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ORIGINAL ARTICLE

Crew resource management training for surgeons: feasibility and impact

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Abstract This paper describes a prospective, within-subjects study to measure the before-after effect of training five general surgery attendings on crew resource management (CRM) strategies on the resultant use and perceived utility of those strategies. Subjects were trained via a 1-h lecture on seven CRM skills after their second observed case, and participated in a 15 min debriefing with the trainers immediately following their fourth through sixth observed cases. These interventions led to a significant increase in frequency (by 26–70%) of preoperative briefing elements over baseline. There was a significant correlation between the use of CRM practices and their perceived utility in improving team coordination and reducing error.

Keywords Operating room · Patient safety · Medical error · Team performance · Video-based research · Crew resource management · Training

1 Introduction

The operating room has been cited as the most common site in hospitals for adverse events to occur (Leape 1994), with peri-operative adverse events being twice as common as medication errors and six times more common than diagnostic or therapeutic errors (Calland et al. 2002). One study found avoidable mortality rates ranging from 19% to nearly 45% depending on surgery service (Healey et al. 2002). Another study reported complications in 39% of general surgery patients, 18% of them believed to be attributable to error (Wanzel et al. 2000).

Most preventable adverse events are not simply due to operator error but from processes and systems that allow or permit errors to remain undetected (Leape 2000). Human factors are especially critical in high-risk settings such as the operative environment as team members from multiple disciplines interact to provide patient care. Although the roles (e.g., anesthesia attending and resident, surgery attending and resident, scrub tech, circulating nurse and medical student) might largely remain the same for a particular type of procedure, the actual team members do not all have the same level of training/experience and are rarely the same from case to case due to staffing and scheduling differences across disciplines. Communication and coordination are thus fundamental to effective care. Research, though limited, has demonstrated that poor teamwork and communication exist during surgical procedures (Helmreich and Schaefer 1994; Sexton et al. 2002) which is not surprising as these skills are neither trained nor rewarded. A study of case observations in the operating room found that team tensions occurred regularly and often spread to other team members and contexts (Lingard et al. 2002). One study reported that numerous errors occur during surgical procedures not because of technical competence, but rather due to interpersonal aspects of the operative team environment (Helmreich and Schaefer 1994). In this same study, two thirds of the operating room members cited in an open-ended query that better communication was most needed to improve patient safety and efficiency in the operating room.

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The aviation industry and its application of a systems approach to safety improvement and error prevention have often been compared to the surgical domain in recent medical literature (Calland et al. 2002; Helmreich 2000). One safety effort, required for flight crews worldwide, has been a type of training known as crew resource management (CRM) which targets such behaviors as communication, leadership, interpersonal relations, conflict resolution, preparation, planning, and vigilance to enhance team communication and coordination.

Many researchers and practitioners are beginning to apply CRM training to healthcare environments but there remain questions as to how best to deliver and measure its effectiveness. Anesthesia Crisis Resource Management (ACRM) is an approach that has successfully been deployed for anesthesia caregivers and has also been adapted to other health domains (Howard et al. 1992; Gaba et al. 2001). ACRM training takes place in a high-fidelity simulator, with an interactive patient mannequin, working monitors, instrument readouts, and other teammates being role played by simulator center staff such that realistic anesthesia crises can be introduced and ACRM skills practiced in a repeatable fashion. Such high-end simulators, however, are expensive to set up and run, and are not yet available in all institutions or for all healthcare disciplines. The question then is whether at least some CRM skills can still be effectively trained and measured without a simulator environment. Although not ideal, such a lower-cost part-task solution may be a way to introduce CRM to an institution or group of caregivers.

Such an approach has been demonstrated to be effective in some health-care settings. A recent multi-center study demonstrated a significant reduction in observed errors in handling of actual emergency medicine cases after the staff had participated in the (non-simulator based) MedTeams training program (Morey et al. 2002). A study at Methodist University Hospital showed that a similar (non-simulator based) CRM training intervention, along with a change in procedures, successfully led to a significant reduction in surgical instrument count problems taking place at that institution (Rivers et al. 2003).

