Multidisciplinary pediatric trauma team training using high-fidelity trauma simulation

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Abstract

Background: Trauma resuscitations require a high level of team performance. This study evaluated the impact of a comprehensive effort to improve trauma care through multidisciplinary education and the use of simulation training to reinforce training and evaluate performance.

Methods: For a 1-year period, expanded trauma education including monthly trauma simulation sessions using high-fidelity simulators was implemented. All members of the multidisciplinary trauma resuscitation team participated in education, including simulations. Each simulation session included 2 trauma scenarios that were videotaped for debriefing as well as subsequent analysis of team performance. Scored simulations were divided into early (initial 4 months) and late (final 4 months) for comparison.

Results: For the first year of the program, 160 members of our multidisciplinary team participated in the simulation. In the early group, the mean percentage of appropriately completed tasks was 65%, whereas in the late group, this increased to 75% ($P < .05$). Improvements were also observed in initial assessment, airway management, management of pelvic fractures, and cervical spine care.

Conclusions: Training of a multidisciplinary team in the care of pediatric trauma patients can be enhanced and evaluated through the use of high-fidelity simulation. Improvements in team performance using innovative technology can translate into more efficient care with fewer errors.

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Injury is the leading cause of pediatric mortality and its optimal management requires a highly functioning multidisciplinary team. Clear and efficient team function is essential to improve patient safety and reduce errors in the high-paced and high-stress environment of a trauma resuscitation [1-3]. Crew resource management (CRM) training has been shown to be an effective method to improve team function, originally in aviation and more recently in health care [4-6]. In aviation, improved communication among all team members as a result of CRM training has contributed significantly to the observed reduction in accidents [7,8]. Key aspects of team function contributing to improvements have been situation awareness shared by all members, problem identification with input from all team members, and decision-making consistent with institutional protocols.
<table>
<thead>
<tr>
<th>Airway Management</th>
<th>Score</th>
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</table>
| 1. Assess airway  | 0 - no assessment  
                      2 - look/listen/feel, talks to pt |
| 2. Oxygen applied | 0 - >60 seconds  
                      1 - 30 - 60 seconds  
                      2 - <30 seconds |
| 3. Intubation     | 0 - no preoxygenation/bagging  
                      2 - preoxygenates and b/twn attempts |
| a. Appropriate use of oxygen | 0 - no preoxygenation/bagging  
                      2 - preoxygenates and b/twn attempts |
| b. Correct positioning | 0 - no c-spine prec  
                      1 - c-spine prec/sniffing  
                      2 - c-spine prec/sniffing/cric pres |
| c. Cricoid pressure applied | 0 - no  
                      2 - yes |
| d. Reassessment of patient | 0 - none  
                      1 - lungs/epigastric auscu  
                      2 - above and ETCO2 |
| 4. Time to recognize need for intubation | 0 - > 3 min  
                      1 - 1 - 3 min  
                      2 - < 1 min |
| 5. Time to secure airway (from reviewers determination of airway need w/ RSI medications) | 0 - > 5 min  
                      1 - 3 - 5 min  
                      2 - < 3 min |

Breathing

<table>
<thead>
<tr>
<th>Breathing</th>
<th>Score</th>
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| 1. Breathing assessed | 0 - > 60 secs  
                      1 - 30 - 60 secs  
                      2 - < 30 secs |

Circulation

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<th>Circulation</th>
<th>Score</th>
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</table>
| 1. Checked monitor for BP, HR (time to recognition of vitals) | 0 - > 60 secs  
                      1 - 30 - 60 secs  
                      2 - < 30 secs |
| 2. Assesses pulses | 0 - no  
                      2 - yes |
| 3. Time to IV access | 0 - > 5 min  
                      1 - 1 - 5 min  
                      2 - < 1 min |

