilitates removal, and improves transfusion efficiency of blood products sooner rather than later during the procedure, if necessary.
- Make a thorough search for accessory spleens before and after the spleen is removed, especially when operating for hematological indications. Accessory spleens are found in 15–35 % of patients undergoing splenectomy and higher in those with hematological diseases. In order of decreasing frequency, accessory spleens are found in the splenic hilum, the splenorenal ligament, the greater omentum, the retroperitoneum near the tail of the pancreas, and the splenocolic ligament. Less commonly, accessory spleens are found in the mesentery of the small and large intestine, as well as the pelvis, in particular the left ureter and left adnexa, and left gonads.
- Mobilize the splenic flexure and the rest of the colon whenever necessary. Be just as careful protecting the colon and the stomach to prevent injury to either hollow viscus.

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Laparoscopic Splenectomy

David I. Watson

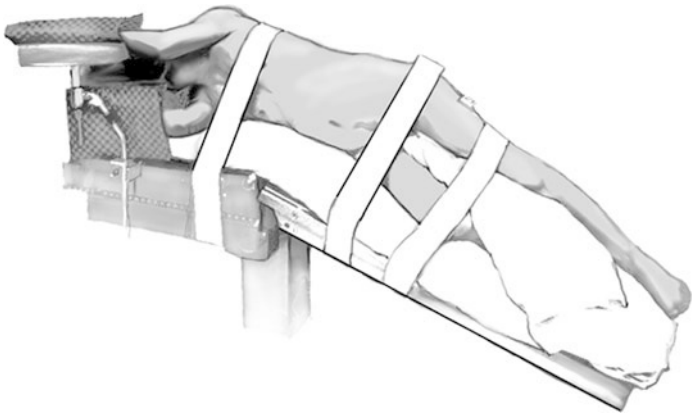
For indications, contraindications, and preoperative investigations, see ▶ Chap. 105 "Open Splenectomy."

Procedure

Step 1

Patient positioning and theater setup (◘ Fig. 106.1)

The patient is positioned in the lateral position (left side up) and with the operating table bent at the level of the patient's waist to flatten the lateral convexity of the patient's flank. The surgeon and assistant stand facing the patient, with the video monitor sited opposite.



◘ Fig. 106.1

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Step 2

Port placement (Fig. 106.2)

An 11-mm port is placed using an open insertion technique in the left upper quadrant, halfway between the mid-clavicular line and the anterior axillary line, immediately below the left costal margin. Secondary ports include a 5-mm port in the left mid-axillary line immediately below the costal margin, and a 12-mm port in the left anterior axillary line also immediately below the costal margin. An additional 5-mm port can be placed more laterally if necessary (optional). In approximately one-third of cases the splenic flexure of the colon must be mobilized to provide lateral access for port placement.



Fig. 106.2

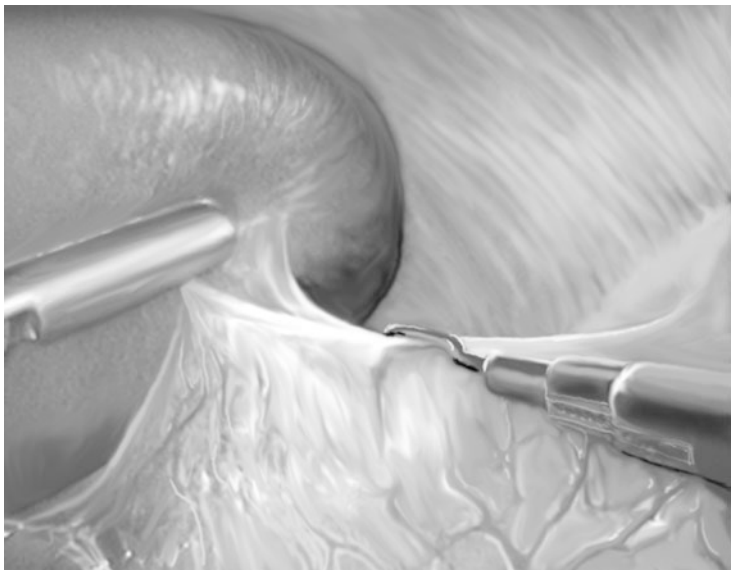
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Step 3

Exposure

No retractors are required. In the lateral position gravity enhances exposure of the posterior splenic attachments. A blunt-ended 5-mm-diameter grasping instrument placed through the most medial port is used to manipulate the spleen, lifting it upwards to expose the hilum, or rotating it towards the midline to expose the posterior attachments. A search for accessory spleens (see ▶ Chap. 105, "Open Splenectomy," overview "Tricks of the Senior Surgeon") should be made before commencing dissection of the spleen, as accessory spleens are more easily identified at this stage, and they should be removed as soon as they have been found. Removal later in the procedure can be more difficult.

With the spleen rotated towards the midline, the posterior peritoneal attachments are divided 5–10 mm away from the splenic capsule using a diathermy hook or ultrasonic shears. The spleen is progressively mobilized towards the midline, exposing the "splenic mesentery," which contains the main splenic vessels inferiorly, the short gastric vessels superiorly, and the tail of the pancreas. For adequate mobilization it is necessary to divide the posterior splenic attachments up to the left side of the esophageal diaphragmatic hiatus superiorly (see ▶ Chap. 105 "Open Splenectomy," Step 3). A combination of gravity and rotation of the spleen displays an avascular fascial plane behind the splenic mesentery. It is important to avoid damage to the tail of the pancreas during this dissection. If bleeding occurs during this step, then dissection is in an incorrect tissue plane (◘ Fig. 106.3).



◘ Fig. 106.3

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Step 4

Vascular control

The vascular attachments are divided next using a 30- or 45-mm endoscopic linear cutting stapler (white cartridge). This is applied sequentially across the splenic mesentery commencing inferiorly, and multiple applications of the stapler are required (usually three to five). The stapler is placed adjacent to the splenic capsule at the hilum, to minimize the risk of damaging the pancreatic tail. When applying the stapler, the spleen is lifted up by a blunt instrument passed through the most medial port. With this technique, dissection of individual splenic vessels is not necessary. Furthermore, attempts to dissect individual vessels may result in vessel damage and hemorrhage. If, when sequentially applying the stapler, it becomes apparent that the spleen has not been adequately mobilized superiorly, additional division of the posterior attachments to the upper spleen is then completed to enable final division of the short gastric blood vessels, and complete separation of the spleen from its remaining attachments (Fig. 106.4).



