Does simulation work? Monthly trauma simulation and procedural training are associated with decreased time to intervention

Caroline Park, MD, MPH, Jennifer Grant, MD, Ryan P. Dumas, MD, Linda Dultz, MD, MPH, Thomas H. Shoultz, MD, Daniel J. Scott, MD, Stephen Luk, MD, MBA, Kareem R. Abdelfattah, MD, *and* **Michael W. Cripps, MD, MSCS**, *Dallas, Texas*

AAST Continuing Medical Education Article

Accreditation Statement

This activity has been planned and implemented in accordance with the Essential Areas and Policies of the Accreditation Council for Continuing Medical Education through the joint providership of the American College of Surgeons and the American Association for the Surgery of Trauma. The American College Surgeons is accredited by the ACCME to provide continuing medical education for physicians.

AMA PRA Category 1 Credits™

The American College of Surgeons designates this journal-based CME activity for a maximum of 1 *AMA PRA Category 1 Credit*™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

Of the *AMA PRA Category 1 Credit*™ listed above, a maximum of 1 credit meets the requirements for self-assessment.

Credits can only be claimed online

AMERICAN COLLEGE OF SURGEONS

Inspiring Quality: Highest Standards, Better Outcomes

100+years

Objectives

After reading the featured articles published in the *Journal of Trauma and Acute Care Surgery*, participants should be able to demonstrate increased understanding of the material specific to the article. Objectives for each article are featured at the beginning of each article and online. Test questions are at the end of the article, with a critique and specific location in the article referencing the question topic.

Claiming Credit

To claim credit, please visit the AAST website at http://www.aast.org/ and click on the "e-Learning/MOC" tab. You must read the article, successfully complete the post-test and evaluation. Your CME certificate will be available immediately upon receiving a passing score of 75% or higher on the post-test. Post-tests receiving a score of below 75% will require a retake of the test to receive credit.

Disclosure Information

In accordance with the ACCME Accreditation Criteria, the American College of Surgeons, as the accredited provider of this journal activity, must ensure that anyone in a position to control the content of J Trauma Acute Care Surg articles selected for CME credit has disclosed all relevant financial relationships with any commercial interest. Disclosure forms are completed by the editorial staff, associate editors, reviewers, and all authors. The ACCME defines a `commercial interest' as "any entity producing, marketing, re-selling, or distributing health care goods or services consumed by, or used on, patients." "Relevant" financial relationships are those (in any amount) that may create a conflict of interest and occur within the 12'months preceding and during the time that the individual is engaged in writing the article. All reported conflicts are thoroughly managed in order to ensure any potential bias within the content is eliminated. However, if you'perceive a bias within the article, please report the circumstances on the evaluation form.

Please note we have advised the authors that it is their responsibility to disclose within the article if they are describing the use of a device, product, or drug that is not FDA approved or the off-label use of an approved device, product, or drug or unapproved usage.

Disclosures of Significant Relationships with Relevant Commercial Companies/Organizations by the Editorial Staff

Ernest E. Moore, Editor: PI, research support and shared U.S. patents Haemonetics; PI, research support, Instrumentation Laboratory, Inc.; Co-founder, Thrombo Therapeutics. Associate Editors David Hoyt, Ronald V. Maier and Steven Shackford have nothing to disclose. Editorial staff and Angela Sauaia have nothing to disclose.

Author Disclosures

The authors have nothing to disclose.

Reviewer Disclosures

The reviewers have nothing to disclose.

Cost

For AAST members and Journal of Trauma and Acute Care Surgery subscribers there is no charge to participate in this activity. For those who are not a member or subscriber, the cost for each credit is $25.

System Requirements

The system requirements are as follows: Adobe® Reader 7.0 or above installed; Internet Explorer® 7 and above; Firefox® 3.0 and above, Chrome® 8.0 and above, or Safari™ 4.0 and above.

Questions

If you have any questions, please contact AAST at 800-789-4006. Paper test and evaluations will not be accepted.

BACKGROUND: Establishing proficiency in specific trauma procedures during surgical residency has been limited to annual courses with limited data on its effect on the delivery of health care and patient outcomes. There is a wide variety of training on content and complexity with recent studies looking at time to imaging or secondary survey. In this study, we implement monthly case-based simulation after initial training on a variety of bedside trauma procedures. The overall goal is to evaluate the effect of simulation on time to specific interventions.