Disability

<table>
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<th>Disability</th>
<th>Score</th>
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</table>
| 1. Assessed responsiveness | 0 - no  
                      2 - yes |
| 2. Pupils | 0 - no  
                      2 - yes |
| 3. Assess GCS | 0 - no  
                      2 - yes |
| 4. OG placed? | 0 - no  
                      2 - yes |
| 5. Recognized Cushings | 0 - no  
                      2 - yes |
| 6. Time to recognize Cushings | 0 - > 5 min  
                      1 - 3 - 4 min  
                      2 - < 3 min |
| 7. Discussed use of HTS or Mannitol | 0 - Did not discuss  
                      1 - Discussed only  
                      2 - Discussed and admin. w/ 5 min |
| 8. C-spine precautions | 0 - none  
                      1 - sometimes  
                      2 - throughout |

**Fig. 1** Sample trauma multidisciplinary team simulation evaluation tool.
members, shared decision making, workload distribution with assigned tasks, time management, and conflict resolution among team members [9]. Achieving a high level of team function requires both education of team members as well as a commitment to a culture change within an institution [6,10-12].

High-fidelity simulators have been extensively used in aviation and the military to improve performance [13,14]. As a consequence of improving technology, high-fidelity human patient simulators are playing an increasing role in training health care professionals [15-17]. Training health care providers to manage trauma resuscitations using simulation has been demonstrated to be feasible for individuals as well as for evaluating specific teams before and after a training period [18-23].

In an effort to continually improve the functioning of the teams caring for our pediatric trauma patients, we have emphasized the importance of team organization and communication during all trauma orientations and educational activities, as well as developed a core trauma nursing team. To complement these efforts, we have implemented a 2-hour trauma simulation training program that emphasizes CRM training techniques to improve team performance. This training is the first that we are aware of to simultaneously train and evaluate a multidisciplinary team of providers in the care of injured children. The current study was therefore designed to evaluate the effectiveness of our multidisciplinary trauma training program on team performance for the first year of its implementation.

1. Methods

For a 1-year study period, an emphasis on team function and communication was incorporated into all trauma education activities including resident orientation, morbidity and mortality conference, monthly videotape review, and quarterly pediatric trauma grand rounds. In addition, a core group of nurses received increased training and education in pediatric trauma. This trauma core nursing team participated in a web-based core curriculum and monthly trauma lectures. To complement all of these activities, 2-hour trauma simulation sessions were developed to reinforce education, provide a safe environment to practice the care of an injured child, and a consistent environment in which to evaluate team performance and provide feedback.

For these simulation sessions, trauma scenarios were developed based upon actual cases previously evaluated and treated at our level I pediatric trauma center. The 3 standard scenarios used for the 1-year time frame of this study included an infant with head injury, a child with a penetrating wound to the back, and an adolescent with multitrauma including an unstable pelvic fracture. All 3 scenarios were developed to evaluate team performance in recognizing and achieving specific goals of the resuscitation. Particular

| Table 1 Multidisciplinary team members participating in simulated trauma sessions |
|---------------------------------|----------|
| Pediatric surgery faculty      | 11       |
| Emergency medicine faculty     | 7        |
| Surgical/pediatric residents   | 72       |
| Nurses (23 trauma core nurses) | 60       |
| Critical care fellows          | 4        |
| Paramedics                     | 2        |
| Respiratory therapists         | 4        |
| Total                          | 160      |
attention was paid to the initial assessment, airway management, cervical spine precautions, and the identification and management of injuries such as pelvic fracture and increased intracranial pressure. All simulations were performed on high-fidelity human patient simulators, SimBaby, Pedia-Sim, and SimMan (Medical Educational Technologies Incorporated, Sarasota, Fla), in a dedicated simulation suite with complete video recording capabilities. Although key aspects of each scenario were kept consistent to ensure reliability of ongoing assessments, minor variations were added to reduce familiarity with the scenarios by participants.

Before each 2-hour simulation session, participants were provided with an online education module emphasizing the core concepts of crew resource management and teamwork. Each team then participated in 2 of the 3 trauma scenarios. Each scenario lasted for approximately 20 minutes and included initial assessment through disposition from the trauma bay. After each scenario, formal debriefing with video review was performed, generally lasting 30 minutes. Debriefing emphasized team performance and communication and also reinforced appropriate care principles for the management of the injured child.

