Not Just Hocus POCUS: Implementation of a Point of Care Ultrasound Curriculum for Internal Medicine Trainees at a Large Residency Program

LT. Thomas E Mellor, MC, USN; CPT. Zachary Junga, MC, USA*; CPT. Sarah Ordway, MC, USA*; MAJ. Timothy Hunter, MC, USA*; CAPT. William T Shimeall, MC, USN*; Sarah Krajnik†; Lisa Tibbs†; COL. Jeffrey Mikita, MC, USA†; LCDR. Joseph Zeman, MC, USN*; MAJ. Paul Clark, MC, USA**

ABSTRACT Introduction: In 2018, the American College of Physicians formally acknowledged the importance of Point of Care Ultrasound (POCUS) to the practice of internal medicine (IM). For the military internist, POCUS training is critical for care of the trauma patient in austere environments, mass casualty events and natural disasters. While emergency medicine and critical care training programs have adopted POCUS education, few IM programs have integrated POCUS into their core curricula. We designed and implemented an iterative POCUS curriculum for trainees at a large military IM residency program over a two-year period. Methods: In collaboration with our critical care and simulation departments, we developed a pilot curriculum consisting of five, 60-minute courses offered on a voluntary basis at monthly intervals throughout 2017. Based on the pilot's success we incorporated a POCUS curriculum into the core academics received by all IM trainees during the 2017–2018 academic year. Trainees attended seven, 3-hour sessions during their scheduled academic time taught by subspecialists with POCUS expertise in an on-site simulation center. Baseline surveys and knowledge assessment examinations were administered during orientation and repeated at the end of the academic year. Comparison of results before and after the POCUS curriculum was the primary outcome evaluated. Results: *Intervention #1: Pilot, 2016–2017 Academic Year* 45 trainees attended at least one course with an average of 1.8 sessions per trainee. Baseline survey data showed 91% of trainees believe POCUS is quite or extremely beneficial for their patients, but 73% feel slightly or not at all confident in POCUS knowledge. The pre-test mean and median scores were 71% and 77% respectively, which both increased to a post-test mean and median of 81%. Post-test mean percentage correct for trainees attending 1, 2, or 3 courses was 74%, 82%, and 91% respectively. *Intervention #2: Incorporation of POCUS into Core Academics, 2017–2018 Academic Year* All 75 trainees participated in training with an average of 3.77 sessions attended per trainee. Survey analysis revealed significant improvement in confidence of performing ultrasound-guided procedures ($p = 0.0139$), and a 37% absolute increase in respondents who anticipate using ultrasound in their clinical practice ($p = 0.0003$). The mean pre-test score was 67.8% with median of 63.6% while mean and median post-test scores were 82.1% and 81.8%, with an absolute improvement of 14.3% and 18.2% respectively ($p = 0.0004$). Conclusion: A structured POCUS curriculum was successfully incorporated at a large multi-service military IM residency program, with demonstrated retention of knowledge, improved confidence in performance of ultrasound guided invasive procedures, and increased interest in the use of POCUS in future clinical practice. Similar programs should be implemented across all IM programs in military graduate medical education to enhance operational readiness and battlefield care.

INTRODUCTION

The current clinical climate for internal medicine physicians calls for the rapid assessment of patients with heavy reliance on objective laboratory data and advanced imaging, exposing a need for efficient and effective bedside diagnostics. Ultrasound technology is a powerful imaging modality that has gained momentum as the future "stethoscope" and adjunct to the physical examination.[1] Due to advances in equipment and improved portable technology, ultrasound has been adopted by emergency physicians and intensivists as a point of care tool to guide both diagnostics and invasive bedside interventions.[2] As internist roles evolve, point-of-care ultrasound (POCUS) is becoming an essential tool in both clinic and hospital settings. Furthermore, while the United States has enjoyed air superiority in every conflict since 1953, this is not an assurance in future warfare engagements underscoring the importance of continued improvement of patient care in theater as well as accurate and timely triage of battlefield wounded.[3,4] The benefits of POCUS use are well established in the trauma setting in addition to any resource limited scenario such as natural disasters, austere deployments and mass casualty situations.[4] Although data

*Department of Medicine, Walter Reed National Military Medical Center, 8901 Rockville Pike, Bethesda, MD 20889.

