Use of Human Patient Simulation and Validation of the Team Situation Awareness Global Assessment Technique (TSAGAT): A Multidisciplinary Team Assessment Tool in Trauma Education

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OBJECTIVE: Situation awareness (SA) is a vital construct for decision making in intense, dynamic environments such as trauma resuscitation. Human patient simulation (HPS) allows for a safe environment where individuals can develop these skills. Trauma resuscitation is performed by multidisciplinary teams that are traditionally difficult to globally assess. Our objective was to create and validate a novel tool to measure SA in multidisciplinary trauma teams using a HPS—the Team Situation Awareness Global Assessment Technique (TSAGAT).

SETTING: Memorial University Simulation Centre.

DESIGN/PARTICIPANTS: Using HPS, 4 trauma teams completed 2 separate trauma scenarios. Student, junior resident, senior resident, and attending staff teams each had 3 members (trauma team leader, nurse, and airway manager). Individual SAGATs were developed by experts in each respective field and contained shared and complimentary knowledge questions. Teams were assessed with SAGAT in real time and with traditional checklists using video review. TSAGAT was calculated as the sum of individual SAGAT scores and was compared with the traditional checklist scores.

RESULTS: Shared, complimentary, and TSAGAT scores improved with increasing team experience. Differences between teams for TSAGAT and complimentary knowledge were statistically significant ($p < 0.05$). Mean checklist differences between teams also reached statistical significance ($p < 0.05$). TSAGAT scores correlated strongly with traditional checklist scores (Pearson correlation $r = 0.996$). Interrater reliability for the checklist tool was high (Pearson correlation $r = 0.937$).

CONCLUSION: TSAGAT is the first valid and reliable assessment tool incorporating SA and HPS for multidisciplinary team performance in trauma resuscitation. TSAGAT could compliment or improve on current assessment methods and curricula in trauma and critical care and provides a template for team assessment in other areas of surgical education. (J Surg 72:156-163. © 2014 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: trauma team performance, human patient simulation, situation awareness, SAGAT, TSAGAT

COMPETENCIES: Patient Care, Medical Knowledge, Interpersonal and Communication Skills

INTRODUCTION

The assessment of trainee performance in dynamic, intense clinical situations such as trauma resuscitation has been traditionally difficult. Properly functioning trauma teams, as part of a trauma system, are vital to improved outcomes in trauma resuscitation and have been shown to significantly reduce the rate of preventable trauma deaths.[1] Trauma resuscitation is usually carried out by the coordinated efforts of multidisciplinary trauma teams. Team

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members typically include a trauma team leader, an airway manager, a trauma nurse, technicians, and various other subspecialists based on patient presentation. Although there is knowledge overlap between specialties during trauma resuscitation, each team member also possesses unique complimentary knowledge and skills that facilitate successful team performance. There are currently few assessment tools that address the challenges in measuring team performance.

The current standard assessment tool in trauma education is a checklist.[2] The checklist puts emphasis on results with minimal insight into process.[3] A trainee may perform well on a checklist despite a series of misconceptions, misinterpretations, and mistakes. Checklists may reward thoroughness rather than competence and may not allow for recognition of alternative approaches to the problem.[4] Failure of this assessment tool to recognize these mistakes could result in poor trauma management in real-life scenarios. In addition, checklists are mostly intended for trauma team leaders, and therefore they do not necessarily apply to other members of a multidisciplinary trauma team. The checklist has been validated for individual trainee assessment. It is not designed to assess team performance. There is a need for trauma skills assessment evolution.

The optimal method of multidisciplinary trauma team assessment is yet to be established. A part of the complexity of the assessment lies in the many aspects of team performance, including communication skills, leadership, assertiveness, and situation awareness (SA). Options commonly employed include video review, observer review, medical notes review, or the use of simulation.[5] New focus on the integration of simulation into trauma and critical care curricula has been enabled by the design of the human patient simulators (HPS) (Medical Education Technology Incorporated, Sarasota, FL). This life-size mannequin shares many realistic features with real patients and has been used extensively in training and assessment worldwide.

