# IMPROVING THE SAFETY AND QUALITY OF PEDIATRIC EMERGENCY CARE WITH POINT-OF-CARE ULTRASOUND: PART 1

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Over the last decade, the use of point-of-care ultrasound (POCUS) in Pediatric Emergency Medicine (PEM) has risen dramatically.

In 2011, 95% of U.S. Emergency Departments (EDs) with a PEM fellowship program reported use of POCUS, compared to 57% in 2006[1]. The first pediatric point-of-care ultrasound textbook was published in 2014[2]. This was also the inaugural year for P2, an interest group dedicated to PEM point-of-care ultrasound (www.p2network.com).

In 2015, the American Academy of Pediatrics (AAP) published the first pediatric-specific POCUS guidelines[3], citing the following advantages:

- Ultrasound imaging performed and interpreted at the patient's bedside can facilitate timely and accurate diagnoses in PEM, accelerate clinical decision-making, aid in procedural guidance, and improve patient satisfaction.
- POCUS can answer specific "yes-no" questions in real time without transporting critically ill or unstable patients outside of the ED.
- Ultrasound may help direct further evaluation to avoid costly and unnecessary testing.

"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," an accompanying AAP technical report[4] concluded, adding that, "Point-of-care [ultrasound] will help us meet that goal[5]." Robust clinical evidence from multiple studies highlights the value of this imaging technology for improving the safety and quality of pediatric emergency care. This review provides an overview of potentially lifesaving applications of this technology in PEM with case examples.

## Minimizing Children's Exposure to Ionizing Radiation

One of the most appealing aspects of ultrasound is its inherent safety, since images are generated with sound waves, rather than with the use of ionizing radiation. A large body of literature has linked ionizing radiation, particularly from computed tomography (CT), to an increased risk for developing solid cancers and leukemias later in life. Children are particularly susceptible, due to their longer lifespans and the higher organ-specific radiation dose they receive with each scan. A recent study projects that the 4 million pediatric CT scans performed annually in the United States, will result in 4,870 future cancers.[6]

Many groups, including the Society for Pediatric Radiology[7], the Food and Drug Administration[8] and the National Cancer Institute[9] recommend using ultrasound as the first diagnostic test whenever possible. The American Academy of Pediatrics (AAP) recently issued the first pediatric-specific POCUS guidelines, which advise optimizing use of ultrasound whenever imaging is indicated.[10] The American Institute of Ultrasound Medicine has created an educational campaign and website aimed at educating clinicians and raising awareness of the increasingly wide range of clinical conditions for which "ultrasound first" is an established guideline due to safety and economic advantages over radiographic examinations (ultrasoundfirst.org).

## Accelerating Assessment and Treatment of Critically Ill or Injured Children

The adoption of POCUS has become widespread in Emergency Medicine, with some applications now being considered the standard of care. While PEM providers have only embraced this technology more recently, a rapidly expanding body of literature has suggested a wide array of applications to aid clinical decision-making and procedural success in the care of children. For critically ill or injured pediatric patients, point-of-care ultrasound can be used as part of the ABCD assessment and resuscitation as follows:[11]

- **Airway**. Ultrasound can aid in the assessment for airway patency, and for the confirmation of proper endotracheal tube placement.
- **Breathing**. Ultrasound can be helpful for assessing the lungs, pleura and diaphragm for identification of pleural effusions and to guide needle aspiration and tube thoracostomy.
- **Circulation**. The rapid, focused cardiac examination includes determining cardiac function and assessing for asystole. Additional applications include evaluating for the presence of a pericardial effusion, and determining the hydration status via evaluation of the Inferior Vena Cava (IVC). Ultrasound guidance can improve the speed and success of central venous catheter (CVC) and peripheral intravenous (PIV) line placement and pericardiocentesis.
- **Disability**. Robust evidence has shown that use of the Focused Assessment Sonography for Trauma (FAST) in adults with penetrating wounds leads to faster operative management and improved outcomes. While evidence for the benefit of FAST over CT is limited for children, it may reveal useful or even lifesaving information in assessing for disability in pediatric patients.

## Lung Ultrasound: Crucial in the Evaluation of Respiratory Distress

It was previously thought that "you cannot ultrasound the lung" due to the presence of air. However, this relatively new POCUS application has proven ultrasound to be a modality that can easily and rapidly detect pneumothoraces and pleural effusions.

Ultrasound has also been shown to be highly accurate for diagnosis of pneumothoraces in neonates.[12] In pediatric ED patients, clinicians can identify the "lung point, which is nearly 100% sensitive and specific for the diagnosis of a pneumothorax."[13]

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Moreover, POCUS examinations can be done at any hour and repeated as needed as the clinical scenario changes. For example, we were consulted on a 14-year-old boy admitted to our ICU with suspected pneumonia. When he suddenly developed chest pain and severe shortness of breath at 3 a.m., a lung ultrasound was performed at the bedside, revealing a massive pericardial effusion. This diagnosis was previously not entertained, and is thought to have been of viral etiology. As a result of the ultrasound, the cardiologists performed a pericardiocentesis: More than a liter of fluid was drained, saving the child's life.

