Team Play in Surgical Education: A Simulation-Based Study

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BACKGROUND: Simulation-based training provides a low-stress learning environment where real-life emergencies can be practiced. Simulation can improve surgical education and patient care in crisis situations through a team approach emphasizing interpersonal and communication skills.

OBJECTIVE: This study assessed the effects of simulation-based training in the context of trauma resuscitation in teams of trainees.

METHODS: In a New York State–certified level I trauma center, trauma alerts were assessed by a standardized video review process. Simulation training was provided in various trauma situations followed by a debriefing period. The outcomes measured included the number of healthcare workers involved in the resuscitation, the percentage of healthcare workers in role position, time to intubation, time to intubation from paralysis, time to obtain first imaging study, time to leave trauma bay for computed tomography scan or the operating room, presence of team leader, and presence of spinal stabilization. Thirty cases were video analyzed presimulation and postsimulation training. The two data sets were compared via a 1-sided t test for significance (p < 0.05). Nominal data were analyzed using the Fischer exact test.

RESULTS: The data were compared presimulation and postsimulation. The number of healthcare workers involved in the resuscitation decreased from 8.5 to 5.7 postsimulation (p < 0.001). The percentage of people in role positions increased from 57.8% to 83.6% (p < 0.46). The time to intubation from paralysis decreased from 3.9 to 2.8 minutes (p < 0.05). The presence of a definitive team leader increased from 64% to 90% (p < 0.05). The rate of spine stabilization increased from 82% to 100% (p < 0.08). After simulation, training adherence to the advanced trauma life support algorithm improved from 56% to 83%.

CONCLUSIONS: High-stress situations simulated in a low-stress environment can improve team interaction and educational competencies. Providing simulation training as a tool for surgical education may enhance patient care. (J Surg 69:63-69. © 2012 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEYWORDS: team play, surgical education, simulation, resuscitation

COMPETENCIES: Patient Care, Interpersonal and Communication Skills, Practice Based Learning and Improvement

INTRODUCTION

Trauma situations represent complex, unplanned, and stressful moments that can be anxiety provoking for even well-trained healthcare professionals. For these situations to be handled properly, healthcare workers need to be familiar with standard algorithms and able to apply them with speed, skill, and ease. Education and experience supply healthcare workers with the confidence to execute the appropriate skills successfully even in stressful circumstances, but in real-life trauma situations, the learner is often replaced by more experienced clinicians; therefore, it may be difficult for healthcare workers to build up the necessary experience or to maintain learned skills.¹ As a result, medical educational paradigms have incorporated simulation-based training, allowing students to experience complex situations in a structured way. This educational innovation, first explored in aviation, allows students to participate as active learners in dynamic situations.² In the healthcare field, simulation allows professionals, as well as students, to practice real-life emergencies in a controlled environment.³ The simulations are designed to address specific learning objectives so the learner practices technical skills, communication, teamwork, and application of knowledge within a particular context. Simulation-based training is not only an important educational tool for preparing healthcare professionals for complex situations, but it may also serve to improve hospital culture and patient care.
In 1999, the Institute of Medicine estimated that 44,000 to 98,000 deaths per year occur as the result of errors in medical care. Simulation training offers a unique solution because it allows healthcare workers to learn and practice the management of complex urgent clinical events without the risk of harm or injury to patients. Furthermore, simulation training is supervised or recorded, allowing the learner to review his process and errors constructively with a more experienced educator, thus encouraging ownership of errors and open communication.

Dr. Gaba, a leader in simulation-based learning, writes that, “No industry in which human lives depend on the skilled performance of responsible operators has waited for the unequivocal proof of the benefit of simulation before embracing it,” and the medical field is no different. Simulation, especially in light of the Institute of Medicine’s report on the prevalence of medical errors, has become an ethical imperative.

In addition to providing a safe environment for trainees to practice particular skills, simulation-based training also improves teamwork and communication. Teamwork is an incredibly important—yet often overlooked—feature of quality healthcare that has been found to impact both error reduction and team performance in medicine. In fact, the 1999 Institute of Medicine report suggested the establishment of “team training programs for personnel in critical care areas,” including the operating room. The Joint Commission on Accreditation of Healthcare Organizations also suggested the inclusion of team training as part of their Patient Safety Plan. Although teamwork is recognized as an important part of clinical practice generally, and surgical practice specifically, it is often underemphasized during medical education. Medical education focuses on the performance and skill of the individual, not on how that individual performs as part of a team. Importantly, effective teamwork does not necessarily develop organically out of working together and the interpretation of the quality of teamwork can vary notably between team members, as demonstrated by several studies of operating room and intensive care unit staff.

