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Ultrasound Curriculum Integration Review and a Survey of its Utility in Regional Medical Campuses

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Abstract

Ultrasonography is a common technique used to visualize anatomic structures for diagnosis and to guide procedures. As the technology becomes more portable and affordable, schools have increasingly utilized this technology in training physicians. Ultrasonography may be especially useful in rural settings to fill the limitations that rural hospitals have in terms of imaging. The mission of many regional medical campuses is to train physicians to work in rural or underserved communities. Given this goal, we wanted to explore how regional medical campuses are utilizing ultrasound preclinically and determine the best approach for developing a standardized ultrasound curriculum, keeping regional medical campus resources in mind. A literature review of medical schools' preclinical ultrasound curriculum was completed, and information was collected regarding curriculum programming, faculty, assessment, and student feedback. Based on data from this search, a 14 question Qualtrics survey was sent out to regional medical campuses with questions regarding the use of ultrasound in their own preclinical curriculum. Of the 11 campuses that responded, 10 (90.9%) indicated that they include ultrasound in their curriculum. Respondents from 9 of these schools progressed through the survey and information regarding topics covered in ultrasound curriculum, teachers of curriculum, patients used, ultrasound equipment used, and assessment of student knowledge all varied among medical campuses. The data suggested that regional medical campuses are focusing on similar aspects of ultrasound curriculum, however a standardized curriculum does not currently exist to ensure that all students are receiving similar ultrasound training.

Introduction

The use of ultrasound has been increasing since 1956 due to the ability to perform quick evaluations and procedures at the bedside, with increased training and technological advantages.³¹ Some research has stated that ultrasound should be considered the "visual stethoscope of the 21st century" due to the ease at which physicians can supplement their physical examinations with ultrasound imaging.¹⁰ More recently, ultrasound has become topical in medical school curriculum as medical educators have started to incorporate this rapidly growing technology into preclinical education. Many experts believe that ultrasound will be increasingly important in student careers.²¹

While ultrasonography undoubtedly has the ability to improve patient care everywhere, there is no doubt that this technology is particularly important in rural and underserved areas that may not have access to more expensive technology.³¹ Within rural, smaller emergency departments there is often less access to

CT and high-slice scanners, and MRIs.¹¹ With the emergence of point of care ultrasound and its increased affordability, the health care system can elevate the level of care that can be provided in rural emergency room and primary care settings. As we begin to see the benefits that ultrasound may have to offer within the rural settings, we must also recognize the importance of ultrasound implementation at the campuses that are producing the highest number of rural physicians.¹⁷ Exposing medical students to ultrasound in the preclinical years equips them with foundational knowledge as they move on in clerkships, residencies, and as practicing physicians. In one study it was determined that 62.2% of medical schools in the United States integrate ultrasound in the first or second year of medical school.² Ultrasound has been shown in multiple studies to drastically increase the knowledge of students in identifying anatomical structures.^{1,4,16} Ultrasound training during the gross anatomy course led to faster interpretation of ultrasound anatomical images.¹³ This fast

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interpretation of anatomical structures using ultrasound could be linked to a broader and more in-depth understanding of the anatomy using imaging to link 2D pictures from books and lecture slides with a 3D picture online. Ultrasound has also been used as an extension of physical examination skills.²⁰ The research on this topic varies as some studies show that integration of insonation with the other core principles of physical examination skill teaching (observation, auscultation, palpation, and percussion) have increased students' physical exam techniques while other studies have indicated that adding insonation to physical exam might increase the cognitive load to where students aren't retaining important material. Compared to students without any undergraduate ultrasound training, integration of insonation led to better scores and performance on a year-end OSCE that included a comprehensive physical examination of a patient supplemented with ultrasound examination of many body systems including lymph nodes, thyroid, lung, and cardiac anatomy.⁶ Similar studies indicate that teaching medical students to use handheld ultrasound increases traditional physical examination skills while improving diagnostic accuracy,^{13,18} although there is still debate on this in the literature.¹⁴

Although ultrasound is a promising modality for teaching use in medical schools, there are still many challenges associated with the use of ultrasound in both regional medical schools as well as all medical schools. These challenges include lack of space in current curriculum, increased cognitive load for students, access to expensive equipment, and trained faculty.^{2,3} Specific problems for regional medical campuses could include lack of access to sufficient equipment and lack of faculty experience with this modality.⁴ The probability of incidental findings when using peers as models is a concern for many schools that may push schools toward using standardized patients,²⁶ and the expense of using standardized patients may be a barrier to expanding ultrasound teaching.

