Evaluation of Trauma Team Performance Using an Advanced Human Patient Simulator for Resuscitation Training

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Background: **Human patient simulation (HPS) has been used since 1969 for teaching purposes. Only recently has technology advanced to allow application to the complex field of trauma resuscitation. The purpose of our study was to validate an advanced HPS as an evaluation tool of trauma team resuscitation skills.**

Methods: **The pilot study evaluated 10 three-person military resuscitation teams from community hospitals that participated in a 28-day rotation at a civilian trauma center. Each team consisted of physicians, nurses, and medics. Using the HPS, teams were evaluated on arrival and again on completion of the rotation. In addition, the 10 trauma teams were compared with 5 expert teams composed of experienced trauma surgeons and nurses. Two standardized trauma scenarios were used, representing a severely injured patient with multiple injuries and with an Injury Severity Score of 41 (probability of survival, 50%). Performance was measured using a unique human performance assessment tool that included five scored and eight timed tasks generally accepted as critical to the initial assessment and treatment of a trauma patient. Scored tasks included airway, breathing, circulation, and disability assessments as well as overall organizational skills and a total score. The nonparametric Wilcoxon test was used to compare the military teams' scores for scenarios 1 and 2, and the comparison of the military teams' final scores with the expert teams. A value of $p < 0.05$ was considered significant.**

Results: **The 10 military teams demonstrated significant improvement in four of the five scored ($p \leq 0.05$) and six of the eight timed ($p \leq 0.05$) tasks during the final scenario. This improvement reflects the teams' cumulative didactic and clinical experience during the 28-day trauma refresher course as well as some degree of simulator familiarization. Improved final scores reflected efficient and coordinated team efforts. The military teams' initial scores were worse than the expert group in all categories, but their final scores were only lower than the expert groups in 2 of 13 measurements ($p \leq 0.05$).**

Conclusion: **No studies have validated the use of the HPS as an effective teaching or evaluation tool in the complex field of trauma resuscitation. These pilot data demonstrate the ability to evaluate trauma team performance in a reproducible fashion. In addition, we were able to document a significant improvement in team performance after a 28-day trauma refresher course, with scores approaching those of the expert teams.**

Key Words: **Simulation, Trauma, Training, Performance assessment.**

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The introduction of simulation into the fields of medical training and competency evaluation is a relatively new endeavor; however, the effective use of simulation technology in fields such as aviation training, military war fighter preparation, and industry has been demonstrated for many years.[1–6] Initial research outside of medicine has demonstrated significant overall cost savings as well as improved trainee performance with the integration of simulation into their training matrix.[1,2] With recent advances in computer technologies, simulator-based learning and evaluation in the medical and allied health communities has become a possibility.[7–10]

The human patient simulator (HPS) was first introduced to the medical community in 1969 by Denson and Abrahamson, who used a patient anesthesia simulator to augment resident training.[5,6] Their study showed a trend toward faster skill acquisition and subjective performance improvement. The anesthesia community in particular has embraced the HPS to teach technical and crisis management skills. Over the intervening years, the medical community has witnessed the proliferation of personal computer-based teaching modules and medical mannequins that are becoming more interactive.[11–14] These educational devices have been combined in the advanced HPS. The present day model is physiologically based and reacts to interventions in real time, which forces the trainee to dynamically interact with the

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device and proceed through the complex decision-making processes involved in actual patient care.

Earlier simulation studies focused on individual performance, yet clinicians recognize that optimal trauma care is delivered by experienced multidisciplinary teams.[15–18] Before the widespread acceptance of simulation as a training platform, we believed that a measurement tool of human team performance should be developed. This tool would then document a change in a team's performance after an educational intervention. In addition, no studies have validated the use of the HPS as an effective teaching or evaluation tool in the complex field of trauma team resuscitation. We report herein the results of the repeated use of the HPS coupled with a human performance evaluation tool over the course of a 28-day trauma refresher course.

MATERIALS AND METHODS

The HPS system used for this study was the METI Advanced Human Patient Simulator (Medical Education Technologies, Inc., Sarasota, FL). The space for the simulation center was a converted patient care area located in the Ben Taub General Hospital. The simulation center staff consisted of active duty military personnel assigned to the Joint Trauma Training Center (JTTC). These personnel were either board-certified surgeons or critical care physicians, nurses, or medics with extensive trauma experience and interest. Each scenario required three staff members to monitor the computer/simulator, manage the scenario, and videotape the sessions. All equipment used for the scenarios was standard medical equipment with which the team was already familiar.