METHODS: This is a prospective, observational study between July 2018 and February 2019 at a single-institution, Level I trauma center with a large surgical residency program. A trauma simulation program was implemented in November 2018 to train and evaluate surgical residents from post-graduate year 1 through 5. All rotating residents participated in an initial course on basic trauma procedures, such as percutaneous sheath placement, tube thoracostomy, and resuscitative thoracotomy followed by an end-of-month simulation. All Level I activations from preintervention starting in July to October 2018 (preintervention) and October 2018 through February 2019 (postintervention) were reviewed; monitored variables included age, sex, mechanism of injury, blunt or penetrating, and time to intervention in the trauma bay. Median times to intervention were recorded with interquartile ranges (IQR). Pearson's coefficient was used to measure the strength of the relationship between simulation and time to patient intervention.

RESULTS: Median time to most interventions improved over time but with more consistent improvement after the implementation of formal simulation and procedural training in November 2018. Median pretraining time for resuscitative thoracotomy was 14 minutes (IQR, 8–32 minutes); posttraining median time was 3 minutes (IQR, 2.7–8 minutes, $p = 0.02$). Median pretraining time to tube thoracostomy was 13 minutes (IQR, 5.5–19 minutes); posttraining time was 6 minutes (IQR, 4–31 minutes, $p = 0.04$). Pearson's coefficient (r^2) measured strength of correlation and was highest for tube thoracostomy followed by resuscitative thoracotomy and percutaneous sheath access with r^2 values of 0.46, 0.35, and 0.24, respectively.

CONCLUSION: High-complexity, routine procedural training, and trauma simulation are associated with decreased time to interventions within a short period of time. Routine implementation of a training program emphasizing efficient, effective approaches to bedside procedures is necessary to train our residents in these high-acuity, low-frequency situations. Future investigations are warranted in the effect of simulation on short-term and long-term patient outcomes. (*J Trauma Acute Care Surg.* 2020;88: 242–248. Copyright © 2019 American Association for the Surgery of Trauma.)

LEVEL OF EVIDENCE: Therapeutic, level III.

KEY WORDS: Trauma simulation; resident performance; time to intervention.

Simulation-based training has been shown to improve performance and retention of procedural and leadership skills.[1–4] However, the clinical impact of these structured courses on resident performance remains unclear, specifically the time to patient-directed care, such as intubation, tube thoracostomy, vascular access, computed tomography (CT) scan, and operative intervention. The degree of the clinical impact of these courses has been limited to earlier studies on mortality rates[5] or time to completion of primary survey, such as intubation and transfusion.[6] To our knowledge, it is not known if standardized, repeated educational, and simulation curriculum implemented in a trauma surgery rotation can affect clinical performance among surgical trainees.

High-yield, effective teaching is paramount, particularly in a learning environment that has become increasingly nonoperative, confined to an 80-hour work week with increasing emphasis on structured curricula and certifications in laparoscopic, robotic and other technical skills. This study aimed to evaluate the impact of routine monthly procedural and simulation training on time to intervention for trauma procedures. We hypothesize that implementation of this training will decrease time to intervention.

Submitted: August 25, 2019, Revised: November 23, 2019, Accepted: November 23, 2019, Published online: December 5, 2019.
From the Division of Acute Care Surgery, Department of General Surgery (C.P., J.G., R.D., L.D., T.S., D.J.S., S.L., K.A., M.C.), University of Texas Southwestern Medical Center, Dallas, Texas.
This paper will be presented at the 78th Annual Meeting of the American Association for Surgery of Trauma and Clinical Congress of Acute Care Surgery, September 19, 2019 in Dallas, Texas.
Address for reprints: Caroline Park, MD, MPH, Department of Surgery, University of Texas Southwestern Medical Center, 5323 Harry Hines Boulevard, Dallas, TX 75390; email: caroline.park@utsouthwestern.edu.

DOI: 10.1097/TA.0000000000002561

MATERIALS AND METHODS

Study Design

We reviewed all trauma patients who met criteria for the highest-level trauma activation between July 2018 and February of 2019 at our institution, which is an urban, safety-net Level I Trauma Center. Patients meeting criteria were excluded if there was insufficient real-time documentation of patient interventions or if interventions were performed after the patient had left the trauma bay for diagnostic studies and returned for ongoing work-up and treatment. Enrollment process and refusal rates were not applicable because these patients were treated urgently as trauma activations.

Data from the medical record were manually extracted at this institution and included demographics as age, sex, signs of life on admission, mechanism, and specific type of injury. Patient interventions recorded included intubation, tube thoracostomy, vascular access, interosseous access, arterial line, resuscitative endovascular balloon occlusion of the aorta (REBOA) device, pelvic binder, resuscitative thoracotomy, CT, and operative intervention. During these resuscitations, a dedicated trauma nurse clinician documents, in real-time and in the electronic medical record, the time of the intervention.

