4-1-2015

Point-of-care ultrasonography by pediatric emergency medicine physicians.

Jennifer R. Marin

Resa E. Lewiss

American Academy of Pediatrics, Committee on Pediatric Emergency Medicine

Society for Academic Emergency Medicine, Academy of Emergency Ultrasound

American College of Emergency Physicians, Pediatric Emergency Medicine Committee

See next page for additional authors

Recommended Citation

Marin, J. R., Lewiss, R. E., ., ., ., ., Conners, G. P. Point-of-care ultrasonography by pediatric emergency medicine physicians. *Pediatrics* 135, 1113-1122 (2015).

TECHNICAL REPORT

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™

Point-of-Care Ultrasonography by Pediatric Emergency Medicine Physicians

Jennifer R. Marin, MD, MSc, Resa E. Lewiss, MD, AMERICAN ACADEMY OF PEDIATRICS, Committee on Pediatric Emergency Medicine; SOCIETY FOR ACADEMIC EMERGENCY MEDICINE, Academy of Emergency Ultrasound; AMERICAN COLLEGE OF EMERGENCY PHYSICIANS, Pediatric Emergency Medicine Committee; WORLD INTERACTIVE NETWORK FOCUSED ON CRITICAL ULTRASOUND

abstract

Emergency physicians have used point-of-care ultrasonography since the 1990s. Pediatric emergency medicine physicians have more recently adopted this technology. Point-of-care ultrasonography is used for various scenarios, particularly the evaluation of soft tissue infections or blunt abdominal trauma and procedural guidance. To date, there are no published statements from national organizations specifically for pediatric emergency physicians describing the incorporation of point-of-care ultrasonography into their practice. This document outlines how pediatric emergency departments may establish a formal point-of-care ultrasonography program. This task includes appointing leaders with expertise in point-of-care ultrasonography, effectively training and credentialing physicians in the department, and providing ongoing quality assurance reviews.

FREE

Point-of-care ultrasonography (US) is a bedside technology that enables clinicians to integrate clinical examination findings with real-time sonographic imaging. General emergency physicians and other specialists have used point-of-care US for many years, and more recently, pediatric emergency medicine (PEM) physicians have adopted point-of-care US as a diagnostic and procedural adjunct. This technical report and accompanying policy statement[1] provide a framework for point-of-care US training and point-of-care US integration into pediatric care by PEM physicians.

HISTORY OF EMERGENCY PHYSICIAN POINT-OF-CARE US

In 1990, the American College of Emergency Physicians (ACEP) published a position statement supporting the performance of US by appropriately trained emergency physicians.[2] The next year, the Society for Academic Emergency Medicine endorsed that statement and called for a training curriculum, which Mateer and colleagues published in 1994.[3,4] By 1996, the published emergency medicine core content included point-of-care

www.pediatrics.org/cgi/doi/10.1542/peds.2015-0343

DOI: 10.1542/peds.2015-0343

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

US for residency graduates.[5] With the passage of the American Medical Association Resolution 802 and policy H-230.960 in 1999, "recommending hospital [privileging] committees recognize specialty-specific guidelines for US credentialing decisions,"[6] emergency physicians were given full responsibility for developing the guidelines of their field. By 2001, the Accreditation Council for Graduate Medical Education mandated that all emergency medicine residents attain competency in the use of point-of-care US,[7] and the ACEP published the first emergency US guidelines.[8] In 2008, the ACEP published an update to the original guidelines, thereby establishing the most comprehensive specialty-specific training and practice to date.[9] Subsequently, the Society for Academic Emergency Medicine, the Council of Emergency Medicine Residency Directors, and the American Institute of Ultrasound in Medicine officially recognized that document.[10,11] Currently, guidelines from the Council of Emergency Medicine Residency Directors consensus documents from 2009 and 2012 are a mainstay for residency education.[10,12] In addition, competency assessment tools for the evaluation of emergency medicine residents are being considered.[12]

POINT-OF-CARE US IN PEDIATRIC EMERGENCY MEDICINE

More recently, PEM physicians have been using point-of-care US for patient care. According to a survey from 2011, 95% of emergency departments (EDs) with a PEM fellowship program use point-of-care US in some manner, and 88% of programs provide training in point-of-care US for their fellows.[13] This is a dramatic increase, because only 57% of programs reported the use of point-of-care US in 2006, and only 65% at that time incorporated training for their fellows.[14] Despite the growing use of point-of-care US by pediatric emergency physicians, there have been no published guidelines specific to pediatric emergency providers. The indications set forth in existing policy statements are written for emergency physicians who predominantly care for adult patients.