HPS has been shown to have training advantages over traditional moulage scenarios,[6] and the use of HPS in conjunction with Advanced Trauma Life Support (ATLS) teaching appears to improve the development of trauma management skills.[6,7] HPS has shown significant potential to facilitate assessment of individual and team performance in practical trauma management.[8,9] As the environment in which individual and team trauma skills are practiced has evolved, the assessment methods for these skills have begun to evolve as well. SA and the Situation Awareness Global Assessment Technique (SAGAT) have recently emerged as areas of interest in trauma and critical care.[3,10-12]

SA is defined as the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future.[13] This psychological construct is critical to decision making in intense, dynamic environments. SA has been extensively studied in aviation, military, and nuclear power plant operations but only recently in medicine. Trauma resuscitation exemplifies the dynamic, stressful environments where SA is critical to good outcomes. SA is subdivided into 3 levels of understanding.

Level I SA refers to perceptions of elements in the environment.[13] This includes all data and stimuli that appeal to the 5 senses. Examples of level I SA in trauma resuscitation would include pulse, blood pressure, airway status, and significant injuries.

Level II SA involves comprehension of level I stimuli. The trainee builds on the data they acquired during their initial patient assessment, for example, a rapid heart rate and low blood pressure may indicate hypovolemia secondary to ongoing blood loss.

Level III SA is achieved when a trainee makes projections based on their understanding of Level I and Level II information. Projection leads to predictions and decision making about events or actions that may occur or be required in the near future.

Endsley defines team SA as the degree to which each team member possesses the SA required for his or her responsibilities.[10] SA is vital to individual performance, and team SA is critical to good team performance. Team members may have different subgoals in a given trauma resuscitation. Team SA can be subdivided into 2 types: (1) shared SA, in which team members possess the same SA and (2) complimentary SA, which represents unique, specialty-specific SA necessary for good team performance[10] (Fig. 1).

The SAGAT is a tool designed to assess trainees based on the 3 levels of SA (perception, comprehension, and projection).[13] This assessment method has been used in a variety of complex, dynamic environments and has recently been validated for individual assessment in trauma education.[11] Just as with individual performance, it would be useful to develop an assessment tool evaluating team performance. Team SAGAT (TSAGAT) could provide valuable information. Good or poor team performance and management decisions could be detected and analyzed to provide constructive feedback. Pervasive deficiencies in team SA across subjects could be useful to identify problems with current training programs.

In conducting this study, our goals were (1) to develop the TSAGAT assessment tool, (2) to use the TSAGAT tool

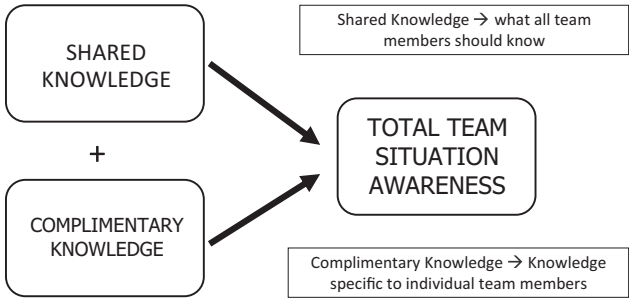


FIGURE 1. Components of Team Situation Awareness.

to assess multidisciplinary trauma teams performing simulated trauma resuscitation, (3) to analyze TSAGAT scores across different levels of experience so as to establish construct validity for the tool, (4) to compare the TSAGAT scores with a traditional checklist assessment tool, and (5) to analyze participants overall satisfaction with the TSAGAT and with the HPS by way of an exit questionnaire.

