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EDUCATIONAL ADVANCE

Pediatric Emergency Medicine Fellow Training in Ultrasound: Consensus Educational Guidelines

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Abstract

The importance of point-of-care emergency ultrasound (EUS) to the practice of emergency medicine (EM) is well established, and mounting research continues to demonstrate how EUS can benefit pediatric emergency department (ED) patients. As members of the EM community, pediatric EM (PEM) physicians should understand the potential value of EUS and seek opportunities to incorporate EUS into their daily practice. Currently, EUS education and training is at an early developmental stage for PEM fellows and varies greatly between programs. The goal of this article is to provide consensus education guidelines and to describe a sample curriculum that can be used by PEM fellowship programs when developing or revising their US training curricula. The authors recognize that programs may be at different stages of EUS development and will consequently need to tailor curricula to individual institutional needs and capabilities. This guideline was developed through a collaborative process between EUS educators and members of the American Academy of Pediatrics Section of EM Fellowship Directors Subcommittee. The guideline includes the following topics: important considerations regarding EUS in PEM, PEM US program framework, PEM US curriculum, PEM US education program, and competency assessment.

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Emergency ultrasound (EUS) refers to point-of-care US performed and interpreted at the patient's bedside by the treating physician to facilitate patient care in the emergency department (ED). Emergency physicians (EPs) use EUS for the resuscitation of critically ill patients, the diagnosis of patients with specific signs or symptoms, monitoring patients with rapidly changing clinical conditions, and the guidance of invasive procedures. The importance of EUS to the daily practice of EPs is underscored in policy statements published by the American College of Emergency Physicians (ACEP). The most recent ACEP policy statement includes comprehensive guidelines for the use of EUS in emergency medicine (EM) and summarizes recommendations for EUS training for EM residents.[1] The training recommendations in this guideline mirror education guidelines delineated in consensus recommendations from the 2008 Council of Emergency Medicine Residency Directors' conference.[2]

The use of EUS by pediatric emergency medicine (PEM) physicians is expanding rapidly, and PEM-specific applications are increasingly being described and studied.[3–5] EUS is listed in the American Board of Pediatrics core content guidelines for PEM fellowship training, and questions related to EUS appear on the subspecialty certification examination for PEM. In a recent survey of PEM fellowship directors, 95% of PEM programs endorse the use of EUS in their EDs.[6] Still, no specific guidelines exist for the training of PEM fellows, and consequently, education varies greatly. The number of programs offering US education to their PEM fellows has increased significantly over the past 4 years.[6–8] Still, according to the most recent published data, only 70% of PEM programs offer their fellows structured EUS rotations.[6] The American Academy of Pediatrics (AAP) Section of EM Fellowship Directors Subcommittee has identified the establishment of an EUS curriculum as one of its primary goals for 2012. The purpose of this article is to provide an educational framework and a sample EUS curriculum for PEM fellows. These recom-

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mendations were developed by a team composed of US educators and PEM fellowship directors. While it is understood that not all PEM fellowship programs will have the resources to institute similar curricula immediately, this can serve as a model for fellowships developing or expanding EUS programs. This curriculum mirrors the ACEP recommendations for EUS training in general EM residency programs, with important adaptations tailored to the unique aspects of EUS as they apply to PEM and pediatric patients.

There are several challenges currently facing PEM programs desiring to educate their fellows in EUS. Most PEM attending physicians who finished their training more than 5 years ago received limited or no EUS education. Consequently, many PEM programs lack skilled faculty members to train their fellows and may need to look to other departments or outside resources for assistance. In hospitals where US studies are readily available through the department of radiology, developing EUS programs will require discussion and negotiation among department and hospital leadership. Prioritizing the best interest of patients and the education of trainees should help to encourage collaboration between hospital departments.

GUIDELINE DEVELOPMENT PROCESS

In October 2011, the AAP Section of EM Fellowship Directors Subcommittee met to discuss ideas for advancing a nationally based PEM fellowship curriculum. This group identified the need for collaboration in the improvement of EUS education for PEM fellows. As a result of this meeting, a team was assembled to develop consensus US education guidelines and propose a sample curriculum for PEM fellowship programs. Collaborators were identified by the chair of the Fellowship Directors Subcommittee and senior author and invited to participate on a voluntary basis. This team consisted of PEM fellowship directors, PEM physicians and EPs with advanced EUS training and EUS educational roles locally and nationally, the chair of the Fellowship Directors Subcommittee, and the past chair of the Pediatric EUS Subcommittee within ACEP. The authors researched past and current training recommendations for EM residents,[2,9] as well as literature related to EUS in pediatric populations and pediatric-specific applications of EUS. These data were reviewed for quality and subsequently used to draft an initial guideline. The team members then reviewed and discussed the guideline, which was revised until consensus was met.

