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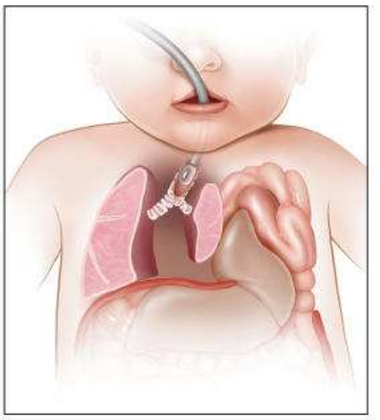

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Outcomes of an Advanced Ultrasound Elective

Preparing Medical Students for Residency and Practice

Michael I. Prats, MD, Nelson A. Royall, MD, Ashish R. Panchal, MD, PhD, David P. Way, MEd, David P. Bahner, MD

Objectives—Many medical specialties have adopted the use of ultrasound, creating demands for higher-quality ultrasound training at all levels of medical education. Little is known about the long-term benefit of integrating ultrasound training during undergraduate medical education. This study evaluated the effect of a longitudinal fourth-year undergraduate medical education elective in ultrasound and its impact on the future use of ultrasound in clinical practice.

Methods—A cross-sectional survey of medical graduates from The Ohio State University College of Medicine (2006–2011) was done, comparing those who participated and those who did not participate in a rigorous ultrasound program for fourth-year medical students. A 38-item questionnaire queried graduates concerning ultrasound education in residency, their proficiency, and their current use of ultrasound in clinical practice.

Results—Surveys were completed by 116 respondents, for a return rate of 40.8% (116 of 284). The participants of the undergraduate medical education ultrasound elective (n = 61) reported more hours of ultrasound training after graduation (hands-on training, bedside scanning, and number of scans performed; $P < .001$), higher ultrasound proficiency (proficiency in using ultrasound for clinical decision making, use in emergency settings, and use of novel techniques; $P < .001$), and higher rates of ultrasound use in clinical practice ($P < .001$).

Conclusions—The longitudinal undergraduate medical education ultrasound elective produced physicians who were more likely to seek additional training in residency, evaluate themselves as more proficient, and use ultrasound in their clinical practice. Early training in bedside ultrasound during undergraduate medical education yields physicians who are better prepared for integration of ultrasound into clinical practice.

Key Words—graduate medical education; sonography; ultrasound education; undergraduate medical education

Bedside ultrasound is rapidly being adopted by physicians in many medical specialties to improve clinical decision making and patient safety.[1,2] Unlike traditional imaging modalities, bedside ultrasound imaging allows a physician to acquire and integrate the ultrasound examination into the diagnostic reasoning process. Furthermore, the use of ultrasound has proven to improve patient safety when used to visually guide the practitioner during invasive therapeutic interventions.[3]

As awareness of ultrasound's benefits spreads, so does demand for ultrasound education programs to adequately prepare new physicians for its use in clinical practice.[2] Despite growing interest in ultrasound among clinicians and trainees, barriers to ultrasound

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Abbreviations
OSU, Ohio State University

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education persist.[4] Questions about how and when ultrasound should be integrated into the physician's education continue to be debated.[5–9]

Although the debate concerning how and when ultrasound education should occur, many medical specialties have adopted ultrasound into their scope of practice.[1] The Accreditation Council for Graduate Medical Education has adopted required ultrasound competencies for graduate medical education programs, including critical care medicine, emergency medicine, internal medicine, obstetrics and gynecology, radiology, and surgical critical care.[10–15] Despite the implementation of these standards, there is still wide variability in the availability and quality of ultrasound education across graduate medical education programs.[16] With increasing duty hour restrictions and substantial clinical responsibilities, some graduate medical education instructors question whether residency programs can or should manage the additional responsibility of training their residents in ultrasound.[17]

In response to the growing interest in ultrasound among medical students and medical educators, many medical schools in the United States have begun integrating basic ultrasound into their undergraduate medical education curricula. Some medical schools use ultrasound on a limited basis for such things as teaching basic science concepts,[9,18–32] whereas others have developed more comprehensive ultrasound education programs.[5–8] Medical educators have identified benefits of bedside ultrasound training, including improvements in physical examination skills, diagnostic acumen, and program satisfaction.[5–8] However, the longer-term impact of ultrasound education on the future practice of the medical student beneficiaries remains unclear.

