Virtual Multi-Specialty Point-of-Care Ultrasound Rotation for 4th Year Medical Students during COVID-19: Innovative Teaching Techniques Improve Ultrasound Knowledge and Image Interpretation

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Abstract:

Objectives

Point-of-Care Ultrasound (PoCUS) has been integrated into undergraduate medical education. The COVID-19 pandemic forced medical schools to evolve clinical rotations to minimize interruption through implementation of novel remote learning courses. To address the students’ need for remote clinical education, we created a virtual PoCUS course for our fourth year class. We present details of the course’s development, implementation, quality improvement processes, achievements, and limitations.

Methods

A virtual PoCUS course was created for 141 fourth-year medical students. The learning objectives included ultrasound physics, performing and interpreting ultrasound applications, and incorporating PoCUS into clinical decisions and procedural guidance. Students completed a 30-question pre and post-test focused on ultrasound and knowledge of clinical concepts. PoCUS educators from 10 different specialties delivered the course over 10 days using video-conferencing software. Students watched live scanning demonstrations and practiced ultrasound probe maneuvers using a cellular telephone to simulate ultrasound probe. Students completed daily course evaluations which were used as a continuous needs assessment to make improvements.

Results

141 students participated in the course, all received a passing grade. The mean pre and post-test scores improved from 58% to 88% (p <0.001) through the course duration. Daily evaluations revealed the percentage of students who rated the course’s live scanning sessions
and didactic components as “very well” increased from 32.7% on day 1 to 69.7% on day 10. The end-of-course evaluation revealed 91% of students agreed they received effective teaching.

Conclusions

In response to the COVID-19 pandemic, our multi-specialty faculty expeditiously developed a virtual PoCUS curriculum for the entire fourth year class. This innovative course improved students’ ultrasound knowledge, image interpretation and clinical application while utilizing novel techniques to teach a hands-on skill virtually. As the demand for PoCUS instruction continues to increase, the accessibility of virtual training and blended learning will be beneficial.

Need for Innovation

As the impact of the COVID-19 pandemic spread across the United States, medical schools were forced to make difficult decisions regarding student participation in patient care. Concerns for high viral infectivity, health risks, social distancing, and shortage of personal protective equipment forced medical schools to remove students from their clinical rotations and transition to remote learning. Educators responded by rapidly developing virtual content to minimize disruption of their students’ education.

Background

Point-of-Care Ultrasound (PoCUS) is used by many specialties to increase diagnostic accuracy, improve safety, reduce radiation exposure, and increase patient satisfaction. There has been an increased integration of PoCUS training in post-graduate and undergraduate medical education. Literature suggests a benefit from integrating PoCUS into medical specialty education and general consensus that ultrasound is important to teach to all medical students.

PoCUS training is a very attractive pedagogy for undergraduate medical education programs but has several implementation challenges including limited curriculum time, expense of equipment, budget constraints, and undertrained faculty. Many of these limitations can be addressed through blended learning that incorporates web-based education with live sessions. Blended learning has been shown to improve proficiency, operator confidence and clinical outcomes. As more undergraduate programs integrate PoCUS education, it is
important to recognize the utility of blended web-based modalities that overcome traditional barriers to ultrasound implementation.\textsuperscript{7,16,22}

Our institution has an integrated ultrasound curriculum (IUC) through all 4 years of undergraduate medical education. The first and second year of instruction use a flipped classroom format with recorded video lectures followed by hands-on ultrasound lab sessions. During third year, students participate in skills labs focused on successfully implementing PoCUS into patient care. Prior to COVID-19, a 4-week PoCUS elective was offered to fourth year students using recorded lectures, online didactics and hands-on scanning sessions by instructors from 10 specialties. In March 2020, the medical school leadership approached the PoCUS elective directors to develop a 2-week virtual clinical PoCUS course for the graduating students remote COVID curriculum.

Objective of Innovation

Objectives for the novel 4\textsuperscript{th} year virtual PoCUS course were for learners to develop a cognitive knowledge of the elements and interpretation of common PoCUS exams and gain an understanding of how to operate the machine, correctly acquire images, and incorporate PoCUS into clinical decision making. The goal of this novel PoCUS course was to create a virtual approximation of the existing 4\textsuperscript{th} year PoCUS elective for the entire class through teaching general ultrasound knowledge, scanning techniques and clinical PoCUS application.

Developmental Process

Ultrasound faculty from various specialties involved in the PoCUS elective provided the didactics and live interactive sessions through Webex video-conferencing software (Cisco Webex, California, USA). This software allowed the presenter to share their screen with participating students who were learning from home across the country. A “chat” function within Webex allowed students to ask questions, and share in discussions. A drawing tool was used for labeling ultrasound images and presenters used live polls to ask multiple choice questions. These sessions were recorded and made available to students unable to attend.

Given the 4-week time period for course development and expected challenges of virtual delivery, a continuous needs assessment using Likert scale was conducted daily. This utilized Problem Identification and General Needs Assessment from Kern’s Curriculum Development,
enabling assessment to proceed alongside course delivery. Kern’s model notes the importance of targeted student needs assessments during a time of limited clinical resources in a unique environment. This daily feedback was used to implement dynamic changes for the following day’s didactics and improve the student experience.

