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EDUCATIONAL ADVANCE

CORD-AEUS: Consensus Document for the Emergency Ultrasound Milestone Project

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Abstract

In 2012, the Accreditation Council for Graduate Medical Education (ACGME) designated ultrasound (US) as one of 23 milestone competencies for emergency medicine (EM) residency graduates. With increasing scrutiny of medical educational programs and their effect on patient safety and health care delivery, it is imperative to ensure that US training and competency assessment is standardized. In 2011, a multiorganizational committee composed of representatives from the Council of Emergency Medicine Residency Directors (CORD), the Academy of Emergency Ultrasound of the Society for Academic Emergency Medicine (SAEM), the Ultrasound Section of the American College of Emergency Physicians (ACEM), and the Emergency Medicine Residents' Association was formed to suggest standards for resident emergency ultrasound (EUS) competency assessment and to write a document that addresses the ACGME milestones. This article contains a historical perspective on resident training in EUS and a table of core skills deemed to be a minimum standard for the graduating EM resident. A survey summary of focused EUS education in EM residencies is described, as well as a suggestion for structuring education in residency. Finally, adjuncts to a quantitative measurement of resident competency for EUS are offered.

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Emergency ultrasound (EUS) in emergency medicine (EM) has developed substantially since the American College of Emergency Physicians (ACEP) first published a position statement in 1990 supporting the performance of EUS by appropriately trained physicians.[1] Soon thereafter, the Society for Academic Emergency Medicine (SAEM) endorsed this position and recommended the development of a training curriculum.[2] In 1994, Mateer and colleagues[3] published the model curriculum for physician training in EUS and by 1996 the EM core content curriculum required EUS competency for residency graduates. A landmark resolution by the American Medical Association in 1999 (Resolution 802 and policy H-230.960) stated that ultrasound (US) is "within the scope of practice of appropriately trained physicians" and that each specialty should decide the necessary training requirements for sonography competency.[4] ACEP further developed the standard recognition of EUS as "a skill integral to the practice of EM" in the 2001 Model of the Clinical Practice of Emergency Medicine (EM Model), which resulted in the Accreditation Council for Graduate Medical Education (ACGME) mandating that all EM residents attain competency in the use of EUS by the completion of residency training.[5] In 2008, as an update and revision, ACEP published more comprehensive specialty-specific guidelines as a standard for EUS.[6] Subsequently, SAEM, the Council of Emergency Medicine

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Residency Directors (CORD), and the American Institute of Ultrasound in Medicine have recognized this document.[7–9]

The 2008 document "Resident Training in Emergency Ultrasound: Consensus Recommendations from the 2008 Council of Emergency Medicine Residency Directors Conference" introduced a suggested model EUS curriculum to assist program directors by providing minimum education standards for the integration of EUS into resident education.[7] Given the rapid growth of EUS at all levels of residency training, and the newly announced ACGME milestones for resident EUS education, there has been an emerging need for an updated framework for EM resident education with suggested standardized components.

The specific term "emergency ultrasound" (or EUS) is used throughout this document to maintain clarity and simplicity and to acknowledge the role EM has played in the history and development of the field. Associated terminology such as "point-of-care ultrasound," "bedside ultrasound," "focused ultrasound," or "limited ultrasound" will not appear. These terms are often used interchangeably as EUS skills apply to other clinical specialties and are a part of a larger field of bedside, clinical, provider-performed, point-of-care US.

IMPACT OF EUS TRAINING

Established in 1989, the Agency for Healthcare Research and Quality (AHRQ) focuses on improving the quality, safety, efficiency, and effectiveness of health care for all Americans. The AHRQ Evidence Reports and Technology Assessments are published to improve the quality of patient care in the United States. In 2001, the AHRQ Evidence Report 43 highlighted real-time US guidance for central line placement as one of 11 most highly rated practices with respect to the degree of evidence supporting implementation.[10] In 2011, Moore and Copel[11] published an article summarizing the current state of EUS. This article reviewed the status of US performed and interpreted by the clinician at the bedside, gave examples of its use across medical specialties, and ended with a call for training and assessment to ensure competent use of this technology.

With a decade of graduates having received training in EUS, there is now a body of literature demonstrating the real and potential effect on health care delivery and safety. Emergency physicians are using EUS and patients are receiving safer care as a result. In 2010, Dean et al.[12] published data regarding the degree to which EM graduates used their EUS skills after completing residency training. Of those who responded to the survey, 98% had used EUS within the past 3 months.

ACGME MILESTONES AND EUS

In May 2012, the ACGME designated US as patient care skill number 12 (PC12) of 24 total subcompetencies under the next accreditation system for all EM residencies. In October 2012, a joint statement from the ACGME and the American Board of Emergency Medicine (ABEM) finalized 23 subcompetencies without substantive changes to PC12.[13]

RESIDENCY TRAINING

While still very general, the subcompetencies for US training provide some structure for residency programs to use to develop and refine their EUS education. There is currently appreciable variability in EUS resident training in programs across the country. A 2010 survey study by Ahern et al.[14] reported the survey results of EUS training in 149 EM residency programs. Of the 65 programs that responded, 40% had EM EUS fellowships, which suggests that the respondents had a more robust EUS education program. A structured EUS education program was in place for 51 of 64 (79%) of the programs; however, resident "self-directed EUS education" was reported in 21% of responding programs. With respect to faculty credentialing, 29 of 62 (47%) of responding programs reported that more than 50% of faculty were credentialed. Details regarding the educational content were not included in the publication. No outcome data were reported except for the number of US scans completed by residents.[14]

In June 2012, we conducted a survey of residency program directors through the CORD listserv (n = 108 respondents). We requested that only program directors respond to the survey, so we estimate that this represents a response rate of 68% (108 of 159 programs). The survey questions and responses revealed a significant discrepancy in the total number of scans required of residents, the number of weeks the residents have dedicated to an EUS rotation, and the means by which resident EUS competency is assessed (see Data Supplement S1, available as supporting information in the online version of this paper). Notably, 25% of EM program directors reported that no minimum number of scans was required before graduation. Although the majority of programs dedicate 3 to 4 weeks of their residency curriculum to EUS, there were nearly 20% that devote 1 to 2 weeks only. Of note, the authors do not feel that 1 to 2 weeks is sufficient to ensure progression in the EUS subcompetencies.