Another question is whether to train all members involved in the procedures (as was done in the latter two studies described in the previous paragraph) as opposed to ACRM training which focuses on just training one discipline (e.g., anesthesia) on skills specific to them. A whole-team approach is particularly relevant for teams that always work together—it makes sense to train them together. A part-team training approach still has merit, however, as it enables a particular group to be trained on items that may not be as relevant to team members in different roles and it avoids the logistical barriers of gathering together whole teams at a time. Regardless of the training approach, one fundamental idea behind CRM is to have team members be able to cross check other team members to the degree possible. Thus, having some knowledge of intentions and status of team members from different disciplines is important.

One challenge with introducing CRM is the time required to participate in CRM training courses, most of which encompass a minimum of one full day of training, (Gaba et al. 2001; Grogan et al. 2004; Kohsin et al. 2002; Morey et al. 2002; Rivers et al. 2003). If limited time outside of practicing medicine were available for key participants (e.g., surgery attendings) what could be effectively taught and how would that improve teamwork performance? How would training just the surgery attending, for example, "trickle down" results to the rest of the operating room team?

One reason to focus on training this population is that the surgery attending is arguably supposed to be the team leader during a surgical procedure and clearly has the most case-specific context for the reasoning behind the procedure about to be performed and the intended goals of the procedure. Earlier observations in our institution have shown that for laparoscopic cholecystectomy (gallbladder removal) procedures, such intentions are not formally communicated, sometimes with detrimental effect. In one case, the attending forgot that he had planned to perform an intraoperative cholangiogram (an imaging study where dye is inserted via a catheter through the cystic duct into the common bile duct and an X-ray taken to see if the patient has gallstones in the common bile duct) until too late in the procedure (it was only after the cystic duct was transected by the resident that the surgeon remembered that was the plan). Human performance literature tells us that when an intention to act is separated in time from when the act can take place, it is extremely common for a lapse to occur (Norman 1981).

But in this particular case, the error of omission was clearly not due to a momentary lapse. The surgeon had never announced his intention to perform a cholangiogram. Thus none of the other team members were able to cross check (e.g., remind him of his intention), nor were they prepared with the right equipment even if he had remembered just at the right time.

This is the idea behind CRM: to train communication skills that will maximize the opportunity for coordination and minimize the chance for errors. One such skill is to perform a preoperative briefing. Routinely having the attending surgeon (as team leader) perform such a briefing not only informs the team of the plan for the case, but it also serves to trigger his memory for intentions specific to the case, minimizing the chance that an incident similar to the above would occur.

We describe here a research study to determine the feasibility and merit of training general surgery attendings on CRM skills with a brief didactic course followed by periodic feedback sessions after observed cases. As we were focusing on discipline-specific training, our outcome measures (collected via questionnaire data described further below) focused on determining whether (1) other team members were able to cross-check surgeons, e.g., because the surgical plan was communicated to them and (2) whether surgeons specifically cross-checked other team members, e.g., regarding administration of antibiotics and setting up all appropriate appliances prior to skin incision.

We had team members rate themselves rather than independent observers. In particular, we found it impossible for outside observers to give "overall" communication scores as has been done in several CRM studies, due to the vagueness of the categories and the changing nature of the task (as well as the difficulty of having trained observers being blinded to study interventions and goals).

1.1 Setting

Laparoscopic cholecystectomy (LC) was chosen as the model procedure for this study as it is one of the most commonly performed general surgical operations, technical performance is fairly consistent among surgeons, and the procedure length is fairly consistent (60–90 min). It is also a relatively "low risk" case, and, along with its frequency, is thus one where CRM skills could be introduced without adding undue mental burden to the surgery attendings. Emergency procedures and those involving children, prison inmates, and the investigators' patients were excluded. The study was approved by the University of Virginia Human Investigation Committee. Informed consent was obtained from all participants including patients, physicians, nurses, operating room staff and students.