Institutional board review was obtained for this observational study, which reviewed all patients meeting Level I trauma activation criteria at our institution from July 2018 through February 2019.

In November 2018, a formal trauma procedural training and simulation (herein summarized as "training") program was launched to review high-yield procedures, including hands-on training for percutaneous sheath and arterial line placement, interosseous line, tube thoracostomy, resuscitative thoracotomy, tourniquet, pelvic binder, and REBOA. Training also emphasizes not only the technique but also the basic knowledge of the equipment, setup, and physical location in the same trauma bay where we receive patients.

At the end of the trauma rotation, simulations were held and entailed a complex, advanced trauma life support (ATLS)-style scenario with a team leader, and designated roles for procedures and evaluation of the organization, flow, and execution of procedures while two rooms focus specifically on procedural competency.

In this study, the recorded time to specific patient interventions was noted at a time stamp and was viewed as a surrogate for team efficiency and dynamics. Time to patient intervention was calculated from the time the patient arrived at the trauma bay. Pretraining variables included patient sex, age, mechanism of injury, presence of signs of life on admission, and time to various patient interventions as those described earlier in our trauma procedural training program. Posttraining variables were identical to those above.

Statistics

Comparisons were made in before and after fashion, with July 2018 through October 2018 as the "pretraining" period and November 2018 through February 2019 as the "posttraining" period. Median times to patient intervention were calculated with interquartile ranges (IQR). Student's *t* test was used to evaluate for any statistical difference in time to intervention in the pretraining and posttraining periods. Pearson's coefficient was performed to assess the strength of correlation between training and time to patient intervention in both the before and after training time frames.

RESULTS

Patient Characteristics

Between July 2018 and February 2019, there were a total of 294 Level I activations. Seventeen patients were excluded secondary to insufficient information on time to patient intervention.

The average age was 41 years (SD, 21 years) with a median of 33 (IQR, 15–100 years). Males accounted for most patients at 77%. Percentage of patients with vital signs on arrival was 87%. Blunt injuries were more common than penetrating (65% vs. 35%). The most common mechanism of injury was motor vehicle accident (24%) followed by gunshot wounds (21%), falls (17%), stab wounds (13%), and auto versus pedestrian (8%). Motor-cycle collisions and other traumatic injuries (assault, crush injuries) accounted for a minority of Level I activations (Table 1).

TABLE 1. Patient Demographics and Mechanism of Injury

Patient Factors and Mechanism of Injury	
Total Level I activations	277
Age, median (range)	33 (12–100)
Male, n/total (%)	214/277 (77)
Mechanism n/total (%)	
MVC	67/277 (24)
GSW	58/277 (21)
Fall	49/277 (18)
SW	37/277 (13)
AVP	23/277 (8)
MCC	14/277 (5)
Blunt, n/total (%)	181/277 (65)
Vitals signs on arrival n/total (%)	241/277 (87%)

MVC, motor vehicle collision; GSW, gunshot wound; SW, stab wound; AVP, auto vs. pedestrian; MCC, motor cycle collision.

TABLE 2. Total Number of Procedures

Intervention	Count, n (%)
Intubation	52 (13)
CT scan	176 (45)
OR	47 (12)
Tube thoracostomy	25 (6)
Percutaneous sheath	28 (7.2)
Arterial line	18 (4.6)
Resuscitative thoracotomy	14 (3.6)
Interosseus line	5 (1.2)
Pelvic binder	5 (1.2)
Tourniquet	3 (<1)
REBOA	2 (<1)

Interventions

Among all interventions, leaving the trauma hall for CT scan was the most common intervention, accounting for nearly 50% of events. We also considered this intervention as a surrogate for evaluation of team efficiency after completion of the primary and secondary surveys. Among procedures, endotracheal intubation consisted of approximately 13% of the procedures, followed by operative intervention (12%), vascular access (7.2%), tube thoracostomy (6%), arterial line (4.6%), and resuscitative thoracotomy (3.6%). Interosseus line, pelvic binder, REBOA remained a minority of procedures performed in the trauma bay (Table 2).