IMPORTANT CONSIDERATIONS REGARDING EUS IN PEM

The role of EUS in the care of pediatric ED patients differs from that of adult patients. Well-established indications of EUS in adults include imaging of the heart, lungs, aorta, biliary tract, urinary tract, musculoskeletal tissues, and lower extremity venous system; evaluation of the trauma patient, pregnant patient, and hypotensive patient; and use of EUS for procedural guidance. Some of these applications are less applicable to the pediatric population. For example, abdominal aortic aneurysm is exceedingly rare in children, and deep venous thrombosis is much less common in pediatric patients than in adults. Thus, these EUS applications are less useful to PEM physicians. Alternatively, the use of EUS to evaluate pediatric patients for bladder volume or conditions such as transient synovitis may be more applicable to PEM physicians. In addition, board certification requirements for PEM differ than those for general EM and do not include specifics related to EUS training. Therefore, although ACEP EUS training recommendations and published "model" curricula for EM residents serve as valuable frameworks, the EUS curriculum for PEM fellows should be geared toward skills most relevant to the care of pediatric patients.

PEM US PROGRAM FRAMEWORK

The introduction of EUS into PEM is recent and evolving. As a result, many PEM faculty members may not have received EUS training and may not possess the necessary skills to train their fellows. Recommendations for the establishment of an EUS program, including personnel, equipment, and quality assurance (QA), have been previously described[10,11] and are summarized here in the context of providing US education to PEM fellows. Programs should attempt to achieve the following recommendations to ensure that PEM fellows received adequate EUS training.

With regard to personnel, the first step is the appointment of an EUS director. This person should have adequate training and exposure to teach the core applications of EUS and the capability to arrange outside opportunities for fellows to gain experience in applications that they cannot learn in their own department. The EUS director should be supported with adequate allocated time for administration and teaching related to the education of fellows.

The EUS director should be charged with the responsibility of instituting a QA plan. Every EUS study should be saved and interpreted by the operating physician at the time the study is acquired. As US is a dynamic study, video clips are preferred to still images. The EUS director and/or other qualified faculty should review studies in a timely manner and provide feedback related to technique (image quality, machine settings, probe selection) and interpretation. As much as possible, novice users should be supervised at the bedside and have their scanning critiqued in real time. Reviewing saved studies should be done when the real-time review is not feasible. Misinterpretations should be addressed in a timely fashion, and specific suggestions for improvement should be included in the feedback. Maintaining this "scan-feedback loop" is one of the most important aspects of teaching EUS. Whenever possible, important teaching points related to individual studies should be reviewed with the trainee and may be used to educate others. In some circumstance, EUS studies may be compared to studies done in the department of radiology for QA purposes; however, it should be recognized that EUS studies are primarily used to promptly answer simple "yes/no" questions in the clini-

cal context of the patient (e.g., "Is there free fluid in the peritoneum?"), whereas studies done in the department of radiology tend to be more comprehensive and descriptive.

A QA database should be maintained to keep track of the total number of studies performed by each trainee. Information pertaining to the quality and accuracy of each study, with summary statistics regarding the total numbers of true and false-positive and -negative studies, should be collected and stored. These data will allow for the assessment of progress and serve as one component in the determination of proficiency.

The EUS director should set forth policies regarding the clinical use of EUS findings. This may involve collaboration with other divisions within the academic center. It is important to specify which applications are considered sufficiently sensitive and specific to guide clinical decision-making and conversely which applications require confirmation by either clinical course or alternate imaging modality. It should also be determined what minimum number of scans and level of training are required to reach proficiency and be credentialed in each application. All studies performed prior to the attainment of credentialing should be considered "educational," and findings should not guide clinical care unless reviewed by a clinician credentialed in that specific application.

There should be a plan in place for incidental findings, both those discovered at the time of the bedside US, and those discovered during QA review of the study. Saved studies should include enough patient and sonographer identifying information to allow for appropriate follow-up on incidental findings. Similarly, a plan should be developed for documentation of educational studies and how these studies are described to the patients and their families.