MATERIALS AND METHODS

TSAGAT Development

Individual SAGAT tools were for a trauma team leader, an airway manager, and for a trauma nurse. General and trauma surgeons, anesthesiologists, trauma nurses, and residents in general surgery and anesthesiology participated in SAGAT development. Questions were developed based on objectives set out by the American College of Surgeons Committee on Trauma ATLS course[14] for the trauma team leader SAGAT and objectives from the Trauma Nursing Core Course[15] for the nursing SAGAT. Objectives and guidelines from Miller's Anesthesia[16] and Clinical Anesthesia[17] were used to develop the airway manager's SAGAT. SA queries were developed using goal-directed task analysis as described by Endsley.[18] Questions were also developed based on previous SAGAT queries developed by Hogan et al.[11] SA requirements included all dynamic information needed to properly identify the major goals and subgoals of each trauma scenario. Once the SA requirements were identified, we developed level I, II, and III SA queries. Table 1 illustrates this process for a patient presenting with inhalational injuries from a house fire.

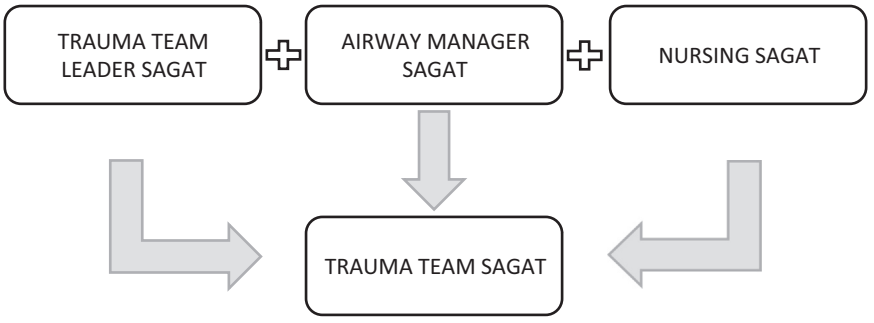
Shared and complimentary knowledge queries were developed for each SAGAT. TSAGAT scores were calculated as the sum of each team member's individual SAGAT score (Fig. 2).

Based on previous designs by Hogan et al.,[11] 2 scenarios were developed. These scenarios conformed to 2 primary clinical foci of trauma assessment as outlined in ATLS. The scenarios were modified to add elements that would require complimentary knowledge and expertise by all trauma team members. Scenarios were completed in the same order for each trauma team. The first scenario involved a polytrauma motor vehicle accident patient. Major subgoals for this scenario were to recognize hypovolemia secondary to major blood loss from internal and external injuries and to recognize the signs and symptoms of a closed head injury. The second scenario involved a polytrauma victim who had jumped from a burning building. Major subgoals for this scenario were to recognize major skeletal injuries and to identify an impending airway compromise secondary to inhalational injuries.

The trauma scenarios were programmed into a HPS. The scenarios were run in a simulation laboratory housing the HPS consistent with a normal trauma resuscitation room. It was equipped with the materials, monitors, and instruments that would normally be present. The trauma simulation laboratory has 4 cameras and 2 overhead microphones to allow for recording of all sessions.

TABLE 1. Goal-Directed Task Analysis for Developing SA Queries on Management of Significant Inhalational Injury

Goal—Keep Patient Alive	
Subgoal—Assess airway/diagnose inhalational injury to airway	
Decision—Intubate the patient	
Situation awareness requirements:	*SAGAT queries*
Clinical recognition of inhalational injury	Level 1 (Perception)
Carbonaceous material around mouth and on clothes	What is the patient's respiratory rate?
Singed eyebrows	What is the patient's oxygen saturation?
Stridor	What physical abnormalities have you noted on your initial examination?
Tachypnea	
Low oxygen saturation	What respiratory abnormalities have you noted on your physical examination?
Mechanism of injury	
Awareness of physiological basis of inhalational injury	Level 2 (Comprehension)
Thermal injury to airway	What is contributing to the patient's airway compromise?
Swelling and edema will obstruct the airway	Is the patient's airway secure?
Airway obstruction and carbon monoxide poisoning will inhibit adequate ventilation	
Awareness of natural history of inhalational injury	Level III (Projection)
Rapid decline	What do you expect to happen to the patient's oxygen saturation over the next few minutes?
Profound hypoxia	
Coma and death	Do you expect the patient's airway status to change over the next few minutes?
	What equipment may you need in the next few minutes?