Beginning in academic year 2005–2006, a longitudinal advanced ultrasound elective course was introduced at The Ohio State University (OSU) College of Medicine.[5,17] The course was developed in response to increased medical student interest, growing faculty interest and expertise, improved portability of ultrasound technology, and the documented benefits to patients.

The purpose of the advanced ultrasound elective curriculum was to develop medical student proficiency in bedside ultrasound and prepare them for use of ultrasound in residency and clinical practice. Specific objectives included: (1) identify appropriate uses of ultrasound; (2) acquire real-time ultrasound images and videos; (3) interpret ultrasound findings; and (4) apply ultrasound findings in clinical decision making. Moreover, the rigor of the program was designed to facilitate valuable leadership and teaching skills that can be used throughout the students' medical careers.

Medical students at our medical school are required to complete 16 clerkships over a 2-year period, including 7 core clerkships in the third year, 4 required clerkships in the fourth year, and 5 elective clerkships. The advanced ultrasound elective course is one of many electives that medical students may choose; however, unlike most electives, this one is longitudinal or threaded throughout the fourth year of medical school instead of being 4 weeks in length.[17] Advanced ultrasound elective students meet several times a month throughout the fourth year for didactic lectures, hands-on training, and literature discussions (journal club). Students also independently complete a series of online learning modules, practice scanning in a clinical skills laboratory, and complete an ultrasound-related project. They are also required to acquire and store a series of scans for an electronic portfolio. (For a thorough description of the program, see Bahner and Royall.[17])

Although many graduates have completed the longitudinal advanced ultrasound elective course, its impact on graduates' future clinical practice is unclear. The purpose of the study was to evaluate the long-term outcomes of the longitudinal advanced ultrasound elective course for fourth-year medical students.

Materials and Methods

Setting and Study Participants

This evaluation was a cross-sectional survey of medical graduates from OSU College of Medicine (2006–2011) comparing those who participated to those who did not participate in the advanced ultrasound elective course. The study was reviewed and approved by the OSU Biomedical Sciences Institutional Review Board.

The population for this study included all OSU College of Medicine graduates from 2006 through 2011. The comparison groups were as follows: (1) an ultrasound training group (advanced ultrasound elective), which included all graduates from the classes of 2006 through 2011 who had participated in the longitudinal advanced ultrasound elective program (n = 142); and (2) a control group: which was drawn from a stratified random sample of graduates who had not participated in the advanced ultrasound elective program. In other words, the comparison group members were randomly selected in a manner that ensured their numbers matched the advanced ultrasound elective group on the key variables of sex and graduating class year (n = 142). A random number generator utility (SPSS Statistics for Windows version 19.0; IBM Corporation, Armonk, NY) was used to select the control group. A total of 284 potential respondents (142 for each group) were identified for participation in the study.

Contact information in the form of e-mail addresses for study participants was obtained from a preexisting database of alumni records maintained by the OSU College of Medicine. If an e-mail address was not available for a control group member, another randomly drawn graduate of the same sex and graduating year was selected to replace that member. At the time of the study, the level of training or practice of participants ranged from the first year of residency (program year 1) to practicing physician with up to 3 years of practice experience.

Questionnaire Design and Implementation

A 38-item electronic questionnaire was designed to assess ultrasound education and experience during and after medical school (Appendix). Survey development involved question generation and expert panel review by content experts and then editing by an expert in survey development. The survey was piloted with residents and fellows (n = 101) who had graduated from medical schools other than the OSU College of Medicine. The pilot study yielded minor modifications to the questionnaire. Survey items were designed to assess recipients' ultrasound knowledge, skill, training, and proficiency and to estimate the frequency of ultrasound examinations performed in their residency program or medical practice. Questions concerning the use of bedside ultrasound in clinical practice were assessed by a Likert-type response set. The responses ranged from 1 to 6, where 1 indicated almost never; 2, rarely; 3, once or twice every few months; 4, monthly; 5, weekly; and 6, daily. The questionnaire was then distributed to the participants (control, n = 142; and advanced ultrasound elective, n = 142) in April 2012 using the Survey Monkey electronic survey service (Survey Monkey, Palo Alto, CA). Survey returns were tracked, and reminder e-mails were sent to nonrespondents at 2- and 6-week intervals after the initial notification. Study respondents were blinded to the study hypothesis, and informed consent was obtained from all respondents before completion of the online survey.

