

A Pilot Study of Comprehensive Ultrasound Education at the Wayne State University School of Medicine

A Pioneer Year Review

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Objective. Ultrasound is a versatile diagnostic modality used in a variety of medical fields. Wayne State University School of Medicine (WSUSOM) is one of the first medical schools in the United States to integrate an ultrasound curriculum through both basic science courses and clinical clerkships. **Methods.** In 2006, 25 portable ultrasound units were donated to WSUSOM. First-year medical students were provided an ultrasound curriculum consisting of 6 organ-system sessions that addressed the basics of ultrasound techniques, anatomy, and procedural skills. After the last session, students were administered 2 anonymous and voluntary evaluations. The first assessed their overall experience with the ultrasound curriculum, and the second assessed their technical skills in applying ultrasound techniques. **Results.** Eighty-three percent of students agreed or strongly agreed that their experience with ultrasound education was positive. On the summative evaluation, nearly 91% of students agreed or strongly agreed that they would benefit from continued ultrasound education throughout their 4 years of medical school. Student performance on the technical assessment was also very positive, with mean class performance of 87%. **Conclusions.** As residency programs adopt ultrasound training, medical school faculty should consider incorporating ultrasound education into their curriculum. Portable ultrasound has the potential to be used in many different settings, including rural practice sites and sporting events. The WSUSOM committee's pilot ultrasound curriculum will continue to use student feedback to enhance the ultrasound experience, helping students prepare for challenges that they will face in the future. **Key words:** ultrasound; ultrasound education; ultrasound use.

Abbreviations

ADUM, Advanced Diagnostic Ultrasound in Microgravity; NASA, National Aeronautics and Space Administration; WSUSOM, Wayne State University School of Medicine

Received October 1, 2007, from Wayne State University School of Medicine, Detroit, Michigan USA (L.v.H., J.L.M., P.B., M.J., S.A.D.); and Departments of Surgery (S.R., J.L.M., A.P., S.A.D.) and Radiology (S.R., J.A.B.), Henry Ford Health System, Detroit, Michigan USA. Revision requested October 15, 2007. Revised manuscript accepted for publication December 17, 2007.

We thank Jeff Peiffer, Susan McGilvray, and Gail Nichols (GE Healthcare, Milwaukee, WI) for technical assistance in support of this program and Jack Butler (Butler Graphics, Inc, Auburn Hills, MI) for graphic assistance. Through a partnership with Wayne State University School of Medicine, Henry Ford Health System, and GE Healthcare, 25 GE LOGIQ E portable ultrasound machines were donated to the School of Medicine.

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The use of ultrasound has expanded across medical specialties, including emergency medicine, family medicine, and surgery. Ultrasound is a relatively inexpensive, noninvasive tool used to visualize normal anatomy and abnormalities; it can be used to detect trauma to the digestive, urinary, cardiovascular, and musculoskeletal systems. Recent advances in ultrasound portability have made the technology more user friendly and accessible. For example, through the Advanced Diagnostic Ultrasound in Microgravity (ADUM) study, National Aeronautics and Space Administration (NASA) researchers have shown that nonphysician operators in space can perform diagnostic-quality ultrasound examinations under the guidance of an off-site sonologist.¹⁻⁵ Similarly, this can be applied to other long-distance settings⁶ to diagnose a

variety of medical conditions. For example, the ADUM team has developed an ultrasound curriculum that trains nonexpert operators, including astronauts and Olympic sports trainers, in the use of ultrasound in less than 3 hours of didactic instruction.

For each specialty, varying ultrasound training standards have been issued by residency review committees such as those of the American College of Radiology, American College of Emergency Physicians, and American College of Cardiology.⁷⁻⁹ Although there is no standardization of ultrasound training among various specialties, it is important that medical educators prepare students for further ultrasound education in residency.^{10,11}

Wayne State University School of Medicine (WSUSOM) is the nation's single largest medical campus, with 290 students per class in its allopathic MD program. The ADUM team, in collaboration with physicians of WSUSOM, adapted the NASA ultrasound curriculum to develop an expanded program of study for WSUSOM. Wayne State University School of Medicine is 1 of only 2 medical schools in the nation to integrate a comprehensive vertical ultrasound curriculum throughout the preclinical and clinical years for the class of 2010. This novel program aimed to increase familiarization with the diagnostic and therapeutic capabilities of ultrasound and highlight future clinical opportunities to use this versatile technology.

Materials and Methods

In 2006, 25 portable ultrasound machines were donated to WSUSOM (Figure 1). A core group of faculty experts in ultrasound developed a standardized curriculum that was presented to the student body. The faculty was responsible for vertically integrated course development, modification of the courses based on feedback, and outcomes analysis.

