# Comprehensive Ultrasound Course for Special Operations Combat and Tactical Medics

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## ABSTRACT

**Background:** Advances in ultrasound technology with enhanced portability and high-quality imaging has led to a surge in its use on the battlefield by nonphysician providers. However, there is a consistent need for comprehensive and standardized ultrasound training to improve ultrasound knowledge, manual skills, and workflow understanding of nonphysician providers. **Materials and Methods:** Our team designed a multimodal ultrasound course to improve ultrasound knowledge, manual skills, and workflow understanding of nine Special Operations combat medics and Special Operations tactical medics. The course was based on a flipped classroom model with a total time of 43 hours, consisting of an online component followed by live lectures and hands-on workshops. The effectiveness of the course was determined using a knowledge exam, expert ratings of manual skills using a global rating scale, and an objective structured clinical skills examination (OSCE). **Results:** The average knowledge exam score of the medics increased from pre-course (56% ± 6.8%) to post-course (80% ± 5.0%, $p < .001$). Based on expert ratings, their manual skills improved from baseline to day 4 of the course for image finding ($p = .007$), image optimization ($p = .008$), image acquisition speed ($p = .008$), final image quality ($p = .008$), and global assessment ($p = .008$). Their average score at every OSCE station was > 91%. **Conclusion:** A comprehensive multimodal training program can be used to improve military medics' ultrasound knowledge, manual skills, and workflow understanding for various applications of ultrasound. Further research is required to develop a reliable, sustainable course.


Keywords: *ultrasound; medics; competency; curriculum*

## Introduction

Proficiency in ultrasound is an established and desirable skill-set among physicians across all specialties. It is an immensely helpful tool for diagnostic and procedural purposes and its use has expanded across healthcare. The portability of ultrasound and ability to obtain rapid results are ideal characteristics in military medicine, particularly when other imaging modalities are unavailable. There are several well-recognized publications describing positive outcomes of ultrasound in the hands of military physicians, which opened the door for nonphysician providers utilizing ultrasound.[1] The use of ultrasound by nonphysician providers is continuing to grow and military medics are a targeted group of interest due to their unique nature of delivering medical care on the battlefield.

Military medics are trained to provide medical care at the scene of the injury, making crucial diagnostic and therapeutic decisions. Utilization of ultrasound can improve clinical detection of injuries such as internal bleeding, reduced cardiac function, bone fractures, and pneumothoraces. A literature review assessing military medics' ability to utilize ultrasound demonstrated favorable results and supported standardized ultrasound training for military medics.[1] Additionally, ultrasound-guided interventions such as central venous line placement, intravenous access, and regional nerve blocks to stabilize those wounded on the battlefield can be performed by military medics. Analysis of Special Operator Level Clinical Ultrasound (SOLCUS), an ultrasound curriculum created for Special Operations Forces medics, demonstrated promising results in these procedures with decreased regional block complications.[2]

Medical education for clinical procedures is variable among specialties and institutions, with the majority of learners learning during their regular clinical workflow with supervision. This method has several drawbacks including nonobjective feedback from the supervisor and inconsistent training time. This is no different with ultrasound, as competency requires repetition and hands-on teaching.[3] Multimodal educational ultrasound courses using simulation-based learning with web-based and live teaching sessions have promising results. Novices such as anesthesiology and surgical interns demonstrated ultrasound proficiency and retention of skill and knowledge after completing an ultrasound course that utilized simulation-based, web-based, and live teaching.[4,5] Military medics are skilled, highly motivated and may similarly benefit

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from a curriculum-based approach for ultrasound training as demonstrated in recent studies on teaching single ultrasound applications to military medics.[6–11] Although these trainings were successful, none taught multiple ultrasound techniques in one course.

Our team developed and implemented a comprehensive, multimodal course for Special Operations combat and tactical medics in ultrasound-guided assessments that included assessments of the heart, lung, and abdomen. It also consisted of the placement of venous catheters and provision of focused regional anesthesia. The program combined online coursework and live didactic sessions, including instructor-led lectures and case-based discussions. It also included hands-on practice sessions on ultrasound simulators, task trainers, and live models with integrated feedback. Our hypothesis was that a 5-day training course for Special Operations combat and tactical medics would improve their level of knowledge, manual skills, and workflow understanding of various applications of ultrasound.

## Methods

### Study Design

Our team conducted a feasibility study on ultrasound training for Special Operations combat medics and Special Operations tactical medics after receiving institutional review board approval for exempt status, with a waiver of documentation of informed consent by the Committee on Clinical Investigations at Beth Israel Deaconess Medical Center (BIDMC). A total of nine medics in two groups participated in the study after being recruited as a convenience sample by one of the authors (DNL), who completed an Adult Cardiothoracic Anesthesia fellowship at BIDMC and regularly trains military medics. Eight participants provided demographic data on their prior experience with ultrasound (Table 1). The goal of this study was to design and implement a comprehensive training program for nonphysician military medics to improve their ultrasound knowledge, manual skills, and workflow understanding so that they can use ultrasound techniques to diagnose casualties on the battlefield.

