Physician leadership

An observational analysis of surgical team compliance with perioperative safety practices after crew resource management training


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Manuscript received December 19, 2006; revised manuscript April 19, 2007

Abstract

Background: Acknowledging the need to improve team communication and coordination among health care providers, health care administrators and improvement officers have been quick to endorse and invest in aviation crew resource management (CRM). Despite the increased interest in CRM there exists limited data on the effectiveness of CRM to change team behavior and performance in clinical settings.

Methods: Direct observational analyses were performed on 30 surgical teams (15 neurosurgery cases and 15 cardiac cases) to evaluate surgical team compliance with integrated safety and CRM practices after extensive CRM training.

Results: Observed surgical teams were compliant with only 60% of the CRM and perioperative safety practices emphasized in the training program.

Conclusions: The results highlight many of the challenges the health care industry faces in its efforts to adapt CRM from aviation to medicine. Additional research is needed to develop and test new team training methods and performance feedback mechanisms for clinical teams. © 2008 Elsevier Inc. All rights reserved.

Keywords: Crew resource management; Patient safety; Team communication; Perioperative

In 2003, a large academic medical center committed to training its entire clinical workforce in crew resource management (CRM) in an effort to improve team communications and patient safety. Similar to many health care organizations, this medical center procured the services of a commercial vendor to introduce the principles and processes of CRM to its clinician and administrators. The introductory training program is an 8-hour course that includes lectures, case studies, and role playing. For the most part, this training has proceeded sequentially through the clinical departments of the medical center, and continues to be offered regularly. The course uses the aviation CRM training model and draws heavily from aviation for examples and teaching points [1]. Recognizing that the 1-day introductory training course is, by itself, insufficient to trigger a metamorphosis of individual and team behavior, medical center administrators have supported and facilitated customized implementation training and tool development for specific clinical departments (ie, the catheter laboratory and emergency department). However, their ability to execute this implementation phase fully has been limited by training costs and other resource constraints. In recognizing the limitations of the medical center’s CRM program, senior administrative and clinical leaders from Perioperative Services elected to use departmental funds to develop a customized CRM training program for the perioperative work environment. Perioperative Services’ CRM training program was designed to be comprehensive and stand-alone from the medical center’s program. The leadership wanted a safety process that would improve team communications and decision making, facilitate team building, improve staff

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morale, and align work processes with the Joint Commission on Accreditation of Healthcare Organizations Safety Goals [2]. The perioperative CRM training program, which has been described previously [3], includes a web-based introductory training module, referred to as the e-learning module, and a CRM implementation toolkit (Table 1). The CRM toolkit incorporates Leape’s [4] error reduction mechanisms, which include the following principles: (1) reduce reliance on memory; (2) improve information access; (3) standardize; and (4) error proof, train, and absorb errors. Functionally, the toolkit provides poster-sized checklists and briefings as memory aids, and a communication whiteboard to improve the visualization and communication of patient and staff information, and any miscellaneous information needed by the staff for effective patient safety communication.

The checklists, briefings, and communication whiteboards are hung directly in the holding room and in the operating room (OR) to assist clinicians in their learning of the CRM processes and behaviors. The checklists are standardized for use in all holding rooms and the briefings and whiteboard items are standardized for use in all ORs. Although the critical information items on the communication whiteboard are standardized, special fields can be added as necessary to satisfy the needs of each surgical specialty. For example, the cardiac team requested that perfusion information be added to their standardized communication whiteboards. Perioperative Services conducted CRM kick-off and on-the-job training sessions for all perioperative faculty and staff, many of which were organized and scheduled by surgical specialty (ie, neurosurgery, cardiac surgery, and so forth).