Fig. 106.4

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Step 5

Removal of the spleen

An AutoSuture Endocatch II retrieval bag (U.S. Surgical, Norwalk, CT, USA) is positioned underneath the spleen, and then opened so that the spleen drops directly into the bag as the bag is opened. Other specimen bags require additional manipulation to get the spleen into the retrieval bag and are more difficult to use. The neck of the bag is then pulled out through the lateral 12-mm port wound (Fig. 106.5).

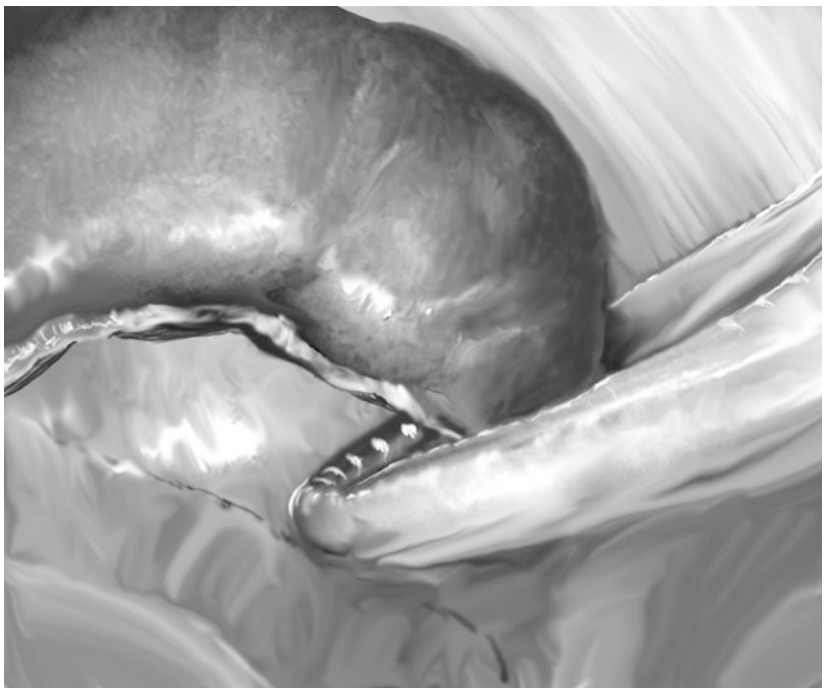


Fig. 106.5

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Step 6

Morcellation of the spleen

The surgeon's index finger is placed inside the bag and through the port wound, to break the spleen into pieces. This is done bimanually with the left hand pushing against the abdominal wall, and the right index finger pushing the spleen against the abdominal wall. Blood released from the broken spleen is then aspirated and an empty sponge-holding forceps is used to remove the spleen in pieces. The surgeon must be careful to avoid spillage of splenic material into the abdominal cavity, which can occur if the specimen bag is broken. An alternative method for spleen removal is to remove the spleen intact through a muscle-splitting abdominal incision, usually in the left lower quadrant (Fig. 106.6).

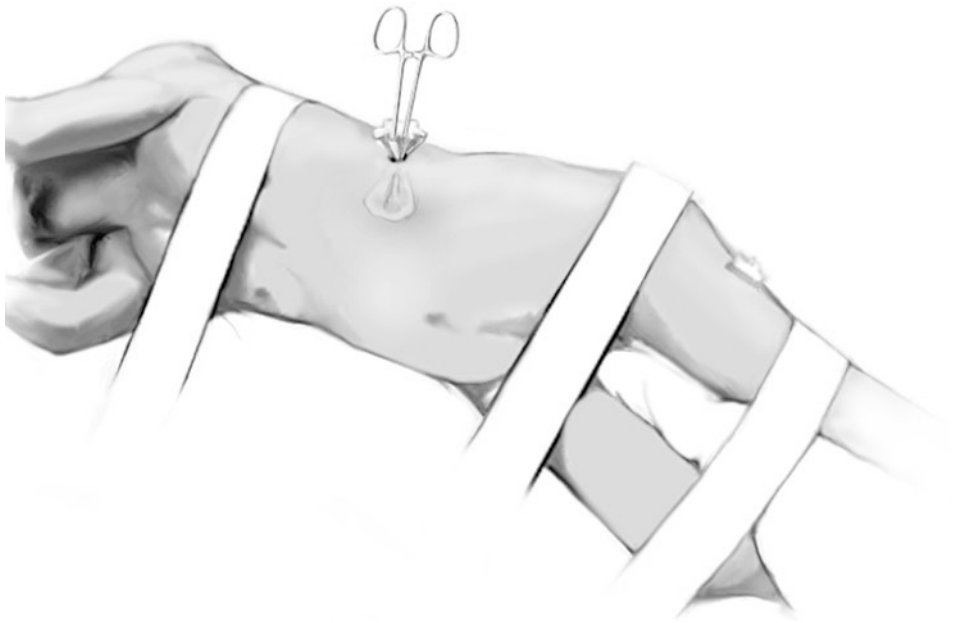


Fig. 106.6

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Tricks of the Senior Surgeon

- This procedure is most suitable for spleens that are normal in size or only mildly enlarged. The size of the spleen is best assessed before surgery with patients in the lateral position. If the spleen is easily palpable then it may be too big for laparoscopic dissection of the hilum in the lateral position.

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Partial Splenectomy, Open and Laparoscopic

Eric C. Poulin, Christopher M. Schlachta, Joseph Mamazza

Indications and Contraindications

Indications

Trauma

- Selected Class II–III–IV splenic injury with the following:
- Hemodynamic stability
- No evidence of other intra-abdominal organ injury
- No associated head injury
- No coagulopathy
- CT confirmation of isolated splenic injury

Elective

- Resection of non-parasitic cysts
- Hamartomas and other benign splenic tumors
- Inflammatory pseudotumor of the spleen, Type 1 Gaucher's disease
- Cholesteryl ester storage disease, chronic myelogenous leukemia
- Thalassemia major, spherocytosis, staging of Hodgkin's disease in children

Contraindications

- Inadequate exposure
- Inability to mobilize the spleen and tail of pancreas to the midline
- Inability to leave >25 % of splenic mass for complete splenic function

Preoperative Investigation and Preparation for the Procedure

See ► Chap. 105, "Open Splenectomy"

P.-A. Clavien, M.G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery,*
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Procedure

Step 1

Planning the partial splenectomy

Assuming that the spleen is appropriately placed for full evaluation and that hemostasis is adequate, the planning for partial splenectomy can start. In trauma cases, it will be dictated by the extent of the injury and, in elective cases, by the nature of the underlying pathology.