ORGANIZATION OF AN EUS RESIDENT ROTATION

This section provides a suggested framework for an EUS rotation as a tool and guideline for program directors and EUS educators. Emphasis is placed on asynchronous Web-based learning coupled with active hands-on learning. Movement away from the traditional passive learning with a majority of the rotation composed of didactic lectures in the classroom is encouraged. These recommendations are based on the experience of the writing group as well as the consensus opinion of EUS resident educators in online discussion groups, listservs, and published documents.[7]

Rotation Length

For novice sonographers in the postgraduate year (PGY)-1 or PGY-2 years, an EUS beginner track rotation should ideally be 4 weeks in duration. Currently, roughly two-thirds of EM program director respondents allocate this amount of time for a rotation.

Beginner Track

EUS educators note that consideration should be made to create a beginner and an advanced EUS education track. Dividing residents into tracks may allow a better educational experience for the resident and a better ability of the educator to assess the appropriate subcompetency progression. A focused introduction to EUS will ensure that residents obtain the necessary fund of knowledge and essential technical skills for self-directed learning throughout residency. While residents will use this training period to develop an understanding of examination indications and technique, they should finish the rotation with the understanding that the goal of EUS education is to foster a mature integration of these newly acquired skills into routine ED patient care (Level 1, 2, and 3 subcompetencies). A longitudinal model that schedules 2 weeks in the first year and 2 weeks in the second year of training could offer the benefit of clinical experience in integrating a meaningful understanding of EUS. That being said, many EUS educators recommend that the 4-week rotation occur in the first year of training.

Advanced Track

An organized advanced track for residents in the PGY-3 or PGY-4 years should focus on fostering the incorporation of EUS into appropriate clinical scenarios during routine patient care (Level 4 and Level 5 subcompetencies). This track would offer senior residents an opportunity not only to teach the more junior residents, but also to learn advanced EUS techniques and participate in the quality assessment of US studies performed in the department. Optional additional rotations, such as senior electives, independent study, and/or research efforts in EUS should be encouraged and may be tailored for interested residents.

Allocation of Rotation Hours and Didactic Learning

With the increasing availability of online education for EUS (e.g., Web-based lectures, podcasts, case-based learning, and online tutorials), traditional didactic teaching has a lot of competition. Online tools have been demonstrated to be as effective as traditional didactic teaching when learning US-guided procedures such as vascular access.[15] Although the evidence that asynchronous EUS learning can be equal to traditional didactic lecturing has not been proven for all applications, there is great support for the majority of in-person EUS education occurring at the patient's bedside. Dynamic US simulators or static task trainers may be acceptable alternatives for bedside learning. Damewood et al.[16] demonstrated that image acquisition and interpretation skills for novice physician sonographers performing the focused assessment of sonography in trauma examination were similar whether using a multimedia simulator or a human model. We recommend that the majority of the in-person rotation hours be directly supervised by attending physicians or EUS fellows (if present at the institution) to foster the early development of proper scanning technique. All resident US images should be reviewed during weekly quality assurance meetings to ensure that timely and instructive feedback is provided during the acquisition of these core skills.

PGY-1 residents are likely first exposed to US in a structured fashion during the EM residency orientation period. With increasing frequency, they will have been exposed to US in medical school; however, the exposure will remain variable for at least the near future. The information covered during the orientation period should serve as a means of standardizing knowledge and skills among the incoming interns. The EUS rotation can then build on the introductory concepts and skills.

Timing of EUS Rotation

We suggest that the EUS rotation should be scheduled during the PGY-1 year to ensure that residents complete a beginner track and develop EUS skills early in their residency training. This will allow adequate time in residency to focus on the integration of EUS into clinical care.

Resident US Skills

The 2008 CORD consensus recommendations,[7] the ACEP 2008 practice guidelines,[6] and consensus through discussion forums and list-serves form the basis for the following skills table.

Core and Advanced Skills

Core skills represent the expected minimum US application content learned by EM residents. Advanced skills are those specific to an EUS fellowship curriculum core content (see Data Supplement S2, available as supporting information in the online version of this paper). An example of how the EUS subcompetency could be integrated into the care of patients with different clinical syndromes is demonstrated in Data Supplement S3 (available as supporting information in the online version of this paper).

RESIDENT COMPETENCY ASSESSMENT

Meeting the ACGME Milestones for EUS in EM requires not only resident education but also knowledge and performance assessment. This section will focus on the concepts of effective assessment and evaluation for EUS competency. Residents should be prepared for practice consistent with the EM Model for which EUS is an integral procedural skill.[17]

Because of the clinical nature of EUS, the progression of learners and the related assessment is well characterized by Miller's framework or pyramid.[18] This framework describes a process of acquisition of knowledge, understanding of how to apply that knowledge, application and demonstration of that knowledge, and integration of that knowledge into practice. Each stage should be evaluated separately and competent performance in one area does not guarantee similar performance in another. It is also clear that assessment of more complex tasks, such as the integration of US into clinical decision-making and patient care, cannot be assessed in a single format, and requires multiple assessment methods.[18,19]

The resident's fund of knowledge, or simple fact recall, can be assessed through the use of standardized testing, which is a well-known, accepted, and validated format.[18] The use of essay-type questions or clinical vignettes can evaluate the application of knowledge and facts.[20] Standardized tests with both types of question formats are widely available for use. Selected questions from each content area can assess fund of knowledge, ideally for more basic level competencies.