TSAGAT = Sum of individual SAGAT Scores

FIGURE. 2

TABLE 2. Trauma Assessment Test Objectives

Scenario 1—Airway and Circulatory Issues

Code: _____

Primary survey
Places patient on the monitor
Assesses airway/assesses patient response
Inspects mouth
Assess neck/determine midline
Administers oxygen
Auscultates chest
Checks pulses
Places 2 large-bore IV catheters
Administers fluids
Types and cross-matches blood
Hematology/chemistry
Assess pupils
Determines Glascow Coma Scale
(/26)

Secondary survey
Head/face
C-spine
Chest
Abdomen
Pelvis
Back/logroll
Rectal examination
Extremities—specifies leg injury
Neurovascular examination—specifies leg
FAST/DPL
(/20)

Diagnostic studies/procedures ordered
CXR
Pelvic x-ray
C-spine views
Femur/leg views
Foley catheter inserted
Foley precautions (rectal/external examination)
(/12)

General performance
Maintains C-spine precautions
Correct sequence of management
Communicates with patient
Wraps the pelvis
Splints femur fracture
(/10)

Airway assessment
Identifies need for intubation
Pre-medicates appropriately
Correct sequence of intubation:
- Pre-oxygenates appropriately
- Bag-mask ventilates
- Collar off before intubation

Confirms airway is protected
Maintains inline stabilization
(/14)

Event identification and management
Identifies hypotension
Administers crystalloid/colloid
Identifies continued blood loss
Administers blood
Pressure on bleeding wounds
(/10)

Plan
Transfer to tertiary care center
Orthopedic consultation
ICU/burn unit consultation
Neurosurgery consultation
(/8)

Total score (/100)

IV, intravenous; C-spine, cervical-spine; ICU, intensive care unit; DPL, diagnostic peritoneal lavage; FAST, focused assessment with sonography for trauma; CXR, chest x-ray.
Scoring: 2, performs task efficiently; 1, performs task; and 0, does not perform task.

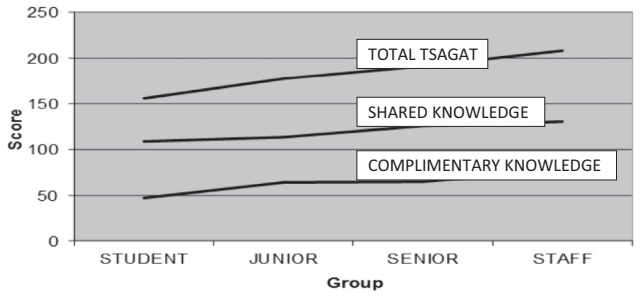


FIGURE 3. Mean TSAGAT component scores.

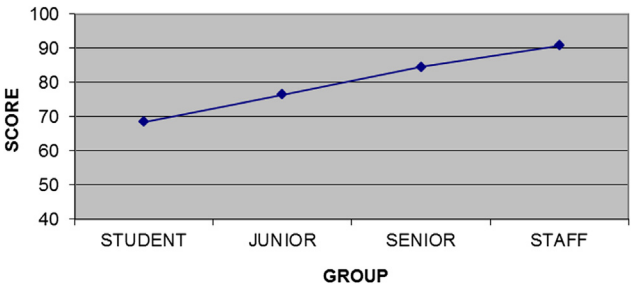


FIGURE 5. Mean checklist scores.

Participants and Design

Overall, 12 participants were chosen based on different levels of experience. Each trauma team consisted of a trauma team leader, an airway manager, and a trauma nurse. A student team was composed of 2 medical students and 1 nursing student. The junior team contained a junior general surgery resident, a junior anesthesia resident, and a junior trauma nurse (<6 months of experience). The senior team consisted of a senior general surgery resident, a senior anesthesia resident, and a senior nurse (less than 5 years of experience). The attending staff team contained a staff general surgeon, a staff anesthesiologist, and a nurse with extensive trauma experience (greater than 10 years).

