

10 IMPORTANT APPLICATIONS OF POINT-OF-CARE ULTRASOUND IN PEDIATRIC EMERGENCY MEDICINE

Written by Jennifer R. Marin, MD, MSc | August 30, 2018

Point-of-care ultrasonography (POCUS) is a safe, effective imaging modality with a rapidly expanding array of lifesaving, timesaving and cost-saving applications in pediatric emergency medicine (PEM). The American Academy of Pediatrics (AAP) recently published the first policy statement endorsing use of POCUS by PEM physicians.[1] An accompanying technical report[2] concluded that, "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-art care. Point-of-care [ultrasound] will help us meet that goal.[3]"

Ultrasound is ideal for children whose smaller body size facilitates sound-wave penetration and resolution to generate images. Ultrasound also spares children the risks associated with ionizing radiation from other imaging methods, particularly computed tomography (CT). It is estimated that the 4 million pediatric CT scans performed annually in the U.S. will cause 4,870 future cancers.[4] Performed and interpreted at the bedside, ultrasound can expedite accurate diagnosis[5] and reduce length of emergency department (ED) stay, charges and complications.[6] This article provides an overview of 10 important applications of POCUS in PEM.

1. Evaluating Young Hearts with Focused Cardiac Ultrasound (FOCUS)

Unlike more comprehensive sonographic assessments of the heart, focused cardiac ultrasound (FOCUS) can be rapidly incorporated into advanced life support protocols without delaying chest compressions, medications and other types of cardiopulmonary resuscitation.[7],[8] FOCUS enables PEM physicians trained in its use to diagnose pericardial effusions, assess cardiac contractility and left ventricular enlargement with 91% accuracy.[9],[10] FOCUS should be considered for assessing patients with signs or symptoms potentially related to cardiac dysfunction or effusion, such as shortness of breath, chest pain, syncope, hypotension/shock or a new murmur. In addition, it may aid in the identification of cardiac tamponade as a cause of cardiac arrest,[11] and may be used to assess for cardiac activity during pulse checks in the setting of cardiac arrest resuscitation.[12]

2. Rapid Ultrasound for Shock and Hypotension (RUSH Exam)

Because POCUS has proven to be such a versatile tool for rapidly assessing patients for life-threatening conditions, there is a growing trend in emergency medicine toward combining goal-oriented applications of POCUS into systematic protocols. For example, the Rapid Ultrasound for Shock and Hypotension (RUSH) exam includes standardized views of the heart, inferior vena cava, lungs and abdomen in order to further categorize the type of shock (e.g. hypovolemic, cardiogenic, obstructive, distributive). First described in 2008[13], this protocol facilitates faster, more accurate diagnosis of adult patients who present with shock.[14],[15],[16],[17] Pediatric use

has also been described.[18] Findings from the sequenced exam, which can be performed in two minutes, are used to guide prompt initiation of the most appropriate treatment.[19]

3. One-stick Vascular Access

Vascular access is one of the most commonly performed procedures, with an estimated 200 million peripheral intravenous (PIV) catheters and 3 to 5 million central venous catheters (CVCs) placed annually in the U.S. to administer fluids, medications and blood products.[20],[21] In a 2016 policy statement, the American College of Emergency Physicians (ACEP) recommended use of POCUS for CVC and PIV line placements to improve safety, reduce procedural attempts and complications, and "enable a one-stick standard" for vascular access.[22] In children with difficult PIV-access ultrasound guidance has a superior success rate, is faster, and is associated with fewer needle redirections, compared to landmark methods.[23], [24]

In 2001, the Agency for Healthcare & Quality Research[25] identified ultrasound-guided central venous catheterization placement as one of the top 11 practices to improve patient safety. Also endorsed in guidelines from numerous medical societies, [26] ultrasound-guided CVC is now considered standard care internationally. Rates as low as zero for CVC complications, including pneumothorax and hemothorax, have been reported with ultrasound guidance, as compared with rates of 4.8% and 4.4%, respectively, for landmark methods. Ultrasound guidance has also been shown to reduce central-line-associated bloodstream infections by 35%.[27]

4. Ultrasound-guided Nerve Blocks as a Safe Alternative to Opioids

Amid a national opioid crisis, emergency physicians are turning to non-narcotic methods of analgesia,[28] such as ultrasound-guided regional anesthesia, for the management of fractures and other painful injuries. Compared to nerve stimulation techniques, ultrasound guidance reduces procedural performance time, while increasing the success and quality of peripheral nerve blocks in pediatric patients, as measured by reduced systemic analgesia use, block duration and pain scores.[29] In children ages 16 months to 15 years with femur fractures, ultrasound-guided regional anesthesia has been shown to provide superior and longer-acting pain control than IV morphine.[30] Ultrasound-guided nerve block has also been described as safe and highly effective for children with traumatic hand pain.[31]