Time to Interventions

To evaluate the impact of procedural training and trauma simulation, we evaluated the time to intervention before initiation of training (July 2018 to October 2018) and posttraining (November 2018 to February 2019). Median times to intervention pretraining were compared with posttraining times. The median time to CT scan was 32.5 minutes pretraining (IQR, 21–180 minutes);

TABLE 3. Time to Intervention Pre- and Post-Simulation

Intervention	Median Time to Intervention: Presimulation (IQR), min	Median Time to Intervention: Postsimulation (IQR), min	*p*	r^2
Resuscitative thoracotomy	14 (8–32)	3 (2.7–8)	0.02	0.35
Tube thoracostomy	13 (5.5–19)	6 (4–31)	0.04	0.46
Introducer sheath	12 (9–30)	7 (6–80)	0.14	0.24
CT scan	32 (21–316)	31 (21–219)	0.36	0.06
OR	16 (10–86)	28 (15–106)	0.07	0.11

Median time to intervention pre- and post-simulation (minutes with interquartile ranges). r^2 = Pearson's coefficient.

median time to CT scan posttraining was slightly decreased to 30.5 minutes (IQR, 21–219 minutes, p = 0.36). The median time to resuscitative thoracotomy pretraining was 14 minutes (IQR, 8–32 minutes); posttraining median time was 3 minutes (IQR, 2.7–8 minutes, p = 0.02). Median time to tube thoracostomy pretraining was 13 minutes (IQR, 5.5–19 minutes); posttraining median time was 6 minutes (IQR, 4–31 minutes, p = 0.04). Pearson's coefficient was utilized to evaluate the strength of association of time to intervention and training preimplementation and postimplementation. This effect appeared to be most significant for tube thoracostomy, followed by resuscitative thoracotomy and percutaneous sheath access with r^2 values of 0.46, 0.35, and 0.24, respectively (Table 3). Figure 1 demonstrates these trends over time.

DISCUSSION

Repetitive training with simulation is no foreign idea to the care of trauma patients. This idea stems over millennia during wartime conflict where soldiers took care of one another to help identify and readily address life-threatening injuries. Established over 40 years ago, ATLS and other formal training programs have evolved to meet the demands of trauma centers across the world to include not only knowledge, but also technical skills and leadership.

From the inception of the ATLS course,[7] there have been several efforts to educate, assess, and enhance the dissemination of trauma resuscitation. As a result, much of the surgical trainings for trauma resuscitation and procedures have evolved from these basic life-saving principles to provide efficient, evidence-based practices with the goal to improve patient care. More recently, there has been increasing emphasis to improve the performance and delivery of these life-saving procedures and resuscitation. These include early simulation utilizing ATLS didactics for medical students and military trainees in operational and military medicine,[8,9] mannequin-based courses[10–13] to perfused cadaver[14] or animal-based models.[15] Additional studies have investigated the clinical impact of these interventions with focused outcomes on morbidity, mortality, and time to operative intervention.[16] More recently, there has been increasing interest on a multidisciplinary approach to trauma simulation training and reduced assessment time during primary and secondary surveys.[17]

High yield, effective teaching of low-frequency, high-acuity procedures in trauma resuscitation is multifaceted and should be multidisciplinary. However, faced with multiple other learning expectations and time restrictions, the surgical trainee's learning environment that has become increasingly nonoperative with less exposure to bedside trauma procedures in the face of a stressful, active resuscitation. In this study, we proposed that the implementation of a monthly trauma procedural training and simulation program not only helps improve resident performance but may also improve time to specific interventions in trauma patients in the trauma bay before definitive care.

We found that monthly procedural training on high-yield procedures is associated with decreased time to patient intervention. This effect was especially pronounced in time to resuscitative thoracotomy, tube thoracostomy, and percutaneous sheath placement.

There are of course a variety of factors that could affect the time to intervention, including PGY level, patient acuity, and