2 Method

From an initial enrollment of seven general surgery faculty physicians who agreed to participate, two surgeons were excluded from the study because of insufficient numbers of qualifying cases performed during the study period. Thus, the study was carried out utilizing data from 40 LC cases performed by five faculty surgeons (8 cases for each surgeon) during the period from November 2002 through July 2003. Due to the limited population of subjects, we focused on a within-subjects (before-after) design of experiments (see Fig. 1). The attending was individually trained via a 1-h lecture (described further below) given by the two first authors after completion of his second case during the study protocol. These same two authors conducted additional follow-up training by holding a feedback session immediately after cases four, five, and six for each surgeon (described further below). For all forty cases, these same authors used the Remote Analysis of Team Environments (RATE) system (Guerlain et al. 2005) to record case events via analog to video data capture and to "mark" observed events to enable quick post-case playback of those events.

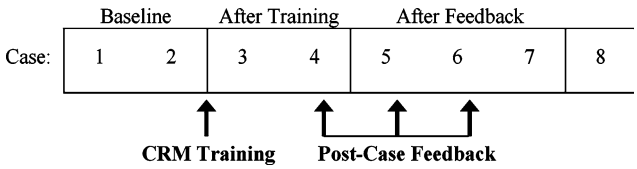

Fig. 1 Within-subjects study design (n = 5 faculty surgeons). Crew Resource Management training was given to each surgeon after his second study case. These elements were then reviewed with each surgeon in a feedback session immediately following cases 4, 5, and 6. Case 8 was eventually dropped from the analysis due to low response rates

Due to differences in case mix, some attending surgeons completed the protocol faster, e.g., one surgeon may have completed two LC procedures and had his initial training before another surgeon had performed his first LC procedure during the study period. The time span for each surgeon to complete the final six cases varied from 60 to 165 days after the training session.

2.1 CRM training

The CRM training focused on a subset of skills trained in the Air Force Medical Team Management Program (Kohsin et al. 2002), a CRM program that is now mandatory for all high-risk clinical areas within Air Force medical facilities. We did not introduce or train on CRM skills related to conflict resolution or on incident-specific crisis management, two common additional foci of CRM training, as this was thought to be too much to introduce at one time and previous observations (Guerlain et al. 2004a; Guerlain et al. 2005) showed that the former practices could be put to the best use for each and every case performed whereas the latter were not commonly required and thus would be difficult to measure in our initial study design. Below is a summary of the team communication skills and how they were taught to each surgery attending after his second but before his third enrolled study case during a private 1-h didactic lecture.

2.1.1 Brief the team prior to first skin incision

The brief should cover five areas:

Team. Introduce anyone not known in the room and find out if there is any turnover expected during the case.

Patient. Give a brief patient history, e.g., the reasons that led to the decision to have the surgery.

Procedure. Describe the plan for the procedure, including any special intraoperative tests planned (cholangiogram, ultrasound) or special equipment needs and whether the case is expected to be difficult and perhaps require conversion to an open procedure.

Empowerment. "If anyone has questions or concerns, please raise them at any time".

Ready? Confirm that all preparatory procedures have been performed (e.g., antibiotics have been administered, and all needed appliances are in place and turned on, such as the Foley catheter (for urine output), the sequential compression devices (which periodically squeeze the patient's legs to keep blood circulation up), the gas (needed to inflate the abdominal area), the suction (for suctioning fluids), the electrocautery footpedal (for cauterizing tissue during the surgery) etc.

2.1.2 Use callouts to indicate completed tasks

This helps others on the team maintain situational awareness.

2.1.3 Use a person's name when making requests

This helps capture attention of the intended recipient and avoids confusion as to who is to respond to a request. It also avoids a feeling of frustration like "no one is listening" and avoids the need to repeat requests multiple times until someone responds.

2.1.4 Read back to confirm actions taken

The recipient of a message repeats back a request. Read back serves as another form of callout, thus providing more situation awareness for the team and reducing anxiety that a request was not heard. Furthermore, the person reading back benefits because saying a message lessens the likelihood of forgetting it.

2.1.5 Voice concerns and step back when feeling the pinch

The "pinch" is an intuitive feeling or that "little voice" that signals something may be wrong. It may manifest itself physiologically, such as having a queasy feeling, butterflies in the stomach, or hair that stands up on the neck. If feeling the pinch, *act* by taking a step back. Stepping back starts by getting the team's attention, e.g., "We need to step back due to...", and possibly asking for feedback from team members before determining the next course of action.