DIAGNOSTIC AND PROCEDURAL INDICATIONS

To date, numerous diagnostic and procedural applications for point-of-care US have been described. The literature supports the ability of general emergency physicians to use point-of-care US to improve the care of adult patients by accurately diagnosing time-sensitive and common ED conditions,[15–38] decreasing patient lengths of stay,[15,39–41] and reducing complications.[15,42–45] Furthermore, emergency physicians are able to achieve competency in performing point-of-care US for various indications after completing adequate training.[20,26,46–48]

Point-of-care US in pediatric patients by PEM providers has recently been adopted into practice, and the literature is still evolving. Nonetheless, there are numerous studies demonstrating the accuracy of point-of-care US by PEM physicians[49–58] and the ability of PEM physicians to become proficient in point-of-care US after adequate training.[55,56,59] Although the point-of-care US examinations performed should be specific to the needs of the department, the most common indications for which point-of-care US is being used in PEM are for focused assessment with sonography in trauma, soft tissue evaluation, and vascular access.[13]

Physicians should be aware that examinations in children and adolescents with disabilities and chronic medical problems may be more challenging to perform and integrate. As always, interpretations should be made carefully in the context of the clinical scenario (eg, the focused assessment with sonography in trauma examination may demonstrate free peritoneal fluid at baseline in a patient with a ventriculoperitoneal shunt).

DEVELOPMENT OF A POINT-OF-CARE US PROGRAM

The development of a point-of-care US program begins with a clinical need for these services. It is not necessary that all relevant applications be introduced at the same time. In fact, it is most effective to identify the applications that will be the most important in emergent scenarios or most commonly used. The program may then be extended as PEM physicians become more proficient. Point-of-care US has become more prevalent in medicine,[60] and consequently more physicians are using this bedside technology. Preparing the workforce of the future for point-of-care US means embedding training strategies in the infrastructure of residency and fellowship training.

Point-of-Care US Leadership

A point-of-care US director or core group of leaders is established to facilitate and manage the educational and administrative tasks of coordinating a point-of-care US program within a division or department. Overall, responsibilities for developing a program include education for the clinician operators and administrative processes and procedures for credentialing and quality assurance (QA).

The point-of-care US director (or several directors) has significant US experience encompassing the breadth of pediatric point-of-care US applications. As more PEM point-of-care US fellowships become available, it is likely that US directors will be fellowship-trained.

The director works with the departmental leaders to define a vision and goals for the program. These include equipment accrual,

training guideline development, QA program development, payment strategies, workflow solution implementation for image storage, and creation of credentialing and privileging documents.

Equipment

Selecting the appropriate equipment depends on a number of factors, including image quality, number of users, breadth of use, ease of use, storage space, connectivity options, memory storage needs, budget, and local contracts with manufacturers at each institution.

According to the American Institute of Ultrasound in Medicine's "Routine Quality Assurance for Diagnostic Ultrasound Equipment," there are 2 types of QA needs: cleanliness and safety, and image display and performance.[61] The regular cleaning and daily maintenance of the machinery may be performed by users, biomedical engineering staff, or environmental service staff and should follow guidelines of the Joint Commission. The technical performance of the machine may be maintained by the manufacturer if the machine is under a service contract, and those in the ED may be responsible for QA.

Many departments with established programs have, at a minimum, a low-frequency and a high-frequency transducer. The high-frequency linear transducer can be used in pediatrics for the soft tissues, abdomen, lung, and spine and for procedural guidance. For the evaluation of deeper structures and evaluation of the chest and abdomen, a lower-frequency transducer will provide improved visualization. The phased-array transducer, with its smaller footprint, is attractive for use in children, given the smaller size of pediatric patients. A curvilinear transducer may be suitable for some applications despite the larger footprint. Other transducers, such a "hockey stick" linear transducer or endocavitary transducer, which can be used for applications including pelvic imaging and peritonsillar abscesses, may be useful depending on the patient population and physician practice patterns. Obtaining service agreements and warranties with equipment purchasing are important because the equipment undergoes more physical deterioration than similar equipment in an isolated suite used by fewer technicians.

Education and Training

When developing a US program, it is important to consider the spectrum of learners, their willingness to accept new innovations, and their learning styles. Each learner needs special educational attention, and several options for US education may be used. As an introduction to US, physicians may use asynchronous online learning material through Web sites, podcasts, or blogs, for example. Synchronized time through an 8- to 16-hour course with education and hands-on experience is a standard foundation for introductory US training and has been recommended in the ACEP 2008 "Emergency Ultrasound Guidelines" and other publications.[9,62,63] Additionally, simulation centers may provide a learning environment to teach and demonstrate the practice of point-of-care ultrasound. Finally, bedside teaching of US on patients is an important part of any educational paradigm, including instruction in acquiring high-quality images, interpreting these images, and incorporating these data into bedside medical decision-making. Evidence suggests this is the best method for learners to understand this modality.[64]

Most novice learners report time constraints as the major hurdle toward learning US and obtaining proficiency.[13] The point-of-care US director is challenged to help integrate various types of US education into the practice patterns of the division or department to meet the needs of all learners. Alternatively, the director may choose to highlight a specific group, such as attending physicians, and develop a focused plan to train them and use their skills in providing training to the other members of the division or department. Another option is to develop US fellows as educators and to have them train attending physicians in turn. Regardless of the approach, it is important to understand and appreciate that learning point-of-care US at any level is time intensive. Overall, it is important to provide a spectrum of didactic and hands-on opportunities that will assist the learner in mastering this technical and interpretive skill.