Data Analyses

All statistical analyses were performed with SPSS Statistics for Windows version 19.0 software. Groups were compared by descriptive and simple inferential statistics. The sampling bias was evaluated between groups on key variables, including return rate, sex, age, level of training, and medical specialty. Survey items posed with Likert-type response sets were analyzed by independent *t* tests. Survey items posed with grouped frequency response sets were analyzed by Mann-Whitney *U* tests.

A Bonferroni correction was used to control for inflated family-wise type I error rates, a concern when conducting multiple inferential statistical tests. Since 28 statistical comparisons were planned, the original criteria for significance was adjusted from $\alpha = .05$ to corrected $\alpha = .002$ by dividing the original value of α by the number of planned comparisons.[33]

Results

We sent surveys to 284 medical school graduates: 142 who participated in the advanced ultrasound elective program and 142 controls. We received completed surveys from 116 of 284 graduates (return rate of 40.8%). Return rates were similar between the advanced ultrasound elective group (61 of 142 [43.0%]) and the nonparticipant control group (55 of 142 [38.7%]).

Demographics

The advanced ultrasound elective and control groups had similar representations with regard to age and sex (Table 1). The control group had slightly fewer graduates from the classes of 2007 (3.6 versus 9.1) and 2009 (14.5 versus 25.5). For the current level of training, residents (program years 1–3) made up 74% (86 of 116) of the total respondents, while advanced trainees (program year 4 and higher or fellow) and practicing physicians accounted for 17.2% (20 of 116) and 8.6% (10 of 116), respectively. The control group was overrepresented at the lower levels of train-

Table 1. Frequencies and Percentages for 61 Advanced Ultrasound Elective Participants and 55 Control Nonparticipants by Selected Demographic Variables

Variable	Control Group (n = 55)	AUE Group (n = 61)
Age, y	29.8	29.7
Female	22 (40.0)	24 (39.3)
Graduation year		
2006	5 (9.1)	3 (5.5)
2007	2 (3.6)	5 (9.1)
2008	6 (10.9)	8 (14.5)
2009	8 (14.5)	14 (25.5)
2010	20 (36.4)	19 (34.5)
2011	14 (25.5)	12 (21.8)
Level of training		
Program year 1	15 (27.3)	14 (23.0)
Program year 2	19 (34.5)	17 (27.9)
Program year 3	7 (12.7)	14 (23.0)
Program year 4 or higher	7 (12.7)	7 (11.5)
Fellow	4 (7.3)	2 (3.3)
Practicing physician	3 (5.5)	7 (11.5)

AUE indicates advanced ultrasound elective.

ing, program years 1 and 2 (61.8% versus 50.9%), whereas the advanced ultrasound elective group had more program year 3 residents (23% versus 12.7%) and practicing physicians (11.5% versus 5.5%).

Graduates who responded to the survey matched in 22 different specialties, including transitional and preliminary programs (Table 2). The graduates in the advanced ultrasound elective group were most represented by diagnostic radiology (n = 8 [13.1%]), emergency medicine (n = 19 [31.1%]), and surgery (n = 9 [14.8%]). In contrast, respondents from the control group were most represented by family medicine (n = 6 [10.9%]), internal medicine (n = 7 [12.7%]), and surgery (n = 7 [12.7%]). Compared to the control group, the advanced ultrasound elective group had more responses from individuals who matched in specialties with high ultrasound use, such as emergency medicine (31.1% versus 3.6%), diagnostic radiology (13.1% versus 0%), and anesthesiology (11.5% versus 7.3%).