Higher-level assessments become more complex and involve evaluating the effective transition from knowledge recall into performance. It is at this level that competency assessments can begin and learners move past the purely cognitive elements of fact recall and on to the application. At this level the residents demonstrate their ability to perform and interpret EUS as they apply previously acquired knowledge.[7] Competency in EUS can be assessed in several formats, including simulation environments, direct observation, and structured examinations.

Simulation has been an effective educational tool for teaching learners the application of knowledge and skill and can be equally effective in assessing the learner.[21–24] Another method for assessment of competency is the objective structured clinical examination (OSCE) format.[25] An OSCE consists of several stations where the learner can be assessed as she or he performs standardized clinical tasks, which could include the use of US phantoms and standardized patients.[22,25,26] In this type of assessment, the learner demonstrates her or his ability and skills for the evaluator. However, it is unclear if performance in a limited simulated clinical environment adequately predicts clinical performance.[19,27]

Resident performance in the clinical setting can be assessed through direct observation by the supervising faculty. The benefit of direct observation is that it allows the evaluation of the learner's performance in true clinical situations.[18,28] It can be difficult to maintain standardization in scoring and evaluation with direct observation as an assessment method.[19] Direct observation is resource-intensive and has the limitation of the Hawthorne effect if the learner is aware of the assessment. Also, due to the resource-intensive nature of direct observation, the sampling can be limited.

One method to maintain and improve the standardization of direct observation assessments is the use of a standardized tool or checklist. These standardized direct observation tools (SDOTs) can be developed independently, based on a review of relevant literature or adapted from those developed and distributed by CORD.[29,30] Data Supplement S4 (available as supporting information in the online version of this paper) provides sample EUS SDOTs.

Maintenance and review of a quality assurance database is an effective way to integrate self-reflection into the learning process.[28] This also provides the ability to review learner performance in image capture and interpretation by the use of indirect observation of images, clips, or videos that are obtained by the learner.[23] Ongoing quality assurance review as an assessment tool removes the simulation and Hawthorne effect limitations of the OSCE and direct observation methods. This review method also allows continuous performance improvement and progression through the higher-level subcompetencies.

A quality assurance database also allows residents and programs to fulfill a minimum requisite number for graduation, i.e., 150 US examinations. The authors feel that the number of completed US examinations is not sufficient to imply competency or adequate performance; other assessment methods beyond a purely numerical evaluation are necessary.[30] Because learning curves for US can vary by learner and application, a numerical approach can only demonstrate exposure and opportunity to achieve competency.[31–33]

Achieving adequate scores in knowledge and application of knowledge does not imply that learners have achieved the higher-level functions of competency and performance. And no singular assessment will be adequate for all learners at all levels.[31–33] Because education methods and learning curves for EUS can vary depending upon the environment, so too can assessment methods be customized to match learner environments.[31–33] Advanced-level performance is achieved through the use of assessment, focused feedback, and deliberate practice to improve.[34] Assessment tool types and their role in the milestones subcompetency are summarized in Data Supplement S5 (available as supporting information in the online version of this paper). Each method of assessment requires different types of resources. Consequently, each residency program should evaluate the equipment, faculty time, and other required resources to determine which combination of assessment methods will best fit the program, learners, faculty, and curriculum.

Data Supplement S2 represents the solicited consensus opinion of the EUS community. Yet, as practice environments and teaching styles differ, controversy regarding designation of core versus advanced skills is expected. Moreover, the five subcompetencies for EUS have elicited controversy among EUS educators and the EUS community. Since the completion of a requisite number of US scans does not ensure a resident's competency, future iterations of the five skill levels may be adjusted in their wording to be less focused on numbers. A meaningful assessment of a given resident's competency in EUS requires evaluation of her or his ability to incorporate US into clinical care and rotations other than those dedicated to US.

Meaningful EUS competency assessment requires evaluation of the residents' ability to incorporate US into clinical care, and therefore a portion of this assessment should be conducted on rotations not otherwise dedicated to EUS. The EUS community and the author group suggest a focus on methods of evaluation that measure the ability of the EM resident to integrate EUS into patient care and clinical decision-making, as opposed to emphasizing the completion of a specific number of EUS examinations. Future directions include medical education and competency assessment research that further delineate effective methods to evaluate resident performance in this core clinical skill.

LIMITATIONS

We recognize that the ability to structure a resident US rotation as outlined may not be possible at all residency programs. We also recognize that there are programs lacking EUS fellowship-trained faculty and/or access to EUS fellows who may serve as resident educators. We do, however, believe that all EM residency programs should identify dedicated EUS faculty to organize, perform, and assess the progression of EM residents through the subcompetencies for all core skills. Dedicated faculty are especially necessary as proving competency across the large variety of EUS core skills creates a burden that may otherwise be difficult to meet.

CONCLUSIONS

The Emergency Medicine Milestones Project, as a joint initiative of the Resident Review Committee for Emergency Medicine under the Accreditation Council for Graduate Medical Education and American Board of Emergency Medicine, has designated emergency ultrasound as a core competency skill for emergency medicine residents. A multiorganizational committee of residency and emergency ultrasound leaders formed to offer updated recommendations to emergency medicine program directors, educators, and residents. A clear delineation of a minimum standard of emergency ultrasound skills for the graduating emergency medicine resident is offered, and tools to assess competency are discussed.

