Training Surgical Residents for Ultrasound-Guided Assessment and Management of Unstable Patients

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OBJECTIVE: Proficiency in the use of ultrasound is presently not an ACGME required core competency for accredited surgical training. There should be a basic unified ultrasound curriculum for surgical trainees. We developed a multimodal ultrasound-training program to ensure baseline proficiency and readiness for clinical performance without impacting trainee duty hours.

DESIGN: We developed and implemented a multimodal curriculum for ultrasound education and its use as a supplement to clinical evaluation of unstable patients.

SETTING: A single-center study was completed in a hospital setting.

PARTICIPANTS: Post-graduate year-1 surgical residents at our institution were invited to participate in a multimodal perioperative course.

RESULTS: 51 residents attended the course over the three sessions. The vignette exam as a whole demonstrated a Cronbach's alpha of 0.819 indicating good internal reliability of the entire test. There was significant improvement in their knowledge in clinical vignettes (55% ± 12.4 on pre-test vs. 83% ± 13.2% on post-test, $p<0.001$).

CONCLUSION: It is feasible to incorporate a focused ultrasound curriculum to assess clinically unstable patients. The multimodal nature of the course aid in the development of preclinical proficiency and decreased the orientation phase of ultrasound use. (J Surg Ed 76:540−547. © 2018 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: Ultrasound, Hypotension, Curriculum, Education, proficiency

COMPETENCIES: Patient Care, Medical Knowledge, Practice-Based Learning and Improvement, Systems-Based Practice

INTRODUCTION

Proficiency in ultrasound (US) has been established as a desirable skillset across all specialties to supplement clinical examination and decision-making to improve patient safety. For surgical residents, US training has traditionally been "on-the-job" during their specific rotations and is not a part of core competency requirements by the Accreditation Council for Graduate Medical Education (ACGME). Although the American College of Surgeons has developed an online curriculum for US education, competency in US requires hands-on teaching and repetitive practical exposure through a curriculum-based approach during training.[1,2] Regulatory training time constraints and preexisting educational mandates make it challenging to introduce new educational curricula. The current paradigm of medical education, however, requires an innovative multimodality approach to ensure a proficiency-based educational model for US training as well as a unified basic US curriculum for surgical trainees that starts during the intern year. This should be coupled with an objective assessment tool to demonstrate progression of skills and knowledge in order to verify the trainee's ability to apply these techniques in clinical practice and to provide proof of preclinical

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proficiency. Early comprehensive exposure to US can develop preclinical proficiency and retention of the skill set.[3,4] By developing preclinical proficiency, residents can subsequently use US for "staged imaging" for quick assessment and intervention without the expense, time, or side effects of advanced imaging or invasive procedures.

We were able to identify hypotension as a key clinical scenario a junior surgical resident routinely triages on the surgical floors, emergency rooms, and intensive care units. The rapid US for shock and hypotension (RUSH) protocol, which was originally developed for the emergency room setting, is a perfect holistic approach for surgical residents to use for assessment of hemodynamic instability. Therefore, the purpose of this study was to develop a multimodal curriculum for a symptom-based approach to the diagnosis and management of hypotension. The secondary purpose was to establish preclinical proficiency, including cognitive understanding and physical skills for diagnosis and management of key pathologies, with the use of an objective assessment tool. To achieve our goals, we first designed a multimodal US course focusing on the assessment of clinical situations leading to shock and hypotension. The program included online flipped classroom teaching, spaced learning reinforcement with online and live case-based scenarios, and supervised deliberate practice of skills and workflow in an US skills laboratory.

METHODS

The study on US education received institutional review board approval for exempt status by the Committee on Clinical Investigations at Beth Israel Deaconess Medical Center. Postgraduate year-1 (PGY-1) surgical residents at our institution were invited to participate in a multimodal perioperative US course. The course was conducted 3 times between November 2015 and November 2017. Total course time was 12 hours which was divided into 3 components: online, hands-on with live lecture, and post-course exam. The online component lasted 4 hours and consisted of online lectures, case scenarios, and an online pretest. This was followed by a 7-hour hands-on training session with live lectures, which was conducted over 2 days. The course concluded with a 1-hour objective structured clinical examination (OSCE) and a clinical vignette post-test. The OSCE format was selected to reinforce the cognitive and workflow understanding and practical application of the skill set for patient management.

