In Situ, Multidisciplinary, Simulation-Based Teamwork Training Improves Early Trauma Care

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OBJECTIVE: Evaluate the impact of a team training curriculum for residents and multidisciplinary trauma team members on team communication, coordination and clinical efficacy of trauma resuscitation.

DESIGN: Prospective, cohort intervention comparing pre- vs. post-training performance. The intervention was a human patient simulator (HPS)-based, in situ team training curriculum, comprising a one-hour web based didactic followed by HPS training in the emergency department (ED). Teams were trained in multidisciplinary groups of 5-8 persons. Each HPS session included three fifteen minute scenarios with immediate video-enabled debriefing. Structured debriefing and teamwork assessment was performed with a modified NOTECHS scale for trauma (T-NOTECHS).

Teams were assessed for performance changes during HPS-based training, as well as in actual trauma resuscitations.

SETTING: The Queen's Trauma Center (Level II); the primary teaching hospital for the University of Hawaii Surgical Residency.

PARTICIPANTS: 137 multidisciplinary trauma team members, including residents (n = 24), ED and trauma attending physicians, nurses, respiratory therapists, and ED technicians.

RESULTS: During HPS-based training sessions, significant improvements in teamwork ratings, and in clinical task speed and completion rates were noted between the first and the last scenario.244 real-life blunt trauma resuscitations were observed for six months before and after training. There was a significant improvement in mean teamwork scores from the pre-to post-training resuscitations. Moreover, there were significant improvements in the objective parameters of speed and completeness of resuscitation. This was manifest by a 76% increase in the frequency of near-perfect task completion (≤ 1 unreported task), and a reduction in the mean overall ED resuscitation time by 16%.

CONCLUSIONS: A relatively brief (four-hour) HPS-based curriculum can improve the teamwork and clinical performance of multidisciplinary trauma teams that include surgical residents. This improvement was evidenced both in simulated and actual trauma settings, and across teams of varying composition. HPS-based trauma teamwork training appears to be an educational method that can impact patient care. (J Surg 68: 472-477. © 2011 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS : team training, trauma, simulation, NOTECHS

COMPETENCIES: Interpersonal and Communication Skills, Systems Based Practice

INTRODUCTION

Traumatic injuries are the leading cause of death in Americans ages 1-44, and remain a leading cause of morbidity for all Americans. Trauma resuscitation is a complex, time-critical enterprise requiring a multidisciplinary healthcare team comprised of highly-trained medical professionals, frequently including surgical residents. Such teams are typically assembled on an ad hoc basis for individual trauma resuscitation events, and team members rarely participate together in structured response-team training.

Preventable trauma deaths occur even in mature trauma systems, with a third of errors occurring during the initial evaluation and resuscitation in the ED.[1,2] Teamwork deficiencies, such as ineffective communication, have been observed in trauma centers,[3,4] and improving teamwork has been proposed as a way to improve trauma patient safety.[5]

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High fidelity HPS have proved a useful tool for instructing physicians in the performance of trauma resuscitation.[6–8] While there has been ample interest and intuitive support for the use of HPS in surgical team training,[9–11] there are few studies to document clinical efficacy of HPS-based team training in either the surgical or medical fields.

Recently, Capella and colleagues demonstrated improvement in teamwork ratings following HPS-based trauma teamwork training. They also reported improvement in clinical parameters in trauma resuscitation following team training, including reduced time to intubation, CT scanning and the operating room. However, the clinical improvements observed were mitigated by confounding factors, including a less severely injured patient population, as well as a more experienced resident team in the post-training time period.[12]

In this study we sought to determine whether an in situ, HPS-based team training curriculum for residents and multidisciplinary trauma team members could improve team communication, coordination and clinical efficacy of trauma resuscitation.

DESIGN

This study used a prospective, interventional design assessing pretraining vs. post-training performance. The intervention was a multidisciplinary, HPS-based, in situ team training curriculum.