A retrospective review of risk management claims from the emergency department found that teamwork failures occurred on average 8.8 times per case, that problems with team coordination contributed to 43% of errors, and that teamwork training would have “mitigated or prevented 79% of the identified failures.” Specifically within the surgical setting, failures in communication were found to lead to significant patient morbidity and were second only to technical errors as a cause of inpatient surgical errors. This suggests that teamwork needs to be learned and practiced, just as any other skill.

Simulation provides a standardized, reproducible, and interactive educational experience. This can increase confidence across multiple domains because scenarios of variable complexity may be created to reproduce emergencies that participants have had little experience handling. Furthermore, after each simulation scenario, participants are debriefed and able to review their errors constructively and repeat relevant skills until they are both comfortable and competent. The purpose of our study is to determine whether simulation training that employs a team approach enhances surgical education and improves patient care in standardized crisis situations.

METHODS

A prospective study was conducted in a New York State–certified level I trauma center. The New York Hospital Medical Center of Queens has a surgical and emergency medicine program, with 4 and 8 categorical residents per class, respectively. Residents from every PGY level were included, with a total of 44 residents (30 surgical and 14 emergency medicine residents) participating in the study. Institutional Review Board approval was obtained, and residents provided verbal consent before participation and were offered the right to decline. Residents involved in the study were all advanced trauma life support (ATLS) certified. Per ATLS protocol, the pre-simulation standard at our institution was to have a team leader and other assigned roles at every trauma event. A trauma alert at our institution is called based on the severity of patient injury as defined by New York State Trauma Program guidelines. Healthcare professionals present at trauma alerts include attending physicians, residents, medical students, nursing staff, physician assistants, and respiratory therapists. All trauma resuscitations are conducted following ATLS guidelines with direct oversight from emergency medicine and surgical attending physicians. The video review of trauma alerts for this study was conducted using a standard form previously developed by the Department of Surgery for use during peer review of trauma cases for educational and training purposes. The form was expanded for this study to include a standard tool assessing the 5 team dimensions described by the MedTeams study: maintaining team structure and climate, applying problem solving strategies, team communication, executing and managing plans, and improving team skills. Hospital staff and patients were not identified on this standardized form.

Thirty activated trauma alerts, including various levels of blunt and penetrating injuries, were reviewed using this standardized process. A committee consisting of a trauma coordinator, trauma surgeon, and student researcher reviewed each video recording, using the standardized form described above, for the following: (1) number of healthcare workers involved in the trauma resuscitation, (2) percent of healthcare workers in role positions, (3) presence of physician spinal stabilization during intubation, (4) need for paralytic, (5) need for intubation, (6) time to intubation, (7) time to intubation from paralysis, (8) time to first imaging study, (9) time to leave the trauma bay for computed tomography (CT) scanner or operating room, and (10) presence of a team leader. These variables were selected because they reflect adherence to ATLS guidelines, important steps in trauma assessment and care, performance of procedures related to higher severity, and efficiency of the delivery of care, all of which could influence outcome. Additionally, these variables were chosen because they require a high degree of teamwork; none can be improved by the mere refinement of 1 individual’s skill and technique.
Residents were then oriented to the Laerdal SimMan technology (LSMT). The human patient simulator is a life-sized mannequin that has an electromechanical interface linked to a computer. It is capable of generating vital signs, vocal sounds, speech, vomiting, and automated responses to drug administration. Furthermore, LSMT has a cardiovascular and respiratory system that is able to create pulses as well as heart and respiratory sounds. Procedural manipulations to the mannequin, such as intubation, needle thoracostomy, and scenario editing enable one to vary the complexity of the scenario.