Interdepartmental Considerations

Working with other medical specialty departments may be useful when beginning a point-of-care US program. Specifically, the point-of-care US directors may find that their US efforts parallel an undeveloped desire of physicians in other disciplines who seek to incorporate US into their practice. Because specialties such as radiology and cardiology have a long history with US use, early collaboration with these departments may enhance the development of a PEM point-of-care US program. In addition, the general emergency medicine community has developed a robust national and international presence to advocate for point-of-care US. They have established guidelines and policy statements regarding the use of point-of-care US in the ED.[9,10] Collaboration with neighboring or affiliated general EDs may also prove beneficial.

POINT-OF-CARE US TRAINING AND CREDENTIALING

Point-of-care US is a multifaceted skill including image acquisition, interpretation, and clinical knowledge. To be considered proficient in point-of-care US, PEM

physicians need the skills to acquire technically adequate images and the ability to interpret these studies to inform clinical decision-making. Additionally, physicians should be aware of the relevant point-of-care US applications and how they apply to the patient population.

Many practicing PEM physicians received little or no point-of-care US education during their training. This section includes suggestions for a PEM trainee pathway ("Training-Based Pathway") and a PEM practicing physician training pathway ("Practice-Based Pathway"). Both pathways require a combination of teaching and hands-on training and include standards for determining proficiency.

Training-Based Pathway

In general, point-of-care US education programs provide trainees with a comprehensive understanding of point-of-care US principles and a skill set that allows them to incorporate point-of-care US into their daily practice. Trainees gain proficiency in the applications most relevant to their practice environment, as determined by the training program. They also develop and understand the advantages and limitations of point-of-care US in their patient population and practice setting. They identify strategies for staying informed of the newest and best evidence-based practices and recommendations.

A point-of-care US education program, adapted from published consensus guidelines for PEM fellow US training[65] and the ACEP policy statement on point-of-care US,[9] is summarized here.

Introductory Instruction

Trainees receive an introduction to point-of-care US early in the course of their training. The introduction incorporates didactics and hands-on instruction and covers important topics such as a brief history of point-of-care US, indications and limitations, and relevant fundamental physics. Practical instruction focuses on machine basics (commonly referred to as "knobology") and image acquisition.

Rotation Components

A dedicated point-of-care US rotation is considered necessary by many US instructors for trainees who will use point-of-care US in their field. In some institutions, this rotation may be coordinated with radiology, cardiology, or subspecialty-specific point-of-care US–trained physician members. During this rotation, trainees have adequate allocated time free from other clinical responsibilities. The rotation is structured in a manner that incorporates the following features:

- **Didactic sessions and hands-on instruction** related to relevant applications. Hands-on training should include live or simulation models.
- **Scheduled scanning sessions** without simultaneous patient care responsibilities, with a majority proctored by the point-of-care US director or qualified clinicians (ie, those who have been trained and credentialed to perform US for that indication).
- **Image review** of exemplary or departmental scans. Review of imaging from other subspecialties (eg, radiology, cardiology) should be incorporated when appropriate.
- **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 point-of-care US textbooks, online resources, image banks, question banks, and electronic educational materials.

If providing a structured quality point-of-care US rotation is not feasible given the resources of a particular program, the point-of-care US directors may arrange for trainees to enroll in an outside, comprehensive continuing medical education (CME) course that includes basic and advanced applications. Alternatively, trainees may arrange for a rotation at another institution with an established rotation to receive adequate training. A pediatric subspecialty-specific point-of-care US course or rotation at an institution with a pediatric focus is preferred.

Longitudinal Experience

Beyond the point-of-care US rotation, longitudinal point-of-care US education is important to maintain skills. This includes ongoing didactics, hands-on instruction, image review, and feedback on individual scans throughout the training. Whenever possible and with patient permission, trainees may scan during their clinical shifts. These practice or "educational" scans are not used for medical decision-making.

It is important for physicians to obtain verbal consent from patients and families before performing an educational scan. Specifically, patients and families are informed that the examination would not be used to inform clinical decision-making, and there would not be a charge incurred for the examination. Timely feedback may be provided on the quality and accuracy of the studies, with attention to improvement and maintenance of skills over time. In many institutions, longitudinal trainee point-of-care US educational opportunities can be combined with physician development efforts.

Programs without the resources to provide a point-of-care US rotation and longitudinal point-of-care US experience for their trainees may use outside courses or institutions. In addition, PEM fellows may supplement their training and develop administrative and leadership skills in point-of-care

US through additional training in a 1-year PEM-specific or general emergency medicine US fellowship program.

Practice-Based Pathway

For practicing physicians who did not receive point-of-care US training during their residency or fellowship, point-of-care US education may be creatively integrated into the physician development curriculum. Physicians can pursue training off site if their clinical setting does not provide adequate point-of-care US teaching faculty or supervisors. The practice-based pathway can focus on applications that will be of highest yield for the practicing physicians based on their specialty, patient population, and practice environment.