The Implementation Phase

The curriculum was taught over 10 days with a different specialty focus each day. The daily schedule began with viewing recorded lectures, reading assignments, and case reviews. The didactics were uploaded to the medical school learning management system to coordinate lectures, post schedules, track assignments, complete needs assessments, and testing. This was followed by virtual conference instruction with other students and faculty.

To teach ultrasound probe manipulation, students participated in live Webex scanning demonstrations utilizing a handheld ultrasound device to review PoCUS applications. These sessions involved the course director scanning his family members with a handheld ultrasound. The imaging screen was visualized on a laptop using Reacts video-guidance software© and the laptop screen was shared over Webex. To synchronize the movement on the ultrasound screen with the verbal description of the scanning activity, an independent camera directed at the scanning region was incorporated.

Students practiced ultrasound probe maneuvers including sliding, rocking, tilting, rotation and compression using their smart phone camera directed toward specific targets. The students created a 3 by 3 grid on a wall with post-it notes 12 inches apart. Their cell phone was held as a probe and placed on top of the thigh while seated. With the camera facing the wall, it was positioned so the post-it note target was centered on the cell phone screen. This low-fidelity probe simulation replaced hands on instruction and allowed every student to practice their probe manipulation skills at no cost. Compared to our normal 4-week POCUS elective that includes direct observation testing of scanning technique, our virtual course did not have the ability to test psychomotor skills.

Outcomes

A multiple-choice test with 30 questions including ultrasound images and clinical PoCUS knowledge was administered before and after the course. A paired-samples t-test was conducted...
to compare pretest and posttest scores. All 141 fourth-year medical students completed the pre and post-tests. The mean pre-test score was 58% (12.67 questions correct, SD=3.35) and the mean post-test score was 88% (26.52 questions correct, SD=1.85) which was a significant difference (p < 0.001).

The student daily feedback responses asked each student to select between “very well”, “okay” or “not so much” for each question. Open ended questions on “What can be improved?” are included in daily feedback to let student provide detailed suggestions on course improvements. Daily emails came from course director addressed the students comments and major learning issues. The percentage of students who rated the courses’ prepared lecture, web-based scanning and question and answer sessions as “very well” improved from day 1 to 10 (see Table 1) as a result of the continuous needs assessment process. The student assignments included keeping a daily PoCUS learning journal with the format determined by the student and summarizing a PoCUS research manuscript applicable to their future specialty. The course was pass-fail with a passing grade obtained if the student participated in online sessions, completed assignments, and received >50% on the post-test. All 141 students improved their score on posttest when compared to their pretest score with the lowest posttest score being 60%. All students completed the required assignments and passed the course. Seventy-five students completed the optional end of course evaluation and reported the most engaging aspects of the course were web-based scanning sessions, daily feedback, clinical cases, polling questions, and interpersonal interaction with faculty’s family members. The areas for improvement included access to portable ultrasound, inclusion of hands-on scanning, minimizing topic overlap, and limiting technical difficulties.

Reflective Discussion

The COVID-19 pandemic forced medical schools to limit in person teaching and find other modalities to educate students. This course illustrates that cognitive testing and general scanning techniques for POCUS can be taught virtually in circumstances where in-person instruction is limited. We targeted improvement in ultrasound knowledge and interpretation by focused objectives, web-based scanning sessions, remote scanning technique practice and continuous needs assessments.
The pandemic presented numerous challenges for implementation of this virtual curriculum including rapidly changing schedules, limited time for curriculum development, coordinating multiple faculty, and students in different time zones. Our course did demonstrate the benefits and success of integrating instruction from a multi-disciplinary ultrasound faculty. The 10 faculty members were able to adapt to virtual POCUS education responsibilities while providing the students with a broad range of clinical exposure including Neuro Critical Care, Medical Critical Care, Emergency Medicine, Internal Medicine, Sports Medicine, General Neurology, Pediatric and Adult Cardiology, Trauma and Obstetrics. Attempting to teach a hands-on-skill remotely requires innovative methods capitalizing on virtual platforms and utilizing cellphone video technology to practice scanning technique. For future virtual courses, the ability to provide hand-held ultrasound devices for the students to practice scanning at home would be ideal. In addition, training educators to use web-based platforms would improve didactic presentations.

Medical students at our institution complete longitudinal ultrasound training so the results of this study may not be generalizable to other institutions with more limited training. In addition, all web-based scanning demonstrations were performed on healthy patient models, which limited the students’ ability to visualize pathology and scan a wide variety of patients. Experts agree that hands-on scanning is a necessary component of developing ultrasound competency and we were unable to assess student’s technical proficiency through our course assessments.

The COVID-19 pandemic presented significant challenges to medical school scheduling and clinical education, in response a multi-specialty faculty expeditiously developed a virtual PoCUS curriculum for the entire fourth-year class. This innovative course improved students’ ultrasound knowledge and image interpretation while utilizing novel techniques to teach a hands-on skill virtually. The success of this ultrasound course has led to interest in creating a blended virtual 2-week clinical POCUS experience for all 4th year medical students.