The ultrasound training program was comprised of a week-long multimodal course designed by experts with more than 15 years of experience in ultrasound education and certified by the National Board of Echocardiography. One author (DNL) who contributed to the design is an attending anesthesiologist at the Navy Trauma Training Center, Los Angeles County and University of California. He serves as a subject matter expert for deployment teams, attends field courses at the Naval Expeditionary Medical Training Institute in Camp Pendleton, CA, and has multiple years of experience in using ultrasound in austere environments and trauma management. The course was based on a flipped classroom model with the total course time of 43 hours, which was divided into an online component and live lectures/reviews followed by hands-on training. Live instruction also included instructor-led discussions where military operational case-based scenarios were discussed to teach medics how to interpret ultrasound findings and make correct diagnoses/medical decisions. The different ultrasound applications taught in the course included abdominal ultrasound, lung ultrasound, rapid ultrasound for shock and hypotension (RUSH), transthoracic echocardiography (TTE), and ultrasound-guided regional anesthesia and vascular access. The effectiveness of the course was evaluated utilizing the following criteria adopted to reinforce the three components of proficiency in ultrasound: knowledge, manual skills, and workflow understanding.[12]

1. For knowledge assessment, participants completed a pre- and post-course exam, which included questions to assess learners' ability to make correct diagnoses based on ultrasound findings.
2. For manual skills, experts evaluated participants' manual skills throughout the course via a global rating scale. This scale asked experts to evaluate skills in terms of image finding, image optimization, image acquisition speed, final image quality, and global assessment. In addition, participants reported their perceived comfort with ultrasound applications before and after the course.
3. To evaluate the ability to perform ultrasound techniques using the appropriate practical steps (workflow understanding) and identify correct diagnoses based on ultrasound findings, participants completed a 2-hour objective structured clinical skills examination (OSCE) at the end of the course.

### Course Description

The comprehensive course schedule comprising of an online component and live instruction is illustrated in Table 2.

### Online Component

Prior to live instruction, participants were expected to complete integrated web-based educational modules and an

**TABLE 1** *Participants' Prior Experience with Ultrasound*

| Participant | How Many Ultrasound Training Sessions Have You Had Prior to This Course? | How Many Ultrasound Exams Have You Conducted Independently? | Which area(s) of ultrasound have you had experience with before (select all that apply)?: Ultrasound-Guided Vascular Access | Ultrasound-Guided Regional Anesthesia | Transthoracic Echocardiography | Abdominal Ultrasound | Lung Ultrasound | RUSH Protocol | Other Ultrasound Technique(s) | None |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2–5 | 6–10 | Yes | No | Yes | No | No | No | Yes | No |
| 2 | 2–5 | 0 | No | No | No | Yes | Yes | No | Yes | No |
| 3 | >5 | >20 | Yes | Yes | No | Yes | Yes | Yes | Yes | No |
| 4 | 2–5 | 1–5 | No | No | No | No | No | No | Yes | No |
| 5 | 2–5 | 11–15 | No | No | No | No | Yes | Yes | No | No |
| 6 | 1 | 0 | No | No | No | Yes | Yes | Yes | No | No |
| 7 | 2–5 | 1–5 | No | No | Yes | Yes | Yes | No | No | No |
| 8 | 1 | 6–10 | Yes | No | No | No | Yes | No | Yes | No |

RUSH = Rapid Ultrasound for Shock and Hypotension.