Despite the amount of research and interest that is being done to introduce ultrasound into undergraduate medical education, training in medical schools is variable regarding both the use in preclinical years as well as longitudinally across all 4 years without any national standards or guidelines.²⁹ The American Academy of Emergency Medicine

released a statement that ultrasound should be integrated into the core curriculum of undergraduate medical education.²⁸ In the future, we hope to see the development of further curricular standards that can guide the teaching of ultrasound to future physicians. The goal of our research was to compare different regional medical campuses' ultrasound curriculum to each other using a survey as well as comparing them to a literature review that looks more closely at what medical schools across the United States are doing to teach their students ultrasound. We aimed to use this information to seek a better understanding of what a broader ultrasound curriculum should look like in a regional medical campus and develop a comprehensive list of standards for early ultrasound exposure while guiding best practices for medical education.

Methods

Literature Review

A literature review was conducted with the help of the University of Minnesota Health Sciences librarians using the search database Ovid MEDLINE. The keywords used in this search included "ultrasound", "curriculum or curricula or training or teaching", "preclinical or year 1 or year 2 or foundational or undergraduate", and "medical school". This yielded a total of 149 results. No limitations on the year of publication were applied. From there, Rayyan QCRI was used to narrow the articles based on exclusion criteria. Papers that were kept were based on the following criteria:

1. The main subject was ultrasound curriculum for medical students.
2. The medical school research came from within the United States.
3. The article's focus was on preclinical curriculum (years 1 or 2). If there was discussion of a longitudinal program covering years 1 through 4 the article was included.
4. The research either discussed implementation or review of ultrasound curriculum.
5. The article had a focus on improving anatomy or physical exam skills as a whole through ultrasound inclusion in the curriculum. If a procedure was included in a curriculum with other more general anatomy the article was included.

Papers were excluded based on the following criteria:

1. Articles written in a language other than English were excluded.
2. Articles that discussed the creation of an ultrasound elective were excluded.
3. Articles with information regarding ultrasound curriculum in years 3 and 4 of medical school only were excluded.
4. Articles that focused on a workshop or experimental ultrasound sessions were excluded.
5. Articles focusing on specific ultrasound assisted procedures (such as central line) or only focused on specific anatomical regions were excluded.
6. Articles that compared the use of ultrasound to cadavers or arthroscopy were excluded.

Using these criteria, 17 articles were included for review as relevant to discussing ultrasound curriculum in medical schools and what it can be used for. Additional sources were then reviewed and selected using Google Scholar and the University of Minnesota Libraries. Secondary references were added from this process due to their relevance in discussing the importance of understanding and using ultrasound and in rural medicine. Fourteen additional articles were included using this process to supplement our additional knowledge of ultrasound.

Ultrasound curriculum directors at both the University of Minnesota Twin Cities Medical School and the University of Minnesota Duluth Medical School were contacted over email regarding what the ultrasound curriculum specifically entails on each campus within the first 2 years of medical school.

Survey

An anonymous online survey was created by the authors and formatted in Qualtrics software. The link to the survey was sent out via the University of Minnesota Medical School Duluth regional campus dean to other regional medical schools through the AAMC Group on Regional Medical Campuses (GRMC) listserv. This listserv contains 415 different regional medical campuses across the US. The survey consisted of 14 questions, which are listed at the end of this article. The first 3 questions were used to determine what campuses the surveys were coming from and if those campuses included medical students years 1 through 4 or a different

combination. The last question was optional and was a way for those who were interested in the survey results to receive a summary. All other questions were required and were available depending on previous answer selections. To maximize the response rate, questions were kept simple and were in the format of multiple choice, select all that apply, and free response. Participants were given 10 days to respond to the survey. The institutional review board at the University of Minnesota reviewed the study design, and the study was determined to be exempt.