Introductory Instruction

For physicians without US experience, point-of-care US training may begin with an introductory course consisting of both didactics and hands-on instruction. Introduction to point-of-care US concepts and basic clinical applications can be provided with online, video, or in-person presentations. Didactics alone are insufficient. Hands-on training with live or simulation models is essential for successful introductory training.

Experiential Training

After completing an introductory course, physicians are encouraged to practice the point-of-care US skills they have learned during their clinical shifts. These practice or "educational" scans are either reviewed in real time or saved for review by the point-of-care US director or other qualified clinicians. Feedback is best provided in a timely fashion on the quality and accuracy of the studies, with attention to improvement and maintenance of skills over time. As in the training-based pathway described in the previous section, it is important for physicians to obtain verbal consent from patients and families before performing an educational scan. Specifically, patients and families are informed that the examination would not be used to inform clinical decision-making, and there would not be a charge incurred for the examination. Department leadership establishes well-defined goals for the numbers of required educational scans in the most relevant applications. Repetition will allow physicians to refine their technique and improve their image acquisition abilities. Ideally, hands-on scanning with a point-of-care US faculty member should complement independent scanning. Participation in image review is an important aspect of point-of-care US training and allows physicians to receive feedback on the quality and accuracy of their scans. By participating in online educational activities and attending conferences, physicians can learn about new point-of-care US applications and stay abreast of developments in the field.

Longitudinal Experience

Establishing requirements for competency (as detailed later) will depend on the clinical setting and the complexity of the individual application. Maintenance of point-of-care US competency requires continued use of the skill. Once it has been determined that a physician is competent in a given application, continued review of a percentage of studies by a supervising point-of-care US physician is important to ensure that the quality of scan acquisition and accuracy of scan interpretation does not decline after competency has been achieved. Frequent review of the recent point-of-care US literature related to the applications used by each subspecialty is also a part of maintenance of proficiency.

Credentialing

Credentialing "defines a physician's scope of practice and the clinical services he or she may provide, and ensures that the physician provides services within the scope of privileges granted."[9] Specifically, the credentialing of physicians to use point-of-care US provides a framework to ensure the appropriate training and implementation of US into clinical practice. Overall, it is important that the credentialing system be a "transparent, high quality, verifiable, and efficient system."[9] Credentialing is typically conferred by the hospital and is achieved through education, training, and practice performance, with subsequent evaluation of individual physician data. For hospitals without an established credentialing process whereby hospital privileges are granted for point-of-care US, the US directors may consider creating a document that delineates the expectations for those seeking privileges. Credentialing should be distinguished from certification, which is made possible by documentation from an outside body attesting that a person has the capability to perform and interpret US.[66] Currently, there is no nationally accepted certification for physician performance and interpretation of point-of-care US. Some physicians may opt to receive the Registered Diagnostic Medical Sonographer certification, but this certification is geared toward US technicians and is not specific to point-of-care US. Accreditation refers to the overall evaluation of a practice, such as an US department at an institution, typically by a national organization.[66]

It is important that the department leaders clearly delineate how point-of-care US will be used in each department, and providers should be skilled in the point-of-care US indications that apply to their practice environment. The ACEP guidelines for emergency physicians suggest physicians should successfully perform 25 to 50 examinations in each application, with a required number of "true positives" with pathologic findings.[9] Ideally, these scans are performed in the ED during clinical encounters.

However, acceptable alternatives may include scanning with other imaging specialists and approved CME activities.

With regard to US-guided procedures, the number of scans needed to define competency varies depending on the procedure and the clinician's experience and comfort with the procedure without US guidance. For most simple procedures with which the clinician is already familiar, previous statements on point-of-care US recommend performing 10 scans. For other applications, the clinician may require additional scans (25–50).[9]

Maintenance of Competency

Hospitals typically reappoint physicians and renew their clinical privileges at regular intervals. To renew hospital privileges, a physician must "demonstrate current clinical competence, skill, judgment, and technique."[9] This includes performing services as specified in their clinical privileges on a regular basis and keeping up to date on the current literature. In addition to the minimum number of hours of CME didactics, clinicians perform a certain number of scans per year to maintain privileges, with monitoring of their accuracy and remediation when necessary.[67]

Point-of-care US is an acquired skill requiring training and practice. Accordingly, ongoing maintenance of proficiency through CME is important. This may be accomplished in a number of different formats, including departmental US conferences, regional courses, image review sessions, online educational activities, morbidity and mortality conferences that have a specific point-of-care US component, in-service examinations, textbook and journal readings, and research. Hands-on sessions are preferred for physicians who use point-of-care US less frequently. The number of CME hours required per CME cycle (every 2 years) to maintain competency may vary, but in general they should be relevant and proportional to the number of credentialed applications. The ACEP recommends 5 hours of CME for general practitioners and 10 hours for US directors to maintain credentialing.[9] However, particularly when point-of-care US practitioners do not have the opportunity to use certain examination skills on a routine basis, additional CME hours should be considered to maintain an appropriate knowledge base and skill level (eg, 10–15 hours per year).