**TABLE 2** *Comprehensive Point-of-care Ultrasound Course for Military Medics*

| Day | Online Component | Live Didactics | Hands-on Practice | Duration of Training |
|---|---|---|---|---|
| | **Pre-course Knowledge Test** | | | |
| 1 | • Basic ultrasound physics and knobology [20 min]<br>• Basic TTE imaging (windows and views) [27 min] | **Live lecture/review (60 min)**<br>1. Introduction to ultrasound<br>2. TTE imaging | **Session 1: Probe orientation, basic knobology, workflow – 1.5 hr**<br>• Probe selection<br>• Orientation to probe movements<br>• Machine operation/basic knobology<br>• Adjustment of ultrasound controls (gain, focus, depth)<br>• Image optimization<br>• Troubleshooting<br>**Session 2: TTE imaging – 4.5 hr**<br>• Probe orientation and manipulation<br>• Acquisition of parasternal, apical, and subcostal views on simulator and live model | **8 hr** |
| 2 | • Ultrasound-guided vascular access [30 min]<br>• Abdominal ultrasound for bleeding [22 min]<br>• Lung ultrasound [30 min] | **Live lecture/review (60 min)**<br>1. Ultrasound guided vascular access<br>2. Abdominal ultrasound<br>3. Lung ultrasound | **Session 1: Ultrasound-guided vascular access – 3 hr**<br>• Appropriate sterile technique<br>• Identification of target vessel in central and peripheral vascular access<br>• Review of equipment<br>• Performane of ultrasound-guided cannulation on a phantom model and mannequin<br>**Session 2: Abdominal and lung ultrasound and review of TTE – 4 hr**<br>• Imaging and assessment of the abdomen on simulator and live model<br>• Imaging and assessment of the lung on live model<br>• Recognition of lung/pleura<br>• Demonstration of M-mode<br>• Identification of lung sliding<br>• Identification and evaluation of left and right upper quadrant structures and viscera<br>• Recognition of intraperitoneal fluid in dependent areas<br>• Review of parasternal, apical, and subcostal views on simulator and live model | **9.5 hr** |
| 3 | • Overview of the RUSH exam [25 min]<br>• TTE: Pericardial effusion and tamponade [25 min] | **Live lecture/review (2 hr)**<br>1. RUSH lecture<br>2. RUSH case-based discussion | **Session 1: Review of TTE, vascular access and abdominal ultrasound – 3 hr**<br>• Review of parasternal, apical, and subcostal views on simulator and live model<br>• Review of abdominal ultrasound on simulator and live model<br>• Review of ultrasound-guided vascular access on a phantom model and live model<br>**Session 2: RUSH practice – 3 hr**<br>• Acquisition of parasternal, apical, and subcostal views on simulator and live model<br>• Identification and evaluation of left and right upper quadrant and pelvis structures and viscera<br>• Recognition of intraperitoneal fluid in dependent areas | **9 hr** |
| 4 | **Apple iBook:** Interactive Ultrasound Guided Regional Anesthesia<br>Section 3 – Regional Anesthesia Complications<br>Chapter 5 – Axillary Block<br>Chapter 9 – Femoral Block<br>Chapter 10 – Popliteal Fossa Block | **Live lecture/review (1.5 hr)**<br>1. Introduction to regional anesthesia<br>2. Upper extremity blocks<br>3. Lower extremity blocks | **Session 1: Review of TTE, abdominal ultrasound and RUSH – 3 hr**<br>• Review of parasternal, apical, and subcostal views on simulator and live model<br>• Review of abdominal ultrasound on simulator and live model<br>• Review of RUSH exam on simulator and live model<br>**Session 2: Regional anesthesia (upper and lower extremity blocks) – 4 hr**<br>• Review of equipment<br>• Probe manipulation<br>• Neurovascular identification of interscalene, supraclavicular, infraclavicular, axillary, and distal nerve blocks of the upper extremity on live model<br>• Neurovascular bundle identification of sciatic and popliteal fossa blocks on live model<br>• Identification of paravertebral space, rectus sheath, and TAP on live model<br>• Ultrasound-guided needling on phantom models and mannequins | **9.5 hr** |
| 5 | Review | Review | **Session 1: Open lab for review of ultrasound-guided vascular access, regional anesthesia, TTE, abdominal ultrasound and RUSH* – 3.5 hr**<br>**Session 2: OSCE and Post-course Knowledge Test – 3 hr** | **7 hr** |
| | **Total Duration of Training** | | | **43 hr** |

*TTE = transthoracic echocardiography; RUSH = Rapid Ultrasound for Shock and Hypotension; TAP = transversus abdominis plane; OSCE = Objective Structured Clinical Examination.

interactive Apple iBook (Apple Inc., https://www.apple.com/) on the respective topics for each day. The online modules (about 20–25 minutes each) were self-paced and included interactive content and practice questions on specific ultrasound topics. These interactive modules were designed to build a satisfactory fund of knowledge prior to live instruction and included the following topics: (1) basic ultrasound physics, (2) lung ultrasound, (3) basic TTE, (4) abdominal ultrasound, (5) RUSH examination, (6) ultrasound-guided regional anesthesia, and (7) ultrasound-guided vascular access.

### Live Instruction

Live workshops were conducted over 5 days with two sessions per day (each lasting about 4 hours). Each workshop consisted of a 30- to 60-minute lecture/review by a faculty member, followed by hands-on practice on live models and simulators capable of simulating both normal and pathological findings. Considering the use of portable ultrasound devices by the medics in the field, the hand-held ultrasound probes used for live model practice included Butterfly iQ (Butterfly Network Inc., https://www.butterflynetwork.com/), SonoQue (Sonoque, https://www.sonoque.com/), and Vscan (GE Healthcare, https://www.vscan.rocks/ ) probes. The simulators used in the course included CAE VIMEDIX (CAE Healthcare, https://www.caehealthcare.com) and Heartworks (Inventive Medical, https://www.inventivemedical.com) simulators, commercial phantom models such as Blue Phantom (CAE Healthcare, https://www.caehealthcare.com), SimuLab regional anesthesia (https://www.simulab.com) and SimuLab vascular access models, and SimuLab venipuncture pads. The windows taught for TTE were the parasternal long and short axis, the apical four-chamber, and the subcostal four-chamber and inferior vena cava (IVC) views. Both normal anatomy and common cardiac pathologies were encountered by the medics. Lung evaluation was focused on identifying pneumothorax and evidence for pleural effusions and edema. The abdominal scans covered the standard three-views (right upper quadrant, left upper quadrant, and pelvis) of a focused assessment with sonography in trauma (FAST) exam to evaluate free fluid. Specific views incorporated the space between the liver and kidney (hepatorenal space or Morison pouch), the area around the spleen, and the area around and behind the bladder (pouch of Douglas). These workshops were supervised by attending anesthesiologists with considerable ultrasound experience and relevant certifications.

