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Evaluating the Efficacy and Feasibility of a Self-Directed Asynchronous Ultrasound Curriculum to Learn Point-of-Care Ultrasound (POCUS): A Pilot Study

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Abstract

Background: Point-of-care ultrasound (POCUS) has become increasingly incorporated into medical school curricula in recent years, despite the rigorous demands of undergraduate medical education. This study aims to explore the feasibility and efficacy of a self-directed ultrasound curriculum to increase undergraduate medical students' knowledge and proficiency in ultrasound techniques outside of the classroom. Additionally, this study explores the use of anatomically based ultrasound models to test students' proficiency by demonstrating their ability to accurately identify and measure various pathologies.

Methods:

We designed an asynchronous ultrasound curriculum and used anatomically based ultrasound models to provide an objective measure of each student's ultrasound technique. Second-year medical students were given access to an assigned Butterfly ultrasound probe, instructed to watch fifty Butterfly iQ training videos, and asked to practice the ultrasound skills throughout a four-week time frame. Students were also encouraged to attend a two-hour training session with a paid sonographer two weeks before the assessment day, where they could ask questions and practice techniques. To evaluate the efficacy of the curriculum, a sonographer used a checklist to grade each student's ultrasound technique and record their measurements of a breast mass and crown-rump length.

Results:

Students' (n=39) overall mean of measurements for both the breast and crown rump length models was an underestimation of the true measurements. Between both models, the majority of participants were able to correctly perform key steps while using the ultrasound, such as rocking and fanning the probe, identifying the mass/fetus, and storing the settings. However, a few students had difficulty picking the correct ultrasound setting, choosing the appropriate orientation, and adjusting depth.

Conclusion: An asynchronous ultrasound curriculum incorporated into undergraduate medical school education may be an effective means of teaching students technical steps in conducting an ultrasound outside of the classroom. Students were able to perform key ultrasound techniques, demonstrating their ability to learn and practice on their own. Refining the models to combat natural variation in their structure over time may translate to improved outcomes in determining the effectiveness of an asynchronous point-of-care ultrasound (POCUS) curriculum in teaching students to accurately measure a breast mass or crown-rump length. Further research is needed to establish objective assessment methods that allow students to demonstrate hands-on ultrasound skills beyond image interpretation and multiple-choice examinations.

Background

Ultrasound curricula have become increasingly more common in undergraduate medical education in recent years due to the high demand for the development of point-of-care ultrasound (POCUS) skills and their incorporation into pre-clinical anatomy curricula. Literature has described ultrasound as a core educational modality and highlighted the need for national standards to guide the integration of ultrasound into medical school curricula (1). Early exposure to POCUS has been shown to enhance students' procedural readiness, anatomy knowledge, and image interpretation skills, better preparing students for clinical rotations and residency (2, 3). POCUS curricula have gained traction in many residency programs, further justifying its place in medical school curricula (4–7). Core clinical ultrasound milestones for medical students have been established in previous literature, but the exact implementation and assessment methods are still being explored (8). Many medical schools have proceeded to incorporate POCUS into preclinical curricula, but there is wide variation in the curriculum design and implementation across institutions, including differences in the instructional format (asynchronous vs. synchronous), curricular composition (self-directed modules vs. in-person instruction), and duration of the educational training (length of course and number of sessions) (9–12).

To evaluate the effectiveness of these curricula, the majority of studies to date use written assessments to measure students' understanding via free-response or multiple-choice questions (12). While these tools can assess conceptual understanding, they often inadequately assess core POCUS techniques and technical abilities, such as probe handling and accurate measurement of pathology (13). In fact, only a few studies have tested students' hands-on skills by assessing their ultrasound proficiency through the accurate identification and measurement of anatomical structures after curriculum completion (13, 14).

Asynchronous ultrasound curricula have the potential to offer scalable, resource-conserving instructional benefits in ultrasound education, especially for institutions with limited access to faculty, resources, or time (15, 16). However, in this instructional format, there is limited evidence regarding the effectiveness of teaching fundamental technical POCUS skills such as image acquisition and measurement accuracy. The use of generalized ultrasound models has been discussed for students to enhance their training (17).

This study seeks to address this gap by evaluating both the feasibility and effectiveness of a self-directed asynchronous POCUS curriculum for second-year medical students, by assessing students' ability to correctly perform technical ultrasound steps, as well as accurately identify and measure clinically relevant structures using two anatomically based ultrasound models: crown rump length and the length and width of a breast mass.