During a 3-month period in the middle of the academic year, residents attended 6 LSMT training sessions. Six standard simulation scenarios, each designed to last 15 minutes, were written by 2 trauma surgeons, an emergency room attending physician, and a critical care physician: tension pneumothorax, acute airway in a nonintubated patient, acute airway in an intubated patient, blunt abdominal trauma, penetrating abdominal trauma, and traumatic brain injury. Residents at each level of training were randomly divided into groups of 4 to 5. Each week new, random groups participated in 1 of the 6 aforementioned clinical scenarios in a fully monitored environment simulating a trauma bay. Before entering the room, each team was given a brief summary of the clinical situation. Advancements through each scenario were made if critical steps in the scenario were achieved successfully. The scenarios were videotaped, and a time log was maintained. The same set of observers rated every simulation training session using the aforementioned standardized checklist. After each session, the groups were debriefed together and essential steps in patient care, including management options, skills, communication, and teamwork, were discussed with a special focus on the 5 MedTeams team dimensions.

After the completion of this 6-week LSMT training, another 30 trauma alerts were reviewed in exactly the same manner as before the simulation training. The variables measured in the 30 trauma alerts before and after simulation training were compared. The 2 ordinal data sets were compared via a 2-sided t test for significance, and the nominal data were analyzed using a Fischer exact test.

RESULTS

Thirty trauma alerts before LSMT training were compared with 30 trauma alerts posttraining. In each trauma alert, the mentioned variables were measured. During the presimulation phase, 24 of the 30 cases required intubation and 22 received a paralytic. Postsimulation, 23 of the 30 cases required intubation and 22 received a paralytic.

When comparing presimulation with postsimulation training data, the number of healthcare workers involved in trauma resuscitation decreased from 8.5 to 5.7 (p < 0.05) (Fig. 1, Table 1); the time to intubation from paralysis decreased from 3.9 to 2.8 minutes (p < 0.05) (Fig. 2, Table 1); and the time to leave the trauma bay for either a CT scan or to go to the operating room decreased from 29.5 to 25.3 minutes (p < 0.05) (Fig. 2, Table 1). The presence of a team leader in trauma alerts improved from 64% to 90% (p < 0.05) (Fig. 3, Table 1).

There was not a statistically significant difference in the presence of cervical spine stabilization throughout the trauma evaluation although it increased from 82% to 100% (p = 0.08) (Fig. 3, Table 1); the number of healthcare workers in role positions (57.8% to 83.6%, p = 0.46) (Fig. 1, Table 1); the time to intubation (9.5 min to 7.7 min, p = 0.45) (Fig. 2, Table 1); and the time to attain the first imaging study (16.4 min to 15.4 min, p = 0.22) (Fig. 2, Table 1).

DISCUSSION

The principles of medical education are in a state of flux. Although more schools are recognizing the importance of behavioral skills, such as teamwork, communication, and empathy, and they are incorporating the development of these skills into their curriculum, students face a medical system that does not compensate these skills. The resident educational experience is also changing; resident work hours are now federally mandated to restrict the amount of time a resident can remain within the hospital. The goal of this restriction was to prevent medical errors from overwork and exhaustion, but as a result
residents now have less operating time, less patient contact, and less direct experience. Residents are also more likely to be caring for sicker patients and to be performing more complex interventions. Thus, there are concerning gaps in skills and experience in medical education and postgraduate training.

Simulation training was pioneered in the late 1980s by Dr Gaba in the field of anesthesia with the development of the anesthetic Crisis Resource Management course. Simulation training is now used with increasing frequency by a number of medical disciplines, including emergency medicine, surgery, ambulatory care, pediatrics, and obstetrics. Within surgical education, simulation training provides a high-fidelity environment that can adapt to the evolution of medicine.

Our study demonstrated that simulation training, with an emphasis on the acquisition of teamwork skills, improved key aspects of trauma management. Despite the fact that all partic-