POINT-OF-CARE US QUALITY ASSURANCE AND QUALITY IMPROVEMENT

Examinations are reviewed and evaluated on a regular basis as part of the overall QA and improvement program at each institution. The purpose of the QA process is to evaluate for maintenance of a minimum standard quality of image acquisition and accurate interpretation. An integral component to point-of-care US is the identification of a person (or people) who will be responsible for ongoing monitoring and QA. This may consist of the US director or an equivalent person with requisite knowledge and experience. Assistance in this capacity may be obtained from physicians with requisite US experience who work outside the pediatric ED (eg, critical care, general emergency medicine, radiology).

In general, the person responsible for QA regularly reviews images and provides timely feedback to physicians performing point-of-care US. Images are assessed for technical components (eg, gain, depth, orientation, labeling, and focus) and interpretative accuracy, comparing the point-of-care US findings with comprehensive or consultant imaging in all cases in which these are obtained, as well as medical or surgical outcomes when available. Discordant findings are monitored and periodically reviewed with the sonologist and through the departmental morbidity and mortality process to identify opportunities to improve patient care. The QA records are regularly maintained and available for review.

It is important to put a process in place to address imaging or interpretive errors of clinical significance in a timely fashion so that potential patient harm is avoided. This includes instances of misinterpretation and the omission of necessary views. The treating physician, QA director, US director, or equivalent ensures that proper follow-up is established, including a return to care if necessary, and documentation of communication is reflected in the patient's charting.

Documentation and Archiving

The manner of documentation for the point-of-care US (eg, hand-written, templated on a computer, or other) depends on the medical record system of the institution. Communication with individual insurance companies and regulators may assist with clarifying the exact wording and level of detail for additional purposes of payment. Elements to include in the documentation are[68,69] indications for the examination; name of sonologists or certified physician performing imaging; views and findings, including incidental findings; limitations and recommendations for additional studies; impression and medical decision-making; and permanently recorded images as part of the medical record. Maintaining standardized documentation ensures that all relevant information for a given examination is included for easier review, data inquiries, retrieval for research, and inclusion of all necessary elements for billing compliance.[70] Images may be archived in a variety of formats. The types of imaging may

include printed thermal images, digital still images, or video clips. Archiving solutions may include CDs, digital video discs, hard drives, local servers, third-party proprietary digital archival servers, or picture archiving and communication system programs. The solution should comply with relevant regulatory and individual institutional risk management policies.

CONCLUSIONS

The evidence in support of point-of-care US as an adjunct to the clinical effectiveness of PEM physicians is growing. Over time, more pediatric EDs will develop point-of-care US programs. By establishing training, credentialing, and QA programs, a director or core group of leaders can ensure that this technology is implemented in a safe and effective manner. Ultimately, this will improve the care of pediatric patients. As stated in a "Perspectives" article in *Pediatrics,* "as much as it is our responsibility to understand the limitations and challenges associated with integrating point-of-care US into pediatrics, it is our responsibility to our patients to stay abreast of the most current advances in medicine and provide the safest, most efficient, state-of-the-art care. Point-of-care US can help us meet this goal."[71]

LEAD AUTHORS

Jennifer R. Marin, MD, MSc
Resa E. Lewiss, MD

FINANCIAL DISCLOSURE/CONFLICT OF INTEREST

Dr Lewiss has no financial disclosures or potential conflicts of interest. Dr Marin receives support from 3rd Rock Ultrasound, LLC for serving as teaching faculty and received support from the Agency for Healthcare Quality and Research (R13HS023498) related to a conference on diagnostic imaging and from the National Institutes of Health (K12HL109068).