### Course Evaluation

The evaluation of the course was based on the three components of ultrasound proficiency: knowledge, manual skills, and workflow understanding.

1. *Knowledge:* Prior to starting the course, participants were asked to complete a pre-course knowledge exam consisting of multiple-choice questions on the various topics of ultrasound covered during the course to identify a baseline level of knowledge. The knowledge exam was adapted from a previously published exam.[4] On the last day of the course, participants were asked to complete the post-course knowledge exam, which was identical to the pre-course exam to maintain the same level of difficulty; the participants were not provided with the correct answers after completion of the pre-course exam. Performance on the knowledge exam was scored out of a total of 28 points.
2. *Manual skills:* The expert instructors observed and provided feedback daily on the participants' progression of manual skills on the simulators based on a global rating scale assessing image finding, image optimization, image acquisition speed, final image quality, and overall performance (global assessment). Each of these elements of performance was rated on a 4-point Likert scale where 1 = Novice level (needing attention), 2 = Pre-trained novice (could make adjustments), 3 = Better than novice (significant improvement), and 4 = Almost expert. The participants were also surveyed for their subjective overall level of comfort with ultrasound applications on a 5-point Likert scale (1 = Very poor; 5 = Excellent) at the beginning and end of the course.
3. *Workflow understanding:* Taking into account the objectives of the course, a previously validated OSCE was used to assess workflow understanding at the end of the course.[13] The transesophageal echocardiography station was excluded from the OSCE as it was not covered in the ultrasound course for the medics. The five stations of the OSCE were composed of military operational scenarios and specific tasks to assess participants' execution of the appropriate practical steps to perform TTE, lung ultrasound, RUSH, and ultrasound-guided vascular access and regional anesthesia (Appendix 1). Every station had a trained examiner to rate participants using an objective scoring sheet comprising of dichotomous items (Yes/No).[13] The maximum scores for the stations were as follows:

- Ultrasound-guided regional anesthesia: 8
- Lung ultrasound: 8
- RUSH: 11
- Ultrasound-guided vascular access: 5
- TTE: 10

### Statistical Analysis

Statistical analysis was performed using Stata/Special Edition 12.1 (StataCorp, https://www.stata.com/company/). Because the scores on the knowledge exam were normal based on a Shapiro-Wilk test, a paired $t$-test was used to compare precourse scores to post-course scores. A $p$-value $< .05$ was considered significant. For manual skills, expert ratings of each aspect (image finding, image optimization, image acquisition speed, final image quality, and global assessment) were analyzed by comparing participants' average ratings on their first three trials (baseline) to their average ratings on their last three trials on day 4 of the course using a Wilcoxon-signed rank test. Because of multiple (5) comparisons, a Bonferroni correction was applied, so a $p$-value of $< .01$ was considered significant. The participants' perceived levels of comfort with ultrasound applications before and after the course are expressed as mean ± standard deviation. For workflow understanding, the participants' scores on each OSCE station are expressed as mean ± standard deviation.

## Results

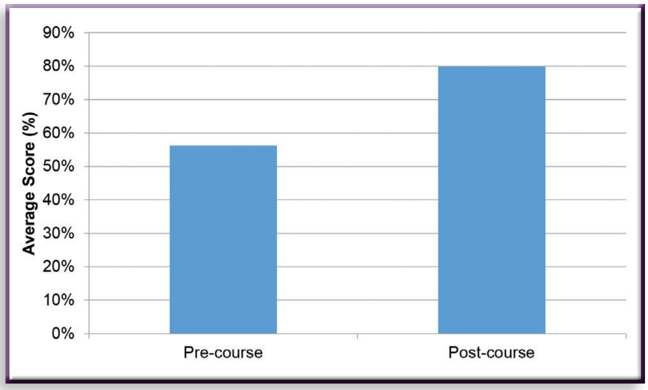
### Knowledge

The knowledge exam scores of the medics improved significantly from baseline with an average pre-course exam score of 56% ± 6.8% compared to an average post-course exam score of 80% ± 5.0% (Figure 1, $p < .001$).

