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Integrating Point of Care Ultrasound into Medical Clerkships in a Statewide Distributed Campus Model

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Abstract

Introduction: Integration of point of care ultrasound (POCUS) into clinical clerkships in a statewide campus is challenging. The objective of this paper was to describe the implementation and evaluation of a POCUS curriculum that was added to Emergency Medicine (EM) and Obstetrics and Gynecology (OB/GYN) core clinical rotations in a distributed campus undergraduate medical education (UME) model. The authors declared no conflicts of interest. The study was reviewed by the institutional IRB and determined to be exempt. Methods: This was a descriptive study of the implementation and evaluation of POCUS into 2 clinical clerkships. In this paper, we describe the development of a grading rubric, educational design, and image transfer process used to evaluate student performance. Results: Implementation occurred in step-wise fashion. In the EM clerkship between 2016 and 2018, 395 students participated with a 100% completion rate. In the 2017-2018 OB/GYN clerkship, 186 students completed the clerkship with all but one successfully completing the assignment. Conclusion: This pilot project demonstrated the successful implementation of a POCUS curriculum in 2 clinical clerkships in an UME distributed campus model.

Introduction

Point of care ultrasound, or POCUS, is the use of ultrasound by a clinician to answer a specific clinical question at the patient's bedside. This powerful tool aids clinicians in rapidly diagnosing emergency conditions, narrowing differential diagnosis, facilitating resuscitation, and guiding procedures.[1,2] Over the past decade, the use of POCUS in clinical practice has increased dramatically and is now the standard of care in many instances including guidance of central venous access and assessment of free intraabdominal fluid in trauma patients with the focused assessment with sonography in trauma (FAST) exam.[2,3]

The use of ultrasound as an educational tool in undergraduate medical education (UME) is also rapidly growing.[4] Many schools have integrated ultrasound into the pre-clinical years as an educational tool for teaching anatomy, physiology, and the physical exam.[5,6,7] However, fewer medical schools have successfully included ultrasound training into the clinical years.[8,9] The Association of American Medical Colleges (AAMC) Curriculum Inventory data shows that in 2015-2016, 101 medical schools offered an integrated ultrasound curriculum; however, the majority of these institutions only offered "relevant content in the first 2 academic years".[10]

Integrating ultrasound into the clinical years of UME is important for the long-term integration of ultrasound skills into clinical practice. Skills that are learned in the first 2 years of medical education wane when not used regularly.[2] Further, integration of POCUS exams into clinical rotations teaches students how to integrate diagnostic imaging skills with patient treatment and management plans. While developing proficiency with any new skill requires sufficient opportunity to practice the procedure as well as quality instruction and feedback, certain scans can be learned successfully within a discreet time frame, increasing the feasibility of POCUS training during a standard six-week clinical rotation.[11,12] For example, Kobal et al. demonstrated that after completing a brief training in cardiac ultrasound, medical students were able to correctly diagnose 75% of cardiac pathologies among 61 patients with known cardiac disease.[11] Krause et al. showed that after completing one hour of training on the FAST exam, third-year medical students were able to increase the accuracy and speed in which they identified and interpreted image results.[12] These results show that when provided training and access to practice clinical ultrasound, UME students can successfully learn and apply these skills to patient care. However, integrating ultrasound into the clinical years of UME is not without challenges.

Barriers to implementing an ultrasound curriculum into the clinical years of UME include: cost of equipment, lack of ultrasound-trained faculty, and limitations on ultrasound use by non-radiology faculty.[9, 13] These challenges are magnified for medical schools that have large classes distributed across multiple campuses that use hospitals and clinical sites over a wide geographic area for clinical rotations (a distributed campus model).[14, 15] Larger institutions, specifically, face the unique challenge of implementing an equivalent educational experience (as required by the Liaison Committee on Medical Education or LCME) when there is large variation in ultrasound resources and faculty with ultrasound-expertise across clinical rotation sites. The objective of this paper was to describe the implementation and evaluation of integrating an ultrasound curriculum into Emergency Medicine (EM) and Obstetrics and Gynecology (OB/GYN) core clinical rotations in a distributed campus UME model.