2.1.6 Maintain a sterile team environment

Minimize distractions in the environment. This is particularly important during high-risk phases of the procedure (times that require undivided attention), and thus it is important for individuals to communicate to the team if something is distracting *them*.

2.1.7 Debrief the team at the end of the case

The debrief is an after-action report and should include thanking everyone, going over what the team did well and discussing any opportunities for improvement. For any obstacles or complications that incurred, actions should be identified to overcome those in the future. For example, if a piece of equipment was faulty or missing, the team should make a plan to ensure it is fixed before the next case.

The lecture lasted approximately 40 min and was followed by two video vignettes, one that showed a medical team lacking in CRM skills and a second that shows a team using several of the skills described during training. These videos were provided by Dynamics Research Corporation, Andover, MA, a firm that conducts CRM training for medical facilities.

2.2 Feedback sessions ($n = 3$)

The same two authors who gave the didactic training held feedback sessions with the attending surgeons immediately following their fourth, fifth, and sixth study cases. The sessions were held during changeover time between cases in a conference room within the surgery suite. While only the surgery attending was required to attend, all other team members were invited to participate. The surgery resident usually came with the attending but no other team members ever chose to participate (not surprising because logistically this is a good time for the surgeons but not a good time for the rest of the team members who are busy with other responsibilities at this time).

The feedback sessions generally lasted 15–20 min. The facilitators briefly went over each of the desired CRM skills that had been covered during the training session, but discussed them with the surgeon(s) in the context of the case that just occurred. The audiovisual record was available to be used although was rarely accessed when discussing CRM skills. If the debriefing had taken place several days or weeks later, it is more likely that such a record would be necessary. However, once the CRM skills part of the session was completed, the surgeon(s) generally liked to use the audio-visual record to go over some of the technical aspects of the case.

Thus, the feedback sessions served as a means to reinforce and expand upon the CRM skills introduced during training but in a case-specific way. This approach to training was thought to be more beneficial because it was spread out over several sessions, each of which reinforced and built upon previous sessions, and was specific to that participant's actual performance and in context to cases just performed. It is also significantly less time-consuming to the participants (the whole CRM intervention takes a total of 2 h spread out over one 1 h lecture and three 20 min debriefs) than current day-long CRM training courses.

2.3 Post-case questionnaires

Immediately following each of the 40 cases (and prior to any feedback sessions), all participants in the case were asked to fill out a double-sided post-case questionnaire asking certain demographic information about the respondent and then asking whether certain CRM skills were demonstrated and if they were perceived as being useful. Respondents were then asked certain "facts" both about the patient (preoperative lab values, imaging findings and imaging indications) and the procedure (whether antibiotics were given and what appliances were in place prior to skin incision). Further details on the questions are shown in Sect. 3.

3 Results

There were a total of 156 questionnaires returned during the study corresponding to 66 participants. Additional staff participated during cases but declined to fill out questionnaires. Only one questionnaire was returned from an anesthesia attending and thus this whole group was discarded from the analysis. Case 8 was also dropped from the analysis due to the low response rate by non-surgeons. This left a total of 141 questionnaires returned by 60 participants. The seven cases completed by each surgeon were grouped into three categories: Baseline (Cases 1 and 2), After Training (Cases 3 and 4) and After Feedback (Cases 5, 6 and 7). Table 1 shows the actual versus total possible response rate by role in the surgery and grouped by case category across all five surgeons for these three case groups. Thus, for Baseline Cases, the maximum response rate is nominally 60 (2 cases $\times$ 5 surgeons $\times$ 6 roles) although there were a few cases for which either an "extra" resident or scrub tech was present and a few cases for which no surgery student was involved in the case (a medical student's role is to operate the laparoscopic camera so if one is not present, then one of the two surgeons operates the camera) so the total possible response rate was adjusted accordingly.