Clinical Data

Clinical data were gathered prospectively for all comparable trauma resuscitations meeting the predefined criteria of blunt, multisystem trauma in non-pregnant patients who were ≥ 6 years old, and transported to the trauma center directly from the scene of injury. This patient population is managed with a consistent protocol for initial evaluation, resuscitation and imaging, which facilitated comparison of pre- and post-training data. Additional demographic data collected on the pre- and post-intervention resuscitations included patient age, gender, whether a "modified" (six member) or "full" (10 member) resuscitation team was activated, Injury Severity Score (ISS), and Trauma Score (TS). Probability of survival was determined with TRISS methodology.[13]

Clinical process parameters were collected and teamwork was scored prospectively by trained critical care trauma nurses (CRN), who served as the scribes during trauma resuscitations. Teamwork was rated immediately after each ED resuscitation using a modified NOTECHS scale for trauma (T-NOTECHS), which includes five main teamwork domains (Table 1)[14,15] illustrated by 47 behavioral exemplars. Clinical process parameters were recorded on a standard trauma resuscitation flow sheet that has been in use previously for 4 years. These parameters included: Time (recorded in military time) to completion and reporting of key elements of the primary trauma survey and adjuncts [eg, vital signs, physical examination, focused abdominal ultrasound (FAST), chest X-ray], time

TABLE 1. Trauma NOTECHS (T-NOTECHS)

Leadership				
5 Clearly defined Team Leader. Good time management, all tasks completed, non-hierarchical	4	3 Individual defined, but some tasks not completed.	2	1 Identity of Team Leader not clear
Cooperation and resource management				
5 All team members clearly fill a role and perform all designated tasks	4	3 Identity of all members not clear, some do not perform assigned tasks	2	1 Unable to discern role identity of team members
Communication and interaction				
5 Clear communication with Team Leader as a hub, relayed to scribe	4	3 Communication not always through Team Leader, or not relayed rapidly to scribe	2	1 Unorganized or incoherent communication on many different levels
Assessment and decision making				
5 Orderly and complete 1° (ABCDE) and 2° surveys. Plan communicated to team.	4	3 Assessment somewhat out of order, all major tasks complete	2	1 1° and 2° surveys disorderly and/or incomplete. Plan not clear.
Situation awareness/coping with stress				
5 Untoward findings and distractions did not upset systematic and orderly flow. Team is calm and plans ahead.	4	3 Untoward findings caused disruption but did not preclude task completion.	2	1 Untoward findings or interruptions completely upset orderly assessment and task completion Not anticipatory.

of entry into and exit from the ED, number and type of procedures performed, units of blood transfused, and unavoidable delays to patient transfer (eg, multiple simultaneous trauma patients, CT scanner malfunction). Thirteen CRN and 4 research assistants (3 medical students and 1 physician) received training in recording clinical data and use of T-NOTECHS before the start of pretraining data collection. Data collector training was provided in a one-hour program which included scoring and clinical process data collection of videotaped simulated trauma resuscitations. When available, research assistants attended trauma resuscitations during both the pre- and post-training periods, and independently recorded clinical process data.

Throughout this study, trauma team members were blinded to our clinical endpoints. Although they were aware that we were observing "teamwork," they were not made aware of the objective clinical process parameters that were being analyzed as part of this study. The times to task completion and total time in the ED were extracted post hoc from the military times recorded on the trauma flow sheet, so the team was not cued to our examination of clinical endpoints. Team members were also blinded to the teamwork rating (T-NOTECHS) during the pretraining phase. After training, ratings were shared with the trauma attending after the T-NOTECHS scores were assigned by the CRN.

A minimum sample size of 200 resuscitations (100 each pretraining and posttraining) was estimated to discern a change in clinical performance, as defined by $\geq 9\%$ decrease in total time in the ED, based on a power of 0.8 and α of 0.05, and literature estimates of resuscitation time.[16]

Team Training

The curriculum we developed was adapted from the crisis team training course of DeVita et al., at the University of Pittsburgh.[17] The curriculum included (1) an online pretest and one-hour web-based presentation that trainees viewed before their simulation session; (2) a three-hour simulation session, comprised of a 30 minute didactic plus 2½ hours of videotaping and debriefing HPS scenarios; (3) an online post-test. Team training, scenario facilitation, and debriefing were conducted by one or both of the board-certified investigators, a critical care trauma surgeon (S.S.), or a critical care specialist (B.W.B.).

HPS training was scheduled and conducted on 19 separate days, for multispecialty trauma teams (5–8 members) in an ED room where trauma resuscitations are routinely performed. Three preprogrammed, beta tested, fifteen minute blunt traumatic shock scenarios were developed for the Laerdal SimMan. Each scenario required completion of eight "key tasks" for optimal HPS "clinical" outcome, three of these tasks (intubation, FAST, central venous catheter) were common to all scenarios. The sequence of scenarios was randomized during the 19 sessions, with no scenario repeated during a session. Scenarios began with a "field medic" giving a history and transport data to the Team Leader who then briefed the team and initiated resuscitation. Team members assumed roles commensurate with their real-life responsibilities (eg, senior residents acted as Team Leaders), rotating roles in successive scenarios when appropriate.