The initial process of developing the simulator scenarios and assessment tool involved the training and familiarization of the JTTC staff with the HPS to include its unique potential applications as well as its limitations. The staff had to become facile with the operation of the simulator to provide a consistent experience for the rotators in addition to eliminating any potential inconsistencies that might result from interinstructor variability. This process was accomplished by an initial week of hands-on interactive training with representatives from METI during the installation of the simulator. This was then followed by several months of practice simulator sessions and scenario development. The instructors used and refined the trauma scenarios as well as the assessment tool for several months before initiating the formal pilot study.

The study participants were members of active duty military trauma teams (Army, Air Force, and Navy, 16–24 personnel) performing a 28-day JTTC rotation at the Ben Taub General Hospital. All members of the team were fully credentialed in their respective specialties. The majority of the teams were assigned at facilities that cared for few acute trauma victims. The physicians, nurses, nurse anesthetists, and medics all were current in their respective Advanced Trauma Life Support (ATLS), Trauma Nurse Clinical Core, or Prehospital Trauma Life Support courses. The 10 three-person teams underwent a brief simulator familiarization session and then were evaluated with an initial simulator scenario (Fig. 1). They then participated in an intensive 28-day trauma rotation consisting of 4 weeks (72 hours each) of hands-on clinical experience, trauma case reviews, 24 trauma lectures, four skill station sessions, and a before and after test of didactic trauma knowledge. At the conclusion of this trauma immersion, they were again evaluated in the simulation center on the final scenario. The individual composition of the teams was identical at both time points. Two standardized and physiologically identical trauma scenarios were used, representing a severely injured patient with multiple injuries and with an Injury Severity Score of 41, (scenarios 1 and 2, both with significant head, chest, abdomen, and extremity injuries; probability of survival, 50%). The simulated patients' underlying physiology and required interventions were identical, allowing meaningful comparisons of required scored tasks and timed interventions. However, the scripted scenarios presented to the rotators were significantly different to avoid pattern recognition. On questioning at the conclusion of the 28-day rotation, the teams did not recognize that the scenarios were physiologically identical. The scenarios were also constructed in a fashion that would allow appropriate evaluation and disposition within a 15-minute time period. The criteria of an effective resuscitation were defined on the basis of ATLS, Prehospital Trauma Life Support, and Trauma Nurse Clinical Core guidelines, with a distinct military emphasis, as these were the primary focus groups for the JTTC rotators.[19–21] As there are no consistent nationally accepted standards for team evaluation that could form the basis of our criteria, we applied the regionally accepted standards of care and extrapolated them to our scenarios. Once these criteria were established, an evaluation tool was created to capture the data and score the performances. This tool included five scored and eight timed tasks, all generally accepted as critical to the initial assessment and treatment of a trauma patient. Scored tasks included organizational skills, airway, breath-

Fig. 1. *The simulator being used by a three-person military team while observed by an experienced trauma physician.*

ing, circulation, disability, and total score. Timed tasks were standard interventions common to trauma patients. Performance was measured through videotape review of the sessions using the human performance assessment tool. The videotapes were recorded using a standard digital hand-held video camera with built-in sound capabilities. The recorded tapes were subsequently reviewed and scored by one of the authors (J.W.C.). The current version of the assessment tool used in this work evolved over 12 months of use, and represents a consensus of a multidisciplinary team expert in trauma care (Fig. 2). The evaluation tool was designed specifically for our scenarios, and an emphasis was placed on objective measurements to improve reliability. The assessment tool should be considered a dynamic document that can be modified to fit other scenarios. As part of the larger JTTC educational program, identical subjective questions were asked of the trauma teams on arrival and again after their 28-day trauma experience.

The five expert teams were composed of experienced trauma surgeons and shock room nurses from the Ben Taub General Hospital. The expert teams provided a standard performance level for meaningful comparison. They underwent the same brief simulator familiarization as the rotating military teams and were videotaped and scored on the same final scenario.

The nonparametric Wilcoxon test was used to compare the military teams' scores at the initial and final assessments, and the comparison of the military teams' final scores with the expert groups. A value of $p < 0.05$ was considered statistically significant. Statistical analysis was performed using the SPSS software package (Version 10.0, SPSS, Inc., Chicago, IL).

