CLINICAL REPORT Guidance for the Clinician in Rendering Pediatric Care

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Use of Point-of-Care Ultrasonography in the NICU for Diagnostic and Procedural Purposes

Dan L. Stewart, MD, FAAP,[a] Yasser Elsayed, MD, FRCPC,[b] María V. Fraga, MD,[c] Brian D. Coley, MD, FAAP, FACR,[d] Aparna Annam, DO, FAAP,[e] Sarah Sarvis Milla, MD, FAAP,[f] COMMITTEE ON FETUS AND NEWBORN AND SECTION ON RADIOLOGY

Point-of-care ultrasonography (POCUS) refers to the use of portable imaging performed by the treating clinician at the bedside for diagnostic, therapeutic, and procedural purposes. POCUS may be considered an extension of the physical examination but not a substitute for diagnostic imaging. Use of POCUS in emergency situations can be lifesaving in the NICU if performed in a timely fashion for cardiac tamponade, pleural effusions, pneumothorax, etc, with potential for enhancing the quality of care and improving outcomes. In the past 2 decades, POCUS has gained significant acceptance in clinical medicine in many parts of the world and in many subspecialties. Formal accredited training and certification programs are available for neonatology trainees, as well as for many other subspecialties in Canada, Australia, and New Zealand. Although no formal training program or certification is available to neonatologists in Europe, POCUS is also widely available to providers in NICUs. A formal institutional POCUS fellowship is now available in Canada, and recently, the Royal College of Physicians and Surgeons (Canada) recognized targeted neonatal echocardiography performed by the neonatologist as area of focus competency for certification. In the United States, many clinicians have the skills to perform POCUS and have incorporated it in their daily clinical practice. However, appropriate equipment remains limited, and many barriers exist to POCUS program implementation. Recently, the first international, evidence-based POCUS guidelines for the use in neonatology and pediatric critical care were published. Considering the potential benefits, a recent national survey of neonatologists confirmed that the majority of clinicians were inclined to adopt POCUS in their clinical practice if the barriers could be resolved. This clinical report describes the current landscape of neonatal POCUS, outlines barriers for implementation, and provides a suggested educational framework and overall strategy for successful implementation of a POCUS

abstract

[a]Department of Pediatrics and International Pediatrics, Norton Children's Neonatology Affiliated with University of Louisville School of Medicine, Louisville, Kentucky; [b]Department of Pediatrics and Child Health, Max Rady College of Medicine, University of Manitoba-Canada, Health sciences Centre-Winnipeg, Winnipeg, Manitoba, Canada; [c]Department of Pediatrics, Perelman School of Medicine, University of Pennsylvania, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania; [d]Departments of Radiology and Pediatrics, University of Cincinnati College of Medicine, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio; and [e]Departments of Radiology and Pediatrics, Vascular Anomalies Center; and [f]University of Colorado School of Medicine, Children's Hospital Colorado, Aurora, Colorado

Dr Stewart conceptualized this project with approval of the Committee on Fetus and Newborn when he was an active member of that committee. Drs Stewart, El-Sayed, and Fraga did the research and wrote and revised the manuscript while considering changes and suggestions from the other co-authors. Input from all reviewers, as well as the Board of Directors, was taken into consideration.

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program. Diagnostic and procedural applications of POCUS in the NICU will be explored in detail in the accompanying technical report, which can be found in this issue of *Pediatrics*.

INTRODUCTION

Since the introduction of point-of-care ultrasonography (POCUS) into clinical medicine more than 2 decades ago and its widespread use,[1–3] the use in pediatric emergency medicine, pediatric critical care, and neonatal–perinatal medicine is rapidly expanding, although it still lags behind adult medicine.[4] POCUS has been undoubtedly the most-recent addition to the modern physician's medical bag and has been incorporated into many medical school curricula. At the present time, there are not any published guidelines regarding the implementation of POCUS programs in NICUs in the United States, and no formal training program or certification is available to neonatologists in Europe. However, POCUS is widely available to providers in European NICUs.[5] Further, in Australia and New Zealand, formal accredited training and certification programs are available for neonatology trainees, as well as for many other subspecialties.[6] However, the clinician needs to be aware that practice models in other countries may be very different, which limits any inference as to the utility and effectiveness of POCUS in the United States. Recently, the first international, evidence-based POCUS guidelines for neonatology and pediatric critical care were published.[7] These guidelines recommended the use of POCUS for specific procedural and diagnostic applications.

