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Transforming Learning Anatomy: Basics of Ultrasound Lecture and Abdominal Ultrasound Anatomy Hands-on Session

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Abstract

Introduction: As point-of-care ultrasound units become more compact and portable, clinicians in over 20 different medical and surgical specialties have begun using the technology in diverse clinical applications. However, a knowledge gap still exists between what medical students are learning in their undergraduate medical education curriculum and the clinical skills required for practice. Over the last 10 years, point-of-care ultrasound content has been slowly incorporated into undergraduate medical education, yet only a handful of medical schools have developed ultrasound curricula. This module was developed at our institution in response to survey feedback from medical students overwhelmingly requesting preclerkship ultrasound education. The target audience for this module is first-year medical students with no prior ultrasound exposure. **Methods:** The module consists of a 1-hour introductory lecture and a 1-hour hands-on session during the abdominal anatomy course. Associated materials include the introductory lecture, presenter notes for the introductory lecture, instructor guidelines for the hands-on session, hands-on session setup instructions, a student handout for the hands-on session, and a module evaluation form. **Results:** We have successfully implemented this module for the past 3-years and learner feedback has been overwhelmingly positive. Learner comments on a postmodule survey included, "Great job of explaining the science behind ultrasounds as well as how to interpret the images." **Discussion:** As a result of our first-year students' evaluation responses, this module has been incorporated into our medical school's anatomy course.

Keywords

Anatomy, Bedside Ultrasound, Point-of-Care Ultrasound, Ultrasound Curriculum

Appendices

- A. Basics of Ultrasound Lecture.pptx
- B. Lecture Presenter Notes .pdf
- C. Hands-on Session Instructor Guidelines.docx
- D. Hands-on Session Setup Instructions.docx
- E. Student Handout for Hands-on.pdf
- F. Postmodule Evaluation Form.docx

All appendices are peer reviewed as integral parts of the Original Publication.

Educational Objectives

By the end of this session, the learner will be able to:

1. Describe the relationship between wavelength and frequency of sound waves.
2. Describe the conversion between electrical and mechanical energy necessary for the function of an ultrasound machine.
3. Describe the phenomenon of echogenicity.
4. Describe the main knobs on an ultrasound machine and their functions.
5. Describe the main ultrasound modes, including 2D, M-mode, color flow Doppler, and spectral Doppler.
6. Identify the gallbladder, liver, right kidney, Morison's pouch, spleen, left kidney, and splenorenal recess.
7. Utilize color flow and spectral Doppler to understand the anatomy of the portal triad.
8. Identify the inferior vena cava and abdominal aorta in long- and short-axis, and use color flow and spectral Doppler to appreciate different flow patterns between the two structures.

Introduction

In 2011, a landmark article in the *New England Journal of Medicine* entitled “Point-of-Care Ultrasonography” described more than 20 medical and surgical specialties currently using point-of-care ultrasound performed by clinicians in their practice.¹ However, only a handful of medical schools have developed ultrasound curricula in response to this knowledge gap.²⁻⁴ Point-of-care ultrasound teaching within undergraduate medical education (UME) has been shown to have several benefits, including understanding anatomy and physiology, learning physical exam and procedural skills, and highlighting the use of an important clinical application.

Of those medical schools with a point-of-care ultrasound curriculum, most do not begin ultrasound teaching until during clerkships; however, anatomy appears to be an optimal time to begin teaching ultrasound.⁵⁻⁷ Recent literature has shown students give high marks to ultrasound teaching during anatomy courses. One prior study showed that teaching cardiac anatomy using ultrasound was equally as effective as using cadaveric dissections.⁸ Another study found that ultrasound’s effectiveness in improving students’ understanding of anatomy correlated with students’ increased confidence in identifying anatomical structures.⁹

Of note, in 2014, a group of radiology educators published an article entitled “National Ultrasound Curriculum for Medical Students” to aid medical schools in incorporating ultrasound into their curricula.¹⁰ The authors offered an example of a preclinical curriculum model in outline form, without any specific details regarding resources or specific steps required for implementation.

A needs assessment at our institution revealed that 96% of emergency medicine rotators, consisting of second-, third-, and fourth-year medical students, desired additional ultrasound teaching during their preclerkship curriculum.¹¹ This module was developed to address that need. The module consists of a lecture on the basics of ultrasound followed by a hands-on abdominal ultrasound anatomy session offered during the abdominal anatomy course in the first semester of the preclerkship curriculum. Compared to presently available resources, this module offers step-by-step instructions, as well specific resources needed, to incorporate ultrasound content into the preclerkship curriculum.

Methods

This module consists of a 1-hour lecture and a 1-hour hands-on session. There are no additional practices or booster sessions.

The target audience of this module is first-year medical students with basic knowledge of abdominal anatomy. Note that the lecture and hands-on session are held during the abdominal anatomy module. The lecture and hands-on session objectives are developed ahead of time in conjunction with the anatomy course director and align with the content of the anatomy cadaver lab. Lecture attendance is required for the hands-on session.

The lecture slide presentation (Appendix A) is offered to all learners simultaneously in a large classroom or auditorium. Presenter notes are also available (Appendix B). The learners view the hour-long slide-show lecture presentation on the day of or prior to the hands-on session.