RESULTS

The study teams demonstrated improvement in four of the five scored ($p \leq 0.05$) and six of the eight timed ($p \leq 0.05$) tasks during the final scenario (Figs. 3 and 4). This also resulted in a significant improvement in their overall score between the initial and final evaluation scenarios. All of the timed tasks with the exception of time to recognize a pneumothorax and the indication for intubation were improved. This resulted in an overall shorter time in recognizing as well as treating the immediately life-threatening injuries. The only scored task not improved on was in the disability section. In addition, there was a more rapid disposition of the simulated patient in the final scenario. This improvement reflects a combination of the teams' cumulative didactic and clinical experience during the 28-day trauma rotation as well as some degree of simulator familiarization. The improved final scores reflected efficient and coordinated team efforts as well as improved verbal and nonverbal communication. In response to the subjective question described previously, the trauma teams felt more comfortable caring for critically ill trauma patients after the 28-day rotation than on arrival.

When compared with the expert teams, there were significant differences between all measured and timed tasks in the initial scenario. However, only the organizational and recognition of the need for a laparotomy scores were different ($p < 0.05$) between the teams' final scenario and the experts' scores. Otherwise, the rotating military teams' final scores approached the expert teams' scores.

DISCUSSION

The principal finding of this study was that a human performance team evaluation tool could be developed to measure the ability of a multidisciplinary trauma team to diagnose and treat a "patient" with multiple injuries. We then used this tool to show the improvement in performance of 10 teams after a 28-day trauma refresher course. The initial challenges of this study included familiarizing the staff with the capabilities of this unique teaching tool as it applies to trauma team training and to define an acceptable set of team performance standards derived from existing national guidelines. The guidelines and course material were designed, however, for individual instruction and assessment. The guidelines were reviewed and the critical components were combined into an evaluation tool that could be used to measure team performance. Each scored and measured task was clearly defined so as to provide measurable results. One individual performed the scoring during this study and was intimately involved in the creation and refinement of the assessment tool.

To our knowledge, such a trauma team assessment tool has not been used for serial assessment of team performance on simulators before and after an intense educational experience. The process and tool were refined for several months before initiation of the pilot study. This trial period allowed us to become familiar with the use of the HPS and to calibrate the evaluation tool. Use of the videotape review was essential, allowing capture of the dynamic nature of the trauma resuscitation. Replay of the tapes was not only critical for scoring the teams but of great instructional value for the teams.[19] Training of the videographer was imperative to capture the dynamic interaction of all the team members as well as the physiologic data on the monitor, which allowed for accurate assessment during the video review. The time spent learning how to best use this advanced educational technology was considered critical to the success of the final project.

The HPS used for this study also has the ability to capture the variation in all physiologic data for the entire duration of an individual scenario; however, this capability was not used for this study. These data points, such as frequency and duration of systolic blood pressures less than 90 mm Hg and arterial oxygen saturations less than 90%, may ultimately decrease the need for subjective assessments of various data points in future studies. The evaluation and correlation of the physiologic data as they pertain to overall team performance as well as patient outcome is ongoing.

Trauma Team Evaluation Tool

Team:	Date:	Session #:	Start Time:	Finish Time:
Team Leader: (Circle one)	MD	CRNA	PA	Med Tech/Medic/Corpsman
Total Team Members:				
Evaluator:				
Scenario #				

I. Team Organization		
1. Clearly defined team leader emerges	0=no delegation/no instruction 1= 2=delegates/instructs others throughout	
2. Other members assume functional roles	0= uninvolved personnel 1= 2=all personnel participate actively	
3. Verbal communication within team	0=no clear instructions 1=some findings called out 2=clear, 2-way communication	
4. Systematic and orderly assessment	0=disorganized 1=vertical resuscitation 2=horizontal resuscitation	
5. Ability to handle distractions	0=allow attention to be diverted 1=temporary diversion 2=utilize or dismiss distractor	