Table 2. Frequencies and Percentages of Specialty Selection by 116 Medical Graduates of OSU College of Medicine From 2006 to 2011

Specialty	Control Group (n = 55)	AUE Group (n = 61)
Anesthesiology	4 (7.3)	7 (11.5)
Dermatology	4 (7.3)	0 (0)
Emergency medicine	2 (3.6)	19 (31.1)
Family medicine	6 (10.9)	2 (3.3)
Internal medicine and subspecialty	7 (12.7)	7 (11.5)
Medicine: pediatrics	5 (9.1)	1 (1.6)
Neurology	2 (3.6)	1 (1.6)
Obstetrics and gynecology	4 (7.3)	1 (1.6)
Ophthalmology	3 (5.5)	0 (0)
Otolaryngology	1 (1.8)	1 (1.6)
Pathology	4 (7.3)	0 (0)
Pediatrics	5 (9.0)	4 (6.6)
Psychiatry	0 (0)	1 (1.6)
Diagnostic radiology	0 (0)	8 (13.1)
Surgery: general and subspecialty	7 (12.7)	9 (14.8)
Other (nuclear and PM&R)	1 (1.8)	0 (0)

AUE indicates advanced ultrasound elective; and PM&R, physical medicine and rehabilitation.

Ultrasound Training in Medical School and After Graduation

We asked survey respondents to estimate the amount of time they spent in training activities for bedside ultrasound during medical school and after graduation in their graduate medical education programs (Table 3). The advanced ultrasound elective participants reported a higher number of training hours during their medical school careers than the control group. These hours included formal didactic lectures ($P < .001$; effect size = 2.1), hands-on ultrasound training ($P < .001$; effect size = 2.4), and bedside scanning time ($P < .001$; effect size = 1.6).

We also observed that the advanced ultrasound elective group reported more hours of ultrasound didactic lectures ($P < .001$; effect size = 0.7), hands-on training ($P < .001$; effect size = 0.6), and bedside scanning ($P < .001$; effect size = 0.7) during their residency education (graduate medical education). The larger amount of training was associated with higher numbers of ultrasound examinations performed compared to the controls ($P < .001$; effect size = 0.6). There was no difference between the groups in the amount of continuing medical education in ultrasound received ($P = .16$).

Table 3. Statistical Comparison of the Amount of Ultrasound Training at the Medical School and Graduate Medical Education Levels for 61 Advanced Ultrasound Elective Participants and 52 Control Nonparticipants

Parameter	Control Group (n = 52)	AUE Group (n = 61)	*t*	*df*	*P*	ES[a]
UME training						
Formal ultrasound didactics, h	2.9 ± 1.4	6.2 ± 1.6	11.1	111	< .001	2.1
Hands-on ultrasound training, h	3.2 ± 1.5	6.6 ± 1.4	12.8	110	< .001	2.4
Bedside scanning, h	2.0 ± 0.8	4.7 ± 2.3	8.5	74	< .001	1.6
Ultrasound exams performed, n	3.3 ± 1.8	8.0 ± 2.5	11.4	111	< .001	2.2
GME training						
Formal ultrasound didactics, h	1.8 ± 1.3	3.0 ± 2.2	3.7	99	< .001	0.7
Hands-on ultrasound training, h	2.4 ± 2.0	3.8 ± 2.5	3.3	110	.001	0.6
Bedside scanning, h	3.3 ± 2.3	4.9 ± 2.4	3.7	111	< .001	0.7
CME training, h	1.2 ± 0.6	1.5 ± 1.7	1.4	77	.16	NA
Ultrasound exams performed, n	4.9 ± 3.4	7.2 ± 3.7	3.4	111	.001	0.6

Data are presented as mean ± SD where applicable. AUE indicates advanced ultrasound elective; CME, continuing medical education; ES, effect size; GME, graduate medical education; NA, not applicable; and UME, undergraduate medical education.

[a]Cohen *D* effect sizes are commonly interpreted as small effect, ≈0.2; moderate effect, ≈0.5; large effect, ≈0.8; and very large effect, ≥1.0.

Assessment of Ultrasound Skills and Use in Practice

We asked survey respondents to self-assess their ultrasound proficiency (Table 4). The advanced ultrasound elective group consistently rated their proficiency in ultrasound skills higher than the control group. This proficiency included the basic use of the machine ($P < .001$; effect size = 1.42), use of different ultrasound modes ($P < .001$; effect size = 1.74), and image interpretation ($P < .001$; effect size = 0.99). Furthermore, the advanced ultrasound elective group reported higher proficiency ratings for situations when ultrasound might affect patient care outcomes, such as performing procedures ($P < .001$; effect size = 1.06), using ultrasound for clinical decision making ($P < .001$; effect size = 0.91), and using ultrasound in emergency settings ($P < .001$; effect size = 1.21). Most importantly, the advanced ultrasound elective group reported higher ratings of overall confidence in their ability to use ultrasound ($P < .001$; effect size = 1.20).