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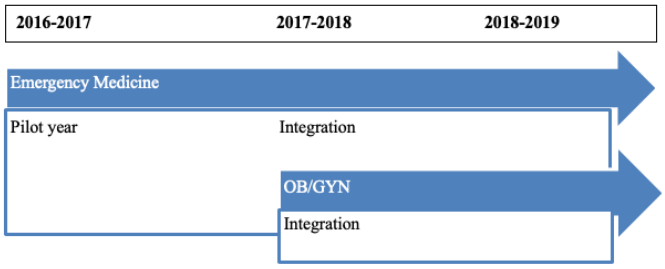
Methods/Implementation

The medical school described in this paper has 240 UME students annually who train at 5 campuses and more than 200 clinical sites across the state (a distributed campus model). Each campus has a dean who coordinates with regional hospitals, clinical practice sites, and physicians to establish clinical clerkship sites. A site director at each hospital, clinic, or physician office is responsible for providing students with adequate resources to provide a standardized educational experience equivalent to all other clinical sites. All sites within each clerkship specialty area share a common clerkship director and are guided by the same goals and objectives. In addition, all sites use a standardized format for each rotation including weekly quizzes, didactic sessions, and a comprehensive student evaluation process. Didactic sessions are conducted by the clerkship director via teleconferencing, allowing all students to have a uniform educational experience.

This research was determined exempt by the institution's institutional review board (IRB) under Health and Human Services Exempt Category 1. As part of this project and of standard educational practice, students obtained consent from patients prior to obtaining and transmitting images. During the consenting process students inform patients that the exam is not for diagnosis, but is only being obtained for educational purposes. However, if concerning medical issues were found by a student, the physician in charge ensured that appropriate followup was scheduled for the patient.

The integration of POCUS into the initial clerkship clinical rotation started with a pilot year (Figure 1) where the ultrasound-based objectives were not part of the students' grades. This was to ensure that any issues with the program could be identified and corrected prior to their impact on students' grades. At the start of the second year, when we were certain any issues had been resolved, the ultrasound-based objectives became part of the students' grade for the rotation. The students were instructed to complete the FAST exam and the third trimester ultrasound exam for the EM and OB/GYN clerkships respectively. Students had previously received didactic training in both the FAST exam and the third trimester US exam as part of the physical diagnosis modules during their first 2 years of UME.

Figure 1. Implementation timeline.



Emergency Medicine Clerkship: During the 2016-2017 and 2017-2018 academic years, 14 hospitals were used as sites for UME student EM clinical rotations. Prior to implementation of POCUS training in the Emergency Medicine Clerkship (EMC), we surveyed each hospital as to the availability and accessibility of ultrasound in their Emergency Department (ED). Two of the 14 hospitals were found to lack an easily accessible ultrasound within the ED for student use. In order to provide parallel learning experiences for all students, the university loaned these 2 sites a Siemens p10 hand held ultrasound system. Each site reported having at least one clinical faculty member who had training in how to perform the FAST exam.

In the 2016-2017 academic year, the pilot year of ultrasound-based curriculum in the EMC, our focus was on the FAST exam. Students were instructed to obtain at least one FAST exam on a patient evaluated during clinical duties. During weekly half-day (4 hour) videoconferences students were presented clinical vignettes with both normal and abnormal FAST exams incorporated. Students were encouraged to engage in group discussion about image interpretation and how findings could be integrated into patient care.

Prior to and during the pilot year, 70% of the student's final grade was derived from their clinical duty, as assessed by faculty evaluations and feedback, 20% of their grade was derived from the National Board of Medical Educators (NBME) end of clerkship test, 5% from weekly quizzes, and 5% from required online asynchronous assignments. After the pilot year, the ultrasound-based objectives were included in their grade, accounting for 5% of the overall EMC grade and the clinical grade percentage was reduced from 70% to 65%.

OB/GYN Clerkship: Based on the implementation in the EMC, the OB/GYN clerkship integration began without a pilot year in the 2017-2018 academic year. There were 18 private practice sites used for the OB/GYN clerkship, all of which had adequate ultrasound equipment available for students to use. Each site had at least one clinical faculty member who was trained in the third trimester POCUS exam (defined in the objective of the rotation), which includes finding fetal heart tones, measuring fetal heart tones on M-mode, identifying fetal presentation (either Cephalic or Breech depending on orientation of the fetus), and identifying placental location. During weekly video conference, similar to the EMC, students were presented ultrasound-based case scenarios to aid with the clinical integration and image interpretation component of the POCUS curriculum. Also, similar to the EMC, the ultrasound-based objective was 5% of the overall grade for the clerkship while 50% came from clinical assessment, 35% from the NBME clerkship test, 6% from quizzes, and 5% from OB/GYN history and physicals (H &Ps).