References

1. American College of Emergency Physicians. Council Resolution on Ultrasound. ACEP News 1990; November.
2. Society for Academic Emergency Medicine. Ultrasound Position Statement. SAEM Newsletter 1991; Summer.
3. Mateer J, Plummer D, Heller M, et al. Model curriculum for physician training in emergency ultrasonography. Ann Emerg Med. 1994;23:95–102.
4. American Medical Association. Policy Sunset Report for 2000 AMA Socioeconomic Policies. Privileging for Ultrasound Imaging. Available at: http://www.ama-assn.org/resources/doc/cms/a10-cms-rpt-6.pdf. Accessed Apr 30, 2013.
5. Hockberger RS, Binder LS, Graber MA, et al. The model of the clinical practice of emergency medicine. Ann Emerg Med. 2001;37:745–70.
6. American College of Emergency Physicians. Emergency ultrasound guidelines. Ann Emerg Med. 2009;53:550–70.
7. 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(Suppl2):S32–6.
8. American College of Emergency Physicians. AIUM Officially Recognizes ACEP Emergency Ultrasound Guidelines. Available at: http://www.acep.org/News-Media-top-banner/AIUM-Officially-Recognizes-ACEP-Emergency-Ultrasound-Guidelines/. Accessed Apr 30, 2013.
9. Moak J. SAEM Endorses the 2008 ACEP Ultrasound Guidelines. Available at: http://new.sinaiem.us/saem-endorses-the-2008-acep-ultrasound-guidelines/. Accessed Apr 30, 2013.
10. Shojania KG, Duncan BW, McDonald KM, Wachter RM, Markowitz AJ. Making health care safer: a critical analysis of patient safety practices. Evid Rep Technol Assess (Summ). 2001;43:1–668.
11. Moore CL, Copel JA. Point-of-care ultrasonography. N Engl J Med. 2011;364:749–57.
12. Dean AJ, Breyer MJ, Ku BS, Mills AM, Pines JM. Emergency ultrasound usage among recent emergency medicine residency graduates of a convenience sample of 14 residencies. J Emerg Med. 2010;38:214–20.
13. American Board of Emergency Medicine. The Emergency Medicine Milestone Project. Available at: https://www.abem.org/PUBLIC/_Rainbow/Documents/EMMilestonesMeeting4_Final1092012.pdf. Accessed Apr 30, 2013.
14. Ahern M, Mallin MP, Weitzel S, Madsen T, Hunt P. Variability in ultrasound education among emergency medicine residencies. West J Emerg Med. 2010;11:314–8.
15. Chenkin J, Lee S, Huynh T, Bandiera G. Procedures can be learned on the web: a randomized study of ultrasound-guided vascular access training. Acad Emerg Med. 2008;15:949–54.
16. Damewood S, Jeanmonod D, Cadigan B. Comparison of a multimedia simulator to a human model for teaching FAST exam image interpretation and image acquisition. Acad Emerg Med. 2011;18:413–9.
17. Perina DG, Beeson MS, Char DM, et al. The 2007 Model of the Clinical Practice of Emergency Medicine: the 2009 update 2009 EM Model Review Task Force. Ann Emerg Med. 2011;57:e1–15.
18. Miller GE. The assessment of clinical skills/competence/performance. Acad Med. 1990;65(9 Suppl):S63–7.
19. Swanson DB, Norman GR, Linn RL. Performance-based assessment: lessons from the health professions. Educ Researcher. 1995;24:5–11.
20. Case SM, Swanson DB. Constructing Written Test Questions for the Basic and Clinical Sciences. Philadelphia, PA: National Board of Medical Examiners, 2002. Available at: http://www.nbme.org/pdf/itemwriting_2003/2003iwgwhole.pdf. Accessed Apr 30, 2013.
21. Cook DA, Hatala R, Brydges R, et al. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis. JAMA. 2011;306:978–88.
22. Rodriguez-Paz JM, Kennedy M, Salas E, et al. Beyond “see one, do one, teach one”: toward a different training paradigm. Postgrad Med J. 2009;85:244–9.
23. Latif RK, Bautista AF, Memon SB, et al. Teaching aseptic technique for central venous access under ultrasound guidance: a randomized trial comparing didactic training alone to didactic plus simulation-based training. Anesth Analg. 2012;114:626–33.
24. Sites BD, Gallagher JD, Cravero J, Lundberg J, Blike G. The learning curve associated with a simulated ultrasound-guided interventional task by

inexperienced anesthesia residents. Reg Anesth Pain Med. 2004;29:544–8.
25. Newble D. Techniques for measuring clinical competence: objective structured clinical examinations. Med Educ. 2004;38:199–203.
26. Hofer M, Kamper L, Sadlo M, Sievers K, Heussen N. Evaluation of an OSCE assessment tool for abdominal ultrasound courses. Ultraschall Med. 2011;32:184–90.
27. Wallenstein J, Heron S, Santen S, Shayne P, Ander D. A core competency-based objective structured clinical examination (OSCE) can predict future resident performance. Acad Emerg Med. 2010;17(Suppl2):S67–71.
28. Rethans JJ, Norcini JJ, Barón-Maldonado M, et al. The relationship between competence and performance: implications for assessing practice performance. Med Educ. 2002;36:901–9.
29. Dorfsman ML, Wolfson AB. Direct observation of residents in the emergency department: a structured educational program. Acad Emerg Med. 2009;16:343–51.
30. Craig S. Direct observation of clinical practice in emergency medicine education. Acad Emerg Med. 2011;18:60–7.
31. Jang TB, Ruggeri W, Kaji AH. Emergency ultrasound of the gall bladder: comparison of a concentrated elective experience vs. longitudinal exposure during residency. J Emerg Med. 2013;44:198–203.
32. De Oliveira Filho GR, Helayel PE, Da Conceição DB, Garzel IS, Pavei P, Ceccon MS. Learning curves and mathematical models for interventional ultrasound basic skills. Anesth Analg. 2008;106:568–73.
33. Gaspari RJ, Dickman E, Blehar D. Learning curve of bedside ultrasound of the gallbladder. J Emerg Med. 2009;37:51–6.
34. Ericsson KA. Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. Acad Med. 2004;10(Suppl):S70–81.