ONLINE COMPONENT

Prior to attending the course, the surgical PGY-1s were asked to complete an online module based on the course curriculum at least 1 week prior to the workshop and to participate in self-study using provided materials. The online modules can be found at the website "https://anesthesiaeducation.net/moodle/course/view.php?id=164" (Username: surgeryUS, Password: surgeryUS) and were designed to build a knowledge base in conjunction with the live and/or hands-on exercises. The online component was comprised of 7 sections with a total duration of 4 hours: (1) Introduction to Ultrasound, (2) Ultrasound Physics Part One, (3) Ultrasound Physics Part Two, (4) Lung Ultrasound for Pneumothorax, (5) Introduction to Transthoracic Imaging, (6) RUSH Examination Part One for Cardiac Assessment, and (7) RUSH Examination Part Two for Abdominal Examination. The online course concluded with a pretest consisting of clinical vignettes and 30 additional questions for self-assessment and learning. The online pretest was identical to the postcourse exam, and as such the residents were not provided the answers to the pretest after completion. The pretest online assessment contained 9 clinical vignettes that comprised the key differential diagnoses for hypotension and shock (Appendix 1). Each clinical vignette included brief history of the patient and multiple corresponding US images. Attendees were asked to identify the various US views being presented, to provide an image analysis including a diagnosis, and to provide a postevaluation patient workup. The online modules remained available to the PGY-1s for reference throughout the course and included 5 case scenarios, which consisted of a patient case report and corresponding US images.

WORKSHOP SESSIONS

We conducted 2 workshops, each lasting 3.5 hours. The 2 workshops were conducted over a 2-week period for spaced learning and an opportunity to pursue the associated online modules. These sessions consisted of a brief review lecture, hands-on practice with live models, and hands-on practice with the simulators including both normal and pathologic findings (Table 2). Course lecturers consisted of 4 attending physicians at our institution with significant US experience and certifications. These same attending physicians also oversaw the hands-on portion of the course to provide feedback to the course attendees. In order to provide exposure to a variety of US machines, 3 different brands of machine were incorporated in the live-model stations including: Siemens X300, Mindray TE7, and Phillips CX-50. The US simulators included CAE VIMEDIX (CAE Healthcare, Montreal, Canada) and Heartworks (Invented Medical Limited, London, UK). The exact layout of the class portion is outlined in Table 1.

The hands-on US training was focused toward obtaining proficiency in a series of exams. These exams

TABLE 1. Detailed Curriculum for Teaching Rapid US for Shock and Hypotension (RUSH)

Element	Cognitive	Workflow	Psychomotor and Management Skills
Description	Demonstration of ultrasound knowledge	Ability to complete procedure nonspecific tasks, from setup to cleanup (excludes "Psychomotor Skills")	Teaching psychomotor and management skills for each specific ultrasound procedure
Method of assessment	Using a flipped classroom model: • Online learning and pretest (4 hours) • In-class lectures and model practice (7 hours) • Post-test (1 hour)	Teaching on live models and ultrasound equipment using the following questions: **Preprocedure questions:** 1. What procedure is being performed? 2. Why is it being performed? 3. Is it being performed in an emergency or elective situation? 4. What equipment do I need? 5. Which machine do I use? 6. Which probe do I use? **Procedural questions:** 1. How to power up the machine? 2. How to calibrate the probe? 3. How to enter patient information? 4. How to optimize my image (depth, gain, focus)? 5. Which images to acquire? 6. How to acquire images? **Postprocedure questions:** 1. How to retrieve acquired images? 2. How to store the study? 3. How to generate a report?	Using haptic simulators or live models for the following: **1. Abdominal assessment** • Identify the descending abdominal aorta and the bladder • Assess for intra-abdominal bleeding • Assessment of vena cava diameter with respiration • Urinary bladder assessment for urinary volume **2. Cardiac assessment using transthoracic echocardiography** • Obtain the parasternal short and long axis, apical 4-chamber, and subcostal 4-chamber and IVC views • Volume assessment • Pericardial effusion (for tamponade physiology) • Right ventricular function (rule out pulmonary embolism and right ventricular failure) • Left ventricular failure • Assessment during cardiac arrest • Major valvular abnormalities (severe aortic stenosis and mitral regurgitation causing hemodynamic instability) **3. Lung ultrasound** • Obtain images of the pleura and lung • Rule out pneumothorax • Rule out pulmonary edema • Recognize pleural effusion
Objective structured clinical examination (OSCE)	Testing of cognitive skills, workflow skills, manual skills, and management assessment will be carried out on haptic simulators, live models, and computer-based case scenarios for assessment of preclinical proficiency		