## Focused Echocardiography: Rapid Diagnosis of Life-Threatening Conditions

One of the most important, lifesaving applications of POCUS is focused echocardiography, which can be used to identify a wide range of conditions, including cardiac and pericardial disorders.[14] However, it is often an underutilized application in pediatric patients. It has been shown that PEM physicians and pediatric intensivists trained in this technique are able to diagnose pericardial effusions, evaluate cardiac contractility abnormalities and left ventricular dysfunction with 91% accuracy. [15,16]

In adult patients, a comprehensive review reported a remarkable increase in diagnostic accuracy by both cardiologists and non-cardiologists when a point-of-care cardiac ultrasound study was added to findings of the physical examination.[17] Mandavia et al reported an overall accuracy of 98% in focused ECHO performed by emergency physicians in patients at high risk for pericardial effusions[18], while Ma et al reported a 100% sensitivity and 99% specificity in patients with chest trauma[19]. In cases of penetrating chest trauma, use of focused ECHO shortens the time to diagnosis (15.5 vs. 42.4 minutes) and dramatically improves survival (100% vs. 57%).[20]

Echocardiography is the most accurate way to detect the presence of tamponade[21], with the potential to detect early signs before the patient becomes unstable.[22] Treatment includes emergent pericardiocentesis to drain the fluid, which can have immediate, lifesaving results. Ultrasound guidance for this procedure is strongly advised due to its efficacy in reducing complications.[23] A study of ultrasound-guided pericardiocentesis in pediatric patients revealed a 99% success rate with a 1% rate of major complications.[24] Prior to the advent of ultrasound guidance, complication rates of 7 to 50% were associated with the blind approach.

## FAST: A Point-of-care Examination that Can Help Save Young Lives

Evidence indicates that emergency physicians can accurately perform the FAST examination,[25] which assesses patients who have sustained truncal trauma for intra-abdominal free fluid (often a sign of internal bleeding in trauma patients). The "extended" FAST examination (e-FAST) also assesses the chest for the presence of a pneumothorax. In adults, the FAST examination has been shown to decrease abdominal CT use and reduce the time for operative care, hospital length of stay and complication rates. [26,27] A recent meta-analysis of 25 studies of 3,838 children demonstrated that the FAST examination has a sensitivity of 80% for the identification of hemoperitoneum. One small pediatric study found that incorporating the FAST examination into other aspects of the trauma evaluation significantly improved the accuracy of the test, increasing its specificity to 98%.[28]

A study by Holmes et al[29] did not show improved patient outcomes in children randomized to receiving a FAST exam. However, this study had significant limitations. Until additional studies are performed, it is prudent to use the FAST examination as another piece of important information as part of an integrated approach to the pediatric trauma patient.

A valuable attribute of POCUS, and particularly the FAST examination, is that it can be quickly repeated at the bedside if the patient's clinical presentation changes. For example, a 15-year-old boy presented at our hospital with a 3-centimeter laceration just lateral and superior to his umbilicus, claiming that the injury occurred when he closed a small pocketknife against his abdomen. He initially exhibited no pain or abdominal tenderness to palpation. An initial FAST examination was performed, revealing no intra-abdominal free fluid. However, while awaiting admission to the hospital for observation and serial abdominal examinations, he developed significant abdominal pain and tenderness on palpation. A repeat FAST examination was performed, revealing fluid in his abdomen that was not initially present. Although a subsequent CT scan was negative for an identifiable injury, the FAST findings and change in physical examination were of sufficient concern to prompt an immediate explorative surgery, which revealed a deep, penetrating wound that extended down to the patient's IVC. Without this prompt diagnosis at the bedside, and ultimate surgical repair of the IVC laceration, the boy would have certainly died.

## Conclusions

The ability of point-of-care ultrasound to reveal an unexpected or potentially life-threatening condition, while also helping improve the safety, speed, success and quality of care for young patients, has already demonstrated impressive benefits. In an era of recognizing the risks of ionizing radiation in pediatric populations and an increased focus on value-based care, we anticipate the development of novel applications for POCUS. POCUS serves clinicians an extraordinary opportunity to further improve and transform the practice of Pediatric Emergency Medicine.

Author bio: Stephanie J Doniger, MD, RDMS, FAAP, FACEP is one of the leading experts in pediatric point-of-care ultrasound. Following her training in Pediatrics and Pediatric Emergency Medicine, she was the first to complete an additional Emergency Ultrasound Fellowship in 2008.

Since that time, Dr. Doniger has authored and co-authored numerous book chapters, articles and other publications on point-of-care ultrasound. She edited the first textbook "Pediatric Emergency and Critical Care Ultrasound," and has lectured on national and international levels in both English and Spanish.

Dr. Doniger has held multiple leadership positions, including the Subcommittee Chair of the ACEP Pediatric Ultrasound Subcommittee for five years and the WINFOCUS Board of Directors. She has been a member of WINFOCUS since 2008 and is currently in charge of organizing pediatric point-of-care ultrasound education throughout Latin America.

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