Supporting Information

The following supporting information is available in the online version of this paper:

Data Supplement S1. 2012 CORD list-serve Emergency Ultrasound education survey questions and responses.

Data Supplement S2. Delineation of EUS core and advanced skills.

Data Supplement S3. Clinical syndromes and a sample of EUS skill competencies that would be demonstrated by the learner.

Data Supplement S4. EUS SDOTs.

Data Supplement S5. Competency assessment methods.

Data Supplement S1

2012 CORD list-serve Emergency Ultrasound education survey questions and responses

1. How many weeks do your residents have dedicated to an EM ultrasound rotation?

   1-2: 18.2%

   3-4: 66.7%

   5-6: 8.1%

   7-8: 3.0%

   >8: 2.0%

2. At what point in residency does a structured ultrasound rotation take place?

   PGY-1: 81.8%

   PGY-2: 31.6%

   PGY-3: 21.6%

   PGY-4: 3.4%

3. The ultrasound rotation includes which of the following?

   Dedicated ultrasound lectures from core faculty during the rotation: 64.8%

   Web-based or DVD lectures: 58%

   Simulator training (either task trainers or dedicated ultrasound simulators): 45.5%

   Weekly review of all resident scans by ultrasound faculty: 73.9%

   Ultrasound journal club: 22.7%

4. What percentage of the ultrasound rotation is dedicated to hands-on scanning?

   0-25%: 1.1%

25-50%: 10.2%

50-75%: 44.3%

75-100%: 44.3%

5. How many scans are your residents required to perform prior to graduation?

150: 37.5%

200: 11.4%

250: 4.5%

>250: 25.0%

No minimum requirement: 21.6%

6. How do you assess resident ultrasound competency before graduation?

Predetermined minimum number of ultrasound examinations performed: 73.7%

Observed ultrasound examinations (SDOT or non-standardized evaluation): 53.6%

OSCE or other simulated encounter: 8.1%

We don’t assess resident ultrasound competency before graduation: 6.1%

Data Supplement S2. Delineation of EUS core and advanced skills. Core skills represent those EUS competencies integral to the practice of emergency medicine residency graduates.

Anatomical Content	**Core Skills**	**Advanced Skills**
Physics	Basic US physics	Advanced US physics
Trauma (FAST only)	Primary survey Pericardial fluid Peritoneal fluid Pleural fluid Pneumothorax	Secondary survey Soft tissue injury Bony injury Optic nerve sheath diameter Limited solid organ injury
Cardiac	Pericardial fluid Asystole Global left ventricular function Global right ventricular size Tamponade physiology	Chamber size evaluation and comparison Regional wall motion Aortic root assessment Valvular assessment Cardiac output estimation
Chest and Lung	Pneumothorax Pleural fluid	Interstitial fluid Consolidation
Aorta	Abdominal aortic aneurysm	Aortic dissection
Renal and male genitourinary	Hydronephrosis Qualitative bladder volume	Renal parenchymal assessment e.g. cysts complex vs. simple cysts, masses Quantitative bladder volume Testicular parenchymal assessment e.g. torsion, masses, and cysts, fracture and epididymis
Hepato-biliary	Gallstones	Common bile duct assessment, Biliary pathology e.g. polyps, masses, emphysematous Liver – size, assessment of parenchyma for masses, disruption of internal architecture, portal venous thrombosis
Non-trauma abdomen		Pancreas – gross assessment for masses or changes in internal architecture

		Spleen – size, assessment of parenchyma for masses, disruption of internal architecture
Gastrointestinal		Appendix Hernia assessment Bowel obstruction or ileus Diverticulitis Pneumoperitoneum
Ocular	Undifferentiated vitreous chamber pathology	Retinal detachment Vitreous detachment Optic nerve sheath diameter Foreign body Lens dislocation Orbital emphysema Retro-bulbar hematoma
Obstetrics/gynecology Trans-abdominal	Identification of intrauterine pregnancy with fetal heart rate Identification of free fluid in pelvis	1st, 2nd, and 3rd trimester gestational dating and presentation Placental location
Trans-vaginal	Identification of intrauterine pregnancy with fetal heart rate Identification of free fluid in the pelvis	1st, 2nd, and 3rd trimester gestational dating Adnexal assessment for cysts or masses e.g. ectopic or tubo-ovarian abscess Ovarian torsion Uterine masses
Procedures	Central venous access Peripheral venous access Thoracentesis Paracentesis Pericardiocentesis Abscess drainage Foreign body detection	Evaluation of tubes – Foley, gastrostomy-tube, jejunostomy-tube Arterial line placement Joint aspiration Endo-tracheal tube confirmation Lumbar puncture Pacer wire placement
Venous/Arterial Assessment		

	Deep venous thrombosis evaluation - two region compression lower extremity Inferior vena cava evaluation	Deep venous thrombosis evaluation – upper extremity and neck Doppler evaluation of arterial and venous structures
Soft Tissue	Abscess vs. cellulitis Foreign body detection	Necrotizing fasciitis Peri-tonsillar abscess
Musculoskeletal		Assessment of bones and joints Assessment of tendons and ligaments Assessment of muscles
Nerve blocks		Brachial plexus, forearm Intercostal, transversus abdominus Femoral, sciatic, tibial
Pediatrics	All appropriate imaging listed above	Hip evaluation Appendicitis Pylorus stenosis Intussusception Lumbar puncture
Head and Neck		Evaluation of neck masses for airway compromise Vocal cord assessment