Before the start of the first scenario, all team members were given a description of the study, an orientation to the HPS and the simulated trauma resuscitation room and to the nature of SAGAT. Informed, written consent was obtained from all study participants. All components of the study were in keeping with the Human Investigation Committee regulations at Memorial University of Newfoundland. At the onset of each scenario, the teams were given a clinical vignette by a simulated ambulance attendant that introduced them to the simulated patient's history and status.

Each scenario was designed to last roughly 15 minutes. Within each scenario, 3 separate "freezes" occurred so as to assess SA of each team members' clinical assessment and decision making for the various problems that arose during the simulation. SAGAT was used to assess respective SA based on shared and complementary knowledge queries. The freezes were designed to correlate with the major subgoals of each scenario. During each freeze, study participants were turned away from the patient and monitor so as to eliminate any visual information that may assist them in answering SAGAT queries. Correct answers were determined before the start of each scenario by consensus of the SAGAT developers. Quantitative answers, such as the heart rate, blood pressure, or oxygen saturation were permitted a range of ± 10% around the correct answer.

To obtain concurrent validity for TSAGAT, teams were also assessed using the "gold standard" traditional checklist system. A score of 2 points was given to each of 50 competencies when observed. Competencies were based on those described in the ATLS student course manual[14] and broadly fit into 7 categories: primary survey, secondary survey, diagnostic studies and procedures, airway management, event identification and management, general performance, and plan (Table 2). The checklists differed slightly for each scenario based on the different patient presentations. Using video review, 2 independent raters assessed each trauma team for each scenario.

Each of the 4 teams (student, junior resident, senior resident, and attending staff) completed 2 trauma scenarios. Teams were assessed using TSAGAT and a traditional checklist. The 4 teams collectively performed 8 scenarios for analysis.

All study participants completed an exit questionnaire to assess satisfaction with HPS and with the TSAGAT tool. The questionnaire had 4 possible responses that ranged on a scale from "strongly disagree" to "strongly agree."

Analysis

A total of 24 individual SAGAT tools were collected and combined to give 8 TSAGAT scores. Checklists were calculated for each scenario. Using retrospective video

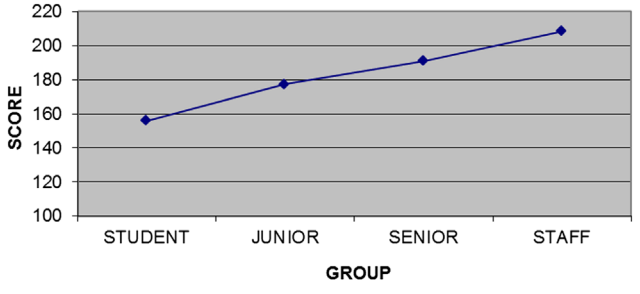


FIGURE 4. Team total score.

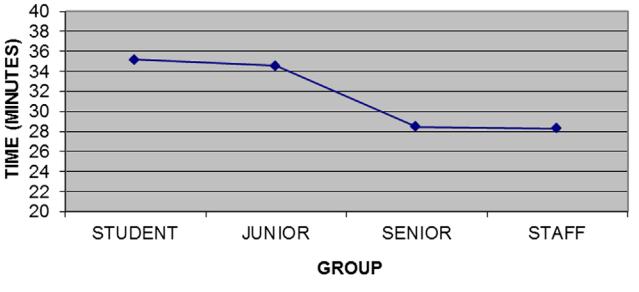


FIGURE 6. Mean time to complete both scenarios.

review, 16 checklists (2 per scenario) were scored by 2 independent raters. Data were analyzed using SPSS software. Construct validity was assessed by comparing TSAGAT scores and checklist scores with level of experience (students, junior residents, senior residents, and attending staff) using analysis of variance. Interrater reliability for the checklist assessment tool was calculated using Pearson's coefficient. The mean time to complete each scenario was calculated using analysis of variance. As teams with higher SA should also be more efficient, we felt that time to complete each scenario would serve as an additional independent variable to demonstrate differences between the trauma teams based on level of experience. Questionnaire results were compiled and analyzed to identify overall satisfaction with TSAGAT and HPS.