†Department of Simulation, Walter Reed National Military Medical Center, 8901 Rockville Pike, Bethesda, MD 20889.

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driven protocols have led to standardized ultrasound training in emergency medicine and critical care training programs, few internal medicine residencies have incorporated POCUS education into their curricula.[5] In this paper, we outline the design and implementation of an iterative POCUS curriculum for trainees at a large multiservice internal medicine residency program over a 2-year period.

METHODS

Data Management and Statistical Analysis

All test scores and survey results were de-identified and recorded in a computer database for analysis. Descriptive statistics were computed for all factors with values expressed as means, medians, standard deviations, and percentages. Data were collated and analyzed using Microsoft Excel. Normally distributed variables were compared using the Student's t-test. We defined statistical significance as a *p*-value of less than 0.05.

Intervention #1: Pilot, 2016–2017 Academic Year

In collaboration with our critical care and simulation departments, we developed a pilot POCUS curriculum for internal medicine residents interested in participating. Our medical facility has an active simulation center with audiovisual support for projection of educational materials and the following available simulation environments: operating room, intensive care unit (ICU) room, eight outpatient examination rooms, four hospital rooms, a multi-purpose room, surgical skills suite, and debrief area. There are multiple high-fidelity interactive mannequins including a human patient simulator, two patient ultrasound simulators, and multiple task trainers for the practice of paracentesis, thoracentesis, and central line catheter placement. Additionally, there are nine bedside ultrasound systems and a large population base of standardized patients with various pathologies. The pilot curriculum consisted of five, 60-minute courses occurring at one month intervals throughout the second half of the 2016–2017 academic year. Topics covered included basics of ultrasound/physics of sonography, extended focused assessment with sonography for trauma (eFAST), vascular, thoracic, and focused echocardiogram examinations. Courses were voluntary, held after normal working hours and taught by critical care and cardiology specialists in our simulation center. Sessions included ten minutes of didactics followed by small group hands-on scanning time using healthy volunteers as models and interactive mannequins to demonstrate pathology. 45 out of 73 total internal medicine residents volunteered to attend at least one of the five ultrasound training sessions offered. We performed baseline surveys utilizing a Likert scale to evaluate prior experience with ultrasound, perceived importance of ultrasound to clinical practice, as well as self-reported knowledge and confidence with ultrasound. Participants completed an eleven-question knowledge assessment prior to the first course and again at the conclusion of the five-month period.

Intervention #2: Incorporation of POCUS into Core Academics, 2017–2018 Academic Year

Based on the initial pilot success, we incorporated a longitudinal POCUS curriculum into the core academics received by all internal medicine trainees at our institution. Our didactic structure consists of mandatory daily case report conferences in addition to a bi-weekly three-hour subspecialty session. Ultrasound sessions were integrated into 12.5% of trainees' total academic half-days, and were taught by subspecialists with POCUS expertise in our simulation center. There were 14 total sessions (seven for interns/medical students; seven for residents) throughout the year covering the topics listed above with the addition of the musculoskeletal exam and a review day. Interns and medical students attended courses on Tuesdays and residents on Thursdays during their regularly scheduled protected academic time. For each session, we utilized three simulation rooms outfitted as either an ICU, inpatient hospital or clinic room with two patient beds per room. Six ultrasound machines were available for use with appropriate ultrasound probes for the given examinations performed. The simulation center staff assisted with setup before each session. Between three and six subspecialty attendings and/or fellows served as teaching faculty for each course. Subspecialty educators were from the cardiology, pulmonology and critical care and rheumatology departments. The three-hour sessions were comprised of small group scanning practice utilizing standardized patients as models and interactive mannequins in concert with or following case-based didactic teaching on the corresponding pathologies. An online teaching module constructed by teaching faculty at our affiliated medical school, the Uniformed Services University of the Health Sciences, as well as selected book chapters[6] were provided to trainees the week prior to each course. A baseline survey and examination assessing knowledge of the cognitive domains covered in the course were administered during orientation and repeated at the end of the academic year. Comparison of these results before and after the POCUS curriculum was the primary outcome evaluated. Secondary outcomes assessed were results of the internal medicine In-Service Training Examination (ITE) and American Board of Internal Medicine (ABIM) certification examination first time pass rate.