Data Supplement S3. Clinical syndromes and a sample of EUS skill competencies that would be demonstrated by the learner

	Skill Levels				
Syndrome	1	2	3	4	5
Shock and unexplained hypotension	Describes the core skills indicated	e-FAST, AAA	e-FAST, AAA, IVC, and IVC assessment for respiratory variation	e-FAST, AAA, IVC, DVT, Global LV function, Global RV size, Tamponade physiology	Integrates advanced skills
Undifferentiated chest pain and/or dyspnea	Describes the core skills indicated	e-FAST	e-FAST, IVC	e-FAST, IVC, Global LV function, Global RV size, Tamponade physiology	Integrates advanced skills
Undifferentiated abdominal pain	Describes the core skills indicated	e-FAST, AAA	e-FAST, AAA, Abdominal pregnancy	e-FAST, AAA, Abdominal pregnancy, Trans-vaginal pregnancy, Hydronephrosis, Gallstones	Integrates advanced skills

EUS = emergency ultrasound; e-FAST = ; AAA = abdominal aortic aneurysm; IVC = ; DVT = deep vein thrombosis; LV = left ventricle; RV = right ventricle

Data Supplement S4. EUS SDOTS

1. Aorta

2. Biliary

3. Cardiac

4. Central venous line access.

5. Deep vein thrombosis

6. FAST

7. Lung

8. Renal

9. Trans-abdominal pelvic

10. Trans-vaginal pelvic

Procedure Competency Form:
Bedside Aorta Ultrasound

Patient Addressograph

❑Resident:
❑Faculty observing:
❑Date:

❑ Informs patient/family of procedure including risks and benefits and obtains verbal consent as appropriate

❑ Enters patient name and MR number into ultrasound machine

❑ Places patient in proper position

❑ Explains steps of procedure to patient throughout the examination

❑ Chooses appropriate ultrasound transducer

❑ Resident cleans the transducer before use

❑ Identifies target aorta, associated inferior vena cava and surrounding local anatomy via compression and/or color flow or pulse wave Doppler

❑ Transverse proximal aorta view obtained with appropriate depth and gain to visualize celiac trunk or superior mesenteric artery and vertebral stripe

❑ Transverse middle aorta view obtained with appropriate depth and gain to visualize superior mesenteric artery, left renal vein, splenic vein and spinal stripe

❑ Transverse distal aorta view obtained with appropriate depth and gain to visualize aortic bifurcation

❑ Longitudinal view of aorta obtained moving the transducer from superior to inferior, visualizing celiac trunk, SMA and spinal stripe

- ❑ Accurately identifies abdominal aortic aneurysm or normal aortic diameter
- ❑ Performs a caliper measurement of each anatomic area from the outer wall to the outer wall of the vessel in anterior-posterior and transverse planes
- ❑ Documents each area of interest with either a representative still image or video clip
- ❑ Relays the findings to the patient and the team involved in the care of the patient
- ❑ Prepares the machine for the next user
- ❑ Procedure note written

Assessment:

- ❑ Unsatisfactory
- ❑ Proficient
- ❑ Mastered

Comments:

Faculty signature:

Procedure Competency Form:
Bedside Biliary Ultrasound

Patient Addressogram

❑Resident:
❑Faculty observing:
❑Date:

❑ Informs patient/family of procedure including risks and benefits and obtains verbal consent as appropriate

❑ Enters patient name and MR number into ultrasound machine

❑ Places patient in proper position

❑ Explains steps of procedure to patient throughout the procedure

❑ Chooses appropriate ultrasound transducer

❑ Resident cleans the transducer before use

❑ Identifies gallbladder (GB) correctly

❑ Visualizes gallbladder in long and short axis in its entirety, including GB neck

❑ Measures length of GB in long axis and the transverse diameter in short axis

❑ Measures GB wall thickness (anteriorly) and notes upper limit of normal thickness

❑ Accurately visualizes and measures CBD in association with the portal vein and notes the upper limit of normal diameter

❑ Accurately identifies the presence or absence of gallstones, pericholecystic fluid and sonographic Murphy's sign

❑ Documents each area of interest with either a representative still image or a video clip and correctly labels images/clips

- ❏ Relays the findings to the patient and the team involved in the care of the patient
- ❏ Prepares the machine for the next user
- ❏ Procedure note written

Assessment:

- ❏ Unsatisfactory
- ❏ Proficient
- ❏ Mastered

Comments:

Faculty signature: ______________________________________

Procedure Competency Form:
Bedside Limited Cardiac Ultrasound

Patient Addressograph

❑Resident:
❑Faculty observing:
❑Date:

❑ Informs patient/family of procedure including risks and benefits and obtains verbal consent as appropriate

❑ Enters patient name and MR number into ultrasound machine

❑ Places patient in proper position

❑ Explains steps of procedure to patient throughout the examination

❑ Chooses appropriate ultrasound transducer

❑ Resident cleans the transducer before use

❑ Obtains subxiphoid view with appropriate depth to visualize entire pericardium

❑ Obtains para-sternal long axis view with appropriate depth to visualize descending thoracic aorta, measures aortic outflow tract appropriately

❑ Obtains para-sternal short axis view with adequate visualization of left and right ventricles, at approximately the level of the papillary muscles

❑ Obtains apical four chamber view with adequate visualization of all four chambers

❑ Accurately identifies presence or absence of pericardial fluid

❑ Accurately estimates global cardiac function

❑ Accurately assesses left ventricular versus right ventricular chamber size

❏ Documents each area of interest with a representative dynamic or still image

❏ Relays findings to the patient and the team involved in the care of the patient