For the hands-on session, students are divided up into groups of four to five, with one instructor. Each hour-long session is divided into a 15-minute introduction and demonstration of the session objectives by the instructor on a standardized patient, followed by 45 minutes of hands-on practice where each student has the opportunity to scan the standardized patient.

The session instructors have typically consisted of emergency medicine department faculty and residents, as well radiology department faculty. Most instructors have a minimum of at least 4 years of hands-on ultrasound experience. Specific preparation details for the hands-on session can be found in the instructor guidelines (Appendix C) and setup instructions (Appendix D). A handout version of the lecture slides is available to the students as a reference (Appendix E).

A postmodule evaluation form (Appendix F) is completed after the hands-on session. The evaluation form can be sent to students via email. There are currently no objective knowledge or skills assessments included at the end of the module.

Results

We have successfully deployed this module for the last 3 years. The learners were the entire first-year class at our medical school, consisting of 134 medical students. The learner feedback has been overwhelmingly positive.

An emergency medicine faculty member delivered the lecture to the first-year medical school class. We held six 1-hour hands-on sessions over a daylong period in two large classrooms. There were 22 to 23 learners taught during each 1-hour session. The instructors for the hands-on sessions were seven emergency medicine faculty members, three radiology faculty members, and five emergency medicine residents who taught at the same stations as the emergency medicine faculty members.

The response rate to the anonymous, voluntary postmodule survey was 59%. The original postworkshop evaluation form included only an open-ended question requesting free-text responses on the Basics of Ultrasound lecture. The evaluation form has since been modified to include a multiple-choice question evaluating the lecture. The lecture was overall well received by the students. The following are all of the comments provided by students about the lecture:

- “The lecture was extremely clear.”
- “The lecturer used repetition well throughout the lecture. Students felt prepared and excited for the hands-on exercise.”
- “Great job of explaining the science behind ultrasounds as well as how to interpret the images.”
- “Great job teaching the ultrasound lecture and putting together the ultrasound workshop which truly helped me learn the material. One of my favorite parts of the module as well.”
- “Awesome summary of ultrasound with hands-on pairing.”
- “Made ultrasound seem really interesting and explained things so clearly.”
- “Very straightforward.”

For the abdominal ultrasound workshop, 99% of respondents recommended it remain part of the anatomy curriculum. The average response to “To what degree did the abdomen ultrasound workshop contribute to my understanding of normal abdominal anatomy beyond what I’ve already learned through traditional teaching methods?” was 3.5 out of 4 (1 = *not at all*, 2 = *only a little*, 3 = *somewhat*, 4 = *very much*). Students also reported that the workshop helped them identify essential abdominal anatomical features (3.8 out of 4) and integrated well with the current anatomy curriculum (3.8 out of 4).

The students specifically enjoyed the small-group setting and active learning process. In response to the question “What worked well in the abdomen ultrasound workshop?”, a review of the students’ free-text responses revealed *small group* and *hands-on* to be the most commonly used phrases. The following feedback is a sampling of the responses (redundant responses have been removed):

- “The repetition of seeing everyone find the same structures and doing it hands-on.”
- “I liked that we were in small groups and all got to try identifying the organs.”
- “Small groups, time for each person to try themselves.”
- “Working in small groups was really great and interactive.”
- “The small groups were key. I found this session extremely informative, useful, and fun.”
- “Hands-on opportunity to use the ultrasound equipment; small group sizes that made it easy to ask questions.”
- “I liked how they broke us up into small groups so that we each had a turn to try the ultrasound.”
- “The small group setting was really conducive to learning and discussion.”
- “It was also very helpful to be able to see the organs we are studying in anatomy lab.”
- “I liked that it was hands-on, and that we got to move the probe around ourselves. It gave me a good understanding of anatomic relations and allowed me to better understand.”

Consistently, the students requested additional time to explore more anatomy, as well as additional opportunities for hands-on ultrasound practice. Students expressed interest in more explanation about probe and image orientation during the workshop. In response to “What could be improved in the abdomen ultrasound workshop?”, a sampling of student suggestions included the following:

- “More explanation of the orientation of the ultrasound.”
- “More ‘exploration time’.”
- “Could it be longer so we can see more structures?”
- “Maybe provide more opportunities to practice with ultrasound.”
- “It could be longer and investigate more structures. A patient with abnormal findings would be even better.”
- “I think a little more time could be spent making sure students understand the orientation of the image on the ultrasound and how the transducer relates to that, because that was something I was confused about.”
- “I think a little more explanation about why an image looks the way it does or has the orientation it has based on holding the ultrasound in long or short axis. I struggled a bit with orientation although I realize that I could have asked more questions about it.”

Discussion

This module addresses the need for medical students to become familiar with point-of-care ultrasound technology and complements their learning of anatomy content. Other medical schools can utilize this curriculum during their abdominal anatomy module. We chose to incorporate ultrasound teaching into the anatomy module since clerkship students had expressed a desire to learn ultrasound content during their preclerkship curriculum and the anatomy module has been shown to be an optimal time to introduce the technology. The brief exposure to ultrasound through lecture and hands-on practice may only be enough time to expose students to the most basic ultrasound concepts. However, the goal of the module is not to teach ultrasound competency but rather to use ultrasound as a tool to augment anatomy teaching.