The purpose of the study was to evaluate the impact of CRM training on team compliance with perioperative safety practices. The medical center’s decision to train its entire clinical workforce in CRM has provided researchers with the opportunity and perhaps the responsibility to evaluate its impact on behaviors and safety outcomes. CRM research is in its infancy in health care, but the demand for information about its effectiveness is growing rapidly as commercial vendors intensify their marketing of CRM as a safety and regulatory solution. The authors draw on the work and recommendations of Eduardo Salas, who has written extensively on CRM in aviation. In the classic article, “Team training in the skies: does crew resource management training work?” Salas et al [5] used Kirkpatrick’s typology [6] as a framework to discuss evaluation studies in aviation. He found that aircrews predominantly had positive reactions to training, learned CRM principles, and showed improved teamwork behavior. Salas et al [5] also found that few multilevel studies had been conducted and virtually no studies had evaluated the impact of CRM on safety outcomes.

As the implementation and integration of CRM has proceeded at our medical center, we have used Kirkpatrick’s typology to guide a series of evaluations. As reported previously [1], clinicians who participated in introductory CRM training provided positive reactions and showed knowledge retention after training. Reactions and knowledge gain were evaluated from anonymous surveys administered immediately before and after the courses. The current study defines team compliance (ie, action completed or not) as a behavior, and aims to evaluate the association among this outcome and level of surgical team training. This study did not evaluate the relationship between previously collected survey data and team behavioral data because provider identifiers required for the analysis were not collected on the survey forms. This study compared team CRM training scores and team compliance scores between 2 surgical departments. The Departments of Neurosurgery and Cardiac Surgery were selected because they had a larger percentage of their clinical staff trained in CRM, but vastly different levels of surgeon training and participation in CRM. The majority of faculty neurosurgeons completed both the medical center’s introductory course and Perioperative Services’ implementation training program. The Department Chair of Neurosurgery attended Perioperative Services’ voluntary CRM kick-off session for the department and announced to all faculty and staff that CRM was a departmental priority. Few cardiac faculty surgeons participated in any training and none attended that department’s CRM kick-off. All holding rooms and ORs used by these surgeons and their teams were equipped with the CRM toolkit despite the differences in training.

### Methods

Three trained investigators observed 30 surgical cases, divided between 15 neurosurgery and 15 cardiac surgeries, performed in an academic medical center’s main operating room (MOR) suite between December 22, 2004, and March 10, 2005. The observational methodology and the subsequent analysis of the collected data were approved by the university’s institutional review board. The Departments of
Neurosurgery and Cardiac Surgery were selected as the study focus groups based on perceived differences in their respective departmental commitments to CRM as shown by attending surgeon participation in both introductory CRM training and subsequent Perioperative Services’ CRM training program. Samples of neurosurgeons (N = 4, 50% staffing MOR) and cardiac surgeons (N = 5, 83% staffing MOR) were selected randomly from the MOR surgeon population. Five cardiac surgeons were selected, rather than 4, to increase the frequency of observations and thus shorten the study period. Eighty-nine total perioperative providers were observed in the MOR, including the 9 attending surgeons mentioned previously, 6 (46%) neurosurgery residents, 3 (100%) cardiac surgery residents, 17 (26%) anesthesiologists, 12 (22%) anesthesiologist residents, 17 (29%) circulating nurses, 11 (69%) OR nurses, 8 (15%) certified nurse anesthetists, and 6 (55%) certified OR technicians. The sample of perioperative staff observed during the study were representative of the larger population in terms of both experience and CRM training. At the time of the observations, more than 90% of the perioperative staff had completed the perioperative training program. The 30 observational sessions were distributed over 8 of the 19 total ORs in the MOR. Surgical cases were selected for observational analysis on the basis of case type (Fig. 1). Therefore, some providers were observed more than once during the study as members of different surgical teams. The observers were blinded to all providers’ training status.