The spleen in the majority of cases can be divided into independent lobes or segments, each with its own terminal blood supply (Fig. 107.1). The superior pole is supplied by the short gastric vessels and the lower pole by branches of the gastroepiploic artery (up to five) known to anastomose with the inferior polar artery. In addition, most patients, despite possible variations, have two or three major vessels entering the hilum. Therefore there are usually five (Fig. 107.1a) or four (Fig. 107.1b) regions or lobes available for partial splenectomy. It is also important to understand that these vessels lie in different supportive ligaments. Vessels to the superior pole (short gastrics) and inferior pole (gastroepiploic branches) rest in the gastrosplenic ligament, whereas the splenic branches proper lie in the splenorenal ligament with the tail of the pancreas.

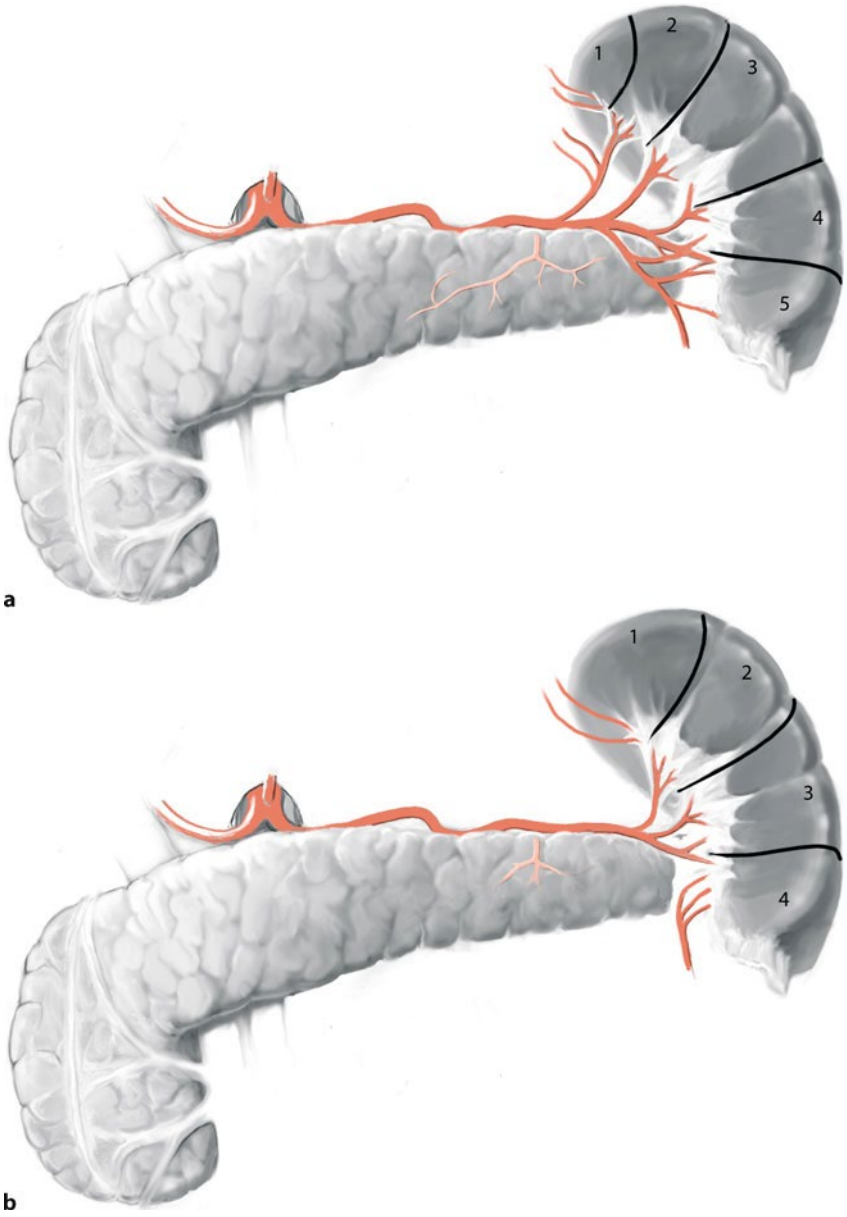


Fig. 107.1

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Step 2

Exposing the entire hilum and ligating appropriate arteries

The next step involves exposure of the entire hilum of the spleen close to the parenchyma. The gastrosplenic and splenorenal ligaments need to be separated while preserving the blood supply to both poles. There is a fairly avascular area of this ligament that needs to be opened between the short gastric vessels to the superior pole and the gastroepiploic branches to the lower pole. This will lead to a complete display of the entire splenic blood supply including both poles.

Selected arterial branches then need to be tediously dissected as close to the spleen parenchyma as possible, noting that the veins are situated posteriorly in close proximity.

The vessels can be doubly ligated, transfixed, or clipped. The long slender laparoscopic clip appliers can be used for this step of the procedure. Once the arterial blood supply is controlled, the affected spleen will visibly demarcate rapidly. If the devitalized spleen corresponds to the intended resection, a similar technique is used on the venous side. Access to the venous side can also be achieved from the posterior aspect of the spleen (Fig. 107.2).