Ultrasound Image Evaluation: Ultrasound images were transferred electronically to a learning management system by students and scored by a single sonographer, employed by the medical school, using a standardized rubric for each exam (see Figure 2 and Figure 3). Prior to the end of the clerkship

students were provided both the score from the grading rubric along with written comments on performance and suggestions on improvement. Students who did not complete the ultrasound component received an incomplete for the clerkship until the assignment was completed (including in the EM pilot year). Since there was no standardized method for electronically transferring the images, as a wide-variety of ultrasound equipment was used throughout the sites, students were encouraged to use smart phones to take a picture of the ultrasound with no patient identifiers included. Students also had the option of extracting and transmitting de-identified JPEG images directly from the ultrasound machines. No patient identifiers or histories were included with the images. Submitted images were evaluated based solely on image optimization and adequacy and not for pathology or diagnosis. If concerning medical issues were found by the student, the physician in charge ensured that appropriate followup was scheduled for the patient.

All students received POCUS performance feedback via several methods. Students received direct feedback on image acquisition while performing the examinations on patients from faculty (physician, resident-physician, or sonographer) at each clinical site. The transmitted images were evaluated using a standardized grading rubric which was the same as that used during the Physical Diagnosis ultrasound assignments as part of the preclinical years of their medical education. This evaluation focused on image quality including appropriate labeling of organs, use of gain and depth, proper probe selection, and correct orientation (see grading rubrics Figure 2 and Figure 3). Students were given written feedback to help improve their image acquisition skills. Image interpretation and clinical integration were also evaluated during the weekly live videoconference.

Figure 2: Phase 3 EMED 5001 EM Clerkship FAST Ultrasound Assessment Rubric

FAST Exam: Focused Assessment with Sonography in Trauma					
25 points	**Score**	**12 points**	**Score**	**0 points**	**Score**
Acquires and correctly identifies RUQ – Hepatorenal recess on Long ultrasound image **(Label image: RUQ)**		Acquires and identifies RUQ – Hepatorenal recess on Long ultrasound image with limited errors **(Label image: RUQ)**		Unable to acquire and correctly identify RUQ – Hepatorenal recess on Long ultrasound image **(Label image: RUQ)**	
Acquires and correctly identifies Subcostal 4-Chamber heart on Trans ultrasound image **(Label image: SUBCOSTAL)**		Acquires and identifies Subcostal 4-Chamber heart on Trans ultrasound image with limited errors **(Label image: SUBCOSTAL)**		Unable to acquire and correctly identify Subcostal 4-Chamber heart on Trans ultrasound image **(Label image: SUBCOSTAL)**	
Acquires and correctly identifies LUQ – interface of spleen and diaphragm on Long ultrasound image **(Label image: LUQ)**		Acquires and identifies LUQ – interface of spleen and diaphragm on Long ultrasound image with limited errors **(Label image: LUQ)**		Unable to acquire and correctly identify LUQ – interface of spleen and diaphragm on Long ultrasound image **(Label image: LUQ)**	
Acquires and correctly identifies Pelvis / Urinary bladder on Trans ultrasound image **(Label image: PELVIS)**		Acquires and identifies Pelvis / Urinary bladder on Trans ultrasound image with limited errors **(Label image: PELVIS)**		Unable to acquire and correctly identify Pelvis / Urinary bladder on Trans ultrasound image **(Label image: PELVIS)**	
Total points ____ / Total points is the sum of your scores (Maximum Score = 100)					

Comments:

Figure 3: Phase 3 OBGN 5000 OB/GYN Clerkship OB Ultrasound Assessment Rubric

OB Point-of-care Ultrasound Exam					
25 points	**Score**	**12 points**	**Score**	**0 points**	**Score**
Correctly identifies **Fetal Heart Tones** on ultrasound image **(Label TRANS)**		Correctly identifies **Fetal Heart Tones** on ultrasound image with limited errors **(Label TRANS)**		Unable to correctly identify **Fetal Heart Tones** on ultrasound image **(Label TRANS)**	
Correctly measures **Fetal Heart Tones** on M-mode ultrasound image **(Label TRANS)**		Correctly measures **Fetal Heart Tones** on M-mode ultrasound image with limited errors **(Label TRANS)**		Unable to correctly measure **Fetal Heart Tones** on M-mode ultrasound image **(Label TRANS)**	
Correctly identifies **Fetal Presentation** on Long ultrasound image **(Label as Cephalic or Breech)**		Correctly identifies **Fetal Presentation** on Long ultrasound image with limited errors **(Label as Cephalic or Breech)**		Unable to correctly identify **Fetal Presentation** on Long ultrasound image **(Label as Cephalic or Breech)**	
Correctly identifies **Placental Location** on Long ultrasound image **(Label as Anterior or Posterior Placenta)**		Correctly identifies **Placental Location** on Long ultrasound image with limited errors **(Label as Anterior or Posterior Placenta)**		Unable to correctly identify **Placental Location** on Long ultrasound image **(Label as Anterior or Posterior Placenta)**	
Total points ____ / Total points is the sum of your scores (Maximum Score = 100)					