Scenarios were captured on a digital video recorder with a synchronized event log. Debriefing with a teamwork expert ("debriefer") was conducted immediately following each simulation for approximately 30 minutes. Team members and debriefers independently scored teamwork via an automated audience response system using the T-NOTECHS. Structured debriefing was then performed, focusing on the teamwork skills outlined in T-NOTECHS. The key tasks for each scenario were not alluded to or included in the debriefing. After each day of training, debriefers performed independent video review of each scenario and recorded time-to-completion of each of eight key tasks.

Data Analysis

Task completion and reporting rates, procedures performed, gender, and mortality were analyzed via χ^2 and Fisher's exact test. Differences in resuscitation times, probability of survival, patient age, and length of stay were analyzed by independent samples t-test. Differences in ISS, milliliters of blood transfused, and teamwork scores were analyzed by the Wilcoxon rank-sum test. Concordance between CRN and research assistants was determined by intraclass correlation coefficient (ICC). Data were analyzed by a biostatistician, with statistical significance determined at $p < 0.05$.

SETTING

This study was completed at The Queen's Trauma Center, which is the only designated Trauma Center (Level II) serving Hawai'i and the Pacific Basin. Queen's is the primary teaching hospital for the University of Hawaii Surgical Residency and the John A. Burns School of Medicine.

PARTICIPANTS

All attending physicians, residents, nurses, respiratory therapists, and ED technicians who respond to trauma calls were asked to participate in this study. This study was approved by our institution's research investigation review committee, and all participants gave informed consent. 137 trauma team members, including 24 residents, completed training. Trainees included 100% of surgical residents and 97% of attending physicians on the trauma team (Table 2). All trauma attending surgeons, ED physicians, and senior surgical residents were certified in Advanced Trauma Life Support (ATLS) at the time of this study, and four were ATLS instructors. Median length of clinical experience as part of a trauma resuscitation team was four years. The majority had received no prior teamwork training.

TABLE 2. Number of Team-Trained Individuals, and Percentage of Total Trauma Responders in Each Discipline

Type of Practitioner	Number TRAINED	% of Trauma RESPONDERS
Attending surgeon	9	100
Attending ED physician	21	95
Physician's assistant	3	100
Surgery resident	18	100
Other resident	6	100
Critical care RN	14	88
ED RN	30	81
Respiratory Therapist	23	96
ED technician	13	72

ED = emergency department; RN = nurse.

RESULTS

During the HPS-based training sessions, there was a significant improvement noted in trauma teamwork from the first to last scenarios. T-NOTECHS scores were captured for 11 of 19 training days. There was a significant improvement in scores given by participants as well as debriefers (Table 3). Although the debriefing sessions focused solely on teamwork skills, rather than resuscitation task performance, we observed a concomitant improvement in the speed and thoroughness of the clinical tasks of trauma resuscitation. In each of the 19 training sessions, from the first to the last scenario, there was a significant improvement in the number of teams who completed ≥ 7 of the eight key tasks in the trauma resuscitations. There was also noted a faster time (107 s, $p < 0.01$) to completion of the three common resuscitation tasks (Table 3).

141 real-life trauma resuscitations were observed by CRN over 6½ months prior (April-October 2009), and 103 after (December 2009-July 2010) trauma teamwork training. Research assistants also attended 69 of these resuscitations (48 pre- and 21 post-training). Demographics for the pre- and post-training patient populations were similar, with no significant difference in age, gender, ISS, or probability of survival. There was also no significant difference in milliliters of blood transfused, the number of patients who required intubation or other physician-performed bedside procedures (chest tubes, central venous or arterial catheters, fracture splinting) (Table 4).

We observed a significant improvement in mean teamwork scores from the pre-to post-training resuscitations. Moreover, there were significant improvements in the objective parameters of speed and completeness of resuscitation. This finding was manifest by a 76% increase in the frequency of near-perfect task completion (≤ 1 unreported task). The mean overall ED resuscitation time was reduced by 16% (Table 4). Clinical process data collected by CRN was corroborated by data collected by the research assistants, who similarly noted a significant increase in T-NOTECHS scores, an 18% reduction in ED resuscitation time, and a 2-fold increase in task reporting rates from the pre-to post-training periods. The concordance, as measured by ICC, between CRN and research assistants was 0.48 for T-NOTECHS scores, 0.96 for ED resuscitation time, and 0.85 for task reporting.