The year 1 ultrasound curriculum consisted of six 90-minute sessions from October 2006 to May 2007. Topics covered included abdominal, cardiovascular, genitourinary, and musculoskeletal ultrasound as well as the fundamentals of ultrasound signal processing and procedural skills (Table 1). The goal of each session was to familiarize the students with the ultrasound

machine, to expose them to normal anatomy, and to provide a foundation for ultrasound use for detecting abnormalities in the clinical years. Although students were encouraged to participate in the ultrasound curriculum, attendance was voluntary.

Ultrasound sessions included didactic, hands-on experience, and clinical correlation components. Each session began with all students attending a lecture covering the prerequisite knowledge needed for their small-group classrooms. Students then practiced using the ultrasound technology. Faculty ensured that all students demonstrated basic competency within their respective curriculum. Twenty-five portable ultrasound units were available for students to check out and practice with throughout the academic year.

The first-year medical student class of 290 students received a schedule and curriculum goals before the start of the academic year. Students also received a CD-ROM containing a multimedia Onboard Proficiency Enhancer, originally developed for NASA ultrasound trials, which addressed topics such as the fundamentals of ultrasound, basic terminology, and a review of human anatomy through the use of games and other interactive programs. The year 1 students were divided into 12 groups and, expert faculty instructors were assigned. Faculty were assisted by Wayne State year 1 and year 2 medical student assistants, who had volunteered to teach their peers and had participated in a review session with the faculty before each ultrasound session.

Figure 1. Portable ultrasound unit.



To assess the efficacy of the program, the faculty administered 2 summative evaluations immediately after the last module. The first evaluation used a 5-point Likert scale (1, strongly disagree; 5, strongly agree) to assess students' overall experience and satisfaction with the ultrasound curriculum during its pioneer year. Outcomes from this evaluation are reported as minimum and maximum values, group mean and SD, and the percentage agreeing and strongly agreeing with the survey questions. The second evaluation assessed students' skills. Specifically, students were exposed to pans filled with a dark gelatinlike composite that contained both grapes and shards of glass. This exercise simulated a clinical scenario involving aspiration of liquid-filled cysts and localization of foreign bodies. Students were evaluated with a 9-item dichotomous evaluation checklist, which assessed students' ability to (1) unfreeze the screen, (2) appropriately place gel on the transducer, (3) understand the orientation of the probe and screen (right versus left and superior versus inferior), (4) acquire an image of the foreign body and correctly identify the number and location, (5) calibrate appropriately (focus and depth), (6) measure the foreign body, (7) label the image, (8) hit the foreign body with a needle, and (9) save the image. A total of 9 points were possible. Outcomes are reported as frequency and group mean and SD.

Results

Students' Overall Experience and Satisfaction With the Ultrasound Curriculum

The 1-page, 7-item questionnaire used a 5-point Likert scale (1, strongly disagree; 5, strongly agree) as well as 2 open-ended items. Of the 121 (42%) evaluations, the mean scores ranged from 3.82 (question 1: Ultrasound education has enhanced my understanding of human anatomy) to a mean score of 4.37 (question 3: I will benefit from continued ultrasound education throughout my 4 years of medical school). Four of the 5 rating items had a mean score of 4.1 or higher. Eighty-three percent of students agreed or strongly agreed that their experience with ultrasound education was positive. Nearly 91% of students agreed or strongly agreed that they would benefit from continued ultrasound education throughout their entire medical curriculum (Table 2).

Faculty Assessment of Student Skills

To evaluate the students' skills with ultrasound, faculty assessed performance using a 1-page, 9-item dichotomous (correct/incorrect) check sheet. Of the 110 (38%) students evaluated, overall student performance for each of the 9 items ranged from 76% to 100% correct. The mean score was 7.83, and the median score was 8, which equates to mean class performance of 87% correct. As shown in Figure 2, the histogram shows a negatively skewed distribution with 74 (67%) of the students scoring in the 89th percentile.

Table 1. Wayne State University School of Medicine Ultrasound Curriculum, 2006–2007

Session	Objectives
1. Introduction to Ultrasound	Basic ultrasound principles Ultrasound terminology Transducer types Essential keyboard controls Basic ultrasound scanning techniques
2. Musculoskeletal Ultrasound	Demonstrate ultrasound appearance of muscle, tendon, bone, and nerve Visualization of forearm muscles Visualization of biceps tendon Visualization of midforearm radius and ulna: transverse and longitudinal Visualization of median nerve and carpal tunnel
3. Vascular and Cardiac Ultrasound	Demonstrate parasternal 4-chamber views of the heart Demonstrate carotid artery/jugular vein images Discuss M-mode and pulsed flow echocardiography Visualization of carotid artery and jugular vein Visualization of aorta and vena cava Visualization of 4-chamber view Visualization of parasternal axis M-mode and pulsed field
4. Ultrasound of the Abdomen	Demonstrate ultrasound appearance of liver, kidney, gallbladder, spleen, bladder, bowel, and pancreas Visualization of liver Visualization of gallbladder Visualization of spleen
5. Genitourinary Ultrasound	Demonstrate ultrasound appearance of bladder, kidney, and ureters Visualization of bladder Visualization of kidney Visualization of ureters
6. Ultrasound and Procedural Skills	Localization of foreign bodies Visualization of internal jugular vein Visualization of radial artery Visualization of needle in vascular space