Survey Participants

An invitation to participate in the survey was sent to the listserv for the AAMC Group on Regional Medical Campuses. No specific schools were targeted. The survey included 8 questions regarding ultrasound curriculum that was estimated to take about 10 minutes to complete. Medical schools receiving the survey were asked to reply in 10 days.

Results

Table 1. Literature Review

Study	Ultrasound Teaching in Years 1/2	Instructor of Ultrasound	Student Assessment of Knowledge
Afonso et al., 2010	First year: organ system sessions focusing on basic ultrasound physics, knobology, and basic image acquisition skills. Second year: cardiovascular and abdominal ultrasound in physical exam, 3 hours of introductory/review material, 2-hour bedside session.	Physician faculty and residents with previous ultrasound experience, 3-hour training session.	OSCEs were used to assess basic ultrasound skills by students assigned to random ultrasound station and required to obtain a specified image in 15 minutes.
Blackstock and Carmody, 2016	First year: 1-hour lecture and 1-hour hands-on session during abdomen anatomy.	Emergency Medicine and Radiology physician faculty and residents.	No assessments of material at this time.
Brown et al, 2012	First year: 60 minutes of didactic sessions including knobology, anatomy of neck, and ultrasound guided procedural skills.	Physician faculty with prior experience in ultrasound.	No assessments.
Dinh et al, 2015 (Effects of Ultrasound Implementation)	Point of care ultrasound applications implemented into lab sessions (90 minutes for teaching of physical exams and 30 minutes for POCUS).	Emergency Medicine physician trained in POCUS.	OSCEs administered at end of the academic year.
Dreher et al, 2013	Two hours didactic sessions and 3.5 hours in laboratory using viewing musculoskeletal, abdomen/thorax, and head/neck anatomy.	Director of Ultrasound of Medical School.	Questions about ultrasound on each practical examination for each anatomy block.
Fu et al, 2016	First year: Integrated in Physical Diagnosis course by organ system, Knobology, positioning, and imaging are discussed. Second year: no specific curriculum.	Physician faculty of medical school, extra peer teaching by Ultrasound Interest Group (USIG).	Assessed through OSCEs of their familiarity with ultrasound fundamentals.
Hoppmann et al, 2015	Web-based learning modules, short videos of ultrasound scanning, and hands-on ultrasound laboratory sessions (5-6 per semester). Knobology, cardiac and abdominal anatomy are covered.	Various faculty members (both physician and PhD trained).	Multiple choice ultrasound questions on regular course exams, image interpretation during practical exams, preceptor feedback during hands-on sessions, and OSCEs.