Comments:

Results

During the 2 academic terms discussed in this paper (2016-2017 and 2017-2018) 581 students participated in the 2 clerkships. During the pilot year the exams were not graded and did not count toward the students' grades. In the pilot year for the EMC 139 students participated. Despite many of the sites having preceptors that were unfamiliar with the FAST exam and not accustomed to using it in clinical practice, students required to complete the FAST exam had a 100% completion rate. Starting in 2017-2018 images submitted by students were assessed according to a rubric specifically designed for each clerkship (Figures 2 and 3). Some of the students did not submit adequate images initially due to poor image acquisition, or failure to submit a complete exam. However, all successfully resubmitted adequate images prior to the end of their clerkships. The vast majority (all but 2) submitted their images via cell phone. The others submitted de-identified JPEG images directly from the ultrasound machine.

During the 2017-2018 school year 256 students participated in the EM clerkship. In total, 27 students did not complete the assignment. However, of these 27 students, 13 were on a 2-week rotation and were not required to complete the assignment and 14 students dropped the course. Of note, 4 students obtained images with the probe in the incorrect orientation and one student selected an inappropriate probe (linear probe) for the FAST exam. Therefore, 229 students turned in images to be assessed by the ultrasonographer. Forty-one percent (95/229) students scored perfectly (100) on the assessment. Fifteen percent (35/229) received an 87 on the assessment. Of the remaining students, 25% (56/229) received an assessment score of between 60 and 79 while 19% (43/229) received a score of 50 or less. While image quality after transmission was an initial concern when developing the ultrasound curriculum, 100% of submitted

images were of adequate quality for grading purposes. No students were required to repeat the FAST exam or re-submit images due to the inability to visualize the transmitted image. During the first year (2017-2018) of the OB/GYN ultrasound implementation, 186 students enrolled in the clerkship with all but one of these students ultimately completing the assignment successfully. Students struggled more with ultrasound skills than with the process of turning in the assignment for grading. For example, 14 students did not label their images at all, 5 labeled their images incorrectly, 4 students did not include all relevant portions of the fetus in the image, and 2 did not provide all of the information for the assignment as per the instructions. None of the students were required to repeat the exam or resubmit images due to the inability to visualize the transmitted image. Students in the OB/GYN clerkship were assessed based on a rubric designed for the OB POCUS exam (Figure 3). Of the 186 students who submitted images for the OB/GYN clerkship, 73% (136/186) received a score of 100, 13% (25/186) received a score of 87, 4% (7/186) received a score of a 75, 3% (5/186) received a score of a 74, and the remaining 7% (13/186) students received a score of 50 or below.

Discussion

Many medical schools, both nationally and internationally, have begun to understand the value of incorporating POCUS into students' preclinical and clinical curricula; however, many continue to face barriers that limit its integration.[16] Prior publications such as the University of South Carolina's, *The evolution of an integrated ultrasound curriculum (iUSC) for medical students: 9-year experience*, discuss the integration of ultrasound into medical student's curricula.[9] These examples, however, focus on the integration of ultrasound into a single campus system. Many medical schools are comprised of multiple campuses and/or clinical sites, making a standard ultrasound curriculum difficult. Moreover, multiple campuses and sites preclude the standardization of equipment and consistency in the POCUS-ability and educational skills of clinical faculty.

EM and OB/GYN are ideal clerkships for the initial implementation of an integrated ultrasound curriculum because they inherently lack many of the barriers to ultrasound adoption in the clinical years of UME. First, most EM physicians regardless of practice location are aware of POCUS as it is part of the Accreditation Council for Graduate Medical Education (ACGME) curriculum for EM residents. Similarly, ultrasound is a critical component of antenatal health and documenting fetal development and plays a significant role in OB/GYN practice. Therefore, EM and OB/GYN faculty in both academic and community settings should have a working knowledge of how POCUS can be used in clinical practice. Second, many EDs have ultrasound available for procedural guidance, particularly for central venous access.[14] In addition, the necessity of ultrasound in the OB/GYN clinic guarantees accessibility for students and eases the burden of access for medical schools with a distributed campus. For the rare sites that do not have ultrasound equipment, medical schools can fill the void by providing small, portable ultrasound devices at a reasonable cost.[17] For these reasons, EM was chosen as the initial clerkship for ultrasound curriculum integration during the pilot year and, once feasibility was determined, was expanded to include the OB/GYN clerkship. While the barriers of faculty education and equipment can be overcome in most circumstances, the presence of an ultrasound education champion is optimal for success. Enthusiasm for the program, from the clerkship director down through the clinical faculty, is also important.