The investigators used a standardized checklist to record provider compliance with integrated perioperative safety and CRM practices throughout the continuum of a surgical case. The checklist was created by itemizing distinct elements of the training curriculum. The compliance checklist (Fig. 2) groups 63 preselected safety practices and CRM processes by the following segments that define the perioperative continuum: (1) holding room (N = 22 practices), (2) OR set-up (N = 4), (3) patient identification in the holding room or OR (N = 7), (4) “time-out” (N = 21), and (5) debriefing (N = 9). These practices represent a combination of existing perioperative safety practices (eg, informed consent, marking the surgical site, and so forth) and fundamental CRM principles that recently were integrated into standard work processes (eg, pre-incision timeout, postcase debriefing, and so forth). The compliance

Fig. 1. Selection of study samples based on CRM training levels of neurosurgeons and cardiac surgeons.
checklist developed by the investigators to score team performance on the time-out is presented in Fig. 2. All observations and data collection started at the time the surgical patient entered the holding room before the start of the case and ended at the time the attending surgeon left the OR at the end of the case. Before starting the study, the investigators observed 4 surgical cases to guide the development of the data collection tool (ie, compliance checklist) and an additional 6 cases after tool development to evaluate inter-rater reliability. Pilot and reliability testing was based on observations of surgical cases performed in a Vanderbilt OR not involved in the study. The investigators performed

<table>
<thead>
<tr>
<th>WHO</th>
<th>WHAT</th>
<th>Yes</th>
<th>No</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Circulator</td>
<td>Announces “Time Out Brief”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Surgeon/Resident Surgeon</td>
<td>States patient’s name,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Surgeon/Resident Surgeon</td>
<td>States patient’s age (this is optional)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Surgeon/Resident Surgeon</td>
<td>States patient’s diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Surgeon/Resident Surgeon</td>
<td>States patient’s surgical procedure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Surgeon/Resident Surgeon</td>
<td>States patient’s expectation of surgery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Surgeon/Resident Surgeon</td>
<td>Verifies surgeon’s initials on surgical site</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Surgeon/Resident Surgeon</td>
<td>States patient’s history</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Surgeon/Resident Surgeon</td>
<td>States patient’s allergy status</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Surgeon/Resident Surgeon</td>
<td>States patient’s medical problems</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Surgeon/Resident Surgeon</td>
<td>States patient’s any potential problems related to surgery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Anesthesiologist/CRNA</td>
<td>States status of induction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Anesthesiologist/CRNA</td>
<td>States needed preparation for potential problems</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>14. Anesthesiologist/CRNA</td>
<td>States administration of antibiotics</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>15. Circulator</td>
<td>Verifies readiness of room</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Circulator</td>
<td>Verifies positioning of patient for surgery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Circulator</td>
<td>Verifies implants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Circulator</td>
<td>Verifies equipment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. Circulator</td>
<td>Verifies mid-case staff changes</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>20. Circulator</td>
<td>Verifies x-rays</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. Surgeon/Resident Surgeon</td>
<td>Invites team members to speak up</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 2. Time-out compliance checklist.
paired observations in the prestudy period and individual observations during the study period. Each observer pair achieved an inter-rater reliability of .92 or higher, calculated using the \( \kappa \) coefficient, in scoring team compliance with perioperative safety practices.

Investigators calculated CRM training and team compliance scores for each surgical case observed. Both CRM training scores and observed team compliance scores could range from 0% to 100%. A CRM team training score was calculated as the percentage of all providers observed during a case who had received CRM training from either the 1-day vendor training course or the perioperative training program (ie, e-learning module). Training modes were weighted equally and the maximum training score any one provider could receive was 1 point. In addition, independent of the medical center’s introductory CRM training course, all perioperative clinicians were offered the opportunity to receive hands-on CRM toolkit training (ie, in the OR) as part of Perioperative Services’ CRM training program. Because this hands-on training was less formalized than the other training programs it was not included in the calculation of provider training scores. The compliance score was calculated as the percentage of all integrated safety and CRM practices performed during the observation of a surgical case. All safety practices and CRM process steps were weighted equally such that a team was given 1 point for compliance with a practice or process and 0 points for noncompliance.

The mean CRM training and practice compliance scores were calculated for each observed case.