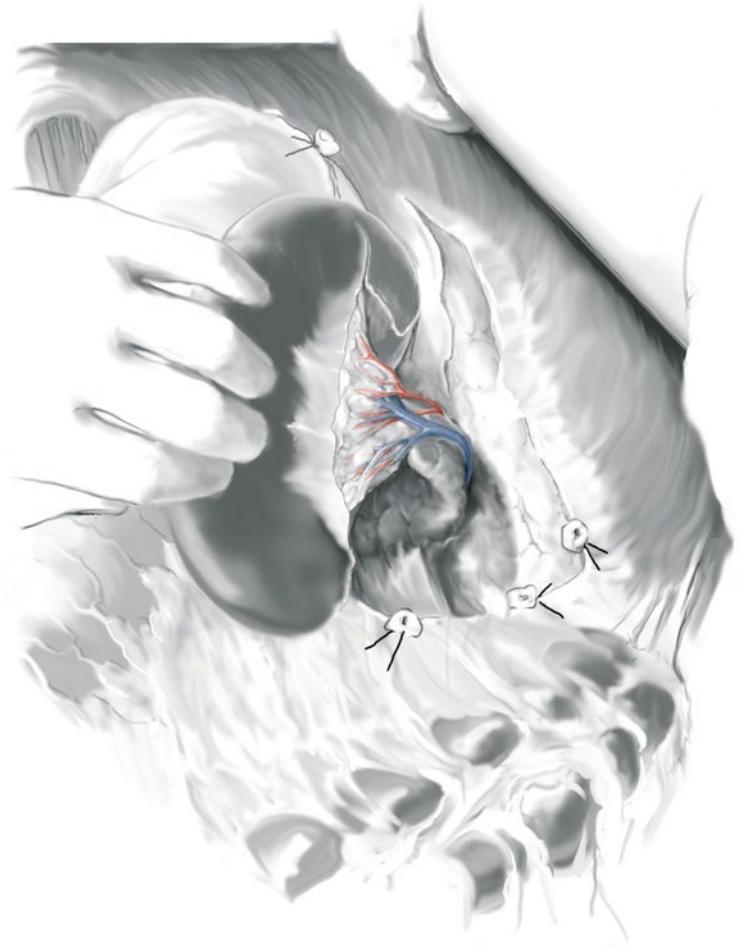


Fig. 107.2

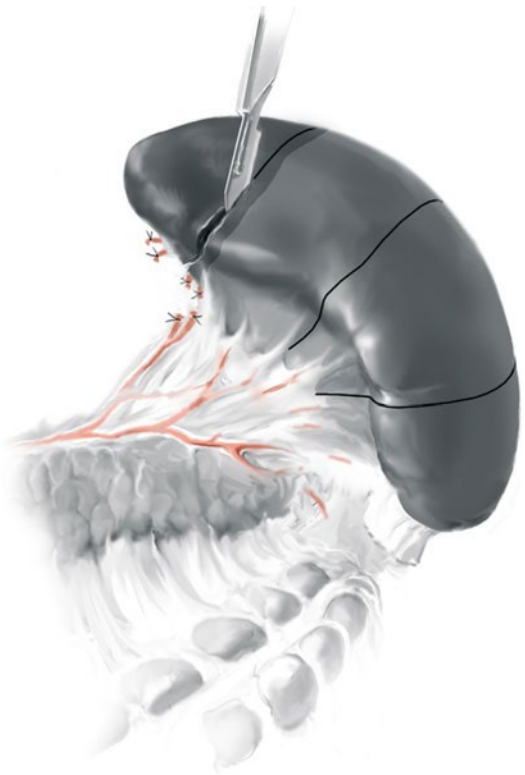
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Step 3

Incising the splenic capsule and resection

The capsule of the spleen is incised circumferentially with a scalpel or monopolar cautery, making sure to leave 5 mm of devitalized tissue in situ. The splenic fragments can be transected with a combination of scalpel, scissors, or monopolar cautery. When enough residual devitalized tissue is left behind circumferentially, very little hemostasis is required and it can usually be achieved by simple means and topical agents.

The abdomen is closed, with or without a closed suction drain, after complete hemostasis is achieved (◘ Fig. 107.3).



◘ Fig. 107.3

Partial Laparoscopic Splenectomy

Step 1

Patient position, trocar placement, mobilization

Patient positioning, trocar placement, and mobilization of the spleen are performed as described in the ▶ Chap. 106, "Laparoscopic Splenectomy."

Care is taken to leave a 2-cm portion of the splenocolic ligament on the spleen side to allow for easier spleen mobilization. Attention is then given to the gastrosplenic ligament anteriorly. It contains the short gastric arteries to the superior pole and the branches of the gastroepiploic artery (up to five branches) to the lower pole.

This allows definition of the type of splenic blood supply, and the number of splenic branches entering the medial aspect of the hilum, thus helping determine the number of splenic lobes.

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Step 2

Dissecting and Clipping the Appropriate Vessels

Once the surgeon has determined what lobe(s) needs resection, tedious dissection of the involved splenic branch(es) is undertaken and the involved artery(ies) is clipped. This dissection can be performed alternatively from the front or the back of the spleen as the spleen can be mobilized fairly easily. The spleen is allowed to demarcate in the chosen region. Once the devascularized area is found to contain the lesion needing resection, attention is given to the corresponding venous drainage, using a similar technique. Veins are situated closely behind the arteries, except at the level of the penultimate and ultimate branches usually within the spleen, where they can be anterior or posterior.