RESULTS

Shared, complimentary, and total TSAGAT scores improved with increasing experience. TSAGAT scores were significantly different based on level of training ($p < 0.05$). The greatest improvements were observed between student and attending staff TSAGAT scores ($p < 0.05$) and student and attending staff complimentary knowledge ($p < 0.05$) (Fig. 3). These findings imply construct validity for TSAGAT.

The mean checklist scores improved with increasing level of experience ($p < 0.05$). Interrater reliability for checklist scores was high (Pearson correlation $r = 0.93675$). TSAGAT scores (Fig. 4) correlated strongly with the traditional checklist performance measures (Pearson correlation $r = 0.99565$; Fig. 5). These findings imply concurrent validity and reliability of the TSAGAT tool.

The mean time required to complete both scenarios was shorter for the senior and attending teams compared with student and junior teams ($p < 0.05$; Fig. 6).

Satisfaction scores were high for the experience with HPS and for TSAGAT. These results are presented in Table 3 as a percentage of participants that answered each question ($n = 12$).

DISCUSSION

Assessment of team performance is challenging and requires consideration of multiple components of teamwork. A myriad of research has been done previously on assessment of communication skills in team environments but none has focused on team SA. We have developed and validated a novel tool to assess team performance in trauma education, incorporating the vital construct of SA. Individual and team SA is crucial to proper team function in dynamic, intense environments where errors in perception, comprehension, and projection can lead to negative outcomes.[10,12] The TSAGAT tool incorporates SA and HPS to assess multidisciplinary teams performing trauma resuscitation. TSAGAT provides insight into the decision making process of trauma teams. TSAGAT could provide valuable information to program and curriculum developers and could influence the current assessment models for multidisciplinary teams performing trauma resuscitation.

Different health care professionals bring different skill sets, knowledge, and experiences that affect team performance. Both shared and complimentary knowledge between

TABLE 3. Survey of Participants

	Strongly Disagree (%)	Disagree (%)	Agree (%)	Strongly Agree (%)
Regarding the use of HPS				
I found the orientation to the simulator adequate	–	–	58	42
The physical signs exhibited by the simulator were readily apparent	–	17	66	17
The monitoring equipment was clear and visible during the scenario	–	17	33	50
The information provided by ambulance and nursing staff was clear	–	–	58	42
The simulator provided a realistic model of a trauma patient presentation	8	8	76	8
The simulated responded in a realistic fashion to clinical interventions	–	8	84	8
The simulator realistically recreated the intensity and dynamic nature of trauma resuscitation	8	25	59	8
Overall, I was satisfied with the use of the human patient simulator for assessment of practical skills	–	8	84	8
Regarding the use of SAGAT				
The orientation to the SAGAT was adequate	–	–	83	17
The SAGAT questions were clear	–	–	58	42
The "freezes" during the scenario adversely affected my concentration and performance	–	75	25	–
The questions asked were pertinent to my understanding of the situation at that moment	–	–	67	33
Overall, I was satisfied with the SAGAT as a tool to supplement practical trauma skills assessment	–	8	58	34

team members is crucial to overall team performance.[10,12] If teams are trained and assessed together, they will likely perform better in real clinical scenarios. Owing to its design, TSAGAT allows for individual and team assessment simultaneously. Different training programs could gain valuable individual assessment information of their trainees in an environment that also promotes and assesses team performance.

Although TSAGAT measures individual and team SA, the checklist assessment tool is better suited to assess knowledge of process and procedure. It is encouraging that both assessment methods displayed strong correlation. This supports the assumption that scores with either assessment method should improve with increasing team knowledge and experience. Taken together, the 2 assessment methods could provide complimentary training and assessment possibilities for multidisciplinary team performance.

Participant satisfaction with HPS and the TSAGAT was high. This is an important finding because this form of assessment could be viewed as intrusive by some participants. The scheduled freezes remove the trainee from the resuscitation environment momentarily to ask level I, II, and III SA queries. As seen in Table 3, 75% of respondents did not feel that the SAGAT style adversely affected their concentration or performance, and overall satisfaction with the SAGAT tool and with HPS was high for 92% of all participants.