**Results**

**CRM training**

The neurosurgical and cardiac surgical teams observed during the study period were characterized by moderately high levels of introductory CRM training (Table 2). On average, 76% of team members observed per surgical case had received some form of introductory CRM training. Gross CRM training scores were similar between observed neurosurgery teams (78%) and the cardiac surgery teams (75%). More providers, from both surgical specialties, received their introductory CRM training from the 1-day commercial vendor training (62%–66%) course than the perioperative e-learning module (49%–51%). Approximately one third of all providers observed during the study period received training from both the course and the online module. There were 3 neurosurgery cases and 3 cardiac surgery cases in which all members of the surgical team had received some form of CRM training. There were no surgical cases in which no member of the team had received CRM training.

The percentage of attending physician teams (attending surgeon and anesthesiologist) with introductory CRM training was 97% across observed cases, indicating that in all but 1 case the attending surgeon or anesthesiologist had received some form of CRM training. More attending surgeons and anesthesiologists received their training from the vendor course than the perioperative online module. A closer analysis of attending physician training revealed that all neurosurgeons (100%) and anesthesiologists (80%–87%) had received training. However, only 47% of the observed attending cardiac surgeons received any introductory training. A small percentage of observed cardiac cases (27%) and neurosurgery cases (37%) included CRM-trained surgical residents.

**Surgical team compliance with safety practices**

Surgical team compliance with integrated perioperative safety and CRM practices did not exceed 60% for either neurosurgery or cardiac surgery after introductory CRM training and toolkit implementation (Table 3). Neurosurgery and cardiac surgery teams showed similar trends in practice compliance across the continuum of surgical cases. Moderate to high levels of compliance were achieved by both teams in the holding room (66%–75%) and operating room set-up (88%–93%) segments of observed cases. Compliance scores for both groups exhibited downward trends over the duration of observed cases (Fig. 3). The 6 fully trained surgical teams (ie, 3 neurosurgery and 3 cardiac surgery) achieved a mean compliance score of 57%, which was approximately equal to partially trained teams.
Aggregate team compliance scores were approximately 50% in completing the 21 safety practices comprising the time-out and the 6 subcomponents required by the Joint Commission on Accreditation of Healthcare Organizations’s universal protocol for preventing wrong site, wrong procedure, and wrong person surgeries [7]. A time-out was called in all but one observed case, however, in only 8 of the 29 (28%) cases were time-outs called by the surgeon at the appropriate time (ie, just before incision). Many of the time-outs were called by the anesthesiologist, rather than the surgeon, immediately after the patient was transported to the OR. The surgical teams achieved high compliance scores for stating the patient’s name (97%) and procedure (97%), but scored low in verifying the surgical site marking (17%), verifying patient positioning (28%), verifying the correct radiograph (17%), and verifying the appropriate equipment or implants (28%) when appropriate. Surgical teams scored the lowest aggregate compliance score (24%) for the debriefing segments of observed cases.

**Comments**

This purpose of this study was to evaluate the impact of CRM training scores on team compliance (ie, behaviors)
with perioperative safety practices. This study was designed within a larger organizational quality-improvement initiative, and the results do not represent the final outcome of the program, but instead feedback from the first cycle of implementation and integration in one clinical setting. The goal of the broader organizational initiative is to translate aviation-based CRM to the medical domain. The perioperative setting was selected for this study because the authors believe that the OR represents medicine’s closest analog to the cockpit in aviation. For this reason, it is reasonable to believe that implementing CRM in the perioperative environment will require less translation and fewer modifications of the aviation model than it will in other clinical settings.

The results showed that surgical team performance on CRM and perioperative safety practices was low (ie, approximately 60%) even when the majority of team members had received training. This result is even more impressive when one considers the potential positive effect that the Hawthorne effect (created by visibility of observers in the holding rooms and ORs) could have had on the study. The trend of decreasing compliance scores across the continuum of surgical cases provides preliminary evidence that surgeon-lead segments, such as the time-out and debriefing, produce some of the lowest team compliance scores. These results are difficult to explain, especially after considering the positive reactions recorded from perioperative clinicians after their introductory training. Perioperative clinicians, including attending surgeons, were nearly unanimous in their agreement that aviation-based CRM had high face validity and has the potential to improve safety in medicine [1]. The study did not specifically evaluate provider-to-provider communication so it is not possible to relate our findings to those of Awad et al [8], who found improved surgeon-anesthesia communications after team training.