The greatest challenges have been finding time in the already packed preclerkship curriculum to integrate ultrasound teaching and recruiting enough instructors to teach the ultrasound sessions. The students have expressed a desire for longer sessions and more exploration time; however, time and resources are limited. The most notable issue has been recruiting enough instructors to maintain the low student-to-instructor ratio. We have had success in recruiting additional instructors by collaborating with other departments within our institution, such as the radiology department. A recent article demonstrated that after minimal training, anatomists were as effective as clinicians at teaching ultrasound sessions in the anatomy module.¹² Additionally, fourth-year medical students who have completed an emergency ultrasound elective may possibly be used as instructors as well.⁵ Given the overall positive student feedback from this module, we have successfully incorporated this ultrasound content in our UME curriculum for the last 4 years. However, still only a handful of medical schools offer point-of-care ultrasound teaching during the preclerkship curriculum. We hope this resource will help other institutions to begin to incorporate ultrasound content into their preclerkship curricula.

In terms of next steps, we plan to develop more rigorous evaluation and assessment tools for this module. We plan to include multiple-choice questions in the end-of-module examination to assess objective knowledge acquisition. Next, we will develop an objective structured clinical examination to assess psychomotor skill acquisition. At this time, we acknowledge that tremendous resources, including instructors and time, would be required in order to assess the entire first-year medical school class. Carving out time in the preclerkship curriculum and developing faculty in point-of-care ultrasound teaching will have to remain a priority to UME leadership.

As previously mentioned, the evolution of ultrasound technology is far outpacing ultrasound learning in the UME curriculum. Medical schools need to take the lead and continue to train their students to be well prepared for future clinical practice.

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References

1. Moore CL, Copel JA. Point-of-care ultrasonography. *N Engl J Med*. 2011;364(8):749-757. <http://dx.doi.org/10.1056/NEJMra0909487>
2. Hoppmann RA, Rao VV, Bell F, et al. The evolution of an integrated ultrasound curriculum (iUSC) for medical students: 9-year experience. *Crit Ultrasound J*. 2015;7:18. <http://dx.doi.org/10.1186/s13089-015-0035-3>
3. Bahner DP, Adkins EJ, Hughes D, Barrie M, Boulger CT, Royall NA. Integrated medical school ultrasound: development of an ultrasound vertical curriculum. *Crit Ultrasound J*. 2013;5:6. <http://dx.doi.org/10.1186/2036-7902-5-6>
4. Fox JC, Schlang JR, Maldonado G, Lotfipour S, Clayman RV. Proactive medicine: the "UCI 30," an ultrasound-based clinical initiative from the University of California, Irvine. *Acad Med*. 2014;89(7):984-989. <http://dx.doi.org/10.1097/ACM.0000000000000292>
5. Bahner DP, Goldman E, Way D, Royall NA, Liu YT. The state of ultrasound education in U.S. medical schools: results of a national survey. *Acad Med*. 2014;89(12):1681-1686. <http://dx.doi.org/10.1097/ACM.0000000000000414>
6. Brown B, Adhikari S, Marx J, Lander L, Todd GL. Introduction of ultrasound into gross anatomy curriculum: perceptions of medical students. *J Emerg Med*. 2012;43(6):1098-1102. <http://dx.doi.org/10.1016/j.jemermed.2012.01.041>
7. Jamniczky HA, McLaughlin K, Kaminska ME, et al. Cognitive load imposed by knobology may adversely affect learners' perception of utility in using ultrasonography to learn physical examination skills, but not anatomy. *Anat Sci Educ*. 2015;8(3):197-204. <http://dx.doi.org/10.1002/ase.1467>
8. Griksaitis MJ, Sawdon MA, Finn GM. Ultrasound and cadaveric dissections as methods for teaching cardiac anatomy: a comparative study. *Anat Sci Educ*. 2012;5(1):20-26. <http://dx.doi.org/10.1002/ase.259>
9. Dreher SM, DePhilip R, Bahner D. Ultrasound exposure during gross anatomy. *J Emerg Med*. 2014;46(2):231-240. <http://dx.doi.org/10.1016/j.jemermed.2013.08.028>
10. Baltarowich OH, Di Salvo DN, Scoutt LM, et al. National ultrasound curriculum for medical students. *Ultrasound Q*. 2014;30(1):13-19. <http://dx.doi.org/10.1097/RUQ.0000000000000066>
11. Blackstock U, Munson J, Szyld D. Bedside ultrasound curriculum for medical students: report of a blended learning curriculum implementation and validation. *J Clin Ultrasound*. 2015;43(3):139-144. <http://dx.doi.org/10.1002/jcu.22224>
12. Jurjus RA, Dimorier K, Brown K, et al. Can anatomists teach living anatomy using ultrasound as a teaching tool? *Anat Sci Educ*. 2014;7(5):340-349. <http://dx.doi.org/10.1002/ase.1417>

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