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References

1. Moore, C.L. and J.A. Copel, *Point-of-care ultrasonography*. N Engl J Med, 2011. **364**(8): p. 749-57.

2. Howard, Z.D., et al., *Bedside ultrasound maximizes patient satisfaction*. (0736-4679 (Print)).

3. Rempell, J.S., et al., *Pilot Point-of-Care Ultrasound Curriculum at Harvard Medical School: Early Experience*. The western journal of emergency medicine, 2016. **17**(6): p. 734-740.

4. Bahner, D.P., et al., *The state of ultrasound education in U.S. medical schools: results of a national survey*. (1938-808X (Electronic)).

5. Hoppmann, R.A., et al., *The evolution of an integrated ultrasound curriculum (iUSC) for medical students: 9-year experience*. (2036-3176 (Print)).

6. Phelps, A., et al., *Incorporation of Ultrasound Education Into Medical School Curricula: Survey of Directors of Medical Student Education in Radiology*. (1878-4046 (Electronic)).

7. Dietrich, C.F., et al., *Medical Student Ultrasound Education: A WFUMB Position Paper, Part I*. Ultrasound in Medicine & Biology, 2019. **45**(2): p. 271-281.

8. Lewiss, R.E., et al., *Point-of-Care Ultrasound Education*. Journal of Ultrasound in Medicine, 2014. **33**(1): p. 27-32.

9. Filippucci, E., et al., *E-learning in ultrasonography: a web-based approach*. (0003-4967 (Print)).

10. Muller, M., J.P. Duperret S Fau - Viale, and J.P. Viale, [E-learning in medicine: appraisal and perspectives. Example of an educational website about echocardiography in anaesthesia, intensive care and emergencies: www.echorea.org]. (1769-6623 (Electronic)).

11. Sekiguchi, H., et al., *A general Critical Care Ultrasonography workshop: results of a novel Web-based learning program combined with simulation-based hands-on training*. Journal of Critical Care, 2013. **28**(2): p. 217.e7-217.e12.

12. Cook, D.A., *Web-based learning: pros, cons and controversies*. (1470-2118 (Print)).
13. Cantarero-Villanueva, I., et al., Evaluation of e-learning as an adjunctive method for the acquisition of skills in bony landmark palpation and muscular ultrasound examination in the lumbopelvic region: a controlled study. (1532-6586 (Electronic)).

14. Arroyo-Morales, M., et al., A blended learning approach to palpation and ultrasound imaging skills through supplementation of traditional classroom teaching with an e-learning package. (1532-2769 (Electronic)).

15. Breitkreutz, R., et al., Focused echocardiography entry level: new concept of a 1-day training course. (1827-1596 (Electronic)).

16. Hoppmann, R.A., et al., An integrated ultrasound curriculum (iUSC) for medical students: 4-year experience. (2036-3176 (Print)).

17. Cook, D.A. and D.M. Dupras, A practical guide to developing effective web-based learning. Journal of general internal medicine, 2004. 19(6): p. 698-707.

18. Kern DE, T.P., Howard DM, Bass EB, Curriculum Development for Medical Education: A Six-step Approach. 1998: The Johns Hopkins University Press.

19. McKimm, J., C. Jollie, and P. Cantillon, ABC of learning and teaching: Web based learning. BMJ (Clinical research ed.), 2003. 326(7394): p. 870-873

20. Norman, G.R., S.I. Shannon, and M.L. Marrin, The need for needs assessment in continuing medical education. BMJ, 2004. 328(7446): p. 999-1001.

21. Anstey, J.E., T.P. Jensen, and N. Afshar, Point-of-Care Ultrasound Needs Assessment, Curriculum Design, and Curriculum Assessment in a Large Academic Internal Medicine Residency Program. South Med J, 2018. 111(7): p. 444-448.

22. Glass, C., Sarwal, A., Zavitz, J. et al, Scoping review of implementing a longitudinal curriculum in undergraduate medical education: The wake forest experience., Ultrasound J, 13, 23 (2021). 111(7): p. 444-448.
|       | Prepared recorded lectures | Live WebEx | Q/A    | Average |
|-------|-----------------------------|------------|--------|---------|
| Day 1 | 42%                         | 25%        | 31%    | 32.7%   |
| Day 2 | 59%                         | 59%        | 56%    | 58.0%   |
| Day 3 | 63%                         | 62%        | 48%    | 57.7%   |
| Day 4 | 59%                         | 68%        | 49%    | 58.7%   |
| Day 5 | 59%                         | 61%        | 63%    | 61.0%   |
| Day 6 | 75%                         | 76%        | 73%    | 74.7%   |
| Day 7 | 68%                         | 68%        | 59%    | 65.0%   |
| Day 8 | 63%                         | 78%        | 73%    | 71.3%   |
| Day 9 | 61%                         | 70%        | 65%    | 65.3%   |
| Day 10| 66%                         | 71%        | 72%    | 69.7%   |