Finally, we observed that advanced ultrasound elective participants used ultrasound in their practices more than their control counterparts. Seventy-eight percent (48 of 61) of the advanced ultrasound elective group reported using ultrasound at least monthly compared to only 37% (19 of 52) of the control group. The difference between the groups' median ratings of ultrasound use was significantly different (mean ± SD: advanced ultrasound elective group, 4.00 ± 1.65, meaning monthly use; control group, 2.00 ± 1.85, meaning rare use; Mann-Whitney *U* test, $P < .001$, effect size = 0.33, which is considered a moderate effect size).[34]

Discussion

Over the last 10 years, ultrasound has become a practical tool for the bedside evaluation of patients. With increased portability of ultrasound devices and decreased prices, many specialties now have access to the use of ultrasound to assist in bedside patient care decisions. With this changing dynamic, there is a need to prepare physicians for practical application of ultrasound technology in patient care. It remains unclear at which stage of training (undergraduate versus graduate medical education) the integration of ultrasound most benefits learners. The purpose of this evaluation was to assess the long-term outcomes of intensive ultrasound training at the undergraduate medical education level in the eventual use of ultrasound in clinical practice.

This study demonstrated that graduates who participated in the longitudinal advanced ultrasound elective course were more likely to seek additional training in residency and were more likely to be using ultrasound in their clinical practice. Specifically, the participants of the undergraduate medical education ultrasound program (advanced ultrasound elective) reported more hours of ultrasound training after graduation (hands-on training, bedside scanning, and number of scans performed; $P < .001$), higher ultrasound proficiency (proficiency in using ultrasound for clinical decision making, use in emergency settings, and use of novel techniques; $P < .001$), and higher rates of ultrasound use in clinical practice ($P < .001$).

Table 4. Statistical Comparison of Self-Ratings of Competency and Proficiency in Bedside Ultrasound Examination Performance for 61 Advanced Ultrasound Elective Participants and 52 Control Nonparticipants

Survey Item	Control Group (n = 52)	AUE Group (n = 61)	*t*	*df*	*P*	ES[a]
Basic use of the machine	3.17 ± 1.06	4.41 ± 0.64	7.34	81	≤.001	1.42
Use of M-Mode, color flow, Doppler	2.41 ± 1.08	4.00 ± 0.71	8.97	84	≤.001	1.74
Performing image measurements	2.59 ± 1.06	4.05 ± 0.74	8.29	87	≤.001	1.60
Probe selection	3.13 ± 1.12	4.38 ± 0.66	7.02	80	≤.001	1.36
Image interpretation	3.10 ± 0.93	3.93 ± 0.73	5.36	111	≤.001	0.99
Performing ultrasound-guided procedures	3.10 ± 1.16	4.16 ± 0.80	5.60	88	≤.001	1.06
Using ultrasound as a tool for clinical decision making	2.88 ± 0.98	3.72 ± 0.86	4.83	111	≤.001	0.91
Using ultrasound in emergency settings	2.55 ± 1.12	3.75 ± 0.85	6.32	92	≤.001	1.21
Using ultrasound for new techniques in contemporary literature	2.10 ± 1.01	3.00 ± 1.01	4.72	111	≤.001	0.89
Teaching ultrasound to others	2.35 ± 1.05	3.79 ± 0.84	7.98	97	≤.001	1.51
Confident in ability to use ultrasound	3.12 ± 1.24	4.31 ± 0.65	6.19	72	≤.001	1.20

Data are presented as mean ± SD where applicable. AUE indicates advanced ultrasound elective; and ES, effect size.
[a]Cohen *D* effect sizes are commonly interpreted as small effect, ≈0.2; moderate effect, ≈0.5; large effect, ≈0.8; and very large effect, ≥1.0.