In terms of equipment, all programs should have US equipment physically available in the pediatric ED on a 24/7 basis. Prior to investing in a device, programs should research the available US equipment and determine which device and transducers are most suited to their practice environment based on published recommendations for US equipment for pediatric EDs.[10,11] The US device should have the ability to record and store images and clips for later review.

Currently, some institutions will not have EUS-trained PEM faculty capable of developing and implementing EUS programs. In these circumstances, it is appropriate to seek guidance and training from other sources. Other imaging specialists, such as EUS-trained general EM faculty and US-trained members of the departments of radiology, gynecology, and cardiology, can play an important role in the development of EUS programs and the training of PEM fellows. Additionally, collaboration with radiology colleagues in the early phases of program development can foster a relationship of partnership and understanding and lead to more effective and efficient program development.

PEM US CURRICULUM

The core applications for EUS in PEM have not been well established. At the time of publication, efforts are under way to establish a policy statement endorsed by the AAP and ACEP for pediatric point-of-care US. These recommendations will be based on both the existing research and expert consensus recommendations. The curriculum presented here includes an array of potential applications that may be considered in PEM, which will likely evolve over time in response to future research. While certain applications may be generalizable to many locations, others may be relevant only to institutionally specific settings and in response to local and changing needs.

Pediatric EM EUS applications can be broadly divided into the following categories: applications relevant to critically ill patients with potentially life-threatening conditions ("resuscitative applications"), applications that may aid in diagnosis and inform decision-making ("diagnostic applications"), and applications for which US can be used to assist with procedures ("procedural applications"). Programs should strongly consider including in their curricula applications potentially relevant to patients requiring resuscitation (signified with an asterisk). It is recommended that PEM fellows are exposed to a variety of applications, including indications, technique, and limitations. Each program should determine which applications are most relevant to that program's practice setting. Applications that are potentially relevant to pediatric patients in the ED include the following (and are expanded in Table 1):

1. eFAST* (the extended focused assessment with sonography for trauma) to identify free peritoneal fluid, pericardial effusion, hemothorax, and pneumothorax in cases of blunt and penetrating abdominal or thoracic trauma;
2. Focused cardiovascular imaging* to identify pericardial effusion and cardiac standstill, evaluate function, and assess inferior vena cava for volume status;
3. Early pregnancy imaging* to identify intrauterine pregnancy and/or free peritoneal fluid in the evaluation for ectopic pregnancy;
4. Soft tissue imaging to identify infection, fluid collections, and foreign bodies;
5. Thoracic imaging to identify pleural fluid, pneumothorax, and parenchymal pathology.
6. Bladder imaging to assess for presence and volume of urine;
7. Focused abdominal imaging to identify appendicitis, pyloric stenosis, intussusception, and free peritoneal fluid;
8. Musculoskeletal imaging to identify fractures and joint effusions;
9. Renal imaging to identify hydronephrosis.
10. Biliary imaging to identify evidence of cholelithiasis or cholecystitis;
11. Deep venous thrombus imaging;
12. Ocular imaging to identify pathology such as retinal detachment and vitreous hemorrhage and to evaluate optic nerve sheath diameter.

PEM fellows should be taught the principles of using bedside US to assist ED procedures. Relevant procedures include the following: 1) central venous catheter

Table 1
Potential Pediatric Emergency Medicine Ultrasound Applications

Resuscitative Applications	Diagnostic Applications	Procedural Applications
eFAST • Identify free peritoneal fluid • Identify pericardial effusion • Identify hemothorax • Identify pneumothorax Focused cardiovascular • Identify pericardial effusion • Identify cardiac standstill • Evaluate function • Assess IVC for volume status Early pregnancy • Identify intrauterine pregnancy and/or free peritoneal fluid in evaluation for ectopic pregnancy	Soft tissue • Identify infection • Identify fluid collection • Identify foreign body Thoracic • Identify pleural fluid • Identify pneumothorax • Identify parenchymal pathology Bladder • Assess for urine Focused abdominal • Identify appendicitis • Identify pyloric stenosis • Identify intussusception • Identify free peritoneal fluid Musculoskeletal • Identify fractures • Identify joint effusions Renal • Assess for hydronephrosis Biliary • Assess for cholelithiasis • Assess for cholecystitis Deep venous • Identify DVT Ocular • Identify retinal detachment • Identify vitreous hemorrhage • Evaluate optic nerve sheath diameter	CVC placement Peripheral intravenous access Abscess incision and drainage Suprapubic bladder aspiration Lumbar puncture ETT position confirmation Nerve block Arthrocentesis Thoracentesis Paracentesis

CVC = central venous catheter; DVT = deep venous thrombosis; ETT = endotracheal tube; eFAST = extended focused assessment with sonography in trauma; IVC = inferior vena cava.

placement,* 2) peripheral vascular access, 3) abscess incision and drainage, 4) suprapubic bladder aspiration, 5) lumbar puncture, 6) confirmation of endotracheal tube placement, 7) nerve block, 8) arthrocentesis, 9) thoracentesis, and 10) paracentesis.