All pediatric and surgical house staff rotating on the pediatric surgical service were required to participate in a 2-hour simulation session at the beginning of their rotation. In addition, all pediatric surgical faculty participating in trauma call responsibilities were required to participate in at least one session annually. To create a realistic multidisciplinary team composition, emergency medicine faculty and fellows, critical care fellows, trauma core nurses, paramedics, and respiratory therapists all participated in these trauma simulation sessions. This training was in addition to Advanced Trauma Life Support and Trauma Nurse Core Course that all surgical staff and trauma core nurses, respectively, had completed before the start of the study period. Members of these multiple disciplines made up the teams of 4 to 7 individuals for each trauma scenario.

For evaluation of trauma teams for the 1-year period, team performance during simulation was compared during the first 4 months of the study, the early group, with those from the last 12 months, a total of 23 two-hour multidisciplinary trauma simulation sessions were conducted in addition to didactic trauma education. These sessions involved 160 individuals from multiple domains of the trauma care team (Table 1). The average team consisted of 6 members. Teams were led by a surgical faculty, emergency medicine faculty, or senior surgical resident. The distribution of team leaders was consistent throughout the study period. The trauma core nurses were the only individuals to participate in greater than one session, with an average of nearly 3 sessions per participant. During the initial 12 months, a total of 46 individual-simulated trauma scenarios were performed.

2. Results

For the 12-month period, a total of 23 two-hour multidisciplinary trauma simulation sessions were conducted in addition to didactic trauma education. These sessions involved 160 individuals from multiple domains of the trauma care team (Table 1). The average team consisted of 6 members. Teams were led by a surgical faculty, emergency medicine faculty, or senior surgical resident. The distribution of team leaders was consistent throughout the study period. The trauma core nurses were the only individuals to participate in greater than one session, with an average of nearly 3 sessions per participant. During the initial 12 months, a total of 46 individual-simulated trauma scenarios were performed.
Comparing the early (first 4 months) to the late (last 4 months), there was a significant improvement in overall performance as determined by the percentage of possible appropriate and timely care measures achieved (Fig. 2). To understand the underlying improvements leading to the overall team performance improvement, specific phases of the resuscitations were compared between the early and late groups (Fig. 3). Criteria assessing skills related to airway management, initial trauma assessment, cervical spine precautions, and pelvic fracture recognition and management all showed evidence of improvement over the time of the study.

During the individual 2-hour trauma simulation session, each team managed 2 trauma patient scenarios. By looking at overall performance stratified by both early and late session group as well as team score for their first or second scenario, we saw the expected sequential improvement (Fig. 4). Not only did we observe improvements for individual teams progressing from their first simulated scenario to their second scenario in both the early and late groups, but we also saw an improvement in the first scenario of the late group compared to performance on either scenario in the early group. These results demonstrated not only immediate improvement as a result of feedback during the initial debriefing but also improvement over time as a consequence of the multifaceted educational initiatives and culture change.

### 3. Discussion

As a consequence of a hospital-wide commitment to quality and improving safety, we have expanded our trauma education initiatives including the addition of multidisciplinary trauma simulation training and evaluation. Previous reports of simulation training have demonstrated improvements of individuals, teams of surgeons only, and previously established military teams [18-21,23]. In most trauma centers however, resuscitations are managed by a complex team made up of trauma surgeons, emergency medicine physicians, residents, nurses, respiratory therapists, and possibly others throughout the hospital. This interdisciplinary team, often unfamiliar with each other, must function efficiently within a highly dynamic and stressful trauma situation. This study demonstrates improvement of trauma performance among a complex and varied team through a combination of traditional teaching techniques and the use of high-fidelity simulation training of complex teams to reinforce and evaluate improvements.

For a 1-year period, emphasis has been placed on team performance and communication during all aspects of trauma education among a multidisciplinary audience. High-fidelity simulated trauma team training was used to complement these activities as well as measure team performance. As a consequence of this approach, we have observed both subjective and objective improvements in team performance. Data from evaluation of team performance during standar-
of simulation training in isolation[15,18,29,30]. The simulated environment provided a safe environment to practice and reinforce effective communication and care of the injured child by team members and was therefore likely a key factor in improving overall team performance. An additional, though unmeasured, benefit of the simulation training was to allow rotating residents to be fully introduced to our trauma system and culture of safety and communication in a consistent and nonthreatening manner.