CONCLUSION

We have developed and validated the team SAGAT assessment tool. TSAGAT is a promising addition to the growing armament of tools available for the assessment of multidisciplinary teams performing trauma resuscitation. TSAGAT is the first valid and reliable assessment tool incorporating SA and HPS for multidisciplinary team performance in trauma resuscitation. TSAGAT could compliment or improve current assessment methods and curricula in trauma and critical care and provide a template for team assessment in other areas of surgical education.

REFERENCES

1. West JG, Trunkey DD, Lim RC. Systems of trauma care: a study of two countries. *Arch Surg*. 1979;114(4):455-460.
2. Ali J, Cohen RJ, Gana TJ, Al-Bedah KF. Effect of Advanced Trauma Life Support Program on medical students' performance in simulated trauma management. *J Trauma*. 1998;44(4):588-591.
3. Wright MC, Taekman HM, Endsley MR. Objective measures of situation awareness in a simulated medical environment. *Qual Saf Health Care*. 2004;13(suppl 1):i65-i71.
4. Regehr G, MacRae H, Reznick RK, Szalay D. Comparing the psychometric properties of checklists and global ratings scales for assessing performance on an OSCE-format examination. *Acad Med*. 1998;73(9):993-997.
5. Georgiou A, Lockey DJ. The performance and assessment of hospital trauma teams. *Scand J Trauma Resusc Emerg Med*. 2010;18:66.
6. Lee SK, Pardo M, Gaba D, et al. Trauma assessment training with a patient simulator: a prospective randomized study. *J Trauma*. 2003;55(4):651-657.
7. Holcomb JB, Dumire RD, Crommett JW, et al. Evaluation of trauma team performance using an advanced human patient simulator for resuscitation training. *J Trauma*. 2002;52(6):1078-1086.
8. Murray DJ, Boulet JR, Kras JF, Woodhouse JA, Cox T, McAllister JD. Acute care skills in anesthesia practice: a simulation-based resident performance assessment. *Anesthesiology*. 2004;101(5):1084-1095.
9. Marshall RL, Smith JS, Gorman PJ, Krummel TM, Haluck RS, Cooney RN. Use of a human patient simulator in the development of resident trauma management skills. *J Trauma*. 2001;51(1):17-21.
10. Wright MC, Endsley MR. Building shared situation awareness in healthcare settings. Nemeth C, editor. Improving Healthcare Team Communication, Building on Lessons From Aviation and Aerospace. Vermont: Ashgate Publishing Limited, 2008. p. 97-110.
11. Hogan MP, Pace DE, Hapgood J, Boone DC. Use of human patient simulation and the situation awareness global assessment technique in practical trauma skills assessment. *J Trauma*. 2006;61(5):1047-1052.
12. Wright MC, Phillips-Bute BG, Petrusa ER, Griffin KL, Taekman JM. Assessing teamwork in medical education and practice: relating behavioural teamwork ratings and clinical performance. *MedTeach*. 2009;31(1):30-38.
13. Endsley MR. Theoretical underpinnings of situation awareness: a critical review. Endsley Mica R, Garland Daniel J, editors. Situation Awareness Analysis and Measurement. Mahway, NJ: Lawrence Erlbaum Associates, 2000. p. 3-32.
14. American College of Surgeons Committee on Trauma. ATLS Student Course Manual. 6th Chicago: ACS; 1997.
15. Emergency Nurses Association. Trauma Nursing Core Course Manual. 6th Illinois: ENA; 2007.

16. Miller RD, Eriksson LI, Fleisher LA. Miller's Anesthesia. 7th Philadelphia: Churchill Livingstone; 2009.

17. Barash PG, Cullen BF, Stoelting RK. Clinical Anesthesia. 5th ed Philadelphia: Lippincott Williams and Wilkins; 2005.

18. Endsley MR. Direct measurement of situation awareness: validity and use of SAGAT. Endsley Mica R, Garland Daniel J, editors. Situation Awareness Analysis and Measurement. Maywah, NJ: Lawrence Erlbaum Associates, 2000. p. 147-173.