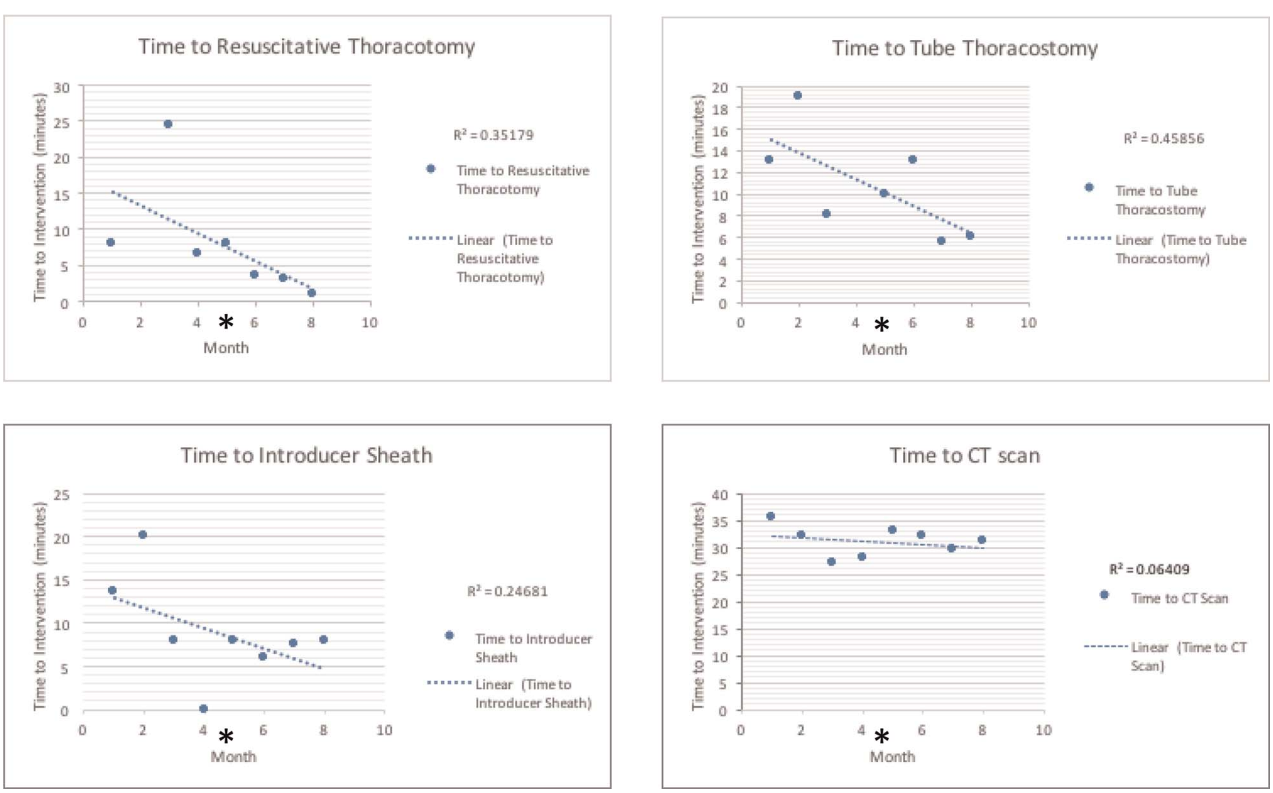

Figure 1. Time (minutes) to patient intervention over time (months). Asterisk * denotes implementation of procedural training and simulation.

other patient-specific factors (obesity, agitation, etc.), and time during the academic year. The intervention was timed about 4 months into the academic year when only a minority of residents had repeated their trauma rotation. Residents may also have had exposure to procedures, such as vascular access and tube thoracostomy, on other rotations, such as intensive care unit and cardiothoracic surgery. Procedures are often performed by PGY-2 or PGY-3 residents, and time to procedure can vary based on level and number of procedures performed.

There are additional reasons that could affect time to intervention, including patient factors. Patients with depressed Glasgow Coma Scale (GCS), hypotension, and suspected pneumothorax or hemothorax are more likely to undergo intervention as intubation, chest tube, percutaneous sheath placement, and resuscitative thoracotomy. Based on the emergent nature of these procedures, they are used quickly and simultaneously, often not requiring pain medication or sedation based on their depressed GCS. There are other specific patient factors that may affect the time to simulation, including morbid obesity, where placing a tube thoracostomy requires the entire length of the index finger for a sweep or a resuscitative thoracotomy may require two finochietto retractors based on a massive chest wall.

We also acknowledge that time to patient intervention is, in many ways, a surrogate of team efficiency. Time to a procedure not only includes the time for diagnosis and triage of a life-threatening problem (i.e., tension pneumothorax requiring chest decompression), but also location of the equipment, preparation, and actual placement. Team dynamics are also variable based on the communication and leadership skills of the team leader.

It is also difficult to analyze the actual effectiveness of our procedural training in a real environment with multiple patient and provider variables in comparison to a purely standardized environment where reality is suspended and the focus is on procedural task. We argue that the stress and complexity of actual trauma activations add layers of complexity to the procedure; stress and complexity are integral parts to resident learning but are difficult to standardize.

Another limitation to this observational study is that our real-time documentation does not consistently include the start time in addition to end time of the procedures. Most of the documentation includes only end time of the procedure (i.e., pelvic binder secured, patient leaves trauma bay to CT scan). Our program is currently working on a quality improvement process to improve our real-time documentation based on video review.