Methods

Design and Participants

This was a quasi-experimental study design approved by Edward Via College of Osteopathic Medicine's (VCOM) Institutional Review Board. The population pool included second-year students from the VCOM-

Carolinas Campus. The study took place at the VCOM-Carolinas campus from November 2024 through March 2025. Students were recruited through an email sent by the principal investigator. All participants provided consent and were made aware that participation in the study or lack thereof would not impact their academic standing. Students who did not want to participate but still wanted to benefit from the curriculum were able to participate upon completion of the study period. Inclusion criteria included being a second-year medical student at VCOM Carolinas and willingness to attend the assessment day. Exclusion criteria included previous experience training with a handheld Butterfly ultrasound probe. Forty-three students initially agreed to participate in the study. Students were sent a poll to see which four-week block they would prefer to participate in, and were split into the three sessions accordingly. Eighteen students started in session 1; however, one student's data was excluded from the study due to meeting the exclusion criterion. 10 students participated in session 2, and all their data were collected. Sixteen students were enrolled in session 3; however, two students' data were not obtained due to personal circumstances that prohibited them from attending the scheduled assessment day. A total of 39 second-year medical students voluntarily participated in and provided data for the study during three separate four-week sessions.

At the beginning of each session, a meeting was held on campus at which each student was assigned a Butterfly iQ ultrasound probe (including the gel and charging equipment) and was asked to read and sign a consent form. These probes were chosen due to availability, affordability, and portability with educational content. Students were then shown how to download the Butterfly iQ app onto their device and how to charge the probe. Students were asked to watch 50 Butterfly iQ training videos and practice the ultrasound skills throughout the four weeks. These videos consisted of focused tutorials of ultrasound exams of the abdomen, heart, kidneys, and pelvis, along with additional instruction on basic ultrasound skills. The total video time was approximately 90 minutes. They were also encouraged to attend a two-hour training session with a sonographer two weeks before the assessment day.

Training Session

During the two-hour training session, students were able to ask the sonographer questions and practice their skills with fellow participants. The crown rump length and breast model were not available to practice on during the training sessions; however, students were able to practice ultrasounding each other and receive feedback from the ultrasonographer on technique.

Assessment

At the end of the four weeks, the sonographer used a checklist to grade each student's ultrasound technique and record their measurements of a breast mass and crown-rump length. The skill checklist was adapted from a previous study, but adapted to fit the models in this study (18). It included variables such as selecting the correct ultrasound setting and orientation, applying an appropriate amount of gel, demonstrating fanning and rocking, adjusting depth and contrast, identifying and measuring the

mass/fetus, and saving the image. The crown rump length model was a plastic “fetus” contained in a water-filled balloon, which was placed in a silicone medium. This model was not validated before use in the study. The breast model was primarily a silicone medium that contained a plastic mass, which represented a breast mass and could be inserted into the model breast for ultrasound practice. The breast model was previously validated in another study prior to its use in this study. The creators of both models gave their permission for them to be used in this study. The sonographer took measurements of both models before the first assessment session, and those measurements were considered the true/correct values when analyzing participant measurements.

Statistical Analysis

Analyses began by summarizing the means and standard deviations of the recorded length and width of the breast model. 39 students reported length, while only 37 reported width. Using 95% confidence intervals, we tested whether there was evidence of underestimation or overestimation by dimension. Similarly, for the crown rump length model, we calculated the mean and standard deviation and 95% confidence interval for the mean to examine evidence of overestimation or underestimation. All analyses were repeated by session. Exact 95% confidence intervals were calculated for the proportions measuring whether the student correctly performed key steps while conducting the ultrasound. All analyses were conducted in SAS 9.4.

Results

39 second-year students participated in the study. Across all three sessions, the mean breast mass length was 2.16 centimeters (cm) with an actual length of 2.65 cm (95% CI [2.04, 2.28], n = 39) (Table 1). The mean breast mass width was 1.57 cm with an actual width of 1.46 cm (95% CI [1.48, 2.28], n = 39) (Table 2). The mean crown-rump length was 4.02 cm with an actual length of 4.76 cm (95% CI [3.76, 4.27], n = 37) (Table 3). Within the breast mass measurements, there was a 100% success rate for applying gel to the probe, choosing the correct orientation, adjusting the depth, rocking, fanning, measuring the lesion, and storing settings (95% CI [0.91, 1.00], n = 39), and a 97% success rate for choosing the correct setting and correctly identifying the lesion (95% CI [0.87, 0.99], n = 39) (Table 4). For the crown rump length measurements, there was 100% success rate for applying gel to the probe, rocking, fanning, correctly identifying the fetus, measuring the fetus, and storing settings (95% CI [0.91, 1.00], n = 39), and a 97% success rate for choosing the correct setting, choosing the correct orientation, and adjusting depth (95% CI [0.87, 0.99], n = 39) (Table 5).