### Manual Skills

Based on expert ratings, the manual skills of the medics improved significantly from baseline to day 4 for image finding

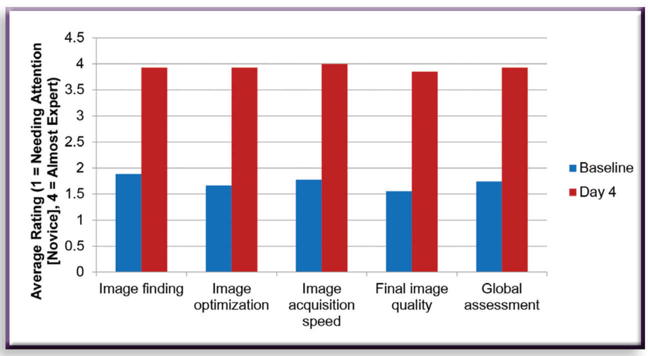
**FIGURE 1** *Average scores on knowledge exam.*




Average knowledge exam scores increased from pre-course (56% ± 6.8%) to post-course (80% ± 5.0%, $p < .001$).

(mean baseline score: 1.89, mean day 4 score: 3.93, $p = .007$), image optimization (mean baseline score: 1.67, mean day 4 score: 3.93, $p = .008$), image acquisition speed (mean baseline score: 1.78, mean day 4 score: 4, $p = .008$), final image quality (mean baseline score: 1.56, mean day 4 score: 3.85, $p = .008$), and global assessment (mean baseline score: 1.74, mean day 4 score: 3.93, $p = .008$) (Figure 2). Participants' average comfort level with ultrasound applications was 2.63 ± 0.744 before the course and 3.89 ± 0.601 after the course.

**FIGURE 2** *Average ratings of manual skills.*




Average ratings for manual skills of the medics improved from baseline to day 4 for image finding (mean baseline score: 1.89, mean day 4 score: 3.93, $p = .007$), image optimization (mean baseline score: 1.67, mean day 4 score: 3.93, $p = .008$), image acquisition speed (mean baseline score: 1.78, mean day 4 score: 4, $p = .008$), final image quality (mean baseline score: 1.56, mean day 4 score: 3.85, p = .008), and global assessment (mean baseline score: 1.74, mean day 4 score: 3.93, $p = .008$). Ratings were based on a 4-point Likert scale (1 = Needing Attention [Novice], 4 = Almost Expert).

### *Workflow Understanding*

The mean scores of the medics at the OSCE stations were as follows (Table 3):

**TABLE 3** *Performance of Medics on OSCE* Stations*

| Station | Maximum Score | Medics Mean Score, ± SD |
|---|---|---|
| Regional anesthesia | 8 | 7.3 ± 0.866 |
| Lung ultrasound | 8 | 7.8 ± 0.441 |
| RUSH | 11 | 10.7 ± 0.707 |
| Vascular access | 5 | 4.7 ± 0.707 |
| TTE | 10 | 9.8 ± 0.441 |

*OSCE = Objective Structured Clinical Examination; SD = standard deviation; RUSH = Rapid Ultrasound for Shock and Hypotension; TTE = transthoracic echocardiography.

- Ultrasound-guided regional anesthesia: 7.3 ± 0.866
- Lung ultrasound: 7.8 ± 0.441
- RUSH: 10.7 ± 0.707
- Ultrasound-guided vascular access: 4.7 ± 0.707
- TTE: 9.8 ± 0.441

The average score at every station was > 91%.

## Discussion

We demonstrated the feasibility of successfully implementing an ultrasound course tailored for military medics that taught multiple ultrasound applications through multimodal educational methods. Additionally, we showed that a short but intensive course can develop ultrasound knowledge, manual skills, and workflow understanding in nonphysician providers such as military medics with varying levels of prior ultrasound experience. Our specific multimodal framework allowed for assessment of knowledge and manual skills at various times. The military medics improved both their knowledge base and hands-on skills as evidenced by their knowledge exam scores and scores on the global rating scale, respectively. After the course, all participants achieved knowledge exam scores exceeding 70%, the threshold previously used as a passing score for an ultrasound knowledge exam for anesthesiology trainees.[14] Our customized OSCE at the end of the course allowed evaluators to assess medics' understanding of the workflow for ultrasound applications. Moreover, participants reported feeling more comfortable with using ultrasound by the end of the course compared to the start of the course.

Earlier studies that involved ultrasound training for military medics are limited to teaching a few specific applications in a short span of time. Alternatively, they are limited to a lack of comprehensive assessment to evaluate the efficacy of the course in imparting knowledge, manual skills, and workflow understanding in ultrasound applications.[2,6–11,15–18] Our course is unique for its robust training time of approximately 40 hours, incorporating a flipped classroom model that allows more time for numerous repetitions and live feedback. Broad training in multiple ultrasound applications was conducted via multimodal teaching tools in an organized fashion. The online modules, live lectures, and substantial case-based discussions by experts expanded the medics' knowledge base while the repetitive deliberate practice with personalized feedback allowed them to solidify their workflow understanding, as well as improve their manual skills. Our curriculum also included open lab time to address areas of individual interests or areas of deficiency, which further improved ultrasound proficiency in participants. A comprehensive assessment with individual components to assess knowledge base, manual skills, and workflow understanding was carried out to confirm the validity and efficacy of the course.