The current widespread institutional variability in resources, US educators, patient populations, and practice settings makes it difficult and unrealistic to universally recommend which applications should be prioritized. While some of these applications are widely accepted and have been studied in pediatric patients, others should be considered advanced, have not been adequately studied, and require significant skill and training. Each program should identify which applications are most useful in that program's practice setting and emphasize related instruction. In the early stages of program development it may be reasonable to focus education around those applications that are most technically straightforward and supported by published data. Each program should strive to expose its fellows to scanning techniques and examples of normal and abnormal studies for those applications not taught in depth during the PEM fellowship.

PEM US EDUCATION PROGRAM

Emergency US should be included in the core education program for all PEM fellowships. Within the goals of every education program should be to provide fellows with a solid understanding of EUS principals and a skill set that allows them to incorporate EUS into their daily clinical practice. PEM fellows should understand the advantages and limitations of EUS and identify strategies for staying abreast of the newest evidence-based practices and recommendations. An US education program for PEM fellows, adapted from recommendations by ACEP for EM residents,[1] is summarized here (also see Figure 1):

Introductory Instruction

All fellows should receive an introduction to EUS early in the course of their fellowship training. This introduc-

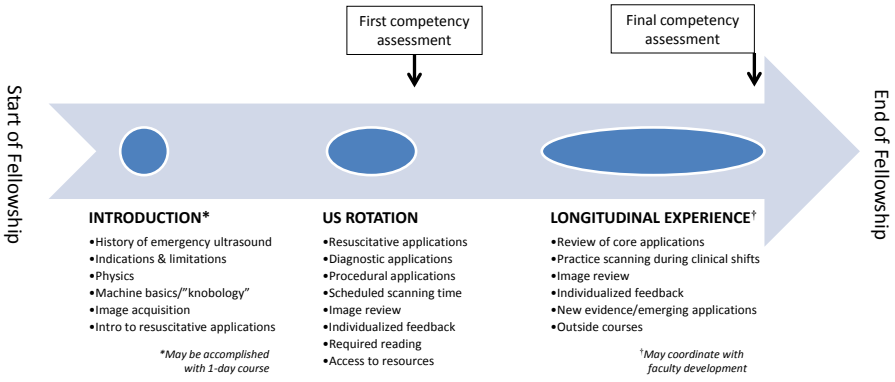

Figure 1. Pediatric emergency medicine ultrasound education program timeline.

tion should incorporate didactics and hands-on instruction and should include the following topics: a brief history of EUS, indications and limitations, relevant physics, and practical applications of EUS in the ED. Hands-on instruction should focus on machine basics (commonly referred to as "knobology") and image acquisition. The resuscitative applications should be introduced as early as possible, with the recognition that proficiency in these applications evolves over time with additional training and practice. A 1-day course in the first year of fellowship can accomplish these goals, with reinforcement of these basic skills as described below.

Rotation Recommendations

A dedicated 1- to 4-week EUS rotation is recommended for all PEM fellows. In some institutions, this rotation may be based in a general "adult" ED with instruction by qualified EM-trained faculty. Alternatively, experience may be sought within the department of radiology if available. During this rotation, fellows should have allocated time free from other clinical responsibilities. The rotation should be structured in a manner to incorporate the following features:

- Didactic sessions and hands-on instruction related to the relevant resuscitative, diagnostic, and procedural applications;
- Scheduled scanning time without simultaneous patient care responsibilities, with a majority of scanning proctored by the EUS director or qualified faculty members, particularly earlier in skill development;
- Image review of exemplary and/or departmental scans;
- Timely review of individual scans with feedback on image quality and interpretation throughout the rotation;
- Required reading from selected textbooks and journals;
- Access to educational resources including EUS textbooks, online resources, image banks, question banks, and electronic educational materials.

If this training occurs in a general ED with primarily adult patients or in the department of radiology, the experience should be augmented with teaching related to aspects of EUS unique to pediatric ED populations. If providing a structured quality EUS rotation is not feasible given the resources of a particular program, the fellowship director may arrange for fellows to enroll in an outside, comprehensive course that includes basic and advanced applications. A pediatric EUS course is preferred, if available.