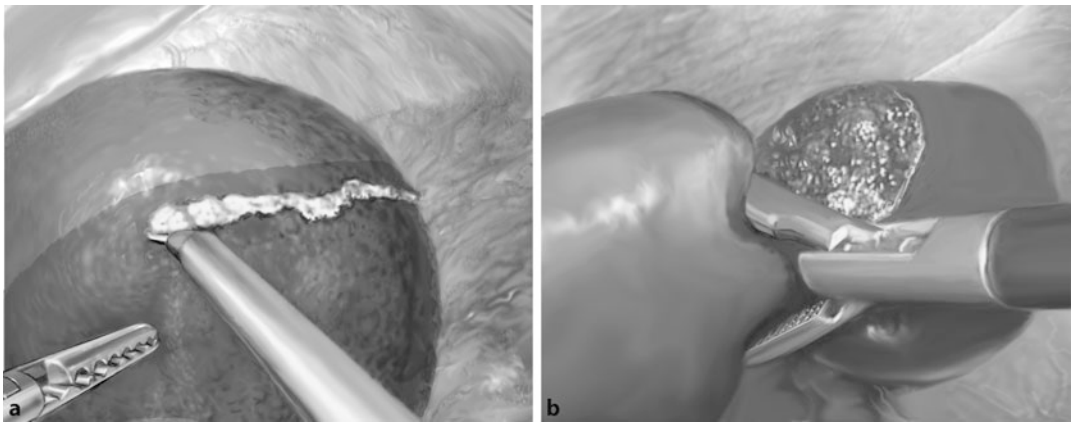
Step 3

Resecting, bagging, and extracting the specimen

The capsule of the spleen is then scored with monopolar cautery on coagulating current circumferentially (30–40 W), ensuring that a 5-mm rim of devascularized splenic tissue remains in situ (◘ Fig. 107.4a). Once the splenic pulp is penetrated, non-crushing intestinal graspers are used to fracture the splenic pulp. A laparoscopic hook and scissors can also be used. If a 5-mm rim of devitalized spleen is left behind, this procedure remains noticeably bloodless. Spot coagulation with monopolar cautery on coagulation or spray current can be used for the remaining hemostasis.

Alternatively the parenchyma can be divided with an endovascular stapler (◘ Fig. 107.4b).

The specimen is removed as per ► Chap. 106, "Laparoscopic Splenectomy."



◘ Fig. 107.4

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Tricks of the Senior Surgeon

- Detailed knowledge of splenic anatomy constitutes the single most important factor that will allow the surgeon to consider all the options available to save splenic parenchyma. There are two patterns of terminal artery branching: *distributed* and *bundled or magistral* (see Step 1). Most specimens have two or three terminal branches (superior polar, superior and inferior terminal) determining lobes or segments. Relative avascular planes are identified between lobes and segments. The surgical unit of the spleen is based upon surgically accessible vessels at the hilum.
- The keys to success with partial laparoscopic splenectomy are experience with advanced laparoscopy, case selection, ability to dissect branches of the splenic artery close to the hilum, and foremost the realization that leaving a 5-mm margin of devitalized spleen in situ greatly simplifies homeostasis.
- Especially in the laparoscopic approach, improper use of the cautery can cause iatrogenic injury to the stomach, colon, and pancreas. Structures close to the lower pole in the gastrocolic ligament can be approached aggressively with the cautery, but blind fulguration of fat in the hilum can result in serious bleeding. The instrument should be activated only in proximity to the target organ to avoid arcing and spot necrosis, which may result in delayed perforation and sepsis.
- The role of the assistants is also important in the prevention of complications. In the laparoscopic approach, all instruments, including those handled by assistants, should be moved only under direct vision. Retraction of the liver and stomach and elevation of the spleen require constant concentration to avoid lacerations with subsequent hemorrhage or perforation and jeopardizing the performance of partial splenectomy.

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Splenic Preservation and Splenic Trauma

Craig P. Fischer, Frederick A. Moore

Indications and Contraindications

Indications

- Injuries to the spleen, when patients are hemodynamically stable.

Contraindications

Hemodynamic instability

- Life-threatening concomitant injuries that are likely to cause hemodynamic compromise in the postoperative period, e. g., severe liver injuries or significant pelvic fractures
- Coagulopathy – the most common cause of coagulopathy in this patient group is hypothermia
- Grade V injuries or the pulverized spleen

Preoperative Investigation and Preparation for the Procedure

Clinical Evaluation

- Hemodynamic status, mechanism of injury, other trauma, comorbidities, age
- Patients who fail non-operative management of blunt splenic injury are usually good candidates for attempted splenic repair. Splenic salvage may also be appropriate when laparotomy is performed for other indications such as penetrating abdominal injury or bowel injury

CT Scan

- *Hemodynamically stable* patients should undergo a CT scan of the abdomen and pelvis with oral and intravenous contrast.
- Two large-bore intravenous catheters should be placed as well as an indwelling urinary catheter and nasogastric tube.

Procedure

Step 1

Incision – midline, exposure, and mobilization

A subcostal incision should not be used in trauma, even if the only suspected injury on preoperative investigations is a splenic injury.

See ▶ Chap. 105, "Open Splenectomy." An initial exploratory laparotomy is performed.

The left upper quadrant should be initially packed with laparotomy pads, then the self-retaining retractor adjusted to facilitate exposure of the left upper quadrant. Gentle pressure on the area of splenic injury with a laparotomy pad will help decrease blood loss.

See splenic mobilization in the ▶ Chap. 105, "Open Splenectomy."

P.-A. Clavien, M. G. Sarr, Y. Fong, M. Miyazaki (Eds.), *Atlas of Upper Gastrointestinal and Hepato-Pancreato-Biliary Surgery*,
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Step 2

Vascular dissection

The lesser sac is entered, somewhat to the left along the greater curvature. The use of an endovascular stapling device will facilitate this step as it is long and capable of angulation. Generally two applications of a 45-mm stapler will allow rapid, wide access to the lesser sac. The splenic artery superior to the pancreas should be identified and may be temporarily clamped if significant bleeding is encountered (see ▶ Chap. 105, "Open Splenectomy"). Be sure the artery is dissected away from the pancreas and does not contain arteriosclerotic plaque before clamping (◘ Fig. 108.1).



◘ Fig. 108.1

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Step 3

Vascular control, hemostasis, splenic preservation

With complete splenic mobilization, the spleen is grasped (Fig. 108.2a). Again, a laparotomy pad is applied to the area of injury. Initial attempts to control bleeding may include simple hemostatic agents, the use of the argon beam coagulator for surface injuries, and suture ligation for deep parenchymal injuries. If injury is to a single pole of the spleen, the distal polar branches of the splenic artery may be ligated within the lesser sac, close to the splenic hilum (Fig. 108.2b). Again, the addition of hemostatic agents and gentle pressure is used.

If initial attempts at hemostasis are unsuccessful, a pledget repair may be used (Fig. 108.2c,d). The splenic capsule in adults will not hold a stitch – use an appropriate pledget, such as Teflon, felt, or autogenous tissue (e.g., posterior rectus sheath). A horizontal mattress technique is used with 3-0 Prolene.

Prior to tying the knots, fibrin glue should be applied to the cleft or site of injury (Fig. 108.2c,d). The use of a spray applicator for the application of fibrin glue is recommended, but not necessary.