During the implementation of the ultrasound curriculum in the pilot year of the EM clerkship several technical and educational barriers were encountered. First, many EM sites did not use the FAST exam as part of their clinical practice. In order to overcome this, we made available online didactic videos (transmitted via a learning management system) to provide background information to each student throughout the rotation. A FAST module was also incorporated into the weekly educational half-day sessions where all students were connected to ultrasound faculty via teleconferencing video. Ultrasound faculty are emergency medicine trained physicians credentialed to use POCUS in clinical practice who have an interest in teaching ultrasound skills. These sessions included review of the important didactic components of the FAST exam, of how to perform the exam, and of ultrasound videos with and without pathology. All students were able to complete a technically adequate FAST exam at each location during their rotation during the initial project year.

While we provided ultrasound-trained physicians for the didactic sessions and sonographers were available at the OB/GYN clinical sites, clinical site faculty often are not trained in POCUS or in how to utilize ultrasound as a teaching tool. This is one of main barriers medical schools face when expanding ultrasound education from the pre-clinical years into the clinical years. Clinical faculty participating in this project were provided online, recorded didactic training and were invited to participate in the academic half-day educational sessions. In addition, EM and OB/GYN clerkships were selected specifically as the initial clerkships as their faculty, as a whole, have more experience with ultrasound. Lastly, in this model, students are expected to perform POCUS exams without direct faculty supervision. This is because students have been trained how to do these exams during the pre-clinical years.

Another barrier to implementation encountered in both EM and OB/GYN was having a secure, standardized, method for transferring ultrasound images to the clerkship directors for evaluation and assessment. Systems such as Q-path can easily be used to electronically transfer images for review when students are at a single site or single campus, however, in a distributed campus model, this can be a problematic solution

to implement. Each health system will have differing barriers such as the lack of wired or wireless connection, the need for licenses for using specific programming on the ultrasound machines, and other technical deficiencies. We found that the use of a learning management system, and cloud based storage ameliorated all transmission issues. In addition, students used their cell phones to capture and transmit anonymous images of the ultrasounds. There were no instances in which patient identifiers were accidentally included in these images.

Cost could be a barrier to integrating a new ultrasound curriculum into an UME curriculum because of the need to purchase technology and to upgrade to newer technology. Two of the 14 sites used for the EMC required a portable US be provided to them which did incur some (although arguably small) cost to the university. Medical schools that house many sites without US equipment may find this to be a greater hardship; however, with the advent of new portable ultrasound technology, specifically the tablet-based ultrasound probes, this barrier will continue to decline. It is of note that none of the OB/GYN sites used for clerkships were found to lack an ultrasound machine, which eased much of the cost burden and logistical issues for implementing the ultrasound curriculum into this clerkship.

Conclusion

As POCUS continues to become a major part of clinical diagnosis it is important that training be extended to all phases of UME including clinical rotations. Therefore, finding ways to effectively implement a POCUS curriculum into the clinical years of UME is necessary. Implementing an ultrasound curriculum into the pre-clinical years has been done in most medical schools. Integration into clinical clerkships can be more difficult due to a variety of barriers that are even greater for schools with a distributed campus model. However, in this paper we have outlined and demonstrated the feasibility of integrating a POCUS curriculum into 2 UME core clinical clerkships in a distributed campus model. As described above we encountered more barriers in one clerkship, EM, than the other, OB/GYN, but the barriers were not insurmountable. Minor difficulties such as lack of equipment, lack of standardization of equipment, and image transfer were overcome.

This pilot project provides a starting point from which to implement a POCUS curriculum over a UME distributed campus model. Future efforts will include more qualitative data collection, such as assessments and student self-evaluations of ultrasound skills before and after their clerkships and student feedback specifically on the ultrasound component of the clerkships. This information may help improve the integration of POCUS into future EM and OB/GYN clerkships as well as be used to design and implement POCUS into other clinical clerkships.

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