Table 1
Estimated Breast Mass Width By Session

Estimated Breast Mass Width By Session					
Session	N	Mean ± STD	95% CI for Mean	Truth	Conclusion
1	16	2.25 ± 0.50	(1.99, 2.52)	2.65	Under Estimation
2	9	2.31 ± 0.21	(2.14, 2.48)	2.65	Under Estimation
3	14	1.95 ± 0.20	(1.84, 2.07)	2.65	Under Estimation
All Sessions	39	2.16 ± 0.38	(2.04, 2.28)	2.65	Under Estimation

Table 2
Estimated Breast Mass Length By Session

Estimated Breast Mass Length By Session					
Session	N	Mean ± STD	95% CI for Mean	Truth	Conclusion
1	16	1.72 ± 0.18	(1.62, 1.82)	1.46	Over Estimation
2	7	1.25 ± 0.20	(1.07, 1.44)	1.46	Under Estimation
3	14	1.56 ± 0.27	(1.41 1.72)	1.46	Correct Estimation
All Sessions	37	1.57 ± 0.28	(1.48, 2,28)	1.46	Under Estimation

Table 3
Estimated Crown Rump Length By Session

Estimated Crown Rump Length By Session					
Session	N	Mean ± STD	95% CI for Mean	Truth	Conclusion
1	16	4.39 ± 0.98	(3.86, 4.91)	4.76	Correct Estimation
2	9	3.61 ± 0.41	(3.30, 3.93)	4.76	Under Estimation
3	14	3.86 ± 0.57	(3.54, 4.19)	4.76	Under Estimation
All Sessions	39	4.02 ± 0.79	(3.76, 4.27)	4.76	Under Estimation

Table 4
Breast Model Skills Check-Off

Breast Model Skills Check-Off				
Variable	N	Number of Yes	Percent	Exact 95% CI
Correct Setting	39	38	0.97	(0.87,0.99)
Applied Gel	39	39	1.00	(0.91,1.00)
Correct Orientation	39	39	1.00	(0.91,1.00)
Adjust Depth	39	39	1.00	(0.91,1.00)
Rocking Technique	39	39	1.00	(0.91,1.00)
Fanning Technique	39	39	1.00	(0.91,1.00)
Correct Identification	39	38	0.97	(0.87,0.99)
Measured Lesion	39	39	1.00	(0.91,1.00)
Stored Settings	39	39	1.00	(0.85,1.00)

Table 5
Crown Rump Length Skills Check-Off

Crown Rump Length Skills Check-Off				
Variable	N	Number of Yes	Percent	Exact 95% CI
Correct Setting	39	38	0.97	(0.87,0.99)
Applied Gel	39	39	1.00	(0.91,1.00)
Correct Orientation	39	38	0.97	(0.87,0.99)
Adjust Depth	39	38	0.97	(0.87,0.99)
Rocking Technique	39	39	1.00	(0.91,1.00)
Fanning Technique	39	39	1.00	(0.91,1.00)
Correct Identification	39	39	1.00	(0.91,1.00)
Measured Lesion	39	39	1.00	(0.91,1.00)
Stored Settings	39	39	1.00	(0.91,1.00)

Discussion

In this education intervention, we describe the integration of a self-directed asynchronous ultrasound curriculum in an institution that did not at the time have formal ultrasound training as part of the preclinical curriculum. Point-of-care ultrasound (POCUS) is becoming increasingly relevant within

medical practice across specialities. There is extensive literature suggesting that early exposure to POCUS skills correlates with increased independence and comfort in visualizing human anatomy and obtaining high-quality images (2, 17, 19). Despite this, many schools have been unable to incorporate ultrasound into their crowded curricula, especially with limited faculty. This paper aims to provide a framework for institutions to implement a self-directed asynchronous ultrasound curriculum and demonstrate that it can be an effective means for students to become proficient in POCUS.