REFERENCES

1. American Academy of Pediatrics, Society for Academic Emergency Medicine, American College of Emergency Physicians, World Interactive Network Focused On Critical UltraSound. Policy statement: point-of-care ultrasonography by pediatric emergency medicine physicians. *Pediatrics*. (in press)
2. American College of Emergency Physicians. Council resolution on ultrasound. *ACEP News*. 1990;9(11)
3. Society for Academic Emergency Medicine. Ultrasound position statement. *SAEM Newsletter*. Summer 1991;3:3
4. Mateer J, Plummer D, Heller M, et al. Model curriculum for physician training in emergency ultrasonography. *Ann Emerg Med*. 1994;23(1):95–102
5. Hall M, DD P, Heller M, et al. Model curriculum for physician training in emergency ultrasonography. *Ann Emerg Med*. 1994;23(1):95–102
6. American Medical Association. AMA Policy H-230.960: Privileging for Ultrasound Imaging. Chicago, IL: American Medical Association; 1999
7. Hockberger RS, Binder LS, Graber MA, et al. The model of the clinical practice of emergency medicine. *Ann Emerg Med*. 2001;37(6):745–770
8. American College of Emergency Physicians. ACEP emergency ultrasound guidelines–2001. *Ann Emerg Med*. 2001; 38(4):470–481
9. American College of Emergency Physicians. Emergency ultrasound guidelines. *Ann Emerg Med*. 2009;53(4):550–570
10. 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
11. American Institute of Ultrasound in Medicine. AIUM officially recognizes ACEP emergency ultrasound guidelines [press release]. November 17, 2011. Available at: www.aium.org/soundWaves/article.aspx?ald=442&ild=20111117. Accessed October 19, 2012
12. Lewiss RE, Pearl M, Nomura JT, et al. CORD-AEUS: Consensus Document for the Emergency Ultrasound Milestone Project. Burton J, ed. *Acad Emerg Med*. 2013; 20(7):740–745
13. Marin JR, Zuckerbraun NS, Kahn JM. Use of emergency ultrasound in United States pediatric emergency medicine fellowship programs in 2011. *J Ultrasound Med*. 2012;31(9):1357–1363
14. Ramirez-Schrempp D, Dorfman DH, Tien I, Liteplo AS. Bedside ultrasound in pediatric emergency medicine fellowship programs in the United States: little formal training. *Pediatr Emerg Care*. 2008;24(10):664–667
15. Melniker LA, Leibner E, McKenney MG, Lopez P, Briggs WM, Mancuso CA. Randomized controlled clinical trial of point-of-care, limited ultrasonography for trauma in the emergency department: the first sonography outcomes assessment program trial. *Ann Emerg Med*. 2006;48(3):227–235
16. Squire BT, Fox JC, Anderson C. ABSCESS: applied bedside sonography for convenient evaluation of superficial soft tissue infections. *Acad Emerg Med*. 2005; 12(7):601–606
17. Tayal VS, Hasan N, Norton HJ, Tomaszewski CA. The effect of soft-tissue ultrasound on the management of cellulitis in the emergency department. *Acad Emerg Med*. 2006;13(4):384–388
18. Plummer D, Brunette D, Asinger R, Ruiz E. Emergency department echocardiography improves outcome in penetrating cardiac injury. *Ann Emerg Med*. 1992;21(6):709–712
19. Mandavia DP, Hoffner RJ, Mahaney K, Henderson SO. Bedside echocardiography by emergency physicians. *Ann Emerg Med*. 2001;38(4):377–382
20. Moore CL, Rose GA, Tayal VS, Sullivan DM, Arrowood JA, Kline JA. Determination of left ventricular function by emergency physician echocardiography of hypotensive patients. *Acad Emerg Med*. 2002;9(3): 186–193
21. Randazzo MR, Snoey ER, Levitt MA, Binder K. Accuracy of emergency physician assessment of left ventricular ejection fraction and central venous pressure using echocardiography. *Acad Emerg Med*. 2003;10(9):973–977
22. Spurney CF, Sable CA, Berger JT, Martin GR. Use of a hand-carried ultrasound device by critical care physicians for the diagnosis of pericardial effusions, decreased cardiac function, and left ventricular enlargement in pediatric patients. *J Am Soc Echocardiogr*. 2005; 18(4):313–319
23. Kendall JL, Shimp RJ. Performance and interpretation of focused right upper quadrant ultrasound by emergency physicians. *J Emerg Med*. 2001;21(1): 7–13
24. Miller AH, Pepe PE, Brockman CR, Delaney KA. ED ultrasound in hepatobiliary disease. *J Emerg Med*. 2006;30(1):69–74
25. Williams J. 50 emergency department gallbladder ultrasounds: correlation with pathology. *Ann Emerg Med*. 2011; 58(4 suppl):S194
26. Marshburn TH, Legome E, Sargsyan A, et al. Goal-directed ultrasound in the detection of long-bone fractures. *J Trauma*. 2004;57(2):329–332
27. Lichtenstein DA, Lascols N, Mezière G, Gepner A. Ultrasound diagnosis of alveolar consolidation in the critically ill. *Intensive Care Med*. 2004;30(2):276–281
28. Kirkpatrick AW, Sirois M, Laupland KB, et al. Hand-held thoracic sonography for detecting post-traumatic pneumothoraces: the Extended Focused Assessment with Sonography for Trauma (EFAST). *J Trauma*. 2004;57(2):288–295
29. Zhang M, Liu ZH, Yang JX, et al. Rapid detection of pneumothorax by ultrasonography in patients with multiple trauma. *Crit Care*. 2006;10(4): r112
30. Lichtenstein DA, Mezière G, Lascols N, et al. Ultrasound diagnosis of occult pneumothorax. *Crit Care Med*. 2005; 33(6):1231–1238
31. Crisp JG, Lovato LM, Jang TB. Compression ultrasonography of the lower extremity with portable vascular ultrasonography can accurately detect deep venous thrombosis in the emergency department. *Ann Emerg Med*. 2010;56(6):601–610
32. Magazzini S, Vanni S, Toccafondi S, et al. Duplex ultrasound in the emergency department for the diagnostic management of clinically suspected deep vein thrombosis. *Acad Emerg Med*. 2007;14(3):216–220
33. Jolly BT, Massarin E, Pigman EC. Color Doppler ultrasonography by emergency

physicians for the diagnosis of acute deep venous thrombosis. *Acad Emerg Med*. 1997;4(2):129–132