Ireson et al, 2019	Didactic sessions, online modules, and hands on sessions covering knobology, abdominal vasculature, organ, and carpal tunnel anatomy.	Various faculty members (physician faculty and physical therapists).	No specific assessments, just tested on anatomy.
Jamniczky et al, 2015	Lectures, web-based materials, and two 50-minute hands on sessions covering knobology, FAST exam, cardiac, thoracic, and abdomen anatomy.	PhD trained anatomy preceptors clinically trained in ultrasound use who underwent a 4-hour training session.	No assessments at this time.
Jurjus et al, 2013	Three hands-on sessions (3-4 hours each) covering musculoskeletal, abdominal, cardiac, head and neck, and ocular anatomy.	PhD trained anatomists with focused ultrasound training and emergency medicine, rheumatology, and surgical clinicians.	No assessments at this time.
Kondrashov et al, 2014	First year: integration into gross anatomy course. Second year: elective course that involved lectures and hands on laboratory sessions. Review of diagnostic ultrasound, musculoskeletal, advanced echocardiography, lung, FAST exam, breast, US guided procedures, and ocular anatomy were all covered.	None listed.	Assessment based on laboratory participation, evaluation of hands-on practical skills in image acquisition, and multiple-choice anatomy exam given at both beginning and end of course.
Mullen et al, 2018	Three hours of hands-on training sessions covering knobology, abdominal, cardiac, thoracic, and urinary bladder anatomy.	Faculty member skilled in point-of-care ultrasound.	Assessment in real time by instructors, participants found target and were then asked to hold the view long enough for evaluation.
Nelson et al, 2017	Twenty to 40 minute modules for view before class followed by hands on scanning sessions covering knobology, cardiac, thoracic, and abdominal anatomy.	Physicians from emergency medicine, critical care, cardiology, and pediatrics.	Students were observed as they performed a sonographic assessment of a standardized patient (cardiac, thoracic, and abdominal).
Rempell et al, 2016	First year: 40-minute introductory lecture with basic ultrasound information, followed by 4 hands-on sessions that included neck, cardiac, abdomen, and musculoskeletal anatomy. Second year: Didactic session	Physicians and residents from a variety of specialties.	No specific assessments of ultrasound skills, just general anatomy questions on examinations.
	followed by hands on session covering knobology, evaluation of neck/thyroid, musculoskeletal exam, and abdominal exam.		
Siegel-Richman and Kendall, 2018	First year: Didactic session followed by hands on sessions covering basic principles, imaging techniques, musculoskeletal, cardiovascular, abdominal, and head and neck anatomy. Second year: Didactic session followed by hands on sessions covering introduction to clinical ultrasound, FAST, focused abdominal and cardiovascular/lung examination.	Physician faculty, fellows, residents, and fourth-year medical students.	Graded solely on attendance and participation.
Smith et al, 2018	First year: Didactic session followed by hands on sessions covering basic principles, imaging techniques, musculoskeletal, cardiovascular, abdominal, and head and neck anatomy. Second year: Didactic session followed by hands on sessions covering introduction to clinical ultrasound, FAST, focused abdominal and cardiovascular/lung examination.	Physician faculty, fellows, residents, fourth-year medical student, and Master of Science in Modern Human Anatomy teaching assistants that were paired with clinicians.	Graded solely on attendance and participation
Webb et al, 2014	Online modules and information viewed before class followed by hands on sessions covering introduction to ultrasound, abdominal and neck anatomy, as well as the FAST exam.	Physician faculty in imaging, fellows, and senior radiology residents.	No specific assessment for the ultrasound skills.

The findings from the literature review are summarized in Table 1. Three major topics that were identified within the literature review were: what was being taught at each school in the preclinical medical education years, who the instructor was for the ultrasound curriculum, and how students were being assessed on this curriculum. The content of many of the ultrasound curriculums were primarily introductions to ultrasonography and then anatomy sessions that were supplemented by ultrasound. Common anatomical regions that were focused on included cardiovascular, abdominal, thorax,

musculoskeletal, head/neck, urinary, and some vasculature. Many schools incorporated the teaching of the FAST exam for second year medical students as well. Less commonly, ultrasound guided procedures and diagnostic ultrasound were taught to second year medical students. The nature of these curricular sessions was a combination of bedside ultrasound sessions, lectures regarding ultrasound material, use of ultrasound within the anatomy laboratory, web-based learning modules, and short videos describing ultrasound scanning assignments.⁸ After reviewing much of the literature, it is notable that many medical schools use ultrasound as a way to supplement their anatomy courses and allow students to delve deeper into a further understanding of anatomy by viewing it on an ultrasound machine. It was less common for diagnostic ultrasound or ultrasound guided procedures to be taught within the preclinical years. Teaching anatomy using small ultraportable ultrasound machines has shown to be successful in helping medical students' study as they have the ability to use the machine at their own leisure and to study at their own pace.^{4,13}

Each campus also greatly varied in who taught their ultrasound curriculum. Faculty with prior experience in ultrasound, Emergency Medicine physicians trained in point of care ultrasound, various faculty members, anatomy professors, physicians and residents from a variety of specialties, fourth-year medical students, and peer teachers were all listed as those who were responsible for teaching the ultrasound curriculum. Professionals from radiology and emergency medicine departments seem to be the most common contributors in ultrasound curriculum.²³ Many schools had separate training sessions for physicians, faculty, and anatomy professors alike. Instructors of the ultrasound curriculum varied widely throughout each school in order to fit their needs. Across other regional medical campuses, it is also common to use faculty and clinicians except for a few who use third and/or fourth year students.