II. Airway		
1. Airway assessed	0=no assessment 2=look/listen/feel, talk to patient	
2. Oxygen applied	0= > 60 seconds 1= 30-60 seconds 2= < 30 seconds	
3. Recognize indication for intubation	0= > 3 minutes 1= 1:31 - 3:00 2= < 1:30	
4. Intubation		
a. Appropriate use of oxygen	0=no preoxygenation/bagging 1= 2=preoxygenates and btw. Attempts	
b. Correct positioning	0=no c-spine prec./position with blade 1= 2=c-spine prec./sniffing position	
c. Correct laryngoscopic technique	0=unfamiliarity with equipment 1= 2=checks equipment/uses cor	
d. Endotracheal tube secured	0=not secured 1=afterthought/delayed 2=secured immediately	
e. Reassessment of patient	0=none 1=lungs/epigastrium ausc. 2=above + monitor check/ ETCO2 cons.	
5. Recognize indication for cricothyroidotomy	0= > 3 minutes 1= 1 - 3 minutes 2= < 1 minute	
6. Cricothyroidotomy		
a. Appropriate use of oxygen	0=no bagging 1=some bagging 2=throughout attempt	
b. Verbalized correct landmarks	0=not done/incorrect 1=incomplete 2=correct	
c. Correct insertion technique	0=no dilation/opening of passage 1=above done but mainstem intubation 2=above + correct position	
d. Endotracheal tube secured	0=not done/incorrect 1=delayed 2=immediately	
e. Reassessment of patient	0=none 1=lungs/epigastrium ausc. 2=above + monitor check/ETCO2 cons.	
7. Time to secure airway	0= > 5 minutes 1= 3-5 minutes 2= < 3 minutes	

III. Breathing		
1. Breathing assessed		
a. Auscultation	0= > 60 seconds 1= 30-60 seconds 2= < 30 seconds	
2. Recognized tension pneumothorax		
a. Difference in auscultated breath sounds (time to awareness of difference)	0= > 3 minutes 1= 1:30-3:00 2= < 1:30	
b. Time to decompression of ptx	0= > 4 minutes 1= 2-4 minutes 2= < 2 minutes	
3. Needle thoracentesis		
a. Verbalized landmarks	0=incorrect 1=incomplete 2=correct	
b. Verbalized proper technique	0=incorrect 1=incomplete 2=over rib/midclavicular line	
c. Reassessment of patient	0=none 1=breath sounds 2=breath sounds + vitals	
4. Recognized indication for tube thoracostomy		
a. Verbalized equipment required (tube, scalpel, Kelly, suture, drainage)	0=unsure of equipment 1=incomplete 2=all equipment identified	
b. Verbalized landmarks	0=incorrect 1=incomplete 2=reasonable	
c. Verbalized insertion technique	0=incorrect 1=incomplete 2=over rib, blunt dissect, digital insertion	
d. Secured tube	0=not done 1=delayed or incorrect 2=done immediately	
e. Attached tube to pleur-evac system	0=not done 1=incomplete 2=complete/suction on	

IV. Circulation		
1. Checked monitor for BP, HR (time to recognition of vitals)	0= > 1 minute 1= 30 - 60 seconds 2= < 30 seconds	
2. Assessed pulses	0=not checked 1=checked 2=noted absent RLE pulse	
3. Applied pressure to stop bleeding (time to adequate pressure applied)	0= > 1 minute 1= 30 - 60 seconds 2= < 30 seconds	
4. Applied tourniquet appropriately (time to tourniquet application complete)	0= > 3 minutes 1= 1-3 minutes 2= < 1 minute	
5. Tourniquet application technique	0=incorrect location or loose 1=did not reassess 2=proper application and reassessment	
6. Time to IV access achieved	0= > 3 minutes 1= 1:30-3:00 2= < 1:30	

V. Disability		
1. Assessed responsiveness	0=no 1=incomplete 2=yes	
2. Pupils	0=not examined 1= 2=examined	
3. Aware of neurologic injury	0=not aware 1=asymmetry noted; unaware of sign. 2=stated neurologic injury	
4. Verbalized therapies for closed head injury (hyperventilate, higher MAP, drugs, crani)	0=none 1=1-2 therapies 2=>2 therapies offered	
5. Examination of abdomen	0=not examined 1= 2=examined	
6. Recognized indication for laparotomy	0=not recognized 1= 2=stated lap indicated	
7. Time to recognize lap indication	0= > 13 min 1= 10-13 minutes 2= < 10 minutes	
8. Full/complete exposure	0=none 1=incomplete 2=complete	
9. C-spine precautions	0=none 1=sometimes 2=throughout	