The introduction of the preclinical ultrasound curriculum was presented as an optional educational opportunity. Similar integration has been implemented in previous studies, however few implement the practice as self-directed with quantitative measures to determine proficiency. The four-week sessions were easy to implement as the practice and assessment occurred outside of regular education hours so as not to interfere with students' exam and class schedules. Since students were still in their preclinical years and did not yet have access to ultrasound in a clinical setting, they were encouraged to practice on friends and family. A paid sonographer was used for the optional training session and assessment.

Findings suggest that this is a feasible and effective method to teach the technical fundamentals of POCUS to preclinical medical students. Students showed strong proficiency in image acquisition and ultrasound technique. Additionally, numerous students took advantage of the optional training session to practice with the sonographer. It was clear that students were passionate about taking the time to work through the curriculum, which was reflected in their ability to replicate the proper ultrasound techniques. This aligns with studies indicating students' desire for an ultrasound curriculum during their undergraduate medical education and their understanding of its clinical importance (20, 21). In regard to the content of the curriculum and equipment, the Butterfly iQ modules and probes were easy to use and contained all the necessary material for students to cover basic ultrasound techniques and focused exams. While the quantitative assessment required measurement of a breast mass and crown rump length, students had the added benefit of learning how to perform a cardiac, renal, and general abdominal exam, along with focused assessment with sonography for trauma (FAST). This allowed students to develop well-rounded skills to help them prepare for the variety of clinical diagnoses they will encounter during their clinical rotations.

Additional research is needed to improve quantitative measurement accuracy in asynchronous POCUS curricula. There was variability between the groups in accurately measuring the models. This project was a means of validating the models, but further evaluation revealed some inconsistencies. The variability was largely attributed to the compressibility of the models and changes in the models over time, which are limitations of the data. Applying a greater amount of pressure led to larger measurements, and the models became more malleable over the course of the study. An additional limitation is that attendance was not recorded at the optional training sessions to determine whether those who attended performed better than those who did not. This study would also benefit from a follow-up study to assess the long-term outcomes of students who decided to participate in the study.

Studies exploring ultrasound curricula can help determine optimal strategies to incorporate this material in a manner that is conducive to student learning. Since preclinical years have much ground to cover regarding clinical knowledge in the classroom, an asynchronous curriculum with video instruction could allow students the time to learn and practice these skills on their own to prepare for their clinical years. This research could be expanded with refinement of the ultrasound models used in this study in order to have more consistent, accurate results for students to test their abilities. The study may also benefit from the use of the ultrasound competency assessment tool (UCAT). This validated instrument allows for targeted assessment across four main domains, including preparation, image acquisition, image optimization, and clinical integration (22). This tool extends beyond the checklist used in this study to evaluate higher-order skills, including clinical indications and image interpretation. Use of instruments such as UCAT and frameworks like the Objective Structured Assessment of Ultrasound Skills (OSAUS) would allow for greater standardization of evaluation while incorporating the significance of clinical findings (22, 23). Further research may also examine the relationship between performance on ultrasound techniques/measurements and attendance at the optional practice sessions with the sonographer.

Conclusion

This study illustrates how a self-directed asynchronous ultrasound curriculum is an effective means for students to learn the technical skills behind point-of-care ultrasound (POCUS). Students demonstrated interest and proficiency, suggesting potential for integration into the formal curriculum with standardized training and evaluation across cohorts. The framework of this study can be used in future ultrasound education interventions through the use of ultrasound-compatible models and/or an asynchronous curriculum.

Abbreviations

POCUS
point-of-care ultrasound
VCOM
Edward Via College of Osteopathic Medicine
FAST
focused assessment with sonography for trauma
UCAT
ultrasound competency assessment tool

Declarations

Ethics Approval and Consent to Participate:

Approved by VCOM Institutional Review Board on 10/23/2024. Board reference number 2024 – 145. All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional research committee and with the Helsinki Declaration. Informed consent was obtained from all individual participants included in the study.

Consent for Publication:

Not applicable

Competing Interests:

Not applicable.

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Author Contribution

MA, AB, and AV designed the curriculum, organized the study, and contributed to writing the manuscript. DR performed analysis and interpretation of participant data. TL provided supervision and guidance for the project. All authors read and approved the final manuscript.

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Data Availability

: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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