A further limitation of the current study is that the impact of the demonstrated improvements during simulations has not yet been studied and evaluated during actual trauma resuscitations. Although demonstrating improvements in the care of real children is the ultimate goal, the variability and inconsistency of actual trauma scenarios make it quite challenging to demonstrate measurable improvements in overall performance for short periods. It is reasonable, however, to predict that measured improvement in the simulated environment will convert to improvements in the real environment as has been observed in aviation.

In addition to continuing our current trauma education program, expansion of our simulation team training to include management of multiple simultaneous resuscitations, operating room resuscitations, and mass casualty events is necessary. Furthermore, use of simulation in the actual trauma bay not only to improve team function but also to help identify real-life safety threats has already begun at our institution. The current study not only supports the use of simulation training in isolation[15,18,29,30]. The simulated environment provided a safe environment to practice multidisciplinary team to improve performance in the care of the injured child.

Acknowledgment

The authors would like to thank the simulator staff at Cincinnati Children’s Hospital (Cincinnati, Ohio), in particular Mike Moyer, Brian Pio, and Tom Lemaster for their expertise and dedication to trauma simulation. We would also like to thank all of the participants throughout the hospital who continue to improve for the benefit of injured children.

References


Discussion

Michael Hirsch, MD (Worcester, MA): I think this was a great study; and very interesting to see team training done this way. I have 2 questions for you: the high-fidelity mannequin that you’ve been using, do you think that it could be substituted with something potentially less costly? Could a volunteer patient do the job? Or do you think that the mannequin itself is critical to the study? Also, have you ever used videotaping of live resuscitations?

Rebeccah Brown, MD (response): Those are very good questions. I think the trauma simulators that we use indeed are quite expensive; and in certain situations where perhaps places can’t afford such simulators, I think probably using a live person in order to do those resuscitations would probably be very good. I think it’s really the communication and teamwork that we’re really trying to achieve in improving our trauma resuscitations. Yes, we videotape all of our trauma resuscitations in our trauma bay. We review those trauma resuscitations and our hope is that with incorporating the trauma simulator sessions and that transmits to improved performance on our actual trauma resuscitations in the trauma bay. And we’ll evaluate that.

Max Langham, MD (Memphis, TN): I would like to applaud both your group and the program committee for putting this paper on the program. I think it provides us a look at technology that may in fact be very important in the 100,000 live campaigns to reduce medical errors and improve all of our performance.

One of the things that I wanted to ask about, which is a little bit subtle, is that you intermingle the terms team and crew. I think that, in fact, the idea of crew resource management in the aviation industry, is exactly what we deal with on a day-to-day basis when we show up for trauma resuscitation or when we go to the OR, in that we have a group of people who all have assigned roles. But it is not a team like my son’s soccer team that practices together day after day after day with a single team working. When we make our call schedules, we don’t look at nursing call schedules; we don’t look at RT call schedules. We don’t look at anesthesia call schedules. So the specific question is during your training, do you work on the initial step in crew resource management that the aviation guys talk about, is a specific crew assignment and crew brief/debrief for the group that will be in the batter’s box on that day for that resuscitation? And how would you advise us to organize our crews, since I think that very few of us will have a team that’s consistent day in and day out within our organizations?

Rebeccah Brown, MD (response): I appreciate your comments. I think that indeed in our own trauma resuscitations, that one of the problems is consistency of trauma team members. One of the most important things that we’ve implemented recently is the development of a trauma core nursing team. It’s hard to have a trauma core anesthesiologist and respiratory therapist and all of those. But at each trauma resuscitation, there is a trauma core nurse that has been highly trained in trauma and has a commitment to trauma. That has helped to improve consistency.

Certainly during our simulator sessions, we have debriefing before and after the sessions in which we talk about roles and assign roles during that time. I think that, although you’re not going to have the same team for every trauma resuscitation, by carrying out the simulator sessions, you become more familiar with those roles. I think it helps improve team function.