Table 2. Students' Overall Experience and Satisfaction With the Ultrasound Curriculum

Question	n	Minimum	Maximum	Mean (SD)	Students Agree or Strongly Agree, %
1. Ultrasound education has enhanced my understanding of human anatomy.	121	1	5	3.82 (0.79)	74
2. I plan to use portable ultrasound in my future clinical practice.	120	2	5	4.1 (0.76)	82
3. I will benefit from continued ultrasound education throughout my 4 years of medical school.	121	2	5	4.37 (0.67)	91
4. All medical schools should provide students with ultrasound education.	121	2	5	4.17 (0.68)	86
5. My experience with the ultrasound education was positive.	121	1	5	4.12 (0.79)	83

Discussion

Ultrasound appears to be a promising educational tool to train future physicians. Several studies have successfully experimented with ultrasound education narrowly tailored to medical students. Students have been taught to use ultrasound to improve anatomic knowledge,¹² to aid in patient care in emergency department settings,⁷ to learn basic scanning techniques,^{13,14} to assist in cardiac¹⁵⁻¹⁸ and physical¹⁹ examinations, as part of a rural medical practice setting,²⁰ and in a radiology core clerkship.²¹ This study documents a comprehensive vertical ultrasound curriculum that integrates didactic, hands-on, and clinical training in a medical school setting.

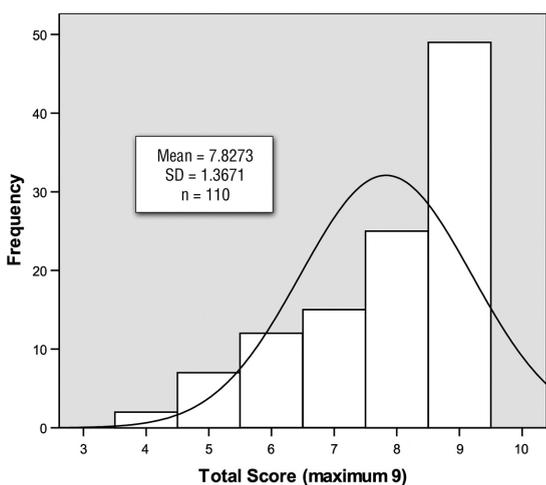
Arguably, as the ultrasound curriculum progresses into its second year, students may find the role of ultrasound to be less abstract. For example,

second year students will begin to scan and recognize abnormalities in the connective tissue, cardiovascular, and neurology courses. During year 3, the ultrasound curriculum will be interwoven with the core clinical clerkships, including emergency medicine, internal medicine, obstetrics and gynecology, pediatrics, and surgery. During their fourth year, students will apply ultrasound in subspecialty fields, including ear, nose, and throat, intensive care unit medicine, neurosurgery, orthopedics, and urology.

This pilot study from WSUSOM has shown that students are enthusiastic about ultrasound technology and believe that they are benefiting from participating in the ultrasound sessions. Most students who returned surveys have endorsed continued ultrasound education throughout their medical school education. Incorporating ultrasound into a medical school curriculum is beneficial for increasing student knowledge and may have a positive impact on patient care when the students progress on to their respective residencies. Most first-year medical students found the ultrasound sessions to be effective teaching tools. Students performed exceedingly well on the ultrasound skills assessment, with most students placing in the top end of the score range with a mean score of 87%. According to Anastasi and Urbina,²² when basic skills are tested, 80% to 85% correct items would suggest complete mastery.

There were limitations to this pilot study. The voluntary nature of this ultrasound curriculum may help explain the 39% attrition from the first to the sixth session. Scheduling problems (ie, during examination week) may have also led to

Figure 2. Faculty assessment of student skills with ultrasound.



decreased attendance, thus skewing outcomes. In addition, a pretest could have been conducted to assess actual knowledge gains (matched pairs), but it was determined that few students would have knowledge of portable ultrasound, and with a limited number of assessment items, there was the potential of introducing a testing bias on the posttest, which would have been a threat to validity.

Finally, incorporation of ultrasound education into the medical school curriculum is just emerging. With future innovations, ultrasound machines will become even more portable, perhaps even approaching the size of a personal digital assistant. Such technology advances broaden the scope of ultrasound and make it practical for use in a variety of venues, including rural practices, the Olympics, and even outer space. The need for ultrasound education is evident, and there is an opportunity for medical educators and medical school administrators to promote medical ultrasound education so that the next generation of physicians will be better equipped to take advantage of this powerful diagnostic and therapeutic tool.

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