TABLE 2. Workshop Design Diagram Including Focused Objectives That Were Conveyed at Each Station. The Workshops Spanned 2 Days and Included a Mix of Both Live Models and Simulator Models

	Station	Setup	Objectives
Day 1	Machine Introduction	Live Model	1. Learn machine knobology 2. Learn proper probe selection and positioning 3. Learn proper image optimization techniques
	Cardiac TTE	Simulator	1. Obtain parasternal LAX and SAX, apical 4-chamber, and subcostal 4-chamber views 2. Assess biventricular function
	Cardiac TTE	Live Model	1. Obtain parasternal LAX and SAX, apical 4-chamber, subcostal 4-chamber, and subcostal IVC views 2. Evaluate the IVC diameter and fluid responsiveness
	Cardiac TTE	Simulator	1. Obtain subcostal IVC views 2. Evaluate the IVC diameter and fluid responsiveness 3. Assess volume (hypovolemia), tamponade, and PE
Day 2	Station	Setup	Objectives
	Lung Ultrasound	Live Model	1. Identify ribs, lung sliding, A-lines, and B-lines 2. Identify pneumothorax 3. Use M-mode for seashore sign and barcode sign
	Abdominal Ultrasound	Simulator	1. Identify the liver and spleen 2. Locate Morison's Pouch (hepatorenal space) and the splenorenal space 3. Evaluate for fluid in the abdomen
	Abdominal Ultrasound	Live Model	1. Differentiate between the aorta and the IVC 2. Use color flow Doppler for pulsatile flow in the aorta 3. Measure the diameter of the aorta and IVC
	Abdominal Ultrasound	Simulator	1. Identify the bladder 2. Locate the pouch of Douglas or the rectovesical pouch 3. Identify an aortic dissection

included ultrasonographic cardiac evaluation, Inferior Vena Cava (IVC) assessment, abdominal, and lung exams. Transthoracic echocardiographic windows that were taught included the parasternal long and short axis, the apical 4-chamber, and subcostal 4-chamber and short axis as well as aorta and IVC assessment with corresponding pathology identification. Lung assessment was focused on identifying pleural effusions and evidence for pneumothorax and pulmonary edema. These skills were combined to allow PGY-1s to establish a workflow for a RUSH exam.

After completion of the course, attendees were asked to complete a post-test. The post-test consisted of the same 9 clinical vignettes used during the pretest (Appendix 1) and a hands-on OSCE evaluation whereby licensed evaluators provided written feedback to examinees. The hands-on OSCE consisted of 5 simulator stations and 2 live-model stations evaluated by course staff. For the live-model stations, attendees were asked to conduct a full RUSH exam with a clinical focus as prompted by the course staff. Attendees were subsequently given feedback on their probe position, ability to obtain an optimal image, and ability to appropriately identify key structures on the US image. For the simulator stations, in addition to a short case presentation to guide the US exam, disease pathologies such as cardiac tamponade and free fluid in the abdomen were uploaded onto each simulator. Attendees were given feedback on their ability to obtain appropriate images. PGY-1s were assessed on their ability to provide any US exam findings, an accurate diagnosis, and appropriate patient workup. Grades from the online postcourse clinical vignettes were recorded and compared with the precourse clinical vignettes via a statistical analysis. The hands-on OSCE feedback was recorded for each examinee and provided to them after the course for self-review.