The last topic that was focused on within the literature review was how schools were assessing student knowledge. Many campuses reported no assessments of ultrasound material or skills whatsoever. Those schools that did assess students used OSCEs, physical examination skills with

ultrasound, questions on multiple choice exams, and evaluation in real time by faculty. Many schools graded their students solely based on their attendance and participation, placing more emphasis on using ultrasound as a learning tool for anatomy, rather than assessment of competency.

Survey

Table 2. Survey Responses

Survey Topic	Number (%) of Respondents (n=9)
Number of Years Ultrasound has been included in preclinical education (Years 1 and 2)	
2	2 (22.2%)
3	3 (33.3%)
4	2 (22.2%)
5	2 (22.2%)
Number of Hours in Curriculum for Ultrasound in Years 1 and 2	
0-10	5 (55.6%)
11-20	1 (11.1%)
21-30	1 (11.1%)
31-40	1 (11.1%)
41+	1 (11.1%)
Teachers of Ultrasound Curriculum	
PhD Trained Anatomists	4 (44.4%)
Clinicians	6 (66.7%)
Peers	2 (22.2%)
Physician Faculty	7 (77.7%)
3 rd /4 th Year Medical Students	3 (33.3%)
Other	2 (22.2%)
Patients for Teaching Ultrasound	
Medical Students	7 (77.7%)
Other Health Care Students	0 (0.0%)
Volunteer Patients	4 (44.4%)
Paid Patients	5 (55.5%)
Other	2 (22.2%)
Type of Ultrasound Equipment Used in Curriculum	
Ultra-Portable Devices (iPad, pocket sized, etc.)	8 (88.9%)
Larger Ultrasound Machines	2 (22.2%)
Assessment of Student Satisfaction and Success in the Ultrasound Curriculum	
Survey of Students	8 (88.9%)
Survey of Faculty	1 (11.1%)
Multiple Choice Questions/Exams	3 (33.3%)
Assessment on Simulators	3 (33.3%)
Others	3 (33.3%)

Table 3. Information Included in Preclinical Ultrasound Curriculum	
Curriculum Component	No (%), n=9
Background Information on US	7 (77.8%)
Anatomy-Cardiac	9 (100%)
Anatomy-Abdominal	9 (100%)
Anatomy-Lung	8 (88.9%)
Anatomy-Head/Neck	6 (66.7%)
Anatomy-Musculoskeletal	7 (77.8%)
Anatomy-Reproductive	3 (33.3%)
Anatomy-Other	2 (22.2%)
Physiology-Cardiac	7 (77.8%)
Physiology-Abdominal	4 (44.4%)
Physiology-Lung	5 (55.6%)
Physiology-Head/Neck	3 (33.3%)
Physiology-Musculoskeletal	3 (33.3%)
Physiology-Reproductive	1 (11.1%)
Physiology-Other	1 (11.1%)
Physical Exam Skill	8 (88.9%)
Procedures	2 (22.2%)
Pathology/Diagnosis	4 (44.4%)
Targeted Workshops/Session	6 (66.7%)
Other	1 (11.1%)

We received responses from 11 regional medical campuses within the United States (response rate of 11/415). Of the respondents, 9 (81.8%) indicated their institution educates years 1 through 4, one (9.1%)

years 3 and 4 only, and 1 (9.1%) years 2 and four. Out of those 11 schools, 10 (90.9%) reported that they used ultrasound within their curriculum and 1 (9.1%) reported that they did not use ultrasound. One of the 10 institutions that indicated they used ultrasound in their curriculum did not continue through the rest of the survey, so the following data are based on 9 total schools.

Ultrasound has been included in preclinical (years 1 and 2) curriculum for less than 6 years for all the responding institutions, with 2 (22.2%) schools indicating the presence of ultrasound for 2 years, 3 (33.3%) schools for 3 years, 2 (22.2%) schools for 4 years, and 2 (22.2%) schools for 5 years (Table 2). Within these 9 regional medical campuses over half the schools (5/9 [55.6%]) taught ultrasound for 0 to 10 hours during years 1 and 2. The 4 remaining schools taught ultrasound curriculum for 11 to 20 hours (1/9 [11.1%]), 21 to 30 hours (1/9[11.1%]), 31 to 40 hours (1/9[11.1%]), and 40+ hours (1/9[11.1%]) (Table 3). Information included in the preclinical ultrasound curriculum varied between the regional medical campuses. However, all the institutions included cardiac and abdominal anatomy within their curriculum and 8 (88.9%) indicated that lung anatomy and physical exam skills were included. A further breakdown of topics included within the curriculums can be seen in Table 4.