Senior administrative and clinical leaders from the medical center and Perioperative Services recognized early in their investment in CRM that it was unrealistic to expect a one-time dose of aviation-based CRM training to have a lasting affect on clinician behaviors. As a result, Perioperative Services developed a CRM training program (ie, toolkit and implementation training) to assist clinicians in translating the aviation model to the perioperative setting. As organizational or departmental culture would dictate, there was significant variation in the degree of enthusiasm and participation in the new CRM-based perioperative work processes. This was well illustrated in the study by differences in the level of CRM training obtained by surgeons representing the Departments of Neurosurgery and Cardiac Surgery. However, despite the positive reactions to training and high training scores for neurosurgeons and their teams, they performed only slightly better than their counterparts in cardiac surgery in complying with perioperative safety practices. One factor that may have had a significant impact on the results of the study was the time gap that clinicians had between introductory CRM training and the perioperative training program. Some perioperative clinicians may have had as much as a 1-year gap between training sessions. However, the observational studies were started within a few weeks of perioperative training sessions and these should have been sufficient to serve as a booster shot. It is conceivable that clinicians interpreted this gap as an indication of low institutional priority and thus questioned its value and viability.

This study methodology has many shortcomings because it was designed as part of a broader quality-improvement initiative. First, the investigators were unable to establish a true control group because they could not randomize providers to CRM-trained or not-CRM-trained groups. It was impossible to perform a pre–post analysis of surgical team compliance with integrated safety and CRM practices because providers could not possibly know what a CRM practice was without having the training. The sample size was relatively small because of the expense (ie, time commitment) associated with performing the observational analyses. A single surgical case easily could last 4 hours or more. In addition, because surgical team structures are never static in either neurosurgery or cardiac surgery, some providers were observed multiple times, usually as a part of different team compositions. Therefore, the results of the study are limited to descriptive statistics because of the small sample size and nonindependence of observations resulting from repeated observations of individual clinicians within different surgical teams. The mixing effect associated with the dynamic composition of surgical teams makes the analysis of team training in the clinical environment extremely challenging. Hierarchical general linear models or mixed effects models can be used to adjust for clustering affects given a sufficient sample size [9]. Medical simulation may be better suited for future research studies on CRM because it allows a greater degree of control of surgical team composition [10]. Finally, observers were very rigid in their scoring of team compliance with safety practices. Only provider actions that were directly visible and/or audible to the observer were scored as compliant. Providers were not given credit for a work-around or nonstandard processes.

The results of the study serve to reinforce and build on some of the recommendations most recently made by Hamman [11] and Musson and Helmreich [12,13]. First, CRM must be translated from aviation to health care through the development of tools and processes that facilitate integration with the clinical work environment and domain-specific work processes. It will take considerable resources to support and manage health care CRM that will exist and succeed only as a continual and evolving process. CRM may be best implemented using the methods of quality improvement, which health care has embraced in years past. CRM training should include individual instruction but should emphasize team training and team exercises. Individuals and teams working to implement CRM in their clinical setting must receive periodic performance feedback both at the team and organizational level [14]. The relevance and importance of personal and team performance in applying CRM skills must be established by linking actual performance data to metrics of system effectiveness, efficiency, and safety. Adverse events (ie, wrong site surgeries, transfusion errors, and so forth) and near misses must be used to create opportunities for learning and improvement. These occurrences must be shared and discussed openly within and among care teams to guide tool and process improvement. Health care CRM also requires physician leadership that is supported by a broader organizational safety culture.
Finally, current CRM research should explore the relationships between training methods and work incentives that trigger behavior modification. It is premature to invest significant resources in CRM outcomes research in health care. Researchers must first establish that CRM can be translated effectively from aviation to health care in a manner that results in tangible changes in individual and team behaviors in the clinical setting.

References