VI. Timed tasks	
1. Time to recognition of vitals	
2. Time to oxygen applied	
3. Time to adequate pressure applied to extremity	
4. Time to auscultation	
5. Time to recognition of pneumothorax	
6. Time to tourniquet applied	
7. Time to chest decompression	
8. Time to recognition of indication for intubation	
9. Time to recognition of indication for cricothyroidotomy (from first intubation attempt)	
10. Time to secure airway	
11. Time to IV access obtained	
12. Time to recognize laparotomy indication	

VII. Total score	
1. Total points	
2. Total points possible	
3. Percentage	

Fig. 2. *The trauma team evaluation tool.*

The HPS was used as only one component of the larger JTTC educational effort. The educational design of the program consisted of five distinct areas: hands-on experience, comprehensive trauma lectures and skills stations, before and after testing, subjective questions and follow-up surveys, and the trauma simulation center. Although the 28-day rotation was primarily a hands-on learning experience for a multidisciplinary trauma team, the educational design

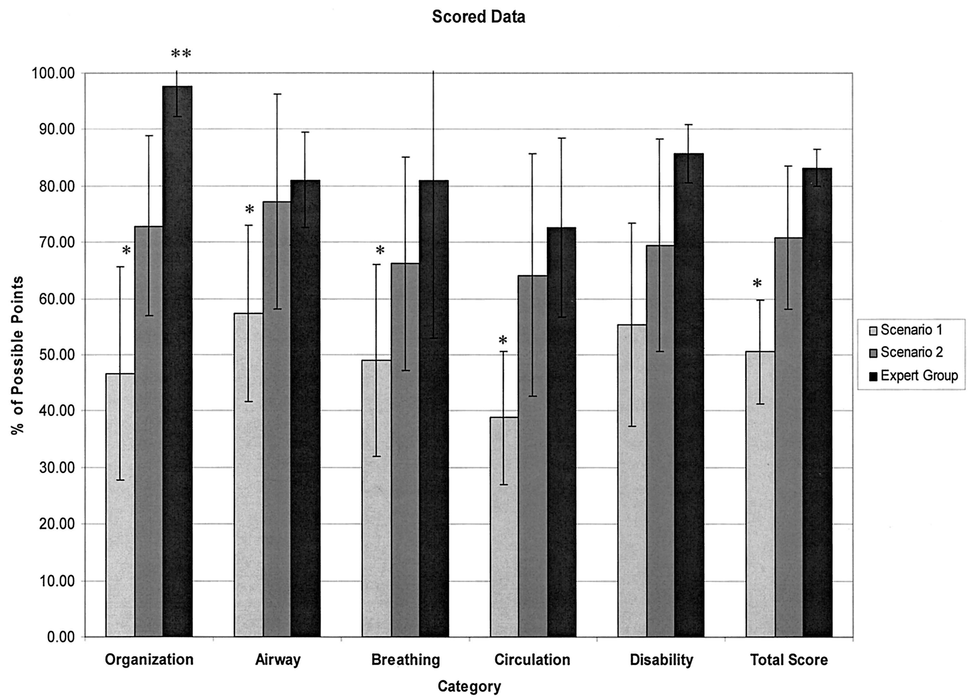

Fig. 3. *The percentage of the five scored tasks and the total score for the military and expert teams.* *$p < 0.05$ *between scenario 1 and scenario 2.* **$p < 0.05$ *between scenario 2 and expert teams.*

included self-confidence type questions focused on the individual and team aspects of their learning experience. There was not a specific question directed toward assessing the self-confidence effect of the simulator, but rather the effect of the entire 28-day rotation. In response to the subjective questions, the trauma teams felt more comfortable caring for critically injured trauma patients after the 28-day rotation than on arrival. In addition, the rotators