Note that some respondents participated in more than one case (possibly for a different attending surgeon). Table 2 shows the frequency with which a particular person returned a questionnaire. Two people were both circulating nurses and scrub techs (but for different cases). Thus, the total number of people involved (as shown in Table 2) is 60, but the sum of respondents acting in roles (as shown in Table 1) is 62.

Tables 3, 4 and 5 show the demographics of respondents (gender, years in role, and hours of sleep in prior 24 h).

Figure 2a shows the questions and results for preoperative CRM briefing elements and their perceived effect on communication, teamwork and errors at three points in the study (cumulative scores on Cases 1 and 2, cumulative scores on Cases 3 and 4 and cumulative scores on Cases 5–7, for all respondents and for non-surgeon respondents).

Table 1 Questionnaire response rate (across all five subjects) grouped by case type

Respondent role	Number responding	Cases			Total	Percent response by role (%)
		Baseline 1 and 2	After training 3 and 4	After feedback 5, 6 and 7		
Surgery students	8	7/9	5/10	3/10	15/29	10.64
Scrub techs	11	9/10	7/11	8/15	24/36	17.02
Circulating nurses	11	8/10	4/10	7/16	19/36	13.48
Anesthesia Residents or Certified Registered Nurse Anesthetists (CRNA)	11	5/10	6/10	2/15	13/35	9.22
Total (w/out surgery residents/attendings)	41	29/39	22/41	20/56	71/136	
Surgery attendings	5	10/10	10/10	15/15	35/35	24.82
Surgery residents	16	10/10	10/10	15/16	35/36	24.82
Total (all respondents)	62	49/59	42/61	50/87	141/207	100.00

Table 2 Frequency table for number of questionnaires returned by respondent

Number of questionnaires returned per respondent	Frequency
1	28
2	15
3	5
4	3
5	3
6	1
7	5
Total	60

Table 3 Role × gender for returned questionnaires

Role	Gender		Total
	Female	Male	
Count			
Surgery attending	0	35	35
Surgery resident	6	29	35
Surgery student	2	12	14
Scrub tech	21	3	24
Circulating nurse	16	3	19
Anesthesia resident or CRNA	6	7	13
Total	51	89	140

Table 4 Role × years in role for returned questionnaires

Role	Years in role (binned)				Total
	0–2	3–5	6–9	10+	
Count					
Surgery attending	15	0	11	9	35
Surgery resident	17	11	7	0	35
Surgery student	14	1	0	0	15
Scrub tech	7	0	0	17	24
Circulating nurse	3	3	0	13	19
Anesthesia resident or CRNA	5	3	0	5	13
Total	61	18	18	44	141

Figure 2b shows the questions and these same sets of results for intraoperative CRM skills (callouts, readbacks and use of names when making requests) and their perceived utility for task completion. Figure 2c shows the post-case "knowledge" questions and their results. Scores for questions shown in Fig. 2a and b are reported as percentages of "yes" responses (where "no", "not sure" and blanks were all counted as non-yes responses). Scores for questions shown in Fig. 2c were calculated as the percentage of respondents who answered these questions correctly as compared to patient and operative records. "Not sure" and blanks were counted as an incorrect answer except for two respondents who did not fill out any of these latter questions. This was deemed as being likely due to an oversight because these were on the back side of the actual questionnaire, so those blank scores were not factored into the analysis.

Table 5 Hours of sleep in past 24 h by role

Role	Hours of sleep in past 24 h				Total
	0	1–3	4–5	6+	
Count					
Surgery attending	0	2	8	25	35
Surgery resident	3	4	2	26	35
Surgery student	1	0	4	10	15
Scrub tech	1	0	2	20	23
Circulating nurse	3	0	3	11	17
Anesthesia resident or CRNA	0	0	0	13	13
Total	8	6	19	105	138

Table 6 shows the significance values of questions grouped (added together) by type on both the overall training effect (responses to these five question types for questionnaires returned from Cases 1 and 2 are compared to responses to these five question types for questionnaires returned on Cases 3–7) and the effect of the Feedback sessions (scores from Cases 1–4 are compared to scores from Cases 5–7). Graphically, these data are shown in Fig. 3. Although there are differences in effect by attending ($r = 0.325$, $P < 0.001$), there is also a correlation among briefings and perceptions of their utility ($r = 0.56$, $P < 0.001$). There is a similar significant correlation ($r = 0.719$, $P < 0.001$) between use of Callouts, Readbacks and Names, and perceptions of their utility even though the use of these practices varied by attending surgeon (see Fig. 4). Overall, there was a significant effect of training on briefing practices ($P < 0.001$, Table 6), with less clear results for the other four categories of questions.