RESULTS

Intervention #1: Pilot, 2016–2017 Academic Year

At the completion of our pilot, 45 trainees attended at least one of the five ultrasound courses offered. The average number of courses attended by a single trainee was 1.8. Survey data prior to the course showed that 91% of trainees believe POCUS is quite or extremely beneficial for the health of their patients, but 73% feel slightly or not at all confident in

their knowledge of POCUS. Prior experience was variable with less than 10% of trainees ever completing a structured ultrasound course in the past. The pre-test mean score was 71% correct with a median of 77%, which increased to mean and median both of 81% on the post-test. There was a direct correlation between the number of courses attended and percentage correct. Post-test mean percentage correct for trainees attending 1, 2, or 3 courses was 74%, 82%, and 91% respectively.

Intervention #2: Incorporation of POCUS into Core Academics, 2017–2018 Academic Year

At the completion of the first year of our formal integrated POCUS curriculum all 75 trainees were included and exposed to training with an average of 3.77 sessions attended per trainee. Demographic data regarding the composition of the residency class can be found in Table I. The baseline survey and pre-test was only completed by new trainees, and residents who had participated in the pilot curriculum the year prior were excluded. Survey analysis, illustrated in Table II, revealed statistically significant improvement in confidence of performing ultrasound-guided procedures ($p = 0.0139$). There was a decline in resident belief of health benefit from ultrasound use, which was discordant with surveys from the pilot intervention, however, the mean absolute value remained high at 4.1 (4 = Quite Beneficial). Additionally, there was a 37% absolute increase in respondents who anticipate using ultrasound in their clinical practice sometimes or frequently (55.5% to 92.1%), which was statistically significant ($p = 0.0003$). Data from the knowledge assessment examination showed a pre-test mean score of 67.8% and median score of 63.6%. Post-test scores increased to a mean of 82.1% and median of 81.8% with an absolute improvement of 14.3% and 18.2% respectively ($p = 0.0004$).

As a secondary outcome, the results of the internal medicine ITE stratified by postgraduate year (PGY) and ABIM certification examination first time pass rate were compared before and after implementation of the POCUS curriculum. Overall, there was an absolute increase in total mean percentage correct of 8% from PGY-1 to PGY-2, and an absolute increase of 7% from PGY-2 to PGY-3. We also looked within specific content areas that were included in the POCUS curriculum. In Pulmonary and Critical Care Medicine, there was an absolute increase in mean percentage correct of 9% from PGY-1 to PGY-2 and 7% from PGY-2 to PGY-3. In Cardiology, there was an absolute increase in mean percentage correct of 7% from PGY-1 to PGY-2 and 5% from PGY-2 to PGY-3. Regarding ABIM certification, the 2018 first time pass rate was 100%, which was an absolute increase of 5% from the year prior.

TABLE I. Internal Medicine Class of 2017–2018 Demographics

	Number of Trainees	Percent of Trainees
Total Trainees	75	
	Branch	
US Navy	38	51
US Army	34	45
US Air Force	1	1
US Public Health Service	2	3
	Postgraduate Year	
PGY-1	30	40
PGY-2	23	31
PGY-3	22	29
	Prior General Medical Officer	
Yes	13	17
No	32	43
N/A	30	40
	Gender	
Female	22	29
Male	53	71

DISCUSSION

POCUS is rapidly becoming an integral part of the internists' arsenal and will soon become the standard of care in the practice of internal medicine. In 2018, the American College of Physicians (ACP) formally acknowledged the importance of POCUS to the practice of medicine as well as their intention to collaborate with other professional societies, including the Society of General Internal Medicine, to establish clinical guidelines regarding appropriate use among internal medicine physicians.[7]

The benefits of POCUS have been well-defined in the medical community over the last two decades with practical application in the military setting. Hemorrhage continues to remain the leading cause of death on the battlefield. While significant improvements have been made with rapid identification and control of extremity bleeding, intraperitoneal and intrathoracic hemorrhage are not easily diagnosed in the early triage period as the clinical examination is not reliable for exclusion. Computed tomography (CT) while highly sensitive, is typically not available in Role 1 and 2 levels of medical care. The focused assessment with sonography in trauma (FAST) examination has become widely adopted as the most advanced diagnostic modality for blunt trauma injuries in these environments with high positive and negative predictive values. This allows for early identification of battlefield related pneumothorax, hemopericardium or abdominal hemorrhage, accurate and timely triage, decreased time to medical evacuation, decreased time to surgical intervention and reduced frequency of unnecessary diagnostic laparotomies.[8–10]