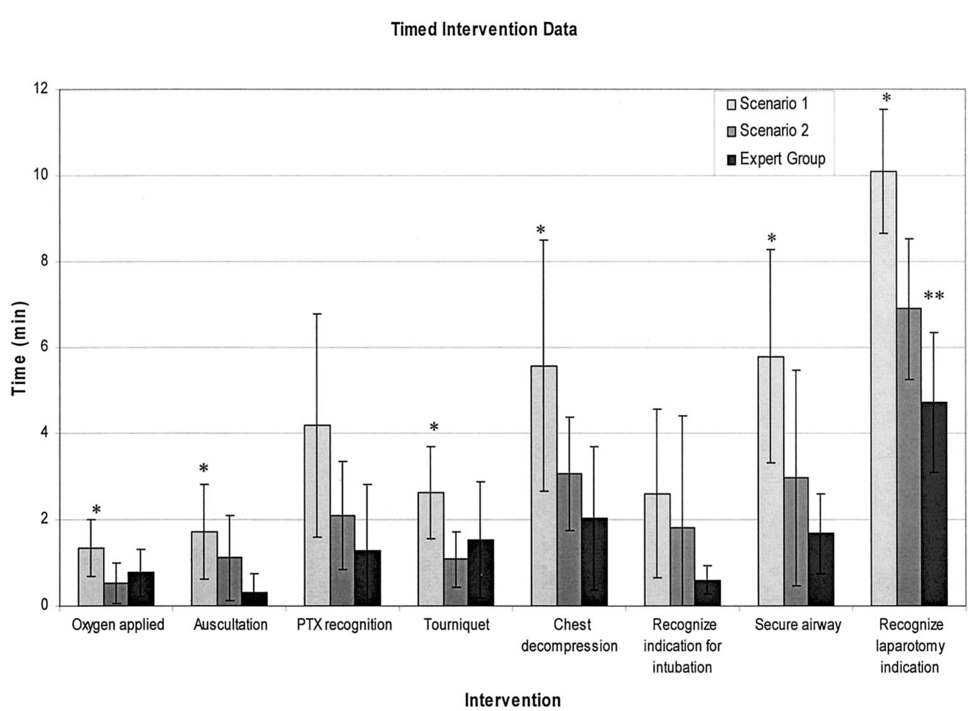

Fig. 4. *Differences in minutes between scenarios 1 and 2 for the military teams and expert teams for the eight timed interventions.* *$p < 0.05$ *between scenario 1 and scenario 2.* **$p < 0.05$ *between scenario 2 and expert teams.*

universally wanted to spend more time on the simulator than was allocated.

Many studies using simulation technology have demonstrated subjective performance improvement as well as increased subjective comfort levels with individual tasks; however, no studies have objectively quantified the performance of a team during the complex and dynamic interactions involved in trauma resuscitation. Simulation studies on aircraft crew performance demonstrate increased comfort with in-flight emergencies as well as decreased overall training cost when simulation technology is added to the training matrix.[1–3] It is reasonable to assume that this type of training may also benefit those in the medical field. However, to demonstrate an improvement using simulation technology, a valid and reproducible assessment modality must be created. Our data demonstrate the ability to capture and quantitatively assess team performance and measure improvement after the JTTC trauma experience using the HPS in a controlled environment (Figs. 3 and 4).

In our preliminary work (not reported) with the HPS, two physiologically different scenarios were used. The day-1 evaluation was a relatively simple patient problem, whereas the day-28 scenario was much more complex. However, to improve our study design, we changed the scenarios to be physiologically identical, thus requiring the same interventions, allowing more meaningful comparisons of times, multiple complex interventions, team interactions, and the effect of the 28-day trauma rotation. The scripted scenarios presented to the rotators were significantly different to avoid pattern recognition. As part of the larger JTTC rotation, significant subjective data were recorded and universally the teams did not recognize that the day-1 and day-28 scenarios were essentially the same.

The ability to transfer the complex skill of trauma evaluation and resuscitation effectively to the clinical environment as well as determining skill degradation rates and training frequencies still require further investigation.[3,22–24] Additional questions include the following: How "much" trauma does a team need to manage to maintain their evaluation skills once they are functioning at a high level? How fast can they regain those degraded skills after a period of clinical inactivity? The HPS technology when combined with clinical trauma activity and a focus on education and simulation may start to answer these questions using the methods presented herein.

Although this study only focused on trained military personnel undergoing a trauma refresher, a major area of obvious benefit of the HPS is in teaching high-risk and/or low-incidence clinical scenarios to trainees of all levels and disciplines. The time-honored tradition of the student-teacher interaction at the patient's bedside is still the teaching modality of choice; however, the addition of the HPS may ultimately prepare the students for more efficient learning at the bedside and maximize the time spent with mentors.[25–29] This potential benefit merits further investigation as to the possibility of integration of this unique teaching modality into the training matrices of several health care professions. As an example, the ATLS course has recently been conducted using simulation devices rather than animals, with approval by the American College of Surgeons Committee on Trauma (Kaufmann et al., unpublished data). Furthermore, the HPS is an excellent crisis management tool.[8] It allows the physician, nurse, and/or medic the opportunity to practice high-risk skills in a risk-free environment. Their "suspension of disbelief" is real, as these trainees feel as if they are taking care of a real patient, and they demonstrate real stress when the simulated patient does not do well. Fortunately, when this occurs, the scenario can be restarted and replayed until the individual or team "gets it right." From an adult education point of view, the simulator sessions were extremely popular with the trauma teams, and the consensus was that increased time spent in the simulation center would be beneficial.