After the conclusion of the course, a postcourse evaluation was organized. The evaluation contained questions pertaining to the knowledge of the instructors, the comfort of the learning environment, and the completeness of the course material (Fig. 1).

STATISTICAL ANALYSIS

The postcourse clinical vignette scores were compared with the precourse test scores for each student using a *t* test to evaluate the efficacy of the course. A p value

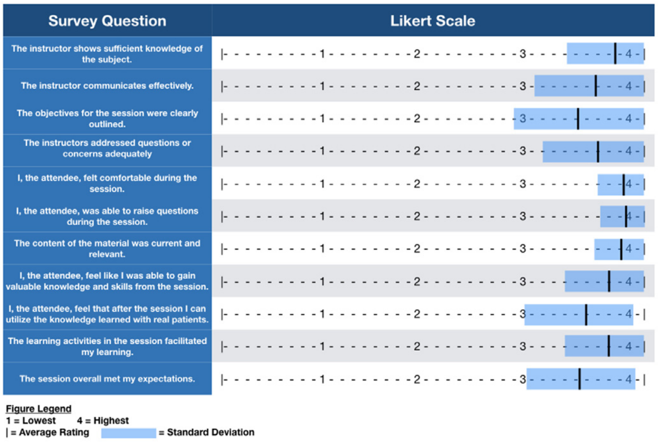

FIGURE 1. Course follow-up survey regarding the in-class portion of the course. Thirty-seven percent of course participants completed the postcourse survey. Response was positive with surgery PGY-1s indicating that the course was highly effective at facilitating an understanding of US assessment of hypotension in hemodynamically unstable patients.

<0.05 indicated a significant difference between the 2 tests.

Internal consistency for each individual vignette question was accomplished using the Kuder-Richardson Formula 20 (KR-20) coefficient. A KR-20 coefficient greater than 0.5 indicated reasonable internal consistency. KR-20 coefficients were also calculated for each individual vignette question to measure item difficulty. Item difficulty closer to 0 indicated a more difficult question, whereas item difficulty closer to 1 indicated an easier question. Item difficulties near 0.5 were considered ideal questions. Finally, internal reliability for the entire clinical vignette exam was calculated using Cronbach's alpha with a value closer to 1 indicating good internal consistency and a value close to 0 indicating poor internal consistency.

RESULTS

Fifty-one surgery PGY-1s attended the course and participated in the clinical vignettes and an OSCE over the 3 sessions. Thirty-seven percent of the course participants also completed the postcourse evaluation. Of those who completed the evaluation, most agreed that they were