POCUS has also proven useful in the treatment of battlefield hemorrhage. The use of ultrasound as an adjunct for venous access increases the rate of successful placement and reduces the number of attempts required for placement of

both peripheral intravenous lines and central venous catheters (CVC) at all sites (internal jugular, subclavian, femoral) as well as decreases the rate of complications from placement of CVC in the internal jugular vein.[11,12] Once vascular access is established, POCUS can aide in guiding adequate resuscitation through sonographic measurement of the inferior vena cava (IVC) diameter.[13] In the setting of head trauma, POCUS can also be used to identify elevated intracranial pressure via measurement of optic nerve sheath diameter with excellent sensitivity.[13,14]

Specific protocols such as the Bedside Lung Ultrasound in Emergency (BLUE) protocol for acute respiratory failure, Rapid Ultrasound for Shock and Hypotension (RUSH) protocol for undifferentiated shock and Cardiovascular Limited Ultrasound Examination (CLUE) protocol for heart failure have been developed and validated to provide a structured workflow for clinical scenarios to integrate POCUS findings as an aide in rapid clinical decision making.[15,16] This has shown benefit in hospital-based settings, however, there is no data to date regarding application of these protocols in battlefield settings. Other well-known applications of POCUS include examination of the vascular, musculoskeletal, genitourinary, thyroid, gallbladder, liver, spleen, and central nervous systems as well as guidance for thoracentesis, paracentesis, pericardiocentesis and chest tube placement. Many of these have significant relevance and practicality in the forward deployed setting. Furthermore, in addition to physicians and advanced practitioners (nurse practitioners and physician assistants), these skills can be learned and utilized by medics and corpsmen aboard helicopters, ambulances, ships and on the battlefield.[13,17]

Despite the general acceptance of POCUS as a valuable and necessary tool, few internal medicine programs, including those within military graduate medical education, have incorporated standardized ultrasound training into the core curriculum.[5] Our study clearly demonstrates that it is feasible to quickly integrate such training into structured didactics. This does require space and equipment, which presumably is available at most academic institutions, as well as simulation capabilities if available. In our study, we utilized standardized patients and interactive mannequins. However, healthy volunteers would suffice as the most critical aspects in early training are familiarization with the technology, ability to identify normal anatomy, and hands on time with ultrasound probes to enhance proper technique in image acquisition. Our pilot was well-received and effective with trainees performing as models for each other. A successful, sustainable program also requires substantial time commitment from subspecialists trained in POCUS.

One initial concern with inclusion of a POCUS program was that these courses replaced academic time dedicated to expanding trainees' knowledge in preparation for clinical practice and the internal medicine board examination through more traditional teaching methods. With this in mind, POCUS sessions were led in a case-based fashion and developed to target core learning objectives specified in the ACP's Internal Medicine In-Training Examination (ITE). Notably, there was an overall improvement among ITE scores and ABIM certification examination first time pass rate after adoption of the POCUS curriculum. These results were not the primary outcome assessed in our study, and there are many confounding variables that affect training examination results, including both trainee, program and teaching factors. While a causative relationship between the POCUS course and these test scores cannot be determined based on our current data, this observation was made in order to monitor for unintended consequences of altering the academic structure. Of considerable importance was the perceived benefit of POCUS training expressed by residents during the annual program evaluation, where this curriculum was identified as the second most valuable and enjoyable educational experience of the academic year.

Although we did not compare operator skills before and after the course, the literature suggests that structured training has the downstream effect of improved image acquisition and ultrasound-guided procedural technique among trainees.[5] Several studies have identified that POCUS knowledge, skills and confidence decline over time in the setting of a one-time training workshop.[5,18] A strength of our curriculum was the longitudinal nature of the course with recurrent short training sessions through which fundamental knowledge and skills were reinforced regularly throughout the year. Our study demonstrated that POCUS knowledge and confidence was retained over the course of an academic year. This supports existing evidence from other internal medicine programs evaluating the inclusion of POCUS training, that this type of curriculum is advantageous over a more intensive single training.[18] An additional outcome that was considered, but did not show a significant difference, was the frequency of procedures performed among housestaff.