Out of the 9 schools completing the survey, 4 campuses (44.4%) indicated that their ultrasound is unique to their specific campus. Three campuses (33.3%) indicated that their ultrasound is identical to an ultrasound curriculum at a different campus within their institution. Two campuses (22.2%) selected "Other", indicating both that the curriculum was only currently offered at one of their campuses and another campus indicating that the curriculum was structured from a main campus curriculum and changed to meet the individual needs of that campus.

As indicated in Table 5, four campuses (44.4%) used anatomists to teach ultrasound, 6 (66.7%) used clinicians, 2 (22.2%) used peer teaching, 7 (77.7%) used faculty members, 3 (33.3%) used third and fourth years medical students, and 2 (22.2%) selected the "Other" box indicating the use of local radiologists and an ultrasonographer as well.

Patients used in the teaching of ultrasound within each campus are reported in Table 6. Seven campuses (77.7%) indicated the use of medical students as the patients, 0 (0.0%) indicated that they used other health care profession students, 4 (44.4%) indicated the use of volunteer patients, 5 (55.5%) used paid patients, and 2 (22.2%) selected the use of "Other" individuals.

Types of ultrasound equipment used at each campus were reported as either ultra-portable devices (such as iPad, pocket sized machines, etc.) or larger ultrasound machines (Table 7). Eight campuses (88.9%) indicated the use of ultra-portable devices, while 2 campuses (22.9%) indicated the use of larger ultrasound machines.

Lastly, data regarding the assessment of student satisfaction and success in ultrasound curriculum was gathered (Table 8). Eight campuses (88.9%) indicated the use of student surveys, 1 (11.1%) indicated the use of faculty surveys, 3 (33.9%) indicate the use of multiple choice questions on exams, 3 (33.3%) indicated assessments performed on simulators, and 3 (33.3%) indicated the "Other" category. The answers indicated within the other category indicated the use of informal feedback, assessment in simulated patient cases, and a final FAST exam. No significance values were included for any data because our sample size was too small.

Table 4. Summary of Guidelines for Ultrasound Curriculum

Guidelines
<ul style="list-style-type: none"> • Start undergraduate medical education on ultrasound with a module containing background information on ultrasound such as knobology, probe specifics, and the basic physics. • Standardized ultrasound curriculum for medical school focus on modules within anatomy, specifically, cardiac, abdominal, lung, head/neck, and musculoskeletal. • While faculty trained in ultrasonography may be an excellent option for teaching, they are by no means the only option. Other options such as peer to peer teaching are also employed. This is excellent news for regional campuses that may have fewer faculty, as it empowers regional campuses to seek alternative creative solutions for delivering this curriculum. • Deciding who to use as patients for ultrasound training can be done in multiple ways. Our data do not currently suggest one method over the other. We do suggest that if students are scanning each other, faculty discuss the possibility of discovering something unknown, emphasize that this is being done for anatomical rather than diagnostic purposes, and give students the opportunity to opt out if they are uncomfortable, much as they would if a standardized patient was engaged in teaching. • Small and large ultrasound machines provide good results and schools should have the freedom to explore which machines make the most sense for them. • We encourage schools to consider more objective assessments, such as assessing student performance in simulation or OSCEs, multiple-choice exams, etc. rather than relying on student perceptions.

Using information from our survey, guidelines were compiled together into Table 4 to summarize what

was discovered to be the most used methods of instruction in ultrasound curriculum.