Longitudinal Experience

Beyond the EUS rotation, fellows should receive longitudinal EUS education, including regular didactics, hands-on instruction, image review, and feedback on individual scans throughout their fellowship training. At some institutions, participation in outside courses may be necessary to provide this longitudinal experience. Whenever possible, fellows should be encouraged to scan during their clinical shifts (even if not for clinical decision-making), and timely feedback should be provided on the quality and accuracy of their studies, with attention to improvement and maintenance of skills over time. New evidence and emerging applications can be discussed during didactic sessions or in the format of a "journal club." At many institutions, longitudinal fellow educational opportunities can be combined with faculty development efforts.

Adaptations to the EUS training program should be made for those PEM fellows who completed primary residency training in EM. Although these trainees will likely enter a fellowship proficient in EUS as it pertains to general EM, they should receive pediatric-specific EUS training and longitudinal instruction.

Programs without the resources to provide EUS rotations and longitudinal EUS experiences for their fellows may use outside courses for current trainees, but should initiate plans toward developing a program with the educational capabilities described above.

COMPETENCY ASSESSMENT

Standards for the assessment of EUS competency in EM are delineated in the most recent ACEP guidelines.[1] These guidelines describe the goal of competency assessment as follows: "to ensure that all EM residents have a basic set of skills to allow for integration of [EUS] into their daily clinical practice after residency

training is complete." Currently, the role of EUS in PEM is still evolving and differs greatly between institutions. Until standardized guidelines for EUS within PEM are available, assessment of competency should be defined within each program. It is important that the department leadership clearly delineate how EUS will be used in their department. The minimum requirements for a fellow (or faculty member) to be deemed "competent" in each specific application should be well defined and based on the principals of competency assessment described for EM.

The two key components of competency assessment for EUS are the assessment of technique (i.e., image acquisition) and image interpretation. Assessment of technique is best accomplished with practical examinations, during which the technical aspects of image acquisition and quality are evaluated (i.e., probe selection, machine settings, technical skill, quality of image, inclusion of minimum images for specific applications). The practical examination can be performed on a patient, volunteer, or US-capable simulator.

The assessment of image interpretation is best accomplished by evaluating a trainee's decision-making skills using saved EUS images or video clips. Many EM programs use online standardized multiple-choice question tests to accomplish this assessment. At the time of publication, no similar examination is widely available for PEM fellows. Until such a tool is created, it is recommended that programs develop their own image banks to be used for testing. Images and video clips can be presented to assess fellows' ability to interpret images and correctly make decisions.

Emergency US is a multifaceted skill that requires clinical knowledge, image recognition, and manual dexterity. It must be practiced regularly to prevent deterioration of skill and confidence over time. Consequently, it is recommended that competency be assessed at least twice, at the end of each EUS rotation and again at the end of the fellowship. This ensures that competency is reached following a period of focused education and retained over time during fellowship training.

CONCLUSIONS

Emergency ultrasound is an important skill that has the potential to improve pediatric emergency care. Mounting evidence supporting the benefits of emergency ultrasound to pediatric patients substantiates the need to establish a curriculum for PEM fellows. Because of important differences between pediatric and adult ED patients, the emergency ultrasound education plan for PEM fellows will differ from the guidelines established by ACEP for EM residents.

Although the development of an EUS education program for PEM fellows requires planning, resources, and commitment, the return on the investment is immense. EUS is an attainable skill with a steep learning curve. Based on the authors' experience, with a robust first-year fellow rotation and longitudinal instruction throughout the second year, many PEM fellows become active EUS educators to both junior fellows and PEM faculty by the completion of the fellowship. It is our hope that these graduates will go on to investigate important research questions that will further support the use of emergency ultrasound in pediatric patients. Presently, the body of evidence related to many EUS applications in pediatric patients is growing, and the role emergency ultrasound plays in PEM is changing rapidly. All PEM physicians who use EUS must be committed to staying informed of the most current literature and recommendations.

The remarkable success of EM residency programs in training their residents supports the adaptation of their model. Each PEM fellowship program should strive to tailor an EUS curriculum best suited to that program's clinical practice setting using the above recommendations as a guideline. The incorporation of an emergency ultrasound curriculum into PEM fellowship training has the potential to benefit both PEM fellows and their patients.

APPENDIX A

CONSENSUS GUIDELINE COLLABORATORS (AUTHORS IN BOLD)

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