Our findings demonstrate that a longitudinal undergraduate medical education program can function as a bridge to future practice. Graduates were able to develop a foundation of ultrasound skills at the undergraduate medical education level, which were reinforced at the graduate medical education level and became practical skills for their future practice. These graduates self-reported a substantial impact on their clinical practice from involvement in an undergraduate medical education program.

We recognize that this study had a number of limitations. First, the study involved self-report measures of ultrasound knowledge and skill and a reliance on the respondent's recall when estimating the amount of ultrasound educational activity in which they had engaged. These limitations are less concerning when we consider that both comparison groups were asked to self-report and estimate. Still, the possibility exists that our participants responded because of their interest in ultrasound.

Second, because some of our control group members may have had some ultrasound activities during medical school or residency, this study may have underestimated the effect of our advanced ultrasound elective (Table 2). At institutions where there is no medical student–level ultrasound training, the addition of a longitudinal ultrasound elective in the fourth year may lead to even larger outcome effects than we observed. In our evaluation, effect sizes of the comparisons were large (by Cohen standards[35]), suggesting a dramatic difference between the advanced ultrasound elective and control groups. In a setting without ultrasound training, the effect size could be even larger.

We observed a high proportion of graduates in the advanced ultrasound elective group who selected specialties that commonly use ultrasound (ie, anesthesia, emergency medicine, and radiology). We are not able to determine whether our ultrasound education program affected residency choice or whether students participated in our program because of early interest in these specialties. Future research will be needed to evaluate the relationship between longitudinal undergraduate medical education electives such as this one and residency selection.

Finally, many of our respondents were first- and second-year residents and therefore not fully engaged in independent medical practice. This factor reduces our confidence in our observation that advanced ultrasound elective graduates are more likely to be using ultrasound in their clinical practice. Again, future research will be needed to strengthen our confidence in the relationship between early undergraduate ultrasound education and the frequency of ultrasound use in clinical practice.

In conclusion, we believe the results of this study show that the introduction of ultrasound at the medical school level had a strong impact on the individuals' seeking further ultrasound training at the graduate medical education level and their use and proficiency of focused ultrasound in practice. Introducing an advanced ultrasound education program at the undergraduate medical education level is a feasible and effective alternative to placing these programs into a densely packed graduate medical education curriculum.

Appendix: Ultrasound Education Survey for Residents

I. Demographics
   A. Please provide your current age in years.
   B. What is your gender?
   C. What is the year of your graduation from medical school?
   D. What is your current level of training?
   E. What is your current medical practice specialty?

II. Ultrasound Education (Part 1)
   A. Did you complete the advanced ultrasound elective during medical school?
   B. How valuable was the advanced ultrasound elective course at OSU in increasing your ultrasound skill?

III. Ultrasound Education (Part 2)
   A. In your current practice (program), how often do you personally perform diagnostic ultrasound examinations?
   - Almost never
   - Rarely
   - Once or twice every few months
   - Monthly
   - Weekly
   - Daily

   B. Directions: Listed below are specific skills that one learns while training to be an ultrasound expert. We are interested in finding out how much training in each skill is required for learners to feel confident. Please self-reflect about each skill and provide an honest assessment of your own level of ability at this point in time by selecting the rating that best fits. Use the following scale:

   1 = very unskilled (novice, need constant supervision in executing this skill)

2 = unskilled (beginning proficiency but still need much guidance)
3 = intermediate performer (can do myself, with occasional guidance from an expert)
4 = skilled (can perform fairly autonomously with little help from an expert)
5 = very skilled (expert, can teach and supervise others on this skill)

Ultrasound Skills
- Basic knobology (power button, gain, depth)
- Using M-mode, Color flow, Doppler
- Measurements (length, volume, rate, etc)
- Probe selection
- Image interpretation
- Performing ultrasound-guided procedures

Practical Ultrasound Skills
- As a general tool for clinical decision making
- In an emergency setting
- For new techniques outlined in contemporary literature
- For teaching ultrasound to others

C. Since graduating from medical school, have you helped develop ultrasound education at your medical facility?
- Yes
- No; this institution already had an ultrasound education program
- No; this institution is not ready for an ultrasound education program
- Other (please specify).