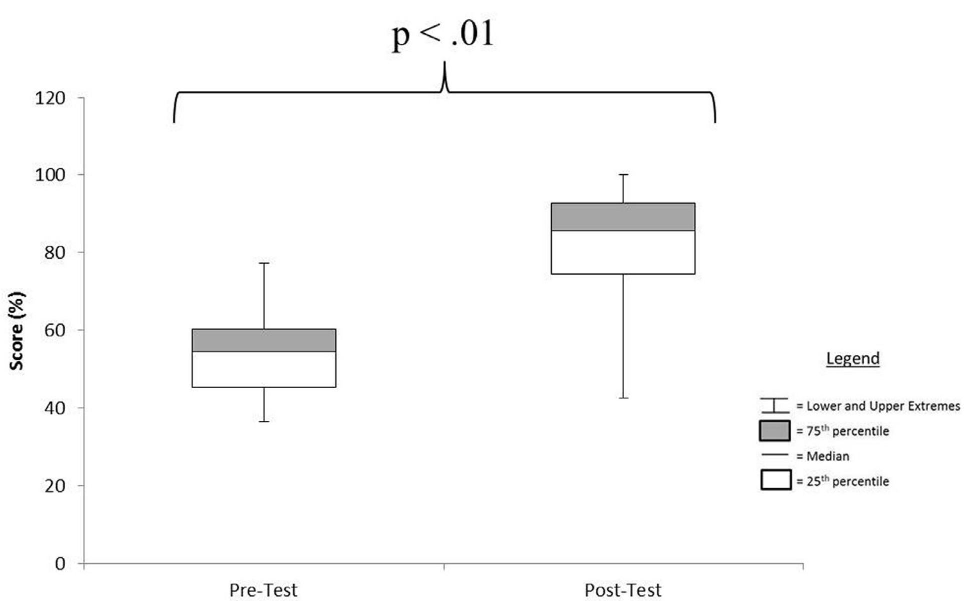

FIGURE 2. Box and whisker plot demonstrating the scores (%) for both the pretest and the post-test. The PGY-1s scored significantly higher on the post-test when compared with the pretest.

TABLE 3. Item Difficulty Measured in KR-20 Coefficient. A Question With an Item Difficulty Closer to 0 Is Considered More Difficult While a Question With an Item Difficulty Closer to 1 Is Too Easy. Item Difficulties Around 0.5 Are Considered Ideal Questions

Case 1		Case 2		Case 3	
Question	**Item Difficulty**	**Question**	**Item Difficulty**	**Question**	**Item Difficulty**
1	1.00	1	0.86	1	1.00
2	1.00	2	0.79	2	1.00
3	0.71	3	0.79	3	0.93
4	0.93	4	0.86	4	1.00
5	0.93	5	0.43	5	0.86
6	0.64	6	0.93	6	0.86
7	0.29	7	0.86	7	0.29
		8	0.71	8	0.57
Case 4		**Case 5**		**Case 6**	
Question	**Item Difficulty**	**Question**	**Item Difficulty**	**Question**	**Item Difficulty**
1	0.93	1	0.86	1	0.93
2	0.43	2	0.57	2	0.93
3	0.64	3	0.79	3	0.79
4	0.57	4	0.57	4	0.93
5	1.00	5	0.36	5	0.86
6	0.93	6	0.43	6	0.57
7	0.93			7	0.07
Case 7		**Case 8**		**Case 9**	
Question	**Item Difficulty**	**Question**	**Item Difficulty**	**Question**	**Item Difficulty**
1	0.86	1	0.71	1	0.93
2	0.57	2	0.57	2	0.86
3	0.79	3	0.79	3	0.86
4	0.93	4	0.57	4	0.36
5	0.79	5	0.71	5	0.64
6	0.64	6	0.36	6	0.43
7	0.50			7	0.57
8	0.21			8	0.14
				9	0.29

able to gain valuable knowledge and skills from the course (average rating of 3.78/4, SD = 0.41) and that they would be able to utilize the knowledge learned during the course clinically (average rating of 3.57/4, SD = 0.50; Fig. 1). The participants also agreed that the combination of the lecture, simulator practice, and live-model practice helped facilitate their learning (average score of 3.78/4, SD = 0.41).

After taking the course, PGY-1s showed significant improvement in their performance from 55.11% (SD = 12.40%) on the pretest to 83.13% (SD = 13.24%) in the postcourse clinical vignettes ($p < 0.001$; Fig. 2).

Additionally, all cases presented in the vignettes displayed KR-20 coefficients greater than 0.50, indicating reasonable reliability (Table 4). The vignette exam as a whole demonstrated a Cronbach's alpha of 0.819 indicating good internal reliability of the entire test (Table 4). Finally, KR-20 coefficients for item difficulty demonstrated a good range of question difficulties with the easiest question demonstrating a coefficient of 1.00 and the most difficult question demonstrating a coefficient of 0.07 (Table 3).

Furthermore, general consensus among OSCE evaluators concluded that all course participants performed adequately on the OSCE exam. In the weeks following the conclusion of the course, many attendees could be found using the simulators to correct any skills in need of remediation as outlined in their individual OSCE feedback.