CONCLUSIONS

In this study we demonstrated that a relatively brief (four-hour) HPS-based curriculum was associated with improved teamwork of multidisciplinary trauma teams that include surgical residents. The improved teamwork was evidenced both in in situ simulated and actual trauma settings. As in many trauma centers, our multidisciplinary resuscitation teams are formed ad hoc, and it is notable that teamwork improved even though the individuals in each team had not trained together as a group.

In addition to subjective improvements in teamwork skills, we observed improvements in clinical process in the six months following teamwork training of most of our trauma team members. Although in this small patient sample we were unable to detect any significant change in global clinical endpoints (e.g., mortality, morbidity and length of stay), we identified improved compliance with completion and reporting of the elements of the primary survey, as well as reduced time to completion of these tasks. There is consensus among trauma surgeons that complete and rapid execution of the primary survey is of paramount importance.[18] Past studies focused on improving trauma resuscitations have been directed at decreasing the time to completion of resuscitation tasks in the primary survey.[16,19,20] Townsend et al., demonstrated a decrease in injury-stratified patient mortality associated with a 9% reduction in resuscitation time.[21] Thus, time to completion of tasks in the primary survey appears to be a valid clinical process measure that is likely to impact patient outcome.

There were a few potential confounding factors in the interpretation of our results. The improvement in teamwork scores (T-NOTECHS) following training may be attributable, in

TABLE 3. Simulation Training Data

	N (Days)	First SCENARIO	Last SCENARIO	p
Mean T-NOTECHS score—debriefer	11	13.3	18.3	<0.001
Mean T-NOTECHS score—CRN	11	15.9	19.5	<0.01
Mean T-NOTECHS score—attending	11	17.2	20.6	<0.05
≥7 key tasks completed	19	32%	84%	<0.05
Mean time (seconds) to completion of 3 common resuscitation tasks	19	460	353	<0.01

TABLE 4. Demographics and Outcomes Pretraining vs Posttraining

	Pretraining (n = 141)	Posttraining (n = 103)	p
Mean age	38.9	39.7	NS
% male	76%	75%	NS
Mean ISS	13.4	10.6	NS
Mean probability of survival	0.96 (n = 123)	0.97 (n = 87)	NS
# patients intubated	14	12	NS
# patients with other physician-performed bedside procedures	21	11	NS
# "full" trauma	15	12	NS
Mean ml blood transfused	97	32	NS
OUTCOMES			
Mean T-NOTECHS score	16.7 (n = 136)	17.7 (n = 99)	<0.05
# with ≤ 1 unreported task	48	62	<0.001
Mean resuscitation time (min)	32	26	<0.05
# died	8	4	NS
Mean hospital LOS days (survivors)	5.1	3.4	NS
Mean ICU days (survivors)	1.9	0.3	NS

part, to the Hawthorne effect. However, it should be noted that the teamwork ratings were never used to evaluate individual performance of residents or other team members. Also, there was no incentive provided to the teams to exhibit better teamwork, other than the concept of improving patient care.

We examined the possibility that improved clinical performance was due to team members gaining more experience in trauma resuscitation over the time course of the study rather than the teamwork training. As the non-resident members of the team were fairly experienced, we considered primarily the impact of resident experience. Our typical trauma resuscitation team includes first-year residents, with senior residents playing a role only for the more critically injured ("full") trauma resuscitations. There was no difference in the percentage of full trauma team participation in the pre- vs. post-training periods. In addition, we observed no significant difference in performance between teams having late first-year residents (April-June) vs. early first-year residents (July-October) in the pretraining period. There was also no difference between teams in the middle (December-March) and late (April-June) intervals in the post-training period.

It is unclear as to whether or not a single teamwork training intervention can result in a durable (> 6 mo) improvement in teamwork and trauma patient care. It is likely that additional training and/or reinforcement will be necessary to sustain this marked improvement in clinical care during trauma resuscitations. The optimal length, format and interval for refresher training will be the foci of future research.

Education, particularly resident education, is only one of many interests vying for hospital resources and healthcare spending. Thus, it becomes increasingly important to demonstrate a link between educational interventions and the expected result of a more capable surgeon who can function well in a health care team. The perceived improvements in individual and team performance should translate into improvements in patient care. Our study adds support for these theoretical concepts.

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