The addition of the expert team as a control group defined an important standard to which we could compare the performance of the rotating trauma teams, and demonstrated that the scoring standards were realistic. The difference between the military teams' initial scores and the expert team performance was significant for all measured variables. However, the military teams' final scores were only different from the experts in the recognition for need of laparotomy and the overall organizational category. All other scores approached those of the expert group. To fully define this component of performance enhancement, we need to allow the expert team to complete a second scenario at a 28-day interval to control for any degree of improvement resulting from simulator familiarization. This component will be added to future studies.

The final scores of the military teams approached those of the expert teams. This may have occurred for several reasons. The intensive experience and teaching over the 28-day rotation may have been successful in bringing the trained surgeons, nurses, and medics up to an expert level. Alternatively, since the military teams had additional HPS exposure, their improved scores could be explained by a greater familiarity with the simulator. Finally, perhaps the expert teams were not quite as skilled as one might expect, or they had difficulty using the simulator. In fact, the expert teams did not voice any overt difficulty with the simulator, and the subjective assessment by the simulation center staff was that the performance of the expert teams was excellent. We believe that the improvement seen in the military teams is largely because of a real improvement in the team resuscitation skills, with some element of increased simulator familiarity.

The principal strength of the study is that the rotating military teams were all fully trained and certified in their respective areas of expertise, and experienced a uniform clinical and didactic trauma rotation. On entry into the study, few had any recent trauma experience. The difference between the initial snapshot of their ability to diagnose and manage a difficult trauma simulation and their score 28 days later reflects the benefit of undergoing an intense trauma refresher experience. From a military point of view, the reproducible and documented improvement in evaluation and decision-making skill of the trauma team is important information in the ongoing debate about the usefulness of a recurring exposure to trauma during one's military career.

There are several weakness in this study. The principal problem is that we did not control for simulator familiarity between the military and expert groups. This could have been controlled by retesting the expert groups 28 days after their initial evaluation, with any improvement attributed to simulator familiarity rather than improvement in clinical skill. Although initially planned, unfortunately this did not occur. The measurement tool was not validated in a standard educational fashion with techniques such as repeated observations in large groups, naive evaluators, and rigorous evaluation of interobserver reliability. However, with the assistance of a trained educator (C.E.S.), the tool went through four versions and in the form presented did document the expected increase in clinical performance after an intensive 28-day trauma rotation. In addition, the expert group scored better than the rotators, adding further validity to the measurement tool. This initial study was designed to help form the background for further work, with the full expectation that the human performance evaluation tool will be modified (Fig. 2). Furthermore, the evaluation tool has not been validated in real trauma resuscitations. The assessment tool should be used in a clinical environment that currently uses video assessment of ongoing trauma resuscitations. Finally, and most important, we do not know whether the improvement in performance documented by the simulator will transfer to the real world of trauma resuscitation at 2:00 AM. The airline industry, space program ,and the U.S. military currently use simulation training extensively. Each of these organizations uses simulation for initial and sustainment training, and they also practice crisis management skills on a routine basis. Trauma resuscitations on critically injured patients are in effect a controlled crisis management activity, albeit one practiced on a routine basis at busy centers. It is a learned skill that improves over time, and the HPS may decrease that learning time. If one believes the simulation data from the airline, space, and military environments, then transference from the HPS to the clinical situation should occur. This remains to be definitively demonstrated.

The concepts of virtual reality and simulation are gaining increasing acceptance in many fields of medical education and training to include the surgical disciplines.[7,30–32] Although the HPS systems currently do not integrate virtual reality components, efforts are underway to merge these technologies. This is a desirable direction because, once this occurs, actual surgical procedures can be incorporated into the training scenarios, allowing a complete continuum of trauma care on the simulator.