DISCUSSION

We were able to design a multimodal curriculum that demonstrated excellent internal reliability and implement it into the surgical PGY-1 training calendar at our institution. Additionally, we showed that a short but focused multimodal

TABLE 4. Exam Internal Consistency Measured by KR-20 Coefficient and Cronbach's Alpha Coefficient. KR-20 Coefficient > 0.5 Indicates Reasonable Internal Consistency. Cronbach's Alpha Measures Consistency of the Entire Test Where a Value Closer to 1 Indicates Good Internal Consistency of the Entire Exam

Case	Mean ± Standard Deviation (%)	KR-20 Coefficient
1	78.6 ± 17.5%	0.559
2	78.6 ± 23.73%	0.802
3	81.3 ± 8.13%	0.655
4	79.6 ± 14.53%	0.665
5	57.1 ± 20.39%	0.610
6	72.4 ± 16.32%	0.603
7	65.2 ± 23.6%	0.678
8	61.9 ± 25.68%	0.560
9	55.5 ± 21.78%	0.608
Case	**Mean ± Standard Deviation (%)**	**Cronbach's Alpha Coefficient**
Entire Test	70 ± 12.04%	0.819

training program can develop preclinical proficiency and help develop surgical PGY-1s into facilitated learners. Our customized clinical vignettes and OSCE allowed us to assess both ultrasonographic knowledge acquired during the course as well as its clinical application in managing patients with hemodynamic instability. The specific multimodal setup for clinical evaluation gave us the opportunity to evaluate the residents for the basis of their knowledge, and assess their skillset at various times. Another important aspect of the study was the feedback survey, which suggested that most residents were confident in their ability to use US and guide management as needed in the clinical setting.

In order to keep up with the innovations in medicine, awareness in patient safety, resident duty hours, and the cost of health care, we have to continuously revise our methodology and focus of teaching to improve the quality of our training and patient care. Extended focused assessments with sonography for trauma (eFAST) and FAST were developed as a structured and standardized assessment method for surgery to evaluate the patients presenting after trauma and have been effective at decreasing the time to establish diagnosis and initiate management, and reducing mortality in these patients.[5] In 2006, an evaluation of the American College of Surgeons (ACoS) US education program reported increased use of US and US-guided procedures in surgical practice as a result of attending ACoS courses. As such, ACoS recommended incorporation of US training into surgical residency programs.[6] A recent survey of graduating surgical residents reinforced that there is a lack of competency in critical care US in the current teaching model and emphasized a need for an US curriculum created specifically for surgical residents that meet the minimum requirements for US examinations.[7,8]

Current practice shows that US use for clinical diagnosis and management is not a luxury, but rather a clinical reality. However, regulatory training time constraints and preexisting educational mandates make it challenging to introduce new educational curricula[7] and the current paradigm of medical education requires an innovative multimodal approach to ensure a proficiency-based educational model for US training. Previous studies suggest that the gain in knowledge and retention of acquired skillsets is increased after a comprehensive flipped classroom learning model with live workshops.[8-10] Similarly, implementing an extensive curriculum-based approach is an effective tool to develop transferability of skillset to patient care.[11] The clinical vignette and OSCE format is also superior to other methods of testing since it requires the participant to combine background knowledge with a physical skillset, which correlates closely with everyday activities of a physician and thus better predicts the translation of the skillset into clinical practice.[12,13] The introduction of the OSCE also showed comparable improvements in trainee performance and understanding as compared with previous studies for US skill assessment.[8] In addition to overall positive feedback of the course, PGY-1s also reported feeling confident in their ability to utilize US, suggesting that good clinical vignette scores correlated with trainees who felt comfortable with the training. Additionally, this program can be used for surgical residents at all levels of training and repeated multiple times during residency to develop competency and establish retention.

Our study did have some limitations. The hands-on portion of the course was conducted over a period of only 2 days. US is a technique that benefits from additional practice, repetition, and guidance. However, the multimodal approach and combination of simulators and live models allowed us to make the course efficient and concise. Additionally, participants were encouraged to return to the simulation lab at any time for further practice. As this initiative is relatively new, there is currently limited follow-up after the course. While residents report confidence in their use of US in clinical settings, further longitudinal follow-up is required to demonstrate a significant increase in the use of US clinically. Furthermore, there may be some selection bias in the self-assessments as only 37% of the course participants completed the postcourse evaluation.