34. Stein JC, Wang R, Adler N, et al. Emergency physician ultrasonography for evaluating patients at risk for ectopic pregnancy: a meta-analysis. *Ann Emerg Med*. 2010;56(6):674–683
35. Moore C, Todd WM, O'Brien E, Lin H. Free fluid in Morison's pouch on bedside ultrasound predicts need for operative intervention in suspected ectopic pregnancy. *Acad Emerg Med*. 2007;14(8): 755–758
36. McRae A, Murray H, Edmonds M. Diagnostic accuracy and clinical utility of emergency department targeted ultrasonography in the evaluation of first-trimester pelvic pain and bleeding: a systematic review. *CJEM*. 2009;11(4): 355–364
37. Via G, Hussain A, Wells M, et al International evidence-based recommendations for focused cardiac ultrasound. *J Am Soc Echocardiogr*. 2014;27(7):683.e1–683.e33
38. Volpicelli G, Elbarbary M, Blaivas M, et al; International Liaison Committee on Lung Ultrasound (ILC-LUS) for International Consensus Conference on Lung Ultrasound (ICC-LUS). International evidence-based recommendations for point-of-care lung ultrasound. *Intensive Care Med*. 2012;38(4):577–591
39. Blaivas M, Sierzenski P, Plecque D, Lambert M. Do emergency physicians save time when locating a live intrauterine pregnancy with bedside ultrasonography? *Acad Emerg Med*. 2000;7(9):988–993
40. Theodoro D, Blaivas M, Duggal S, Snyder G, Lucas M. Real-time B-mode ultrasound in the ED saves time in the diagnosis of deep vein thrombosis (DVT). *Am J Emerg Med*. 2004;22(3): 197–200
41. Blaivas M, Harwood RA, Lambert MJ. Decreasing length of stay with emergency ultrasound examination of the gallbladder. *Acad Emerg Med*. 1999; 6(10):1020–1023
42. Randolph AG, Cook DJ, Gonzales CA, Pribble CG. Ultrasound guidance for placement of central venous catheters: a meta-analysis of the literature. *Crit Care Med*. 1996;24(12): 2053–2058
43. Miller AH, Roth BA, Mills TJ, Woody JR, Longmoor CE, Foster B. Ultrasound guidance versus the landmark technique for the placement of central venous catheters in the emergency department. *Acad Emerg Med*. 2002; 9(8):800–805
44. Keyes LE, Frazee BW, Snoey ER, Simon BC, Christy D. Ultrasound-guided brachial and basilic vein cannulation in emergency department patients with difficult intravenous access. *Ann Emerg Med*. 1999;34(6):711–714
45. Brannam L, Blaivas M, Lyon M, Flake M. Emergency nurses' utilization of ultrasound guidance for placement of peripheral intravenous lines in difficult-access patients. *Acad Emerg Med*. 2004; 11(12):1361–1363
46. Ma OJ, Mateer JR, Ogata M, Kefer MP, Wittmann D, Aprahamian C. Prospective analysis of a rapid trauma ultrasound examination performed by emergency physicians. *J Trauma*. 1995;38(6): 879–885
47. Gaspari RJ, Dickman E, Blehar D. Learning curve of bedside ultrasound of the gallbladder. *J Emerg Med*. 2009;37(1): 51–56
48. Jang TB, Ruggeri W, Dyne P, Kaji AH. Learning curve of emergency physicians using emergency bedside sonography for symptomatic first-trimester pregnancy. *J Ultrasound Med*. 2010;29(5): 1423–1428
49. Fox JC, Boysen M, Gharahbaghian L, et al. Test characteristics of focused assessment of sonography for trauma for clinically significant abdominal free fluid in pediatric blunt abdominal trauma. *Acad Emerg Med*. 2011;18(5): 477–482
50. Iverson K, Haritos D, Thomas R, Kannikeswaran N. The effect of bedside ultrasound on diagnosis and management of soft tissue infections in a pediatric ED. *Am J Emerg Med*. 2012;30(8): 1347–1351. doi:10.1016/j.ajem.2011.09.020
51. Sivitz AB, Lam SHF, Ramirez-Schrempp D, Valente JH, Nagdev AD. Effect of bedside ultrasound on management of pediatric soft-tissue infection. *J Emerg Med*. 2010;39(5):637–643. doi:10.1016/j.jemermed.2009.05.013
52. Marin JR, Dean AJ, Bilker WB, Panebianco NL, Brown NJ, Alpern ER. Emergency ultrasound-assisted examination of skin and soft tissue infections in the pediatric emergency department. *Acad Emerg Med*. 2013; 20(6):545–553
53. Chen L, Hsiao AL, Moore CL, Dziura JD, Santucci KA. Utility of bedside bladder ultrasound before urethral catheterization in young children. *Pediatrics*. 2005;115(1):108–111
54. Witt M, Baumann BM, McCans K. Bladder ultrasound increases catheterization success in pediatric patients. *Acad Emerg Med*. 2005;12(4):371–374
55. Shah VP, Tunik MG, Tsung JW. Prospective evaluation of point-of-care ultrasonography for the diagnosis of pneumonia in children and young adults. *JAMA Pediatr*. 2013;167(2):119–125
56. Riera A, Hsiao AL, Langhan ML, Goodman TR, Chen L. Diagnosis of intussusception by physician novice sonographers in the emergency department. *Ann Emerg Med*. 2012;60(3):264–268
57. Pershad J, Myers S, Plouman C, et al. Bedside limited echocardiography by the emergency physician is accurate during evaluation of the critically ill patient. *Pediatrics*. 2004;114(6). Available at: www.pediatrics.org/cgi/content/full/114/6/e667
58. Sivitz AB, Tejani C, Cohen SG. Evaluation of hypertrophic pyloric stenosis by pediatric emergency physician sonography. *Acad Emerg Med*. 2013: 20(7):646–651
59. Marin JR, Alpern ER, Panebianco NL, Dean AJ. Assessment of a training curriculum for emergency ultrasound for pediatric soft tissue infections. *Acad Emerg Med*. 2011;18(2):174–182
60. Moore CL, Copel JA. Point-of-care ultrasonography. *N Engl J Med*. 2011; 364(8):749–757
61. American Institute of Ultrasound in Medicine. Standards and guidelines for the accreditation of ultrasound practices. 2011. Available at: www.aium.org/officialStatements/26. Accessed September 4, 2013
62. Jang TB, Coates WC, Liu YT. The competency-based mandate for emergency bedside sonography training and a tale of two residency programs. *J Ultrasound Med*. 2012; 31(4):515–521
63. Mandavia DP, Aragona J, Chan L, Chan D, Henderson SO. Ultrasound training for

emergency physicians: a prospective study. *Acad Emerg Med*. 2000;7(9):1008–1014

64. Bahner DP, Hughes D, Royall NA. A novel model for teaching and performing focused sonography. *J Ultrasound Med*. 2012;31(2):295–300
65. Vieira RL, Hsu D, Nagler J, et al; American Academy of Pediatrics. Pediatric emergency medicine fellow training in ultrasound: consensus educational guidelines. *Acad Emerg Med*. 2013;20(3):300–306
66. Moore C. Credentialing and reimbursement in point-of-care ultrasound. *Clin Pediatr Emerg Med*. 2011;12(1):73–77
67. Stein JC, Nobay F. Emergency department ultrasound credentialing: a sample policy and procedure. *J Emerg Med*. 2009;37(2):153–159
68. Resnick J, Hoffenberg S, Tayal V, Dickman E. Ultrasound coding and reimbursement update 2009. Emergency Ultrasound Section. American College of Emergency Physicians. Available at: www.acep.org/content.aspx?id=32182. Accessed March 26, 2013
69. ACR Practice Guideline for Communication of Diagnostic Imaging Findings. 2010. Available at: www.acr.org/~/media/C5D1443C9EA4424AA12477D1AD1D927D.pdf. Accessed December 26, 2013
70. ACR-SPR-SRU practice guideline for performing and interpreting diagnostic ultrasound examinations. Available at: www.acr.org/~/media/ACR/Documents/PGTS/guidelines/US_Performing_Interpreting.pdf. Accessed November 17, 2012
71. Vieira RL, Bachur R. Bedside ultrasound in pediatric practice. *Pediatrics*. 2014;133(1):1–3. doi: 10.1542/peds.2013-0750

Point-of-Care Ultrasonography by Pediatric Emergency Medicine Physicians

Jennifer R. Marin, Resa E. Lewiss, AMERICAN ACADEMY OF PEDIATRICS, Committee on Pediatric Emergency Medicine, SOCIETY FOR ACADEMIC EMERGENCY MEDICINE, Academy of Emergency Ultrasound, AMERICAN COLLEGE OF EMERGENCY PHYSICIANS, Pediatric Emergency Medicine Committee and WORLD INTERACTIVE NETWORK FOCUSED ON CRITICAL ULTRASOUND

Pediatrics originally published online March 30, 2015;

PEDIATRICS®
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Point-of-Care Ultrasonography by Pediatric Emergency Medicine Physicians

Jennifer R. Marin, Resa E. Lewiss, AMERICAN ACADEMY OF PEDIATRICS, Committee on Pediatric Emergency Medicine, SOCIETY FOR ACADEMIC EMERGENCY MEDICINE, Academy of Emergency Ultrasound, AMERICAN COLLEGE OF EMERGENCY PHYSICIANS, Pediatric Emergency Medicine Committee and WORLD INTERACTIVE NETWORK FOCUSED ON CRITICAL ULTRASOUND

Pediatrics originally published online March 30, 2015;