

The Emerging Role of Point of Care Ultrasound in Pediatric Care

Medicine has always evolved at the intersection of advancing technology and clinical acumen. In recent years, Point of care ultrasound (POCUS) has emerged as one of the most transformative bedside tools in patient care. Unlike traditional ultrasound, which is performed in a radiology or cardiology department, POCUS is carried out by the treating clinician at the bedside, integrated directly into real-time clinical decision-making. In pediatric practice, where time, patient cooperation, and non-invasive diagnostics are of paramount importance, POCUS has the potential to bridge critical gaps between examination, diagnosis, and intervention. While the initial surge of POCUS adoption was seen in adult emergency and critical care in the last two decades, the discipline of pediatrics is now rapidly embracing this technology.

Over the past ten years, portable ultrasound devices have become a routine tool at the bedside of critically ill children worldwide. Their use for both diagnostic and procedural purposes by non-cardiology and non-radiology specialists, particularly pediatric emergency physicians, pediatric intensivists, and neonatologists has transformed traditional clinical practices. With these machines now widely available across pediatric acute care settings, the current challenge lies in determining the best strategies to fully integrate this technology into everyday patient care. Pediatricians across emergency rooms, intensive care units, general wards, and even outpatient clinics are recognizing that a portable ultrasound probe can extend their senses, much like a stethoscope once revolutionized auscultation.

POCUS has evolved from a niche tool for detecting abdominal trauma to a widely adopted diagnostic and procedural aid across multiple medical specialties. Its rise parallels advances in ultrasound technology, where machines have become smaller, portable, and increasingly affordable, allowing clinicians to perform rapid, focused assessments right at the bedside.

Unlike a comprehensive radiologist or cardiologist performed ultrasound, POCUS is designed to answer specific clinical questions in real time, integrated seamlessly into patient evaluation without interrupting workflow. This capability is particularly valuable in pediatrics, where timely, non-invasive, and radiation-free diagnostics are critical to safe and effective care.

POCUS offers immediate visual information about anatomy, physiology, and pathology, information that must always be interpreted in the context of a complete history and physical examination. It is not a replacement for these fundamentals, nor for a detailed imaging study when required, but rather a powerful extension of the clinician's senses.

RELEVANCE OF POCUS IN PEDIATRICS

Pediatric patients are not “small adults”. Their anatomy, physiology, and disease patterns differ significantly, making timely diagnosis and minimal invasiveness crucial. Many pediatric conditions starting from dehydration to pneumonia, from cardiac dysfunction to abdominal emergencies, can be assessed swiftly with POCUS. In situations where children are unstable, anxious, or require urgent intervention, POCUS provides a rapid, radiation-free diagnostic alternative.

One of the key advantages in pediatric care is the availability of