5. Accurate Diagnosis of Pneumonias and Pleural Effusions

POCUS can be a valuable aid for evaluating pediatric respiratory symptoms and identifying pneumonias and pleural effusions. For the diagnosis of childhood pneumonia, POCUS has a reported sensitivity of 96% and a specificity of 93%, suggesting that it may be a safe,

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effective alternative to chest radiography.[32] During the 2009 H1N1 flu pandemic, lung ultrasound was found highly effective for distinguishing between viral and bacterial pneumonia,[33] and suggests POCUS may be used to reduce unnecessary antibiotic prescriptions for children with viral illness. Moreover, POCUS is useful for distinguishing between parapneumonic pleural effusion and empyema, and may replace chest CT for evaluating complex effusions.[34]

6. The Imaging Standard for the Diagnosis of Intussusception

Ileocolic intussusception is a relatively common surgical emergency in infants during the first year of life.[35] Historically, contrast or air enema was used for diagnostic and therapeutic purposes. However, ultrasound has become the standard diagnostic test. PEM physicians can accurately diagnose intussusception with POCUS, with a reported sensitivity of 85% and specificity of 97%, suggesting that it can be used to rule in the diagnosis in pediatric patients with suspicion for intussusception.[36]

7. Improving Management of Soft-tissue Infections

Physical examination is often unreliable for distinguishing cellulitis from an abscess requiring incision and drainage.[37] Uncertainty if purulent material is present may result in needless drainage, a procedure that may require sedation in children. Conversely, if an abscess is missed, the disease process may worsen, requiring additional ED visits. POCUS can improve management of pediatric skin and soft tissue infections (SSTIs). [38],[39] In a series of 50 children with SSTIs, evaluation with bedside ultrasound altered physician intervention in 22% of cases and demonstrated a specificity of 90% and sensitivity of 83% for differentiating cellulitis from abscess, versus 75% and 80%, respectively, for clinical suspicion.[40]

8. A Valuable Tool for Diagnosing and Treating Children's Hip Pain

POCUS can accelerate diagnosis and treatment of pediatric patients with lower extremity pain, limp, or refusal to bear weight by evaluating for the presence of a hip effusion, and thus narrowing the differential diagnosis. Using POCUS, PEM physicians can detect hip effusions in children with a reported sensitivity of 85% and a specificity of 93%.[41] POCUS has also been used to guide successful hip arthrocentesis in children.[42]

9. Near-Perfect Accuracy for Detecting Pyloric Stenosis

Hypertrophic pyloric stenosis (HPS) is the most common surgical cause of vomiting in infants.[43] Often the classic physical

examination finding of a palpable “olive” in the right upper quadrant of the abdomen (signifying an enlarged pylorus) and the laboratory finding of hypochloremic hypokalemic metabolic alkalosis are absent during the initial presentation.,[44] [45] First used to diagnosis HPS in 1977,[46] pyloric ultrasound is now the imaging standard. When PEM physicians used POCUS to evaluate 60 infants with suspected HPS, all cases were correctly identified and the measurements obtained were consistent with those from radiology.[47]

10. Accelerating Diagnosis of Pneumothorax and Guiding Treatment

Pneumothoraces are associated with high morbidity and mortality in neonates, particularly in those who are critically ill, preterm or require ventilation.[48] Ultrasound has demonstrated 100% accuracy in diagnosing pneumothoraces in critically ill neonates, versus a sensitivity of 84% and specificity of 56% for clinical evaluation.[49] Moreover, POCUS expedites diagnosis, with an ultrasound examination taking an average of 5.3 minutes versus 19 minutes for a chest x-ray. Successful use of ultrasound to guide needle aspiration of pneumothoraces in a preterm infant[50] and in a case series of pediatric ED patients[51] through tracking the sonographic “lung point” [52] have also been reported.

This innovative use of ultrasound to rapidly identify and treat a potentially life-threatening disorder in newborns highlights the power of this versatile bedside technology to take the practice of PEM to a higher level. The 2009 ACEP policy statement described ultrasound as “an ideal diagnostic tool for children,” noting that “emergency ultrasound for children can be lifesaving, timesaving, increase procedural efficiency and maximize patient safety.”[53]

It is anticipated that as pediatric care providers and hospitals are increasingly integrating POCUS into practice, growth of applications and implementation will be exponential. With ultrasound at the bedside, PEM physicians are ideally equipped to diagnose and manage pediatric patients more accurately, safely, and efficiently.

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