Finally, in 19/35 cases (54%), at least one team member reported feeling "the pinch" or that an adverse event occurred and in 15 of these 19 instances (79%), they reported speaking up about what was concerning them. For those where they did not speak up, in one case, the Anesthesia Resident/CRNA reported that there was high blood pressure and positive airway pressure but that he "took care of it himself", two surgery students "lost understanding of how the camera should be directed" and finally, a surgery resident reported being "unsure" if he was feeling the pinch and "unsure" if there was an adverse event, but did not report what specifically was bothering him, nor did he report speaking up about it.

Fig. 2 Responses to questionnaire items grouped by Case Type (Baseline, After Training or After Feedback) and Respondent Set (with or without surgery attending and resident). *a* Qs 1–8. Frequency of pre-operative briefing practices and whether they were perceived as useful. *b* Qs 9–13. Frequency of intra-operative team communication practices and whether they were perceived as useful. *c* Qs 14–18. Percent correct on post-case knowledge of patient-specific facts and case-specific facts

Table 6 Effect of question types on before-after case groupings

Surgeon(s)	All[a]	1[b]	2[b]	3[b]	4[b]	5[b]
Overall training effect (Cases 1 and 2 versus Cases 3–7)						
Briefing elements (Qs 1–5)	0.000*	0.019*	0.044*	0.001*		0.011*
Had benefit (Qs 6–8)	0.029*					0.003*
Intraoperative communications (Qs 9, 11, 13)	0.087**				0.002*	0.001*
Had benefit (Qs 10, 12)						
Case and patient knowledge (Qs 14–19)	0.048*			0.034*	0.016*	
Effect of feedback sessions (Cases 1–4 versus Cases 5–7)						
Briefing elements (Qs 1–5)	0.000*	0.056**		0.004*		0.074**
Had benefit (Qs 6–8)	0.072**					
Intraoperative communications (Qs 9, 11, 13)			0.072**		0.028*	
Had benefit (Qs 10, 12)	0.026*				0.095**	
Case and patient knowledge (Qs 14–19)		0.095**		0.014*		

* $P < 0.05$, ** $P < 0.10$

[a] P values from repeated measures ANOVA

[b] P values from Wilcoxon two-sample test

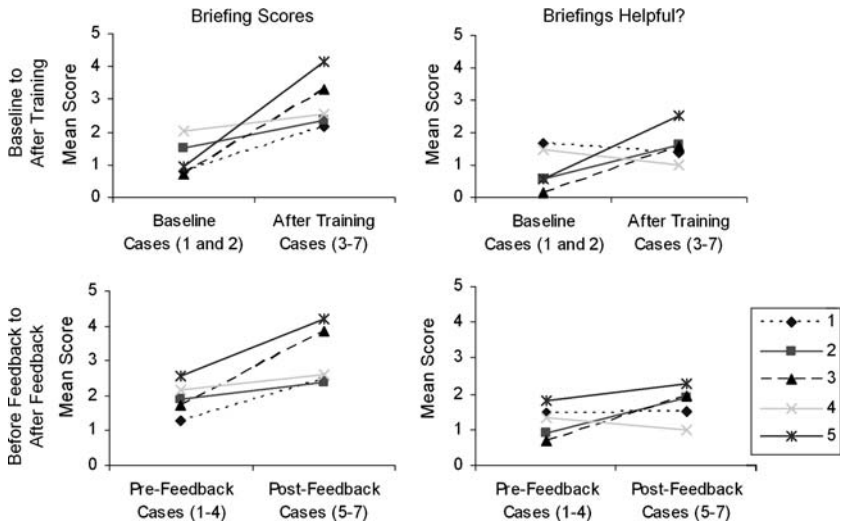

Fig. 3 Effect of level of training on briefings and perceptions of their utility, by subject