D. Undergraduate Medical Education Ultrasound Training: Please estimate the number of hours spent in each category while a medical student. Include hands-on skills training in your estimates.
- Number of hours of formal (classroom) ultrasound didactics
- Number of hours of hands-on ultrasound training
- Number of hours of clinical or bedside scanning

E. Graduate Medical Education Ultrasound Training: Please estimate the number of hours spent in each category since graduation from medical school. Include hands-on skills training in your estimates.
- Number of hours of formal (classroom) ultrasound didactics
- Number of hours of hands-on ultrasound training
- Number of hours of clinical or bedside scanning
- Number of ultrasound scans performed
- Number of hours of continuing medical education training in ultrasound

F. Continuing Medical Education Ultrasound: Since medical school, have you pursued additional certification in ultrasound?
- Yes, American Registry for Diagnostic Medical Sonography
- Yes, American College of Chest Physicians Certificate of Completion for Critical Care Ultrasonography
- No
- Other (please specify).

References

1. Moore CL, Copel JA. Point-of-care ultrasonography. *N Engl J Med* 2011; 364:749–757.
2. Greenbaum LD, Benson CB, Nelson LH, Bahner DP, Spitz JL, Platt LD. Proceedings of the Compact Ultrasound Conference sponsored by the American Institute of Ultrasound in Medicine. *J Ultrasound Med* 2004; 23:1249–1254.
3. Shekelle PG, Wachter RM, Pronovost PJ, et al. Making health care safer II: An updated critical analysis of the evidence for patient safety practices. *Evid Rep Technol Assess* (*Full Rep*) 2013; 211:1–945.
4. Ahern M, Mallin MP, Weitzel S, Madsen T, Hunt P. Variability in ultrasound education among emergency medicine residencies. *West J Emerg Med* 2010; 11:314–318.
5. 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.
6. Hoppmann RA, Rao VV, Poston MB, et al. An integrated ultrasound curriculum (iUSC) for medical students: 4-year experience. *Crit Ultrasound J* 2011; 3:1–12.
7. Rao S, van Holsbeeck L, Musial JL, et al. A pilot study of comprehensive ultrasound education at the Wayne State University School of Medicine: a pioneer year review. *J Ultrasound Med* 2008; 27:745–749.
8. 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; 89:984–989.
9. 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; 89:1681–1686.
10. Accreditation Council for Graduate Medical Education. Accreditation Council for Graduate Medical Education (ACGME) program requirements for graduate medical education in emergency medicine. Accreditation Council for Graduate Medical Education website.https://www.acgme.org/acgmeweb/tabid/131/ProgramandInstitutionalAccreditation/Hospital-BasedSpecialties/EmergencyMedicine.aspx. Accessed December 13, 2013.
11. Accreditation Council for Graduate Medical Education. Accreditation Council for Graduate Medical Education (ACGME) Program requirements for graduate medical education in diagnostic radiology. Accreditation Council for Graduate Medical Education website.

https://www.acgme.org/acgmeweb/tabid/148/ProgramandInstitutionalAccreditation/Hospital-BasedSpecialties/DiagnosticRadiology.aspx. Accessed December 13, 2013.