Although not evaluated in the current study, we also used the HPS for evaluation and familiarization with new devices and for teaching purposes. The videotapes that were used for scoring purposes were also reviewed with each military team for their educational value. In addition, 150 medical students were introduced to the basic concepts of trauma patient evaluation using the HPS. As the HPS used in this study simulates the gas exchange of a ventilated human, we used this feature to evaluate a new portable anesthesia device (Fig. 5). Allowing the rotating military personnel to become familiar with the device on the simulator rather than on a patient was seen as a real benefit. The HPS is an excellent device for these uses, and in postrotation comments the simulator sessions were counted as a highlight of the trauma rotation. With the recent heightened public concern of preventable medical errors, efforts to institute measures that avert or significantly reduce problems could be rigorously evaluated on the HPS platform.[33] The HPS could be used in a continuous quality improvement process to reproduce identified clinical problems, and then train individuals or teams in optimal solutions.

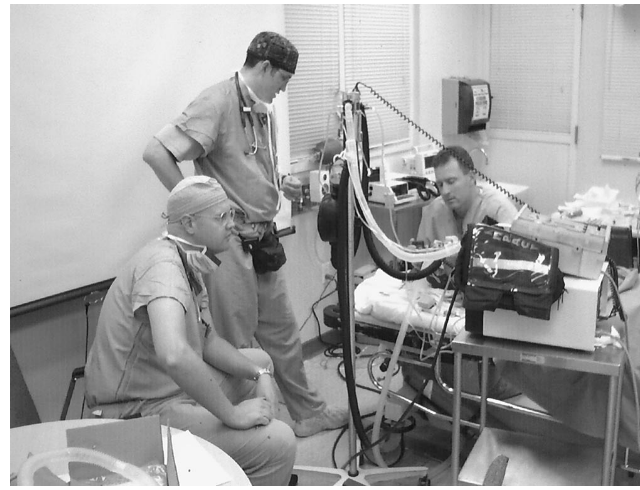

Fig. 5. *Using the HPS to evaluate new portable anesthesia equipment.*

CONCLUSION

These data demonstrate the ability to evaluate trauma team performance in a reproducible fashion. This initial validation step, although tedious and time consuming, is a necessary step before any institution of policies that assess competencies using the HPS. Although these practices are already surfacing in various health care fields, the first step is to prove that the HPS can measure the skill in question and that competency (or lack of competency) on the simulator correlates with the presence or lack of clinical competency. The intense 28-day trauma experience at the JTTC resulted in a measurable improvement in team performance in the pilot study group. Further studies using larger groups and multiple independent reviewers are warranted on the basis of these initial pilot data. Future studies should control for the simulator familiarization effect. Furthermore, adding automatically recorded physiologic data to the evaluation process will increase the collection of objective data, allowing improved discrimination between teams and possibly decreasing the tedious process of videotape review required to generate the team scores.

Ultimately, the initial practice and acquisition of medical skills (technical and evaluation) may take place in the simulation environment. For military and civilian prehospital personnel, this environment could be modified to include variations in light, sound, available assets, and numbers of casualties. This risk-free and reproducible environment may be an ideal modality for augmenting the training of individual medical practitioners as well as multidisciplinary teams. Linking simulators together to replicate a mass casualty event could evaluate not only individual triage decisions but also the decisions of larger teams and commanders. In no way do we suggest that the simulator can take the place of actual supervised or independent clinical experience. Its use may, however, better prepare those who are about to venture into the clinical arena for the first time or possibly refresh skills and/or decision-making processes for uncommon or infrequent occurrences.

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EDITORIAL COMMENT

The Human Patient Simulator (HPS) has gained increasing acceptance as a tool in medical education, as it poses no clinical risks to patients during the learning process, allows for simulation and thus exposure to a variety of potential clinical situations in a short time frame, and provides for team-building, which is an essential skill in complex patient care management scenarios including trauma resuscitation. HPS can evaluate decision-making, assessment skills, diagnostic skills, and timeliness of interventions and team function. These are useful measures for some learning situations, particularly the one described in this paper. A disadvantage of HPS at the present time is the significant fixed cost associated with acquisition and the ongoing maintenance costs for the equipment.

The authors used the HPS in a "before and after" role with a 28-day trauma rotation as the experience tool in between. Predictably, performance improved after the trauma rotation as measured by team performance on the HPS. Further work by the authors and others will be required to determine the long-term effectiveness of the HPS in training, but as an initial training tool, it clearly is effective. The HPS may be an important adjunct to the many other didactic trauma training programs currently in use and may replace "live" simulation laboratories with better scenario-based learning experiences.

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