TABLE II. Comparison of Survey Results after Intervention #2

Question	Pre-Course Survey	Post-Course Survey	SE	*P*
How confident are you in your knowledge of ultrasound? [a]	2.48	2.87	0.21	0.069
How beneficial do you believe ultrasound skills will be for the health of your patients? [a]	4.7	4.1	0.16	0.0003
How confident do you feel performing procedures under the guidance of ultrasound? [a]	2.62	3.26	0.25	0.0139
How often do you currently/intend to incorporate the use of ultrasound into your practice? [b]	2.63	3.37	0.19	0.0003

[a]1 = Not at all 2 = Slightly 3 = Moderately 4 = Quite 5 = Extremely.
[b]1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently.

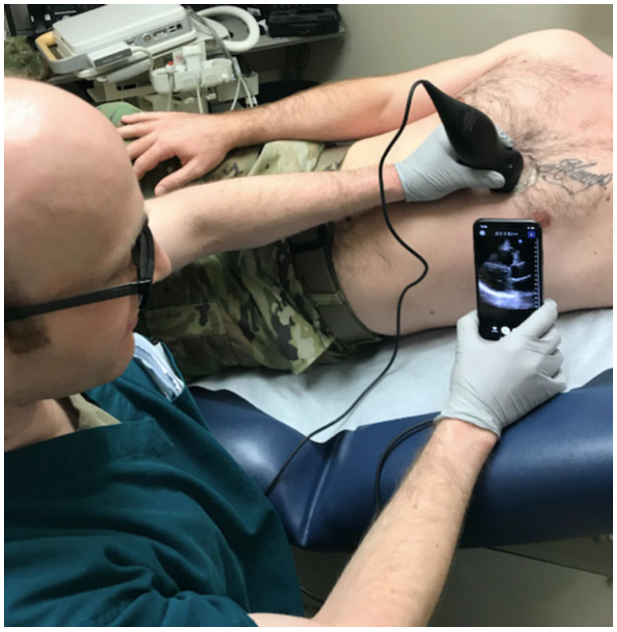

FIGURE 1. Demonstration of a portable, smart-phone compatible ultrasound transducer in performing the focused cardiac examination on a healthy model.

There are noteworthy challenges to consider in future POCUS training efforts. One recurrent theme is apprehension regarding appropriateness of documentation and coding for POCUS examinations. While these are valid concerns from a medicolegal standpoint, we would argue that this should not be a barrier to the use of POCUS by trainees. POCUS is intended to be utilized as an extension of the clinical exam to aid in clinical decision making after appropriate training similar to the physical examination itself. This leads to another legitimate concern: assessing competency. While there is no clear guidance for internal medicine trainees at this time, the ACP is actively working to define the educational curriculum required to train residents and internists in the use of POCUS in internal medicine.[7] Refinement of these objectives will allow residency programs to better develop more standardized training programs and evaluate POCUS competency in trainees.

Another potential challenge is the cost and practicality of equipping every echelon of medical care with ultrasound capability. Historically, ultrasound technology has been expensive with a large logistical footprint that was not a feasible option for smaller facilities including role 1 and 2 levels of care. Over the last decade, portability has improved with the advent of small, handheld devices that are easily carried on bedside rounds within the hospital setting. In recent years, ultrasound transducers have been developed that are compatible with smartphone- and tablet-based software with comparable ease of image acquisition and excellent image quality for interpretation (Fig. 1). Additionally, prices for these devices are substantially lower than traditional ultrasound systems. These advances have allowed for a cost-effective and compact option making the equipping of all battlefield medical assets with ultrasound capability a realistic strategy.

CONCLUSION

A structured POCUS curriculum was successfully established at a large multi-service internal medicine residency program in the military health system with demonstrated retention of knowledge, improved confidence in performance of ultrasound-guided invasive procedures, and increased interest in the use of POCUS in future clinical practice. Similar programs should be considered for implementation across all internal medicine programs in military graduate medical education. This can have profound implications on the battlefield for rapid diagnosis and treatment in the austere environment.

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