12. Accreditation Council for Graduate Medical Education. Accreditation Council for Graduate Medical Education (ACGME) program requirements for graduate medical education in obstetrics and gynecology. Accreditation Council for Graduate Medical Education website. https://www.acgme.org/acgmeweb/tabid/138/ProgramandInstitutionalAccreditation/SurgicalSpecialties/ObstetricsandGynecology.aspx. Accessed December 13, 2013.
13. Accreditation Council for Graduate Medical Education. Accreditation Council for Graduate Medical Education (ACGME) program requirements for graduate medical education in internal medicine. Accreditation Council for Graduate Medical Education website. https://www.acgme.org/acgmeweb/tabid/134/ProgramandInstitutionalAccreditation/MedicalSpecialties/InternalMedicine.aspx. Accessed December 13, 2013.
14. Accreditation Council for Graduate Medical Education. Accreditation Council for Graduate Medical Education (ACGME) program requirements for graduate medical education in surgical critical care. Accreditation Council for Graduate Medical Education website. https://www.acgme.org/acgmeweb/Portals/0/PDFs/Milestones/SurgicalCriticalCareMilestones.pdf. Accessed December 13, 2013.
15. Accreditation Council for Graduate Medical Education. Accreditation Council for Graduate Medical Education (ACGME) program requirements for graduate medical education in pulmonary disease and critical care medicine. Accreditation Council for Graduate Medical Education website. https://www.acgme.org/acgmeweb/Portals/0/PFAssets/2013-PR-FAQ-PIF/156_pulmonary_critical_care_int_med_07132013.pdf. Accessed December 13, 2013.
16. Akhtar S, Theodoro D, Gaspari R, et al. Resident training in emergency ultrasound: consensus recommendations from the 2008 Council of Emergency Medicine Residency Directors Conference. *Acad Emerg Med* 2009; 16(suppl 2):S32–S36.
17. Bahner DP, Royall NA. Advanced ultrasound training for fourth-year medical students: a novel training program at The Ohio State University College of Medicine. *Acad Med* 2013; 88:206–213.
18. Dreher SM, DePhilip R, Bahner D. Ultrasound exposure during gross anatomy. *J Emerg Med* 2014; 46:231–240.
19. Afonso N, Amponsah D, Yang J, et al. Adding new tools to the black bag: introduction of ultrasound into the physical diagnosis course. *J Gen Intern Med* 2010; 25:1248–1252.
20. Wittich CM, Montgomery SC, Neben MA, et al. Teaching cardiovascular anatomy to medical students by using a handheld ultrasound device. *JAMA* 2002; 288:1062–1063.
21. Angtuaco TL, Hopkins RH, DuBose TJ, Bursac Z, Angtuaco MJ, Ferris EJ. Sonographic physical diagnosis 101: teaching senior medical students basic ultrasound scanning skills using a compact ultrasound system. *Ultrasound Q* 2007; 23:157–160.
22. Butter J, Grant TH, Egan M, et al. Does ultrasound training boost year 1 medical student competence and confidence when learning abdominal examination? *Med Educ* 2007; 41:843–848.
23. DeCara JM, Kirkpatrick JN, Spencer KT, et al. Use of hand-carried ultrasound devices to augment the accuracy of medical student bedside cardiac diagnoses. *J Am Soc Echocardiogr* 2005; 18:257–263.
24. Gogalniceanu P, Sheena Y, Kashef E, Purkayastha S, Darzi A, Paraskeva P. Is basic emergency ultrasound training feasible as part of standard undergraduate medical education? *J Surg Educ* 2010; 67:152–156.
25. Wright SA, Bell AL. Enhancement of undergraduate rheumatology teaching through the use of musculoskeletal ultrasound. *Rheumatology (Oxford)* 2008; 47:1564–1566.
26. Syperda VA, Trivedi PN, Melo LC, et al. Ultrasonography in preclinical education: a pilot study. *J Am Osteopath Assoc* 2008; 108:601–605.
27. Tshibwabwa ET, Groves HM. Integration of ultrasound in the education programme in anatomy. *Med Educ* 2005; 39:1148.
28. Tshibwabwa ET, Groves HM, Levine MA. Teaching musculoskeletal ultrasound in the undergraduate medical curriculum. *Med Educ* 2007; 41:517–518.
29. Arger PH, Schultz SM, Sehgal CM, Cary TW, Aronchick J. Teaching medical students diagnostic sonography. *J Ultrasound Med* 2005; 24:1365–1369.
30. Shapiro RS, Ko PK, Jacobson S. A pilot project to study the use of ultrasonography for teaching physical examination to medical students. *Comput Biol Med* 2002; 32:403–409.
31. Yoo MC, Villegas L, Jones DB. Basic ultrasound curriculum for medical students: validation of content and phantom. *J Laparoendosc Adv A* 2004; 14:374–379.
32. Blickendorf JM, Adkins EJ, Boulger C, Bahner DP. Trained simulated ultrasound patients: medical students as models, learners, and teachers. *J Ultrasound Med* 2014; 33:35–38.
33. Bland JM, Altman DG. Multiple significance tests: the Bonferroni method. *BMJ* 1995; 310:170.
34. Grissom RJ, Kim JJ. *Effect Sizes for Research: Univariate and Multivariate Applications*. 2nd ed. New York, NY: Taylor & Francis; 2012.
35. Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. 2nd ed. Hillsdale, NJ: Lawrence Erlbaum Associates; 1988.