Although the performance and interpretation of ultrasonography (U/S) have traditionally been limited to pediatric radiologists and pediatric cardiologists, POCUS refers to U/S performed at the bedside by nonradiology and noncardiology practitioners to assist procedures and perform time-sensitive assessment of the symptomatic patient with immediate identification of pathologic processes that can guide resuscitative and lifesaving interventions.[8–10]

U/S delivers no ionizing radiation, is readily available, does not require sedation, and is less expensive than MRI and computed tomography.[11,12] Recent models of U/S devices are relatively compact and portable, which allow for their use in essentially all locations where medical care is delivered. Additionally, technology advances have resulted in improved image quality and easier-to-use systems, increasing accessibility beyond traditional imaging specialists.

The incorporation of POCUS in clinical decision-making is fundamentally different from the traditional practice model, in which a provider orders a study, waits for an external service to acquire and interpret the images, and then applies the findings into clinical context. POCUS is used as a specific tool to answer a defined urgent clinical question that requires immediate intervention to achieve a desired therapeutic impact rather than a replacement for medical imaging performed or interpreted by the radiologist. POCUS is dynamic; the same provider performs and interprets the study, integrates this information within the clinical context, and has the ability to monitor changes associated with the intervention.

In critically ill patients in the NICU, the availability of POCUS may serve as a lifesaving tool with the potential to enhance quality of care and improve clinical outcomes.[13] In a recent survey of neonatologists, 62% of responders had multiple encounters with infants with suspected cardiac tamponade or pleural effusions, and only 20% reported the availability of emergent imaging.[14] The same national survey of neonatologists lists (1) lack of training, (2) inadequate collaboration with imaging services, and (3) risk of litigation as the major barriers for its widespread use. In 2020, the Emergency Care Research Institute, one of the most trusted voices in health care in the United States, committed to address patient-safety challenges and raised concerns regarding POCUS use by nontraditional imaging specialties. Its statement mentioned that "safeguards for ensuring that POCUS users have the requisite training, experience, and skill have not kept pace with the speed of adoption. The lack of sufficient oversight increases the potential that patients will be adversely affected by problems associated with use, or lack of use, of this technology."[15] The only way to a successful POCUS program implementation that will serve to overcome these concerns requires the urgent development of essential infrastructural elements, including POCUS curriculum, quality assurance, and credentialing processes.

This clinical report describes the current landscape of neonatal POCUS, suggests strategies for the successful development and implementation of a POCUS program in the NICU, and lists emergent and

nonemergent diagnostic and procedural uses of focal POCUS examinations. To facilitate safety and proficiency in performing POCUS in the NICU and ongoing quality assurance (QA), the American Academy of Pediatrics proposes the establishment of a formal training program to promote expertise.

DEVELOPMENT OF A POCUS PROGRAM IN THE NICU

Although there are increasing diagnostic and procedural POCUS training opportunities developed for neonatal providers, such training does not necessarily translate into expertise that can be readily incorporated into clinical care. Translation of POCUS training to practice requires infrastructural support that is often not present within departments and institutions. Many years ago, adult emergency medicine successfully incorporated POCUS in clinical training and practice. Furthermore, the American College of Emergency Physicians (ACEP) has published comprehensive guidelines to integrate POCUS into training programs.[16] These guidelines emphasize the importance of core structural elements, including training, credentialing, image storage, documentation, and QA.[16]

There are many fundamental elements that need to be in place to develop a POCUS program. First, the hospital administration and the physician staff from pediatric radiology and pediatric cardiology ought to agree on and support the development of the program. The support of local pediatric cardiology and radiology is needed in the development of any POCUS program, providing advice, backup, and guidance when the limitations of the neonatologists in terms of coverage, expertise, and technical infrastructure are exceeded.

Reaching agreement regarding the scope of neonatal POCUS practice between divisions is also essential. The differences in studies performed by neonatologists, pediatric radiologists, and cardiologists need to be well established and clearly delineated. An example of these differences has been outlined in Table 1.