Although our curriculum is time-intensive and appropriately assessed ultrasound knowledge, manual skills, and workflow understanding, there is still a question of skill decay weeks to months after the course ended. This can easily be evaluated with follow-up knowledge exams, assessment of manual skills on simulators, and OSCEs. The addition of spaced learning is desirable with appropriate interval refresher training exercises. There is also potential for more ultrasound applications to be incorporated in this curriculum that may be helpful for military medics. These include bone fracture detection, assessment of intraocular pressure, and additional regional anesthesia techniques. In a previous study, musculoskeletal application was a large portion of the military medics' ultrasound encounters.[1] Some additional regional anesthesia procedures that could be added are adductor canal blocks and ankle blocks to further address this need.

### Limitations

Although our initial results are promising, we note the following limitations:

1. Our sample size (a convenience sample of nine medics) was small. Given the Coronavirus Disease 2019 (COVID-19) restrictions, we were unable to hold courses with larger numbers of learners. Despite our small sample size, we detected improvements in proficiency in ultrasound after the course.
2. Although the knowledge exam and global rating scale were developed and reviewed by experts who designed the course for content validity, further validation is needed for future courses.
3. Although our knowledge exam and OSCE assessed participants' ability to make correct diagnoses, they did not include questions to assess logical decision-making that Special Operations medics need to make on the field based on ultrasound findings, such as whether a medical evacuation (MEDEVAC) or casualty evacuation (CASEVAC) is needed. Our focus in this pilot study was to improve proficiency in ultrasound, but this focus should expand to ensuring that medics can make correct management decisions based on ultrasound findings regarding casualties.
4. We did not have a control subject group, such as novice physicians (i.e., interns, first-year anesthesiology resident physicians, etc.), that would have allowed us to have a frame of reference for the medics' learning curve and overall proficiency at the end of the course as was done in a previous study for Extended Focused Assessment With Sonography for Trauma (eFAST).[11] The addition of a control group and further validation of our assessment tools, which are lacking in many studies on ultrasound training, would strengthen the validity of our results.[19,20]
5. While our course improved medics' proficiency in multiple ultrasound techniques, it was relatively more resource- and time-intensive than previous successful ultrasound training for medics that taught single ultrasound applications.[6–11] Rather than teaching ultrasound applications individually, we aimed to create a comprehensive course in which medics would learn many ultrasound applications from a consistent group of instructors. The course will need to be refined so that it can be feasible given the constraints of resources, time, and expert-instructor availability inherent in military medical training.

## Future Directions

Further investigation with larger participant numbers, a control group, and further validation of our assessment tools is necessary to provide stronger confirmatory results of proficiency in ultrasound after this course. Future courses should modify the knowledge exam and OSCE to include questions to assess logistical decision-making based on ultrasound findings to assess whether the ultrasound knowledge and skills gained by medics in this course affect their management decisions on the battlefield.

Moreover, participants' proficiency in ultrasound needs to be reassessed at specific intervals in order to measure the rate of skill decay over time. This assessment will allow us to create strategies to help retention of ultrasound knowledge, manual skills, and workflow understanding using spaced learning and/or refresher training exercises. We can also utilize more objective assessment methods, such as metrics from hand motion tracking systems. Our course instructors were experts in ultrasound with multiple years of teaching medical trainees, allowing them to provide instruction and assess skills based on the global rating scale simultaneously. However, as this course becomes more widely available with instructors of varying degrees of experience, objective data measures will be necessary to standardize the evaluation of skills.

Finally, the course should be refined with the input of military medical personnel to ensure that this course can be implemented widely and efficiently in the long term. This may result in adjustments such as a shorter course, more online self-paced learning, remote training, and/or training medics or other military medical personnel to be prospective trainers for other medics at times and locations that fit the existing constraints for military medical training. Input from military medical personnel should also be used to further tailor this program to fit the clinical needs of military medics. The clinical utility of ultrasound for military medics has the potential to improve frontline clinical decision-making, and further analysis is required to refine this course into a reliable, sustainable ultrasound course.

### Author Contributions

HF and SK helped design, draft, and revise the manuscript, and interpret the data. VB, VTW, OC, and AS helped with design, acquisition of data, analysis, and revision of the manuscript. JWB, AL, KRM, AP, LAR, DPW, LJK, and JKS helped with acquisition of data, interpretation of data, and revision of the manuscript. JW, FM, and RM helped with design, interpretation of data, and revision of the manuscript. DNL and JDM helped with conception, design, and revision of the manuscript. All authors approved the final manuscript.

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### Conflict of Interest

The authors report no conflict of interest.