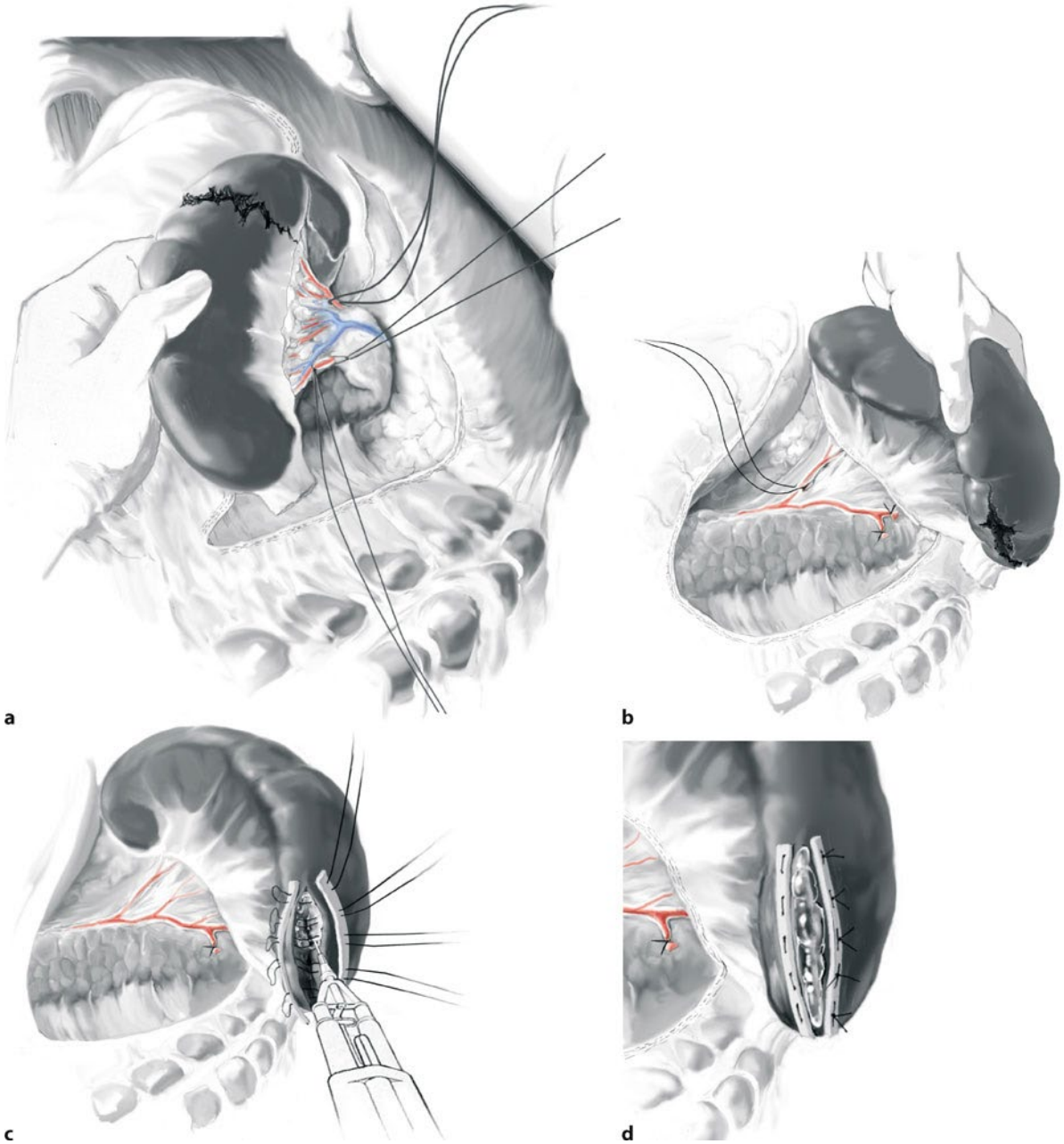


Fig. 108.2

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Step 4

Other techniques of splenic preservation

An additional technique that can be used in conjunction with a pledget repair, or alone, is the use of a woven mesh (Fig. 108.3a). A sheet of appropriate material such as polyglycolic acid is obtained and a center cut is made to allow passage of the splenic vessels via the hilum. This technique is particularly useful when capsular injury is encountered. Fibrin sealant should be applied, via an aerosolized technique, to the injured area of the spleen. For the use of a wrap to be successful, all of the short gastric vessels must be ligated to fully mobilize the superior pole and allow for a circumferential application of the wrap.

After application of fibrin glue, the woven mesh is closed circumferentially with a running absorbable suture (Fig. 108.3b). Care is taken to ensure the mesh is tightly applied to ensure hemostasis and that an adequate opening is left at the hilum that does not encumber either the splenic artery or the splenic vein.

Another technique in splenic salvage is ligation of the splenic artery and vein. This is successful in spleen preserving distal pancreatectomy, and the surgical technique is identical. The splenic artery and vein are ligated en masse with an endovascular stapler. Care must be taken *not to ligate* the short gastric vessels in this case. Additional use of simple hemostatic measures will give a satisfactory result – the spleen will not infarct if the short gastric vessels are left intact.