CONCLUSION

There are innumerable training and simulation programs to help teach and reinforce technical skill in bedside trauma procedures and resuscitation. In our study, we found that monthly high-yield procedural training and simulation may help decrease time to patient intervention. This effect was most significant in resuscitative thoracotomy, tube thoracostomy, and percutaneous sheath placement. This effect of procedural training and simulation on patient outcomes has not yet been explored and remains an area for further research. We hope to trend this performance data over time to help identify deficiencies and strengths and ultimately build an objective assessment tool specific to trauma and emergency procedures that can be utilized across other surgical training programs.

AUTHORSHIP

C. P., M. C., J. G., R. D., D. J. S., S. L. participated in the study concept and design. C. P., M. C., J. G., R. D., L. D., T. S. participated in the data collection and analysis. C. P., M. C. participated in the writing. C. P., K. A., M. C. participated in the critical revision.

DISCLOSURE

The authors declare no funding or conflicts of interest.

REFERENCES

1. Vestrup JA, Stormorken A, Wood V. Impact of advanced trauma life support training on early trauma management. *Am J Surg*. 1988;155(5):704–707.
2. Ali I, Cohen R, Reznick R. Demonstration of acquisition of trauma management skills by senior medical students completing the ATLS program. *J Trauma*. 1995;38(5):687–691.
3. Ali J, Cohen R, Adam R, Gana TJ, Pierre I, Bedaysie H, Ali E, West U, Winn J. Teaching effectiveness of the advanced trauma life support program as demonstrated by an objective structured clinical examination for practicing physicians. *World J Surg*. 1996;20(8):1121–1125; discussion 1125-6.
4. Brenner M, Hoehn M, Pasley J, Dubose J, Stein D, Scalea T. Basic endovascular skills for trauma course: bridging the gap between endovascular techniques and the acute care surgeon. *J Trauma Acute Care Surg*. 2014;77(2):286–291.
5. van Olden GD, Meeuwis JD, Bolhuis HW, Boxma H, Goris RJ. Clinical impact of advanced trauma life support. *Am J Emerg Med*. 2004;22(7):522–525.
6. Hedges JR, Adams AL, Gunnels MD. ATLS practices and survival at rural level III trauma hospitals, 1995–1999. *Prehosp Emerg Care*. 2002;6(3):299–305.
7. Collicott PE, Hughes I. Training in advanced trauma life support. *JAMA*. 1980;243(11):1156–1159.
8. Cowan ML, Cloutier MG. Medical simulation for disaster casualty management training. *J Trauma*. 1988;28(Suppl 1):S178–S182.
9. Siriratsivawong K, Kang J, Riffenburgh R, Hoang TN. Immersion team training in a realistic environment improves team performance in trauma resuscitation. *Surgery*. 2016;160(3):586–590.
10. 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.
11. Block EF, Lottenberg L, Flint L, Jakobsen J, Liebnitzky D. Use of a human patient simulator for the advanced trauma life support course. *Am Surg*. 2002;68(7):648–651.
12. Fernandez GL, Page DW, Coe NP, Lee PC, Patterson LA, Skylizard L, St Louis M, Amaral MH, Wait RB, Seymour NE. Boot cAMP: educational outcomes after 4 successive years of preparatory simulation-based training at onset of internship. *J Surg Educ*. 2012;69(2):242–248.
13. Sparks JL, Crouch DL, Sobba K, Evans D, Zhang J, Johnson JE, Saunders I, Thomas J, Bodin S, Tonidandel A, Carter J, Westcott C, Martin RS, Hildreth A. Association of a Surgical Task during Training with Team Skill Acquisition among Surgical Residents: the missing piece in multidisciplinary team training. *JAMA Surg*. 2017;152(9): 818–825.
14. Grabo DJ Jr., Polk T, Strumwasser A, Inaba K, Foran C, Luther C, Minneti M , Kronstedt S, Wilson A, Demetriades D. A Novel, Perfused-Cadaver Simulation Model for Tourniquet Training in Military Medics. *J Spec Oper Med*. 2018;18(4):97–102.
15. Perkins RS, Lehner KA, Armstrong R, Gardiner SK, Karmy-Jones RC, Izenberg SD, Long WB 3rd, Wackym PA. Model for team training using the advanced trauma operative management course: pilot study analysis. *J Surg Educ*. 2015;72(6):1200–1208.
16. Murphy M, Curtis K, Lam MK, Palmer CS, Hsu J, McCloughen A. Simulation-based multidisciplinary team training decreases time to critical operations for trauma patients. *Injury*. 2018;49(5):953–958.
17. Long AM, Lefebvre CM, Masneri DA, Mowery NT, Chang MC, Johnson JE, Carter JE. The Golden opportunity: multidisciplinary simulation training improves trauma team efficiency. *J Surg Educ*. 2019;76(4):1116–1121.