### References

1. **Hile DC, Morgan AR, Laselle BT, Bothwell JD.** Is point-of-care ultrasound accurate and useful in the hands of military medical technicians? A review of the literature. *Mil Med*. 2012;177(8):983–987.
2. **Morgan AR, Vasios WN, Hubler DA, Benson PJ.** Special operator level clinical ultrasound: an experience in application and training. *J Spec Oper Med*. 2010;10(2):16–21.
3. **Cartier RA, Skinner C, Laselle B.** Perceived effectiveness of teaching methods for point of care ultrasound. *J Emerg Med*. 2014;47(1):86–91.
4. **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(7):119–123.
5. **Mahmood F, Bortman J, Amir R, et al.** Training surgical residents for ultrasound-guided assessment and management of unstable patients. *J Surg Educ*. 2019;76(2):540–547.
6. **Driskell DL, Gillum JB, Monti JD, Cronin A.** Ultrasound evaluation of soft-tissue foreign bodies by US Army medics. *J Med Ultrasound*. 2018;26(3):147–152.

7. **Meadows RM, Monti JD, Umar MA, et al.** US army combat medic performance with portable ultrasound to detect sonographic findings of pneumothorax in a cadaveric model. *J Spec Oper Med*. 2020;20(3):71–75.
8. **LaDuke M, Monti J, Cronin A, Gillum B.** Ultrasound detection of soft tissue abscesses performed by non-physician U.S. Army medical providers naïve to diagnostic sonography. *Mil Med*. 2017;182(3):e1825–e1830.
9. **Betcher J, Becker TK, Stoyanoff P, Cranford J.** Military trainees can accurately measure optic nerve sheath diameter after a brief training session. *Mil Med Res*. 2018;5(1):42.
10. **Heiner JD, Baker BL, McArthur TJ.** The ultrasound detection of simulated long bone fractures by U.S. Army Special Forces Medics. *J Spec Oper Med*. 2010;10(2):7–10.
11. **Monti JD, Perreault MD.** Impact of a 4-hour Introductory eFAST Training Intervention Among Ultrasound-Naïve U.S. Military Medics. *Mil Med*. 2020;185(5–6):e601–e608.
12. **Yeh L, Montealegre-Gallegos M, Mahmood F, et al.** Assessment of perioperative ultrasound workflow understanding: a consensus. *J Cardiothorac Vasc Anesth*. 2017;31(1):197–202.
13. **Fatima H, Mahmood F, Mufarrih SH, et al.** Preclinical proficiency-based model of ultrasound training. *Anesth Analg*. April 2021.
14. **Mitchell JD, Mahmood F, Wong V, et al.** Teaching concepts of transesophageal echocardiography via Web-based modules. *J Cardiothorac Vasc Anesth*. 2015;29(2):402–409.
15. **Backlund BH, Bonnett CJ, Faragher JP, et al.** Pilot study to determine the feasibility of training Army National Guard medics to perform focused cardiac ultrasonography. *Prehosp Emerg Care*. 2010;14(1):118–123.
16. **Monti JD, Younggren B, Blankenship R.** Ultrasound detection of pneumothorax with minimally trained sonographers: a preliminary study. *J Spec Oper Med*. 2009;9(1):43–46.
17. **Vasios WN, Hubler DA, Lopez RA, Morgan AR.** Fracture detection in a combat theater: four cases comparing ultrasound to conventional radiography. *J Spec Oper Med*. 2010;10(2):11–15.
18. **Hampton KK, Vasios WN, Loos PE.** SOLCUS: update on point-of-care ultrasound In Special Operations medicine. *J Spec Oper Med*. 2016;16(1):58–61.
19. **Pietersen PI, Madsen KR, Graumann O, et al.** Education and training in lung ultrasound: a systematic review. In: *Medical education, web and internet*. European Respiratory Society; 2018:OA1639.
20. **Østergaard ML, Ewertsen C, Konge L, et al.** Simulation-based abdominal ultrasound training: a systematic review. *Ultraschall Med*. 2016;37(3):253–261.

## APPENDIX 1
## Objective Structured Clinical Examination (OSCE) Scenarios and Tasks

### Station 1: Ultrasound-guided Regional Anesthesia (Live Model)

#### Scenario

A 31-year-old Operator is presenting status post gunshot injury to the right forearm. He had QuikClot Kerlix used on the wound with good hemostasis. He is complaining of 9/10 pain and has a concomitant head injury, so you want to avoid altering his mental status after neurosurgeon consultation at a Role 2. There are no contraindications for an upper extremity block.

#### Tasks

Probe selection (linear)
Yes ( ) No ( )

Adequate depth setting (<6 cm)
Yes ( ) No ( )

Acceptable gain setting
Yes ( ) No ( )

Apply gel
Yes ( ) No ( )

Probe placement on adequate anatomical location
Yes ( ) No ( )

Probe orientation
Yes ( ) No ( )

Identify the brachial plexus at interscalene level (**ASK SPECIFICALLY**)
Yes ( ) No ( )

Identify the brachial plexus at supraclavicular level (**ASK SPECIFICALLY**)
Yes ( ) No ( )

### Station 2: Lung Ultrasound (Live Model)

#### Scenario

A 28-year-old male Operator presented after a blow to the right chest after being struck by large rocks to the right flank after an IED roadside explosion.