❏ Prepares the machine for the next user

❏ Writes a procedure note

Assessment:

❏ Unsatisfactory

❏ Proficient

❏ Mastered

Comments:

Faculty signature: ___________________________

Procedure Competency Form: Ultrasound guided Central Venous Access

Patient Addressogram

❑Resident:
❑Faculty observing:
❑Date:

- ❑ Informs patient of procedure and obtains consent consistent with hospital policy
- ❑ Enters patient name and MR number into ultrasound machine
- ❑ Places patient in proper position
- ❑ Explains steps of procedure to patient throughout the procedure
- ❑ Chooses appropriate ultrasound transducer
- ❑ Resident cleans the transducer before use and performs surveillance of local anatomy and vessel location
- ❑ Confirms correct location of probe marker and orientation
- ❑ Identifies target vein, associated artery and surrounding local anatomy via compression and/or color flow Doppler
- ❑ Prepares self and patient using proper sterile technique
- ❑ Observes sterile technique to place sterile probe cover on ultrasound probe
- ❑ Adequately anesthetizes target tissue area
- ❑ Measures depth of target vein to determine needle insertion point
- ❑ Observes proper needle angle during insertion
- ❑ Accurately identifies needle tip vs. needle down artifact prior to advancement of needle

- ❑ Documents needle insertion during cannulation of vessel with either a representative still image or a video clip
- ❑ Uses ultrasound to evaluate causes of difficulty advancing wire when applicable
- ❑ Properly secures line and orders chest radiograph to confirm placement when applicable
- ❑ Prepares the machine for the next user
- ❑ Procedure note written

Assessment:

- ❑ Unsatisfactory
- ❑ Proficient
- ❑ Mastered

Comments:

Faculty signature: ___________________________

Procedure Competency Form:
Bedside DVT Ultrasound

Patient Addressograph

❑Resident:
❑Faculty observing:
❑Date:

❑ Informs patient/family of procedure including risks and benefits and obtains verbal consent as appropriate

❑ Enters patient name and MR number into ultrasound machine

❑ Places patient in proper position

❑ Explains steps of procedure to patient throughout the examination

❑ Chooses appropriate ultrasound transducer

❑ Resident cleans the transducer before use

❑ Identifies the great saphenous vein, common femoral vein and common femoral artery

❑ Observes complete collapse of the great saphenous vein and femoral vein with the artery remaining uncompressed or identifies the absence of compressibility

❑ Resident continues by moving the transducer distally approximately 1-2 cm at a time, compressing the femoral vein down to the superficial femoral and deep femoral veins, identifying the presence or absence of compressibility

❑ The transducer is positioned behind the knee in the popliteal fossa and the resident identifies the popliteal vein located on top of the popliteal artery

- ❑ The popliteal vein is compressed down to the trifurcation of the popliteal vein and the resident identifies the presence or absence of compressibility
- ❑ Documents each area of interest with either a representative still image or video clip
- ❑ Relays the findings to the patient and the team involved in the care of the patient
- ❑ Prepares the machine for the next user
- ❑ Procedure note written

Assessment:

- ❑ Unsatisfactory
- ❑ Proficient
- ❑ Mastered

Comments:

Faculty signature:

Procedure Competency Form:
FAST exam

Patient Addressograph

❑Resident:
❑Faculty observing:
❑Date:

❑ Informs patient/family of procedure including risks and benefits and obtains verbal consent as appropriate

❑ Enters patient name and MR number into ultrasound machine

❑ Chooses appropriate ultrasound transducer

❑ Resident cleans the transducer before use

❑ Subxiphoid view obtained with appropriate depth to visualize entire pericardium

❑ RUQ view obtained, scanning through Morrison's pouch, making sure to visualize the tip of the liver and the inferior pole of the right kidney

❑ LUQ view obtained, scanning through the splenorenal recess, making sure to visualize the inferior pole of the left kidney

❑ Pelvic view obtained, scanning through the entire bladder in transverse and sagittal planes

❑ Accurately identifies free fluid or lack of free fluid

❑ Documents each area of interest with either a representative still image or video clip

❑ Relays the findings to the patient and the team involved in the care of the patient

❑ Procedure note written

Assessment:

❑ Unsatisfactory

❑ Proficient

❑ Mastered

Comments:

Faculty signature:

Procedure Competency Form:
Bedside Lung Ultrasound

Patient Addressograph

❑Resident:
❑Faculty observing:
❑Date:

- ❑ Informs patient/family of procedure including risks and benefits and obtains verbal consent as appropriate
- ❑ Enters patient name and MR number into ultrasound machine
- ❑ Places patient in proper position
- ❑ Explains steps of procedure to patient throughout the procedure
- ❑ Chooses appropriate ultrasound transducer and states reasoning for choice
- ❑ Resident cleans the transducer before use
- ❑ Anterior chest views obtained in proper positions with appropriate depth to easily visualize entire pleural sliding
- ❑ Accurately identifies presence or absence of pleural sliding
- ❑ Accurately identifies presence or absence of pleural effusion
- ❑ Documents each area with a representative clip, M-mode, or color documentation
- ❑ Relays findings to the patient and the team involved in the care of the patient
- ❑ Prepares the machine for the next user
- ❑ Writes a procedure note

Assessment:

- ❏ Unsatisfactory
- ❏ Proficient
- ❏ Mastered

Comments:

Faculty signature: ___________________________

Procedure Competency Form:
Bedside Renal Ultrasound

Patient Addressogram

- ❑ Resident:
- ❑ Faculty observing:
- ❑ Date:

- ❑ Informs patient/family of procedure including risks and benefits and obtains verbal consent as appropriate
- ❑ Enters patient name and MR number into ultrasound machine
- ❑ Places patient in proper position
- ❑ Explains steps of procedure to patient throughout the procedure

- ❑ Identifies the indication for the examination
- ❑ Resident chooses the appropriate transducer
- ❑ Resident cleans the transducer before use
- ❑ Performs adequate examination of each kidney and the bladder including image optimization using depth, gain, focus and mode as needed
- ❑ Recognizes clinical indications for simultaneous aorta ultrasound
- ❑ Trouble shoots technical limitations (body habitus, bowel gas, tenderness, empty bladder, inability to position patient)
- ❑ Correctly identifies normal anatomy and pathology (presence or absence of hydronephrosis, renal stones)

- ❑ Obtains and appropriately labels representative images of each kidney in two orthogonal planes and bladder volume measurements (if indicated)
- ❑ Relays the findings to the patient team involved in the care of the patient
- ❑ Prepares the machine for the next user
- ❑ Procedure note written

Assessment:

- ❑ Unsatisfactory
- ❑ Proficient
- ❑ Mastered

Comments:

Faculty signature: ___________________________

Procedure Competency Form:
Bedside Trans-abdominal Pelvic Ultrasound

Patient Addressograph

❑Resident:
❑Faculty observing:
❑Date:

❑ Informs patient/family of procedure including risks and benefits and obtains verbal consent as appropriate

❑ Enters patient name and MR number into ultrasound machine

❑ Places patient in proper position

❑ Explains steps of procedure to patient throughout the examination

❑ Chooses appropriate ultrasound transducer

❑ Resident cleans the transducer before use

❑ Obtains long and short axis views of the uterus scanning the entirety from fundus to cervix

❑ Accurately identifies the presence or absence of free fluid in the cul-de-sac

❑ Scans through both ovaries in two planes (if visible)

❑ Accurately identifies the presence or absence of an intrauterine pregnancy

❑ Measures the endo-myometrial mantle and recognizes that thickness less than 7 mm is concerning for an interstitial pregnancy

❑ Performs a FAST exam if the patient has a positive pregnancy test with absence of a visualized intrauterine pregnancy

- ❏ Documents each area of interest with either a representative still image or a video clip
- ❏ Relays findings to the patient and the team involved in the care of the patient
- ❏ Prepares the machine for the next user
- ❏ Writes a procedure note

Assessment:

- ❏ Unsatisfactory
- ❏ Proficient
- ❏ Mastered

Comments:

Faculty signature: ___________________________

Procedure Competency Form:
Bedside Trans-vaginal Pelvic Ultrasound

Patient Addressograph

❑Resident:
❑Faculty observing:
❑Date:

❑ Informs patient/family of procedure including risks and benefits and obtains verbal consent as appropriate

❑ Enters patient name and MR number into ultrasound machine

❑ Places patient in proper position

❑ Explains steps of procedure to patient throughout the examination

❑ Chooses appropriate ultrasound transducer

❑ Resident cleans the transducer before use

❑ Uses appropriate clean probe cover

❑ Applies sterile surgilube gel to a covered clean transducer

❑ Obtains coronal and sagittal views of uterus with appropriate depth to visualize the posterior cul-de-sac

❑ Scans through entire uterus in two orthogonal planes

❑ Scans lateral of uterus on left and right to identify adnexae

❑ Evaluates adnexae by scanning through in two orthogonal planes

❑ Accurately identifies free fluid or lack of free fluid

❑ Accurately identifies presence or absence of definitive intra-uterine pregnancy (yolk sac and beyond)

❑ Measures endomyometrial mantle at thinnest point and recognizes that thickness less than 7 mm is concerning for an interstitial pregnancy

❑ If identified, measures fetal heart rate using M-mode

❑ Documents each area of interest with a representative still image or video clip

❑ Relays findings to the patient and the team involved in the care of the patient

❑ Prepares the machine for the next user

❑ Writes a procedure note

Assessment:

❑ Unsatisfactory

❑ Proficient

❑ Mastered

Comments:

Faculty signature: ___________________________

Data Supplement S5. Competency assessment methods

Assessment	Skill tested	Example	Limitation	Milestone Skill level
Standardized testing	Fund of knowledge, Application of knowledge	Multiple choice, clinical vignettes	Technical skill not evaluated	1,2,3
Self-assessment	Fund of knowledge, Technical skill	Comparison to criterion standard e.g. Department of Radiology report, operative report	No EUS educator oversight	1,2,3
Case Log	Technical skill	150 US scans for evaluation	Self reported without quality assurance	3,4
Web-based learning	Fund of knowledge	Asynchronous learning lecture, Case series with pre and post tests	Technical skill not evaluated	1,2,3
Task simulator	Technical skill	Low and high fidelity models	Limitations of model, isolated from a patient case	2,3,4,5
Observed structured clinical examination (OSCE)	Fund of knowledge, technical skill, clinical integration	Human model presenting with a sample syndrome	Resource intensive, Hawthorne effect	1,2,3,4,5
Standardized direct observation tool (SDOT)	Fund of knowledge, technical skill, clinical integration	SDOT checklist, Mastery learning checklist	Binary assessment, Hawthorne effect	2,3,4,5
Simulation scenario (blended learning)	Fund of knowledge, technical skill, clinical integration	Task simulator plus case scenario	Resource intensive, Hawthorne effect	1,2,3,4,5
Direct observation in clinical practice	Fund of knowledge, technical skill, clinical integration	Real-time patient care	Resource intensive, Hawthorne effect	1,2,3,4,5
Quality-assurance review	Fund of knowledge, technical skill, clinical integration	Weekly case review with EUS educator	Resource intensive, Database dependent	1,2,3,4,5