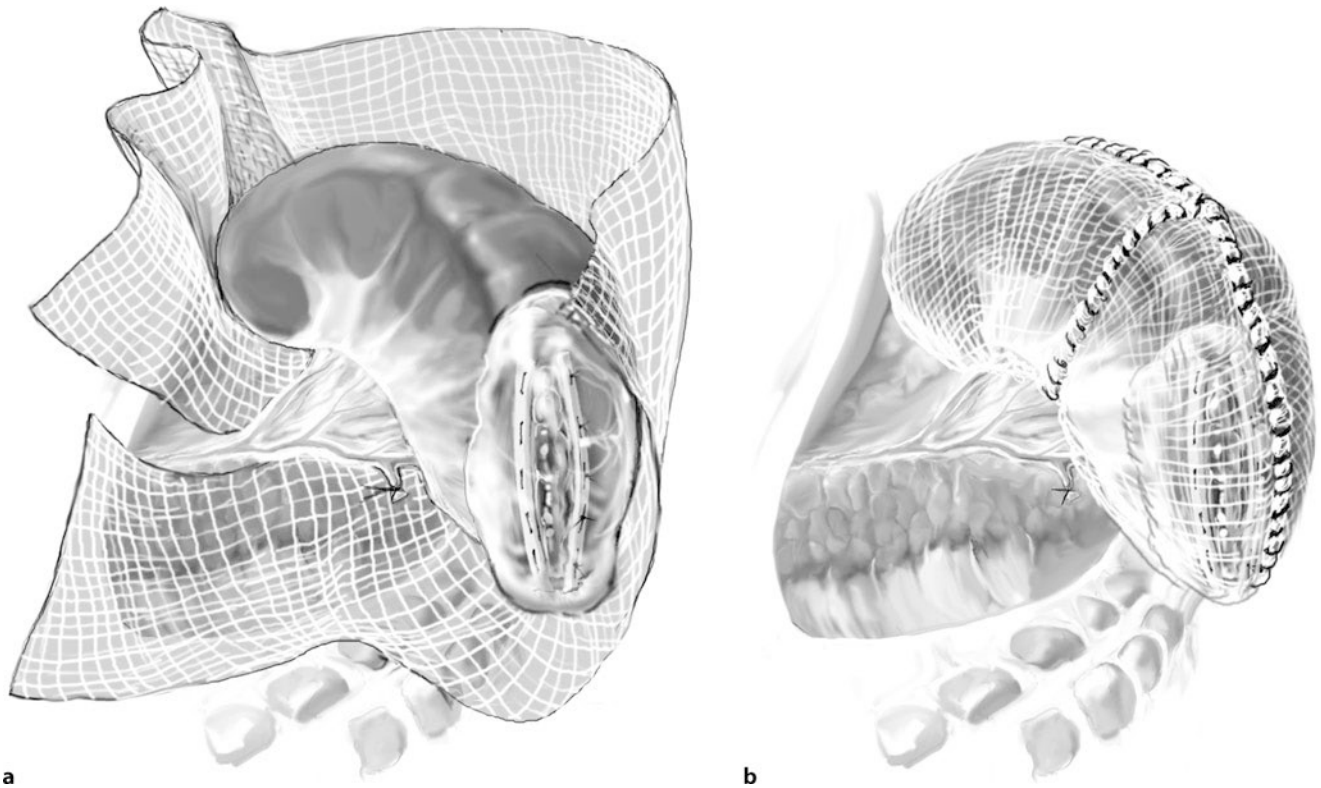


Fig. 108.3

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Postoperative Tests

See ▶ Chap. 105, "Open Splenectomy."

Postoperative Complications

See ▶ Chap. 105, "Open Splenectomy."

- Splenic infarction or splenic abscess is uncommon after splenic repair.
- Postoperative bleeding requiring reexploration. If bleeding (or fresh clot) at site of repair, splenectomy is indicated.

Tricks of the Senior Surgeon

- Do not repair a spleen if it is not bleeding.
- When performing splenic repair early in one's experience, choose the right patient. This generally is a young patient with few other life-threatening injuries.
- Do not accept blood loss while performing the repair – if you cannot quickly stem major hemorrhage, remove the spleen.
- If the patient continues to bleed postoperatively, reoperate promptly.
- When performing ligation of a branch of the splenic artery, or indeed the main artery and splenic vein, do not divide the short gastric vessels.

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Laparoscopic Unroofing of Splenic Cysts

Marco Decurtins, Duri Gianom

Indications and Contraindications

Indications

- Nonparasitic cyst > 5 cm without symptoms
- Nonparasitic cyst < 5 cm with symptoms
- Cyst-related complications (spontaneous or traumatic rupture, abscess formation)

Preoperative Investigations/Preparation

- Serological testing for echinococcus

Procedure

Step 1

Access and insertion of trocars

The patient is positioned in a 45° right lateral position. The surgeon and the camera assistant stand at the patient's abdominal side, video-monitor on the opposite site. The first trocar (umbilical, 12 mm) is inserted in an open technique (T1) and the pneumoperitoneum (14 mmHg) is introduced.

Further trocars are inserted under visual control in the left lower abdomen (T2, 10 mm) and in the left midaxillary line just below the costal margin (T3, 10 mm). If needed, additional trocars are placed semicircularly in relation to the spleen (*dotted line*) (Fig. 109.1).

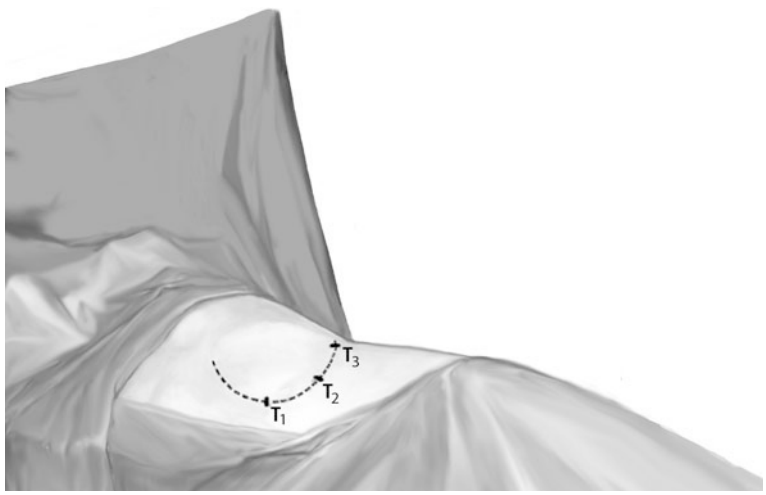


Fig. 109.1

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Step 2

Aspiration of the cyst contents and resection of the cyst wall

The cyst is opened in an avascular region with electrocautery and the contents aspired. The adhesions to the surrounding tissue are dissected and the spleen needs to be completely mobilized as for a laparoscopic splenectomy. Care should be taken with the diaphragmatic adhesions, which can be particularly dense (Fig. 109.2).