Discussion

While there is variability in the ultrasound curriculum throughout medical schools in the United States, our survey of regional medical campuses and overall literature review found some similarities that guide our recommendations for a standardized ultrasound curriculum. We recommend starting undergraduate medical education with a module containing background information on ultrasound such as knobology, probe specifics, and the basic physics. This type of curriculum is used by most regional medical campuses within our survey and would ensure that students have a general understanding of the machine to move on to more cognitively demanding modules such as anatomical understanding of ultrasound.¹⁴ We also recommend that a standardized ultrasound curriculum for medical school focus on modules within anatomy, specifically, cardiac, abdominal, lung, head/neck, and musculoskeletal, specific areas that are already being implemented by most of the regional medical campuses within our survey and were highlighted as important topics throughout our literature review. Different approaches to integrating ultrasound certainly exist but given that the evidence was strongest for aligning ultrasound skills with anatomy, that is an approach we would recommend taking at this time.¹⁶ These skills could be critical in helping integrate ultrasound into routine physical examination to create a better understanding of the clinical presentation,^{1,6} but evidence around aligning ultrasound modules with clinical exam in the preclinical years is currently more mixed.

The mode of delivery was something that greatly varied between schools. Variations in who taught the ultrasound curriculum, patients used, and equipment used made for differences in curriculum between schools that best fit their own goals. As stated above, trained faculty or local physicians, anatomists, and other students have all been utilized for delivering curriculum.^{15, 27} Medical student involvement in ultrasound curriculum teaching can help to enhance leadership skills and provide more opportunities for feedback on ultrasound curriculum.^{5, 9} After reviewing results both from the literature review and the survey

regarding the best instructor for ultrasound curriculum, either faculty physicians or physicians from local hospitals with special training in ultrasound provide for the best experience and learning environments for students. While trained faculty may be a preferred option, they are by no means the only option. This is excellent news for regional campuses that may have fewer faculty, as it empowers regional campuses to seek alternative creative solutions for delivering this curriculum.

Deciding who to use as patients for ultrasound training can be challenging. Having medical students scan each other is the most used method amongst students surveyed, which does prove to have many benefits. Finding volunteer or paid patients can be difficult and allowing medical students to scan each other can allow each student to have more time with the ultrasound equipment and visualizing structures, which may lead to better retention of knowledge.²² However, the issue of privacy and discovering pathology unknown by the medical student can lead schools away from this. Volunteer and paid patients are preferred in this regard because they are anonymous to the students. At this time, our data does not suggest that one method is better than the other as each method has advantages and disadvantages, and the flexibility of different methods may be helpful at a regional medical campus. We do suggest that if students are scanning each other, faculty discuss the possibility of discovering something unknown, emphasize that this is being done for anatomical rather than diagnostic purposes, and give students the opportunity to opt out if they are uncomfortable, much as they would if a standardized patient was engaged in teaching.²⁶

The most common piece of equipment used by schools for ultrasound scanning is ultra-portable devices (iPad, pocket sized, etc.). These devices can allow ease of movement when scanning and might be preferable in providing each student their own ultra-portable machine that they can use on their own time as well as in the presence of an instructor. The ultra-portable devices are also much less expensive than the larger ultrasound machines and may offer more flexibility within curriculum if renting the machines and scheduling proves to be difficult. In summary, our research would suggest that schools would have good

results with both smaller and larger machines and should have the freedom to explore which machines make the most sense for them.

The literature review and survey results noted that few schools assessed their students based on the knowledge obtained within the ultrasound session. Instead, they were often graded solely on attendance and participation and success of the sessions were based on surveys of student satisfaction. While this approach has merit, we would encourage schools to consider more objective assessments, such as assessing student performance in simulation or OSCEs, or multiple-choice exams. Formal assessment of this material may instill a sense of importance of the material to the students through providing points based on understanding of the material.¹⁹ Medical school curriculums are crowded, and implementing a hands-on approach, may mean that other material needs to be left out. As such, as this field grows it is critical to understand what outcomes this type of education achieves. We recognize that this is a challenge but feel that this first step of learning is fundamental to prepare students for the next stages and eventual future scope of practice that their career will encompass. A focus on residencies perceptions of student preparedness could be another opportunity for future assessment and research to further understand the implications of early ultrasound teaching during years 1 and 2 of medical school.