CONCLUSION

The results of our course indicate that it is feasible to incorporate a focused US curriculum to assess hypotension in hemodynamically unstable patients, a clinical scenario that requires rapid evaluation and frequent management by surgical residents multiple times throughout their residency. Combining online training with live lecture, hands-on simulators, and live model training is also effective in improving the overall US knowledge and skillset of surgical PGY-1s and is supplemented with clinical vignettes and OSCEs as adequate assessment tools for preclinical proficiency.

REFERENCES

1. Cartier RA, Skinner C, Laselle B. Perceived effectiveness of teaching methods for point of care ultrasound. *J Emerg Med*. 2014;47:86–91. https://doi.org/10.1016/j.jemermed.2014.01.027.
2. Akhtar S, Theodoro D, Gaspari R, et al. Resident training in emergency ultrasound: consensus recommendations from the 2008 Council of Emergency Medicine Residency Directors Conference. Vol 16 Suppl 2. Blackwell Publishing Ltd; S32–S36. https://doi.org/10.1111/j.1553-2712.2009.00589.x.
3. Perera P, Mailhot T, Riley D, Mandavia D. The RUSH exam: rapid ultrasound in shock in the evaluation of the critically lll. *Emerg Med Clin North Am*. 2010;28:29–56. https://doi.org/10.1016/j.emc.2009.09.010.
4. Mitchell JD, Mahmood F, Bose R, Hess PE, Wong V, Matyal R. Novel, multimodal approach for basic transesophageal echocardiographic teaching. *J Cardiothorac Vasc Anesth*. 2014;28:800–809. https://doi.org/10.1053/j.jvca.2014.01.006.
5. Richards JR, McGahan JP. Focused assessment with sonography in trauma (FAST) in 2017: what radiologists can learn. *Radiology*. 2017;283:30–48.
6. Staren ED, Knudson MM, Rozycki GS, Harness JK, Wherry DC, Shackford SR. An evaluation of the American College of Surgeons' ultrasound education program. *Am J Surg*. 2006;191:489–496. https://doi.org/10.1016/j.amjsurg.2005.10.023.
7. Ratnasekera A, Ferrada P. Ultrasonographic-guided resuscitation of the surgical patient. *JAMA Surg*. 2018;153:77. https://doi.org/10.1001/jamasurg.2017.4440.
8. Beal EW, Sigmond BR, Sage-Silski L, Lahey S, Nguyen V, Bahner DP. Point-of-care ultrasound in general surgery residency training: a proposal for milestones in graduate medical education ultrasound. *J Ultrasound Med*. 2017;36:2577–2584. https://doi.org/10.1002/jum.14298.
9. Mitchell JD, Montealegre-Gallegos M, Mahmood F, et al. Multimodal perioperative ultrasound course for interns allows for enhanced acquisition and retention of skills and knowledge. *A A Case Rep*. 2015;5:119–123. https://doi.org/10.1213/XAA.0000000000000200.
10. Mitchell JD, Mahmood F, Wong V, et al. Teaching concepts of transesophageal echocardiography via web-based modules. *J Cardiothorac Vasc Anesth*. 2015;29:402–409. https://doi.org/10.1053/j.jvca.2014.07.021.
11. Bose RR, Matyal R, Warraich HJ, et al. Utility of a transesophageal echocardiographic simulator as a teaching tool. *J Cardiothorac Vasc Anesth*. 2011;25:212–215. https://doi.org/10.1053/j.jvca.2010.08.014.
12. Mookherjee S, Strujik J, Cunningham M, Kaplan E, Çoruh BA. Independent and mentored video review of OSCEs. *Clin Teach*. 2018;82:S69. https://doi.org/10.1111/tct.12755.
13. Jayaweera HK, Potts HWW, Keshwani K, et al. The GP tests of competence assessment: which part best predicts fitness to practice decisions. *BMC Med Educ*. 2018;18:2. https://doi.org/10.1186/s12909-017-1111-0.

SUPPLEMENTARY INFORMATION

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