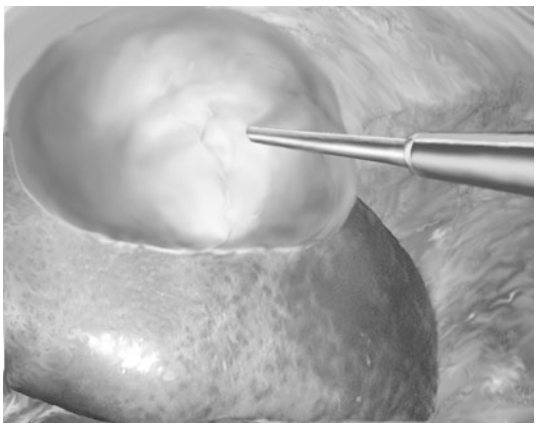


Fig. 109.2

Step 3

Unroofing cyst

The cyst wall is unroofed using diathermy or harmonic shears until unaffected splenic parenchyma is reached. During the resection of the cyst, meticulous hemostasis is important to prevent impairment of the view. To minimize the risk of recurrence, the largest possible amount of cyst wall should be resected. The excised tissue is placed in an endoscopic plastic bag and removed.

When technically feasible, an omentum patch is placed in the remaining cyst cavity and the trocar incisions are closed without drainage (Fig. 109.3).

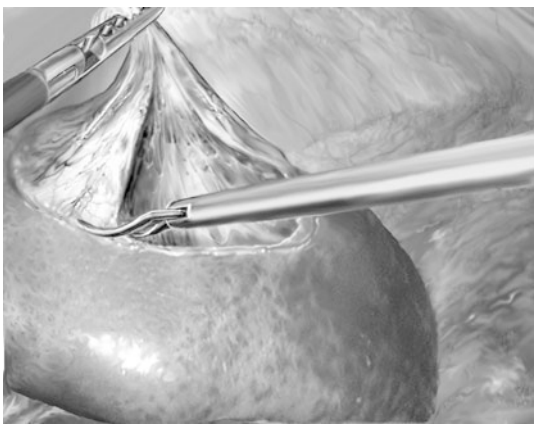


Fig. 109.3

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Postoperative Tests

See ▶ Chap. 105, "Open Splenectomy."

Postoperative Complications

See ▶ Chap. 105, "Open Splenectomy."
Cyst recurrence

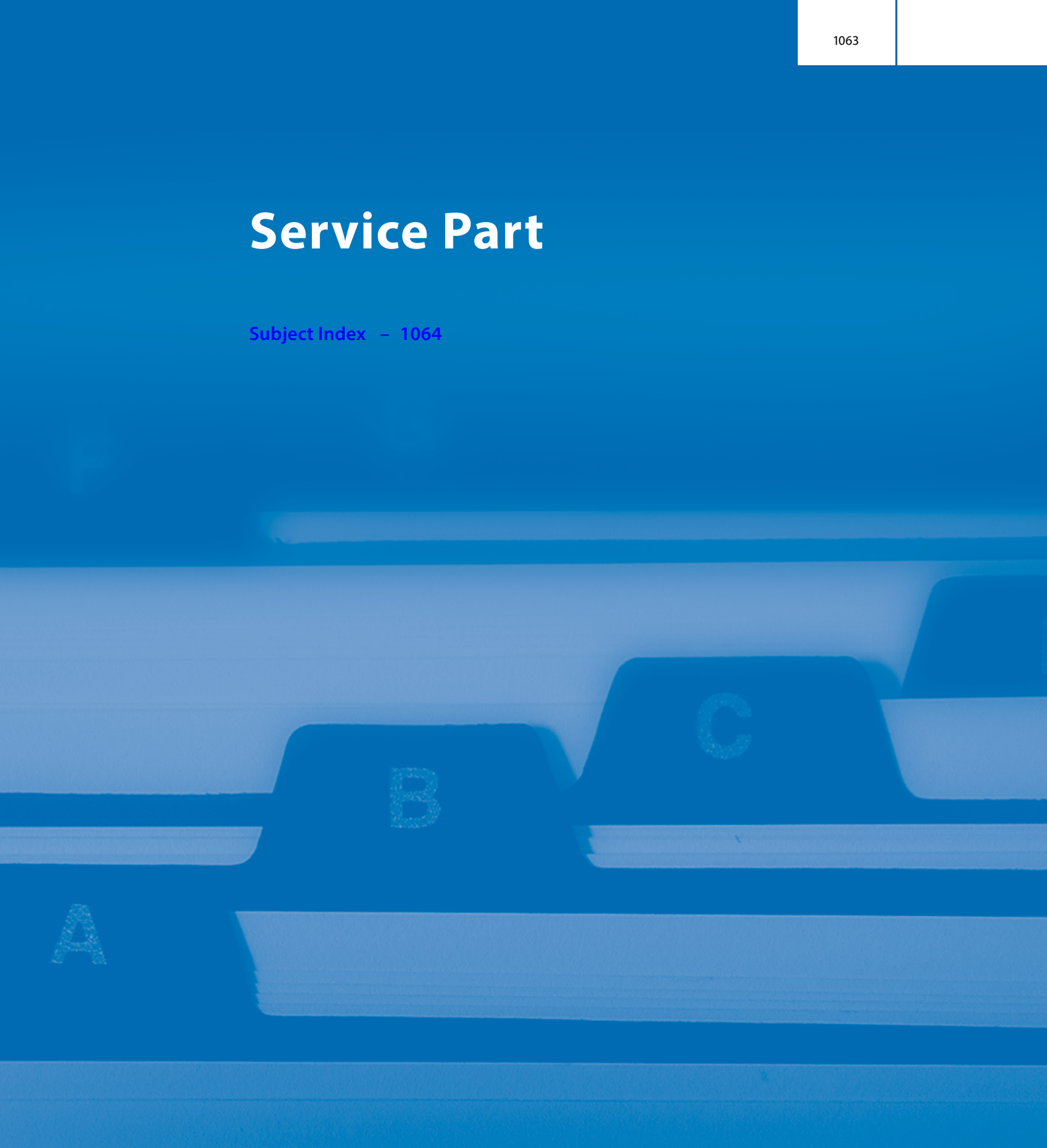
Tricks of the Senior Surgeon

- Complete mobilization of the spleen prior to resection of the cyst wall is imperative.
- To reduce the risk of bleeding, use dissection with a stapler device in situations where the cyst wall is covered with normal splenic parenchyma. This is especially useful in the region of splenic hilus.
- Use an open approach in parasitic and neoplastic cysts.

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Service Part

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