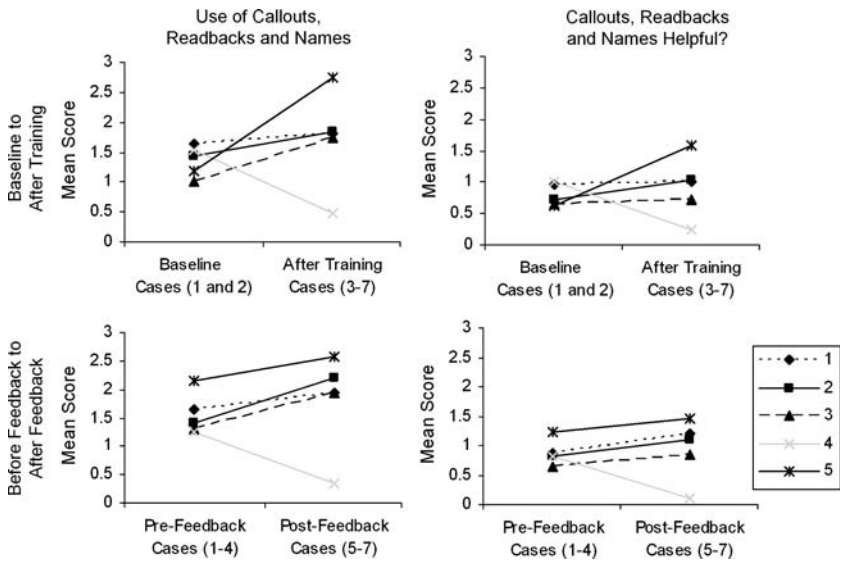

Fig. 4 Effect of level of training on use of names, callouts, and readbacks and perceptions of the utility of these practices, by subject

4 Discussion and conclusions

Despite the small sample size of this study, we see evidence that CRM training had a significant impact on briefing practices for 4/5 surgeons, and that these practices were highly correlated with respondents' perceptions of communication, teamwork, and potential for reducing errors. These latter results are important should the continued use of these practices be embraced. If team members understand their benefit, it is more likely that they will be practiced than if they are seen as superfluous.

Graphically, one can see a difference depending on the population mix of the respondents to certain questions in Fig. 2. Having the surgery residents and attendings in the mix "brought up" the scores about the patient history (image findings, image indications and lab values) as might be expected but "brought down" the scores on scheduled break relief and the use of readbacks. These are interesting findings as they show a difference in knowledge about some case events for surgeons versus non-surgeons, even after training. Perhaps, for example, the non-surgeons have discussed shift changes amongst themselves but this was not always communicated to the surgeons.

Based on baseline scores, we can see that desired pre-briefing elements are not often or consistently practiced in surgery (ranging from 6 to 45% depending on the briefing element prior to study interventions) and training increased their frequency significantly (ranging from 35 to 73% for the After Feedback cases). Although significant in some cases, less consistent success was seen on changing intra-operative communication practices, with baseline ranges from 31 to 49% depending on the practice to 46–73% after both sets of interventions. These practices were not predicted to increase as much as briefing practices, however,

since only the attending surgeon was trained and these communication strategies need to be used by everyone on the team. However, there was a strong correlation between use of these strategies and perceptions of utility, again lending evidence that they are at least perceived to be important by all team members.

Further study should look at whether training the whole team creates a better effect on performance. Training for other team member roles could focus more on readbacks, callouts and use of names. It is likely that assertiveness training (to speak up when appropriate) would also be important for these other groups due to the hierarchy implicit among team members in the operating room.

The debriefing method of reinforcing CRM skills was surprisingly easy to accommodate during the turnover time between cases. This proved to be a good time to review the case with the surgeons. The RATE hardware/software system made instant review of case events easy given that we were in the room to mark off key points during the case, thus facilitating finding that aspect of the case again quickly. The attending surgeon and resident often spontaneously wanted to review various technical elements of the case and thus a possible further study would be to expand upon the use of such a system for this purpose with an ability to easily save video clips for training purposes (e.g., as was done in Guerlain et al. 2004b).