### TABLE 1. Trauma Management and Performance Pre- and Post-Simulation Training

<table>
<thead>
<tr>
<th></th>
<th>Presimulation</th>
<th>Postsimulation</th>
<th>p-Value</th>
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<tbody>
<tr>
<td>No of healthcare workers involved in trauma resuscitation</td>
<td>8.5 ± 3.4</td>
<td>5.7 ± 1.3</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>% of healthcare workers in role positions</td>
<td>57.8 ± 22.1</td>
<td>83.6 ± 21.7</td>
<td>0.46</td>
</tr>
<tr>
<td>Time to intubation (min)</td>
<td>9.5 ± 4.9</td>
<td>7.7 ± 4.8</td>
<td>0.45</td>
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<tr>
<td>Time to intubation from paralysis (min)</td>
<td>3.9 ± 3.1</td>
<td>2.8 ± 1.7</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Time to first imaging study (min)</td>
<td>16.4 ± 8.8</td>
<td>15.4 ± 7.5</td>
<td>0.22</td>
</tr>
<tr>
<td>Time to leave the trauma bay for imaging or operating room (min)</td>
<td>29.5 ± 15.7</td>
<td>25.3 ± 10.8</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Presence of a team leader (% yes)</td>
<td>64</td>
<td>90</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Presence of spinal stabilization (% yes)</td>
<td>82</td>
<td>100</td>
<td>0.08</td>
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**FIGURE 2.** (A) Time to intubation pre- and post-simulation. (B) Time to intubation from paralysis (p < 0.05). (C) Time to attain the first imaging study. (D) Time to leave the trauma bay for either imaging or to go to the OR (p < 0.05).

**FIGURE 3.** (A) Presence of a team leader in trauma alerts (p < 0.05). (B) Presence of cervical spine stabilization throughout trauma evaluation.
Participants were ATLS trained and had practiced the delegation of roles during mock codes, including the assignment of a code leader; they did not follow the standardized ATLS approach during actual trauma alerts. After simulation training, it was more likely that the team had an identifiable leader that facilitated the resuscitation. This was further reflected in the participation of only necessary healthcare professionals, decreasing the number of caregivers present and reducing the amount of chaos in an already stressful situation. When additional healthcare providers participate in a trauma alert, beyond the necessary team members, the roles of each participant overlap and become ambiguous. There is a greater risk of error either from duplication of efforts or from failure to perform a critical task. Thus, a reduction in the number of healthcare professionals participating in each trauma alert reflected closer adherence to ATLS guidelines, clearer definition of team roles, and better overall communication. Improved team coordination also resulted in a more rapid response to traumatized injured patients and closer attention to the essential treatment events and their sequence. Although we cannot correlate our findings with patient outcome, as we did not collect patient data, there is clear evidence that both simulation and teamwork training improves performance and reduces human error.14

Real-life trauma resuscitations are strenuous, time pressured, and complex as a result of the uncertainty of the process and patient responses. Learning during these high-stress situations is generally poor. Our findings may be explained by the idea that simulation training provides an environment where basic ATLS principles are emphasized, but more importantly, learners can practice various critical care scenarios, including uncommon events, in a controlled, standardized, and risk-free manner. In our study, the use of video-based debriefing focusing on a team approach adds relevance to educational material and is a useful method to reinforce and sustain learning.13 We observed trauma alerts soon after simulation training and therefore assumed that our results were temporally associated with our intervention.

A review of studies that advocate high-fidelity patient simulators (HFPS) found that most are either observational in design or use self-report responses with a limited number of participants.21 There are minimal data showing the effect of simulation on measurable clinical variables. Focusing on the evaluation of HFPS as an educational tool within emergency medicine, McFetrich22 identified the following common themes: “(a) quicker responses; (b) less deviation from guidelines; (c) realistic; (d) good training experience; and (e) learning not hindered by artificial situation.” The MedTeams study showed that team-based behavioral teaching, using the Emergency Team Coordination Course (ETCC), reduces human error in the emergency department as measured by a validated behavioral anchored rating scale.14 In another study, team behavior was further improved by simulation training in a group of emergency department staff previously trained using the ETCC. The control group, emergency department staff members trained in the ETCC who did not complete the simulation training, spent an equal amount of clinical time working together, but without the improvement in teamwork.9 This supports the assertion by previous researchers that teamwork is a skill that requires development and practice.12,13 During our debriefing period, aspects of teamwork skills were emphasized based on the ETCC (ie, maintaining team structure and climate, applying problem-solving strategies, team communication, executing and managing tasks, and improving team skills).14 We believe, based on the changes in communication and team behavior observed during the trauma alerts before and after simulation training, that the simulation training and debriefing improved team communication, structure, and problem-solving.