DISCUSSION

MARK W. BOWYER, M.D. (Fairfax, Virginia): Good afternoon. I'd like to thank the Association and the moderators for the privilege of reviewing this important and nicely presented paper by Dr. Park and her colleagues. And I also thank the authors for presenting me the manuscript well in advance for my review.

I think this paper is based on two very intuitive and logical assumptions, the first one being that time is critical in the treatment of traumatically injured patients, and that, by extension, the faster the intervention, the better the outcome.

The second assumption is that repetitive practice of the skills that we need to care for trauma patients will increase efficiency, therefore the time to intervention, and also, therefore, improve outcomes.

Dr. Park and her colleagues designed and carried out this study to evaluate whether a formalized repeated simulation-based trauma training curriculum, including team roles and hands-on training for high-stakes interventions and procedures, would reduce the time to intervention, which was used as a surrogate measure for team efficiency and dynamics.

Over an eight-month period beginning in July of 2018, they had 277 evaluable Level I trauma activations, and the time to intervention for several high-stakes procedural interventions was divided into these two four-month periods, pre-training, and for four months following the training.

As might be expected, focused training did indeed decrease the time to intervention, with a median time to CT decreased by two minutes in the post-training group; and this was used as a measure of completement of primary and secondary survey.

Two specific procedures, as you heard, were noted to have significantly decreased time to intervention. The median time to tube thoracostomy was reduced from 13 to 6 minutes, and the time to resuscitative thoracotomy was reduced from 14 to 3 minutes, post-training.

One, to me, unexpected finding was that median time to OR actually increased from 16 minutes pre- to 28 minutes post-training, a detail which I will shortly ask you to comment on.

The authors have correctly identified a number of limitations and confounding variables with this study in the manuscript, to include the potential effect of training groups being later in the academic year, the PGY year, and previous experience with procedures and patient variability.

The use of simulation as part of a high-yield focused training curriculum is increasingly necessary in this era of work-hour restrictions and decreased clinical exposure.

It's no surprise to me that repetitive practice by surgical trainees led to improved efficacy and efficiency in the management of trauma patients, but the ultimate question is, does this lead to improved outcomes? I hope that the authors will continue this important work to address this question.

Again, I congratulate Dr. Park and her colleagues on this important work, and I would like to ask a few short questions regarding this paper.

We all know that trauma is a team sport and that the leader is only as good as the team. Did your training include all members of the non-physician members of the team?

Did you evaluate the success of the interventions performed? For instance if a chest tube was placed, was it placed correctly?

You demonstrated a significant decrease in the median time to resuscitative thoracotomy from 14 minutes to 3 minutes. From looking at your manuscript and your presentation, it's difficult from the data you presented for me to evaluate the significance of this.

You had 36 patients present without vital signs on arrival, and only 14 patients underwent resuscitative thoracotomy. Were there differences in presentation?

For instance, were there patients who arrived who lost vital signs within five or ten minutes after arrival, versus those who had no vital signs on arrival? Can you provide some clarification about this finding?

And the next question is were trauma attendings immediately present for every activation, and if not, did this make a difference in the time to intervention?

And finally, can you speculate or explain why the median time to the OR was 12 minutes shorter in the pre-training group?

Thank you for the opportunity to discuss this.

MAHER MATAR, M.D. (Ottawa, Ontario, Canada): Great paper. Two questions.

One, do you have other players in your simulation, i.e., other members of the trauma team, anesthesia, whatnot, that are present during your trauma team activations?

Number two, did you ask the residents or survey the residents why they were becoming more proficient at the procedures, whether the fact that they've had training or they understood the layout of the trauma bay?

Thank you.

JOSE L. PASCUAL, M.D. (Philadelphia, Pennsylvania): So, I applaud you for trying to derive patient-centered outcomes from simulation, right, that's the ultimate finding. Most people can review whether you get better at simulations, but they can't translate that to a better outcome in patients.

I would caution you, though, that a lot of things happened in your pre- and your post-intervention. And we talked about the possibility of being a more advanced class that you saw in the second part, but even just having residents that are better instructed, better taught, maybe they were exposed to more cases, nothing really specifically addresses causation, whether that was what changed over time.

I would also encourage you in your Table 1 to not only give the demographics of the patients, but the demographics of the learners.