No known drug allergies. PMHx: Seasonal allergic rhinitis, on singular.

*Physical exam:*
GCS 15. BP 85/40mmHg, HR 125/min, $Sa_{O_2}$ 92% on $Fi_{O_2}$ 1.0, RR 28 shallow.
Bruising to chest bilaterally, tender, R > L.
No flail segment or open wound.
Breath sounds indistinct bilaterally.
Heart sounds rapid and faint.

#### Tasks

Most appropriate probe selected (Please write which probe was selected by the trainee)
Yes ( ) No ( ) Probe selected: ______________

Probe orientation with marker cephalad
Yes ( ) No ( )

Image optimization
Yes ( ) No ( )

Identification of locations for lung examination
Yes ( ) No ( )

Please perform a lung ultrasound and identify the following structures:
- Visceroparietal pleural interface
  Yes ( ) No ( )
- Ribs
  Yes ( ) No ( )

Identify the presence of lung sliding
Yes ( ) No ( )

Select M-mode and place cursor at appropriate location between the ribs (**ASK SPECIFICALLY**)
Yes ( ) No ( )

### Station 3: Transthoracic Echocardiography (TTE) (Simulator)

#### Scenario

A 32-year-old Operator presents after driving an HMMWV that resulted in a rollover accident during low visibility. Initial presentation after primary exam revealed bruising to the left flank and chest, with stable vital signs on presentation. After 1 hour he presents dyspneic, diaphoretic with moderate central chest pain, lightheaded, and nauseous.

*PMHx:* GSW to right calf 1 year ago with DVT as a complication.

*Physical exam:*

BP 80/60mmHg, HR 105/min, $Sao_2$ 90% (face mask 8L), RR 18/min

Lung fields clear. Muffled heart sounds.

*ECG:* No ischemic changes. Low voltage.

*CXR:* Small right pleural effusion. No evidence of pneumothorax.

#### Tasks

Most appropriate probe selected (Please write which probe was selected by the trainee)
Yes ( ) No ( ) Probe selected: ______________

Probe orientation with marker cephalad
Yes ( ) No ( )

Image optimization
Yes ( ) No ( )

Identification of locations for TTE examination
Yes ( ) No ( )

Please obtain the following images from a starting position of the probe in the patient's right shoulder:

- Parasternal long axis
  Yes ( ) No ( )
- Parasternal mid-papillary short axis
  Yes ( ) No ( )

Apical 4-chamber
Yes ( ) No ( )

Subcostal 4-chamber
Yes ( ) No ( )

Subcostal inferior vena cava
Yes ( ) No ( )

Ask the trainee what the most likely diagnosis is. Is the diagnosis correct?
Yes ( ) No ( )

### Station 4: Rapid Ultrasound in Shock and Hypotension (RUSH) (Simulator)

#### Scenario

A 25-year-old Operator brought to the Role 2 FOB intubated and blood transfusing through a femoral central line. The patient was found unconscious on the side of the road with bruises on his abdomen and chest with a large crater from a presumed IED 20 yards away. After a quick assessment, it was determined he needs to go to the OR.

*PMHx:* not known

*Vital signs:* BP 70/45mmHg, pulse 130/min

The surgeon asks for a quick ultrasound exam to rule out intra-abdominal bleeding.

#### Tasks

Curvilinear probe selected
Yes ( ) No ( )

Application of gel
Yes ( ) No ( )

Probe orientation with marker cephalad
Yes ( ) No ( )

Image optimization
Yes ( ) No ( )

Please identify the following structures:

- Liver in the right upper quadrant
  Yes ( ) No ( )
- Kidney in the right upper quadrant
  Yes ( ) No ( )
- Morison's pouch
  Yes ( ) No ( )
- Spleen
  Yes ( ) No ( )
- Kidney in the left upper quadrant
  Yes ( ) No ( )
- Bladder
  Yes ( ) No ( )
- Pleura on left and right upper quadrants
  Yes ( ) No ( )

### Station 5: Ultrasound-guided Vascular Access (Live Model)

#### Scenario

A 36-year-old Operator was brought to the Role 1 STP after resuscitation for a lower extremity blast injury resulting in amputation below the right knee. A tourniquet is in place with good hemostasis. He has received 2 units of LTFWB. An 18-gauge PIV is not flushing, and 20-gauge PIV is working but very slow and you cannot draw back on it.

*Vitals signs:* 100/60mmHg, HR 60/min.

You decide to place a central venous line in the right internal jugular vein for resuscitation and potential need for pressor/ionotropic support.

#### Tasks

Optimizes position of the patient
Yes ( ) No ( )

Identifies internal jugular vein
Yes ( ) No ( )

Identifies carotid
Yes ( ) No ( )

Evaluation "in plane" and "out of plane" of internal jugular and carotid (**ASK SPECIFICALLY**)
Yes ( ) No ( )

Activates color flow Doppler (**ASK SPECIFICALLY**)
Yes ( ) No ( )

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