The primary goal of our study was to evaluate the function of the team as a whole and the team’s response times during a critical care event. As a result, team members were not assessed individually for specific skills (ie, intubation technique) but as a function of the team. Although groups of 4 to 5 residents underwent simulation training together for each scenario, the composition of the groups between scenarios and during real-life resuscitations changed. The random combination of personnel participating during trauma alerts meant that it was not possible to follow an individual team from pretraining, through simulation training, to posttraining. Although this prevents the evaluation of the growth of an individual team, it reduces selection bias, such as the level of residency training, previous experience, temporal proximity of ACLS training to participation, and number of previous intubation. Furthermore, this demonstrates that the team skills acquired during simulation training are generalizable to real trauma cases. Although the participants of each group varied between each scenario session, all groups were debriefed together, thus ensuring similar teamwork training. During simulation training, the participants included only residents and a static intensive care unit nurse. In actual trauma alerts, nurses, respiratory therapists, physician assistants, and emergency department attending physicians were present who did not receive similar training. This was consistent across all 30 trauma alerts presimulation and postsimulation training. The decision was made to train residents to improve their clinical practice by enhancing communication with other members of the trauma alert team and encouraging them to think in a team-centric way. Each team caring for a patient during the trauma alerts postsimulation included residents involved in the HFPS training who were leading patient care. It is telling that an improvement was noticed in team communication, clarity of team roles, and time to intubation and CT or operating room simply by providing simulation and team training to residents. This improvement was observed despite the fact that the personnel comprising the teams changed randomly between each scenario and trauma alert.

The participants being studied were blinded to the study variables, thus eliminating any bias that may have been present if they were aware of the variables being measured or which alert...
was video reviewed. No validation tool was used to assess the video review process, and the reviewers were not blinded to the study. However, the same 3-person team measured each variable using a standardized video review methodology, including a detailed checklist.

We maintained complete patient anonymity during the video review process, as per our institutional review board, which prevented us from completing a chart review and collecting clinical and outcome data. As such, an injury severity score (ISS) was not determined in each case. The cases reviewed, however, are similar, as a trauma alert is only called in our institution in accordance with New York State Trauma Program guidelines. In addition, 22 and 20 trauma alerts, presimulation and postsimulation, respectively, required intubation showing a similar overall urgency in the 2 groups.

The nonresident staff (nursing, attending physicians, respiratory therapists, and others) present at trauma alerts was not tracked across any of the pretraining or posttraining trauma alerts, and thus, this represents a possible source of bias. The LSMT-trained members of each trauma team, and their PGY level, was not tracked and represents a possible confounding variable. Additionally, as residents perform more resuscitations, they gain clinical experience that may represent an independent source of improvement in their performance. Patient information and clinical outcomes were not collected; therefore, we cannot assess the benefit of the teamwork training on clinical outcomes. It is possible that the severity and types of traumas differed between pretraining and posttraining, so this is also a possible confounding variable. Finally, the time of day of the pretraining and posttraining trauma alerts was not tracked, and it represents another potential confounder.

CONCLUSIONS

We have an “ethical obligation to make all efforts to expose health professionals to clinical challenges that can be reasonably well simulated before allowing them to encounter and be responsible for similar real-life challenges.” High-fidelity simulation training of residents in a low-stress, standardized, and controlled environment improves team communication, interaction, management, delegation, leadership, and “followership.” After simulation training, the team response times in stabilizing the traumatically injured patient and proceeding through the ATLS management algorithm in actual trauma alerts improved.

Medicine is a high-risk, high-stress industry in which human error can cost lives, but medical education continues to limit its acceptance of simulation training. Patient safety experts believe that study designs affecting processes that improve intermediate measures, and not necessarily patient level outcomes, are sufficient until new methodologies for assessing error can be devised and validated. An increase in simulation-based studies is necessary to determine the full potential of this unique educational tool. Specifically, comparison between a control group and an HFPS trained group on measurable outcomes both as a team and as individuals may lead to more substantial findings. Additionally, although we studied the effect of team-based simulation training for postgraduate medical trainees, an analysis from the perspective of multidisciplinary interactions (ie, among emergency medicine, surgery, and nursing) could add to the growing knowledge on simulation training. Other questions for investigation include the determination of appropriate frequency of training and the long-term retention of learned skills.

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