Were they different surgical specialties, people that congregate in the trauma team, could be anesthesia, emergency medicine, and so forth? I think with that, you could find causation, although I find the differences or improvements in timing to be remarkable for the interventions you describe.

Thank you.

THOMAS K. DUNCAN, D.O. (Ventura, California): Great presentation. We conduct monthly simulations in our shop, and has been ongoing over the past ten years. I'm just wondering, are these simulations videotaped, such that learners can go back to review them and learn from their errors?

Also, I think it's great that you have such sessions, because even things as simple as knowing where the REBOA kit is, or knowing where the pelvic binder is in crunch time is really important; because sometimes the patients come in, and no one knows where such items are located, then the patient starts decompensating due to lost time. Once again, nice job.

JORDAN A. WEINBERG, M.D. (Phoenix, Arizona): If I understood your presentation correctly, one of the procedures you simulated was resuscitative thoracotomy, and if that's the case, could you describe practically what model you used and how you made that somewhat realistic? Thank you.

CAROLINE PARK, M.D., M.P.H. (Dallas, Texas): Thank you for all those insightful questions. I will try to get to all of them as best I can.

I will first address Colonel Bowyer's questions. Trauma is absolutely a team sport. We include all players in our trauma resuscitations—trainees, staff surgeons and trauma nurse clinicians. The trauma nurse clinicians are an essential part of our team. They help deliver great care to our patients and assist our surgical trainees in their orientation and familiarity of the trauma hall—we appreciate their work.

Your second question relates to measuring success for interventions performed, such as a chest tube. At this time, and for this particular study, we do not have a reliable way to document the success of an intervention –only when it was initiated, and often when it has been completed. If we did have this capacity, we would have to consider who would evaluate the procedure–would it be a second nurse, senior resident, or attending who would review this.

Video review of course would obviate this need – and is feature that we could utilize to evaluate success. We are currently considering this option for quality improvement and educational purposes and could certainly parallel this data with our real-time documentation. Dr. Ryan Dumas here at Parkland is especially interested and involved in this field.

The third question relates to the number of resuscitative thoracotomies performed and the range in time to resuscitative thoracotomy. Generally speaking, surgeons will have different opinions about the indications and timing—blunt versus penetrating, length of CPR, et cetera—it is also not a very common procedure, so that may speak to why only a handful of patients with a blunt traumatic mechanism underwent a resuscitative thoracotomy.

When I looked back at those several patients that underwent resuscitative thoracotomy, the upper range corresponded to a select few patients that presented to the trauma bay with vital signs then deteriorated at some point in their primary or secondary survey – thus prompting a resuscitative thoracotomy. The time to thoracotomy for these patients would obviously be longer since our index ‘start time’ is the time of arrival in the trauma bay.

There is of course plenty of room for detailed analysis—in this study I was able to evaluate time of arrival to time to intervention. What would be more powerful would be to note when the decision was made to do the thoracotomy, when it was initiated and then completed.

In response to the trauma attending presence – chief residents, fellows, or trauma attendings should be present immediately to all Level I trauma activations. Presence of an attending or fellow could certainly influence the time to intervention—especially if the resuscitation is then directed by the attending and facilitates and supervises procedures. Again, these are essential and multifaceted components to a trauma resuscitation and are factors to consider in ongoing simulation and quality improvement.

Colonel Bowyer, you noted a longer time to the operating room in the post-training group. I looked into those outliers as well–some of these patients were either transferred from other hospitals or required several procedures or ongoing resuscitation in the trauma hall prior to their next phase (in this case, OR).

I would like to now address the questions from the audience. Our simulation team should be identical to that of our every-day trauma teams – thus we absolutely include trauma nurse coordinators, trauma nurses, trainees, fellows, and attendings–and without everyone’s support and participation, this wouldn't happen.

The second question from the audience asks about a survey for proficiency. This is an excellent idea, and in fact, one of our faculty, Dr. Jennifer Grant, is working on a similar project, assessing their comfort level before and after training. Establishing proficiency and standardizing education and assessment is something that plan to utilize in our trauma curriculum.

The next question from the audience was on causative factors in the pre- and post-implementation phases. There are several contributing factors to time to intervention. For example, residents that have already gone through thoracic surgery might be more comfortable putting a chest tube in. Others may have spent several nights at the VA coding medical ICU patients in the middle of the night—so that resident may be more comfortable placing and expediting vascular access. Prior exposure to procedures is a very valid point, and one that we also discuss in this study. To evaluate the effect of exposure and training, we are performing a separate, subset analysis of individual surgical trainee performance in resuscitation and specific procedures as they progress through their training programs.

And, I think that's all I have time for. Thank you