For successful program development, a medical director of the POCUS program in the NICU ought to be identified from the Division of Neonatal Medicine. This director then establishes the vision of the program while promoting competence and quality of care by measuring structure, processes, and outcomes. In a collaborative fashion, the director can manage educational and administrative tasks within the division and/or department. In consultation with all vested parties, appropriate equipment and transducers needs to be selected. Factors involved in this decision-making include image quality, number of users, ease of use, storage space, connectivity options, discussion of archiving and accessibility to other services, necessity of reporting, billing, and budget.[17]

According to the American Institute of Ultrasound in Medicine (AIUM)'s "Routine Quality Assurance for Diagnostic Ultrasound Equipment," there are 2 types of QA needs: (1) cleanliness and safety performed by users or biomedical or environmental staff, and (2) image display and performance maintained by the manufacturer. Given the lack of national consensus and national guidelines for translation of neonatal POCUS programs into clinical practice, multiple institutions across the United States and Canada have created their own POCUS training programs for diagnostic and procedural applications. Yet, it is concerning that, within many of these programs, some of the core elements required for their implementation and the infrastructure suggested by the ACEP guidelines appear to be underdeveloped or not present.[4]

Institutional credentialing protects institutions and providers by identifying consistent criteria to establish provider skills to support their clinical practice. It also protects patients by ensuring physician competency in clinical care. Until national POCUS program development and training guidelines are issued, we recommend that institutional guidelines for the use of POCUS include the following[18]:

- Development of a hospitalwide POCUS committee with oversight responsibilities for the implementation and QA of the program. This committee needs to have representation from the Divisions of Pediatric Radiology and Pediatric Cardiology and from the divisions or departments where POCUS is practiced (Neonatology, Emergency Medicine, Critical Care, Anesthesia, General Pediatrics, etc).
- Collaboration between pediatric radiologists, pediatric cardiologists, and POCUS practitioners in support of the POCUS program that includes review of the studies performed by the POCUS providers and interdisciplinary educational activities.
- Clear delineation of the scope of practice within domains of expertise in neonatology. Defining scope of practice is dependent on geographic location, local patient populations, hospital structure, and clinical needs. This avoids interdisciplinary conflicts and results in the identification of specific skills that will require structured training. Finally,

TABLE 1 Differences Between Neonatologist-Performed POCUS and Radiologist-Performed Ultrasonography

	Neonatologist-Performed POCUS	Radiologist Performed-Ultrasonography
Main scope	Answer-focused clinical question that requires immediate intervention or guides immediate change in therapy in "real time"	Ranges from routine to emergent, and guides therapeutic decisions beyond the interpretation of the bedside clinician
Main goal	Directed to delineate pathophysiology or system-specific physiology	Directed to delineate anatomic or pathologic details
Operator	Performed and interpreted by the bedside clinician	Performed and interpreted by the radiology team
Usefulness	Triggers immediate therapy changes/interventions	Detailed assessment of organ-specific injury Interpretation described in detail Includes differential diagnoses Guides involvement and interventions of other clinical specialists
Duration	Short and focused	Relatively long and detailed

development of structured training will create a path to competence in practice.

- Appropriate privileging resulting from structured training at both provider and instructor levels to be established in every institution.
- Development of image storage and documentation are required for medical–legal reasons and as part of the medical record.
- A QA process that evaluates image quality and interpretative accuracy. Timely feedback to providers is crucial to promote skill development and prevent harm.

These core elements are important components for quality and safety assurance within patient care and provide institutional protection from medical–legal concerns. Figure 1 summarizes a proposed strategic framework for POCUS program development.

NEONATAL POCUS TRAINING PROGRAM

Implementation and incorporation of POCUS into patient care requires that the clinicians receive additional education and training and demonstrate mastery of the use of bedside U/S, including U/S safety and knowledge of U/S protocols. An expert consensus model for systemwide clinical U/S program development[18] is located at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6040893/. A training program may consist of an introductory POCUS course with in-person didactic lectures, podcasts, and/or the use of Web site teaching modules. As important as acquiring a solid knowledge base, these individuals need to acquire dexterity and competency while performing "hands-on" scans to incorporate POCUS effectively and safely into their clinical practice. It is of utmost importance to understand that learning POCUS at any level is time-intensive. A spectrum of didactic and hands-on and/or U/S simulation session opportunities will assist the learner in acquiring and mastering the technical and interpretive skill.