Limitations

Limitations within this study include the limited response rate from regional medical campuses. More responses for our survey could have given us a better idea of exactly what other regional medical campuses are doing for their ultrasound curriculum. In the future, it could be possible to engage similar campuses in more targeted surveys where we identify and contact campuses directly, rather than rely on a survey. Despite this limitation, our literature review did give us a knowledge base regarding how ultrasound curriculum is conducted in medical schools across the United States. This knowledge base not only helped us shape the survey, but it also complemented and supplemented the results, allowing us to draw additional conclusions. Another limitation of our work is that as intended, it speaks most to preclinical outcomes, and does not consider clinical outcomes. As point of care ultrasonography

gains popularity, undoubtedly this will be part of the clinical future for many physicians—future studies could look at clinical skills more explicitly. Additionally, currently the evidence is strongest when ultrasound is used to supplement anatomy knowledge. Further ultrasound research could be focused on whether ultrasound should be used to supplement physical examination skills or how curriculum could be tailored to serve rural or underserved communities.⁷ Finally, selection bias is a potential in study like this which uses survey data. There is a potential that only schools who do use ultrasound in their preclinical curriculum responded to the survey and this would skew the results that we received.

Conclusions

The results of the literature review and survey data suggest that many medical schools, regional and main campuses, contain similar aspects within their ultrasound curriculum. However, a standardized approach with specific modules as outlined above might be helpful to ensure schools provide similar training.^{2, 23} The literature also would suggest an inclusion of anatomical ultrasound would be important to a standardized curriculum required by medical schools.

When creating a standardized approach to ultrasound curriculum in medical schools it is important to consider that regional medical campuses may not have the same access and funding as their main campus counterpart.²² At the main campus of many medical schools, their proximity to multiple hospitals offers access to a wide variety of local clinicians. However, their regional counterpart has less available clinicians. Finding time in a busy medical school curriculum is also a limitation for all medical schools, but this may be compounded with slight variations in curriculum that are already in place for regional medical campuses.³⁰ These aspects make implementing and maintaining an ultrasound program at regional campuses more difficult than their main campuses, but as noted above, programs have solved these issues by being creative with their use of models, equipment, and facilitators. We are excited to see how the benefits of teaching students at regional medical campuses preclinical ultrasound

skills can benefit future patients in their practices, which are often in underserved areas.

Section Header

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Survey Questions Attachment

1. University/Institution Name:

2. Campus:

3. Is your campus

- Years 1 and 2 only
- Years 3 and 4 only
- Years 1-4
- Other (please specify)

4. Do you include ultrasound in your preclinical (years 1 and 2) curriculum?

- Yes
- No

5. How many years has ultrasound been included in your preclinical (years 1 and 2) curriculum? (FR)

6. How many hours are used to teach ultrasound in years 1 and 2? (FR)

7. Do you have a unique ultrasound curriculum or is it identical to the curriculum at a different campus?

- The ultrasound curriculum is unique to our campus
- The ultrasound curriculum is identical to another campus

8. What is included in your preclinical ultrasound curriculum? (Select all that apply)

- Anatomy-Cardiac
- Anatomy-Abdominal
- Anatomy-Lung
- Anatomy-Head/neck
- Anatomy-Musculoskeletal
- Anatomy-Reproductive
- Anatomy-Other
- Physiology-Cardiac
- Physiology-Abdominal
- Physiology-Lung
- Physiology-Head/neck
- Physiology-Musculoskeletal
- Physiology-Reproductive
- Physiology-Other
- Physical exam skills
- Procedures
- Pathology/diagnosis
- Targeted workshops/sessions
- Other? Please list:

9. Who is teaching your ultrasound curriculum? (Select all that apply)

- Anatomists
- Clinicians
- Peers
- Faculty

- Medical students in years 3/4
- Other? Please specify

10. Who acts as the patient for teaching ultrasound? (Select all that apply)

- Medical students
- Other health care students
- Volunteer patients
- Paid Patients
- Other? Please specify

11. What type of ultrasound equipment is being used in your curriculum? (Select all that apply)

- Ultra-portable devices (iPad, pocket sized, etc)
- Larger ultrasound machines

12. How are you assessing success and student satisfaction of the ultrasound curriculum? (Select all that apply)

- Surveys of students
- Surveys of faculty
- Multiple choice questions/exams
- Assessment on simulators
- Other? Please specify

13. Is there anything else we should know about your ultrasound program? (FR)

14. If you are interested in receiving a summary of our findings, when available, please include an email address: (FR)