Whole-team debriefing was difficult to accommodate for two reasons. One, team members are changing for almost every case. Two, each team member disperses to perform different follow-up tasks immediately following a procedure. It is unclear how such whole-team debriefing could ever occur.

In feedback sessions, subjects admitted not knowing how best to introduce others, and not knowing how to address someone by name if they forgot either who was in the room or the name of that person. One subject suggested that perhaps the Scrub Tech should be the "communications manager" between the surgery team and the rest of the team. This was an interesting idea, that the scrub tech should be responsible for passing information in addition to passing instruments.

It was admirable to see the effort of the surgeons to conduct a good briefing although some reported it felt awkward to do so. We heard things like, "Now, let's see, is the foley in? SCDs on? Antibiotics were given, right? Everyone know each other? Everyone OK? Everyone happy?" One surgeon even had to say, "Now listen up. This is important!" He then repeated parts of his briefing in order to be heard. There were also instances of the surgery attending asking team members to read back when he made a request. One readback instance was caught as being a misinterpretation.

Thus, we saw evidence that the subjects in our study were willing to apply the CRM practices to the best of their ability. Despite these efforts, there were still many instances where things were not set up or turned on, e.g., the foot pedal not being in the right place or suction not turned on. Sometimes these were caught at the beginning when going over the briefing, but not always. This lends more evidence to the need to train more than just the surgery attending, that the whole team needs to be trained to actually check each and every appliance as the briefing is taking place and to perhaps have a different team member lead this aspect of the briefing.

It is difficult to tease out the effect of the didactic lecture from the feedback sessions in terms of their impact. Certainly having observers present and questionnaires being distributed all had some impact as well on whether the skills were attempted and improved upon. It was not our intention to try to tease out these effects as they are all likely important; one must first gain knowledge about a skill and then practice it with feedback before being expected to gain proficiency.

The demographic data are alarming. Table 4 shows that the respondents were still in the early stages of their training (and thus many of the participants are performing a relatively novel and high-risk task), with a significant portion of them having little to no sleep (Table 5). The surgery residents are the ones actually performing the surgery (with assistance and guidance by the attending) and yet about 1/4 of them were operating with less than 5 h of sleep in the prior 24 h. One third of the surgery students (who operate the camera with no prior training) also have less than 5 h of sleep in the prior 24 h. There is a strong evidence for a learning curve for this surgical procedure (Moore and Bennett 1995) as well as evidence for sleep impairing surgical performance (e.g., Taffinder et al. 1998). The combination of the two cannot be good. This finding may be different now with the institution of regulated resident and student work hours. These have led to mandatory time off after shifts and other changes that should decrease sleep impairment.

This study introduces a relatively efficient and inexpensive (no simulators required) CRM training approach that meets many of the requirements of a good CRM course (Salas et al. 2000). The methodology provides a combination of lecture (information presentation) ability to practice skills on multiple occasions with feedback on processes used (not outcomes as the two are not correlated) and stresses that team leaders should provide a role model for teamwork. The study also demonstrates a methodology for measuring the effectiveness of that training during actual practice in an evidence-based manner with measurement criteria that are linked to scenario events and debriefing.

Having trainers participate in live observations likely encourages participants to try out new skills and gives the trainers insight as the challenges faced with use of those skills "in situ", e.g., whether they are being successfully employed and where improvements can be made. We demonstrate that surgeons are willing to try out the skills and that all operating room staff, including the surgeons, see a strong correlation between the use of these skills and their utility for improving team communication and reducing error, similar to findings from other CRM studies (e.g., Grogan et al. 2004). This study also yielded insights into other systems factors that can affect patient safety and team efficiency, such as a lack of checklists to ensure that all equipment is set up appropriately for particular procedures (often resulting in them not being set up) and lack of sleep for a significant portion of the healthcare providers, primarily those who are least experienced. Finally, participants in our study were faced with challenging events (defined here as "feeling the pinch") in over half of the laparoscopic cholecystectomy procedures performed.

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