Guidelines and practice parameters from the AIUM[19,20] can be found at: https://www.aium.org/resources/viewStatement.aspx?id=74 and https://www.aium.org/resources/guidelines/pointofcare.pdf. The establishment of standards for diagnostic and procedural use of POCUS in the NICU needs to follow recommendations of the expert consensus model for systemwide clinical U/S program development[18] and guidelines and practice parameters from the AIUM,[19,20] as well as the previously published guidelines from the ACEP, which are endorsed by the American Academy of Pediatrics.[16]

NEONATAL POCUS APPLICATIONS

The use of POCUS in emergent situations and for procedural guidance are usually the first applications to be adopted. However, the scope of practice has widened among procedural and diagnostic applications, and needs to be tailored to individual and institutional needs. The following diagnostic and procedural applications of POCUS in the NICU will be explored in detail in the technical report, which can be found in this issue. Procedural applications include (1) vascular access, (2) lumbar puncture, (3) fluid drainage, and (4) endotracheal intubation. Diagnostic applications include (1) lung U/S, (2) cardiac U/S, (3) abdominal U/S, (4) cranial U/S, and (5) central-line tip position assessment. A summary of POCUS applications is included in Table 2.

BARRIERS TO POCUS PROGRAM IMPLEMENTATION

Barriers to POCUS training and practice are present across disciplines. However, the relevance of these barriers depends on practice environments. In neonatology, the main perceived barriers to implementation are (1) lack of training guidelines, (2) availability of equipment, (3) insufficient number of mentors, (4) lack of support from local radiology and cardiology departments, and (5) legal concerns.[7]

Legal concerns were listed as 1 of the 3 top barriers in adopting POCUS in clinical practice.[7] A recent

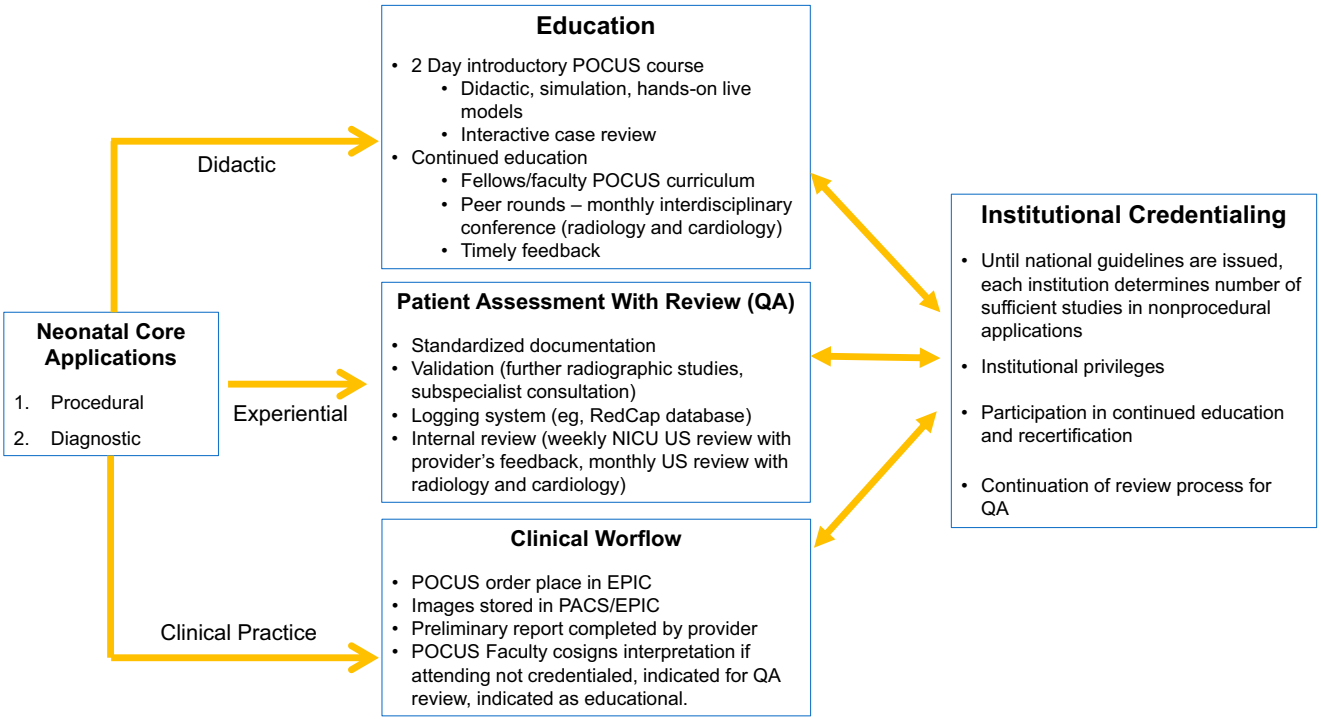

FIGURE 1

Proposed framework for POCUS program development (adapted from *Children's Hospital of Philadelphia*). EPIC, Electronic Privacy Information Center; PACS, picture archive and communication system.

retrospective study of all United States-reported state and federal cases involving either neonatologists or a pediatric subspecialist in the Westlaw database from January 1990 to October 2015 was performed. Of the 468 results, only 2 were relevant to the study objective. Two cases were related to failure to perform a diagnostic test and no cases were related to performance or interpretation of POCUS.[21] The Westlaw study only captures cases that proceeded to trial and does not include liability claims that were settled before trial. In addition, there are also costs incurred in defending those claims that are closed without indemnity. Therefore, the medical liability risk is not well defined because the use of POCUS has dramatically expanded since 2015.

Standardization of POCUS training and development of QA processes will help to overcome many barriers. However, some of them need to be solved at the division level, for example:

1. the need for recording and storage of images during POCUS;
2. defining scope of practice and exact boundaries of nonspecialists performing focused emergent examinations versus the specialist performing comprehensive examinations; and
3. establishing training requirements and hospital credentialing.

If these barriers are overcome, POCUS training and POCUS program development can be successfully incorporated into neonatal practice.

CONCLUSIONS

The acceptance and the use of POCUS as a clinical skill for timely decision-making are increasingly embraced by neonatal providers. This increase is reflected by the number of POCUS programs worldwide and the increasing utilization of POCUS as an adjunct to clinical acumen. POCUS is moving forward in many academic divisions of neonatal medicine across the United States, and there is a perceived, pressing clinical need for proactive planning to disseminate POCUS skills. However, its implementation is yet to be standardized and core elements and infrastructure are underdeveloped. Standardization ought to result in shared solutions across institutions, and more importantly, shared solutions might overcome shared barriers. The establishment of standardized training programs and programmatic platforms, as well as quality improvement and QA programs, allows for safe and effective implementation of these programs.[14] As stated in a "Perspectives" article in *Pediatrics*, "as much as it is our responsibility to understand the limitations and challenges associated with integrating POCUS into pediatrics, it is our responsibility to our patients to stay abreast of the most-current

TABLE 2 Summary of Potential POCUS Applications, Supportive Evidence, and Related Commentary

U/S Application	Routine Imaging Approach	Accuracy	Comments	References
LUS in diagnosis of pneumothorax	Chest XR	LUS is as sensitive and specific as chest XR	LUS shows similar accuracy to chest radiograph, outperforming clinical evaluation and markedly reducing time to diagnosis and drainage	Raimondi et al (2015)[23]
LUS in diagnosis of TTN	Chest XR	LUS is highly sensitive and specific	LUS is accurate and reliable for the early diagnosis of TTN and also very useful to distinguish TTN from RDS	Liu et al (2014)[24]
LUS in diagnosis of RDS	Chest XR	LUS is more sensitive	LUS was highly sensitive for the detection of neonatal RDS, although there is potential to miss comorbid air-leak syndromes	Hiles et al (2017)[25]
LUS in prediction of BPD	Chest XR	LUS is predictive to BPD	In VLBW infants without BPD, LUS score increases during the first week of life and decreases thereafter, whereas, among subjects with BPD, the LUS score remains high until 36 wk' PMA	Alonso-Ojembarrena and Lubián-López (2019)[26,27]
Heart ultrasonography performed by the neonatologist	Clinical parameters and echo by cardiologist	Applying echo performed by neonatologist proven to shorten time to clinical recovery	Applying cardiac POCUS is helpful to formulate a pathophysiologic-based medical recommendation	Elsayed et al (2017)[28]
Intestinal ultrasonography in diagnosis of NEC	Abdominal XR	Intestinal ultrasonography is sensitive and specific	Intestinal ultrasound is more helpful as adjuvant modality to abdominal XR, particularly cases in which XR finding does not match clinical examination	Cuna et al (2018),[29] Chen et al (2018),[30] and Silva et al (2007)[31]

BPD, bronchopulmonary dysplasia; LUS, lung U/S; NEC, necrotizing enterocolitis; PMA, postmenstrual age; RDS, respiratory distress syndrome; TTN, transient tachypnea of the newborn; VLBW, very low birth weight; XR, x-ray.

advances in medicine and provide the safest, most-efficient, state-of-the-art care. POCUS can help us meet this goal."[22]

LEAD AUTHORS

Dan L. Stewart, MD, FAAP
Yasser Elsayed, MD, FRCPC
María V. Fraga MD
Brian D. Coley, MD, FAAP, FACR
Aparna Annam, DO, FAAP
Sarah Sarvis Milla, MD, FAAP

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Laura Laskosz, MPH

ABBREVIATIONS

ACEP: American College of Emergency Physicians
AIUM: American Institute of Ultrasound in Medicine
POCUS: point-of-care ultrasonography
QA: quality assurance
U/S: ultrasonography

taking into account individual circumstances, may be appropriate.

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Address correspondence to: Dan L. Stewart, MD, FAAP. E-mail: Dan.Stewart@louisville.edu.

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REFERENCES

1. Kendall JL, Hoffenberg SR, Smith RS. History of emergency and critical care ultrasound: the evolution of a new imaging paradigm. *Crit Care Med.* 2007; 35(5 Suppl):S126–S130
2. Abu-Zidan FM. Point-of-care ultrasound in critically ill patients: Where do we stand? *J Emerg Trauma Shock.* 2012; 5(1):70–71
3. Gillman LM, Kirkpatrick AW. Portable bedside ultrasound: the visual stethoscope of the 21st century. *Scand J Trauma Resusc Emerg Med.* 2012;20: 18
4. Nguyen J, Amirnovin R, Ramanathan R, Noori S. The state of point-of-care ultrasonography use and training in neonatal-perinatal medicine and pediatric critical care medicine fellowship programs. *J Perinatol.* 2016;36(11):972–976
5. Roehr CC, Te Pas AB, Dold SK, et al. Investigating the European perspective of neonatal point-of-care echocardiography in the neonatal intensive care unit–a pilot study. *Eur J Pediatr.* 2013;172(7): 907–911
6. Singh Y, Gupta S, Groves AM, et al. Expert consensus statement 'Neonatologist-performed Echocardiography (NoPE)'-training and accreditation in UK. *Eur J Pediatr.* 2016;175(2): 281–287
7. Mirza HS, Logsdon G, Pulickal A, Stephens M, Wadhawan R. A national survey of neonatologists: barriers and prerequisites to introduce point-of-care ultrasound in neonatal ICUs. *Ultrasound Q.* 2017;33(4):265–271
8. Moore CL, Copel JA. Point-of-care ultrasonography. *N Engl J Med.* 2011;364(8): 749–757
9. McLario DJ, Sivitz AB. Point-of-care ultrasound in pediatric clinical care. *JAMA Pediatr.* 2015;169(6):594–600
10. Noori S, Seri I. Does targeted neonatal echocardiography affect hemodynamics and cerebral oxygenation in extremely preterm infants? *J Perinatol.* 2014;34(11):847–849
11. Dietrich CF, Goudie A, Chiorean L, et al. Point of care ultrasound: a WFUMB position paper. *Ultrasound Med Biol.* 2017; 43(1):49–58
12. Nazarian LN. Sound judgment. *J Ultrasound Med.* 2012;31(2):187
13. Burdjalov V, Srinivasan P, Baumgart S, Spitzer AR. Handheld, portable ultrasound in the neonatal intensive care nursery: a new, inexpensive tool for the rapid diagnosis of common neonatal problems. *J Perinatol.* 2002;22(6):478–483
14. Singh Y, Tissot C, Fraga MV, et al. International evidence-based guidelines on point of care ultrasound (POCUS) for critically ill neonates and children issued by the POCUS Working Group of the European Society of Paediatric and Neonatal Intensive Care (ESPNIC). *Crit Care.* 2020;24(1):65
15. ECRI. Top 10 health technology hazards executive brief. Available at: https://www.ecri.org/landing-2020-top-ten-health-technology-hazards. Accessed April 5, 2022
16. Ultrasound guidelines: emergency, point-of-care and clinical ultrasound guidelines in medicine. *Ann Emerg Med.* 2017;69(5):e27–e54
17. Marin JR, Lewiss RE. 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. Point-of-care ultrasonography by pediatric emergency medicine physicians. *Pediatrics.* 2015;135(4):e1113–e1122
18. Strony R, Marin JR, Bailitz J, et al. Systemwide clinical ultrasound program development: an expert consensus model. *West J Emerg Med.* 2018; 19(4):649–653
19. American Institute of Ultrasound in Medicine. Training guidelines for physicians and advanced clinical providers performing point-of-care ultrasound examinations. Available at: https://www.aium.org/resources/viewStatement.aspx?id=74. Accessed April 5, 2022
20. AIUM practice parameter for the performance of point-of-care ultrasound examinations. *J Ultrasound Med.* 2019;38(4):833–849
21. Nguyen J, Cascione M, Noori S. Analysis of lawsuits related to point-of-care ultrasonography in neonatology and pediatric subspecialties. *J Perinatol.* 2016; 36(9):784–786
22. Vieira RL, Bachur R. Bedside ultrasound in pediatric practice. *Pediatrics.* 2014; 133(1):1–3
23. Raimondi F, Rodriguez Fanjul J, Aversa S, et al. Lung Ultrasound in the Crashing Infant (LUCI) Protocol Study Group. Lung ultrasound for diagnosing pneumothorax in the critically ill neonate. *J Pediatr.* 2016;175:74–78.e1
24. Liu J, Wang Y, Fu W, Yang CS, Huang JJ. Diagnosis of neonatal transient tachypnea and its differentiation from respiratory distress syndrome using lung ultrasound. *Medicine (Baltimore).* 2014; 93(27):e197
25. Hiles M, Culpan AM, Watts C, Munyombwe T, Wolstenhulme S. Neonatal respiratory distress syndrome: Chest X-ray or lung ultrasound? A systematic review. *Ultrasound.* 2017;25(2):80–91
26. Alonso-Ojembarrena A, Lubián-López SP. Lung ultrasound score as early predictor of bronchopulmonary dysplasia in

very low birth weight infants. *Pediatr Pulmonol.* 2019;54(9):1404–1409

27. Pezza L, Alonso-Ojembarrena A, Elsayed Y, et al. Meta-analysis of lung ultrasound scores for early prediction of bronchopulmonary dysplasia. *Ann Am Thorac Soc.* 2022;19(4):659–667
28. Elsayed YN, Amer R, Seshia MM. The impact of integrated evaluation of hemodynamics using targeted neonatal echocardiography with indices of tissue oxygenation: a new approach. *J Perinatol.* 2017;37(5):527–535
29. Cuna AC, Reddy N, Robinson AL, Chan SS. Bowel ultrasound for predicting surgical management of necrotizing enterocolitis: a systematic review and meta-analysis. *Pediatr Radiol.* 2018;48(5):658–666
30. Chen S, Hu Y, Liu Q, Li X, Wang H, Wang K. Comparison of abdominal radiographs and sonography in prognostic prediction of infants with necrotizing enterocolitis. *Pediatr Surg Int.* 2018;34(5):535–541
31. Silva CT, Daneman A, Navarro OM, et al. Correlation of sonographic findings and outcome in necrotizing enterocolitis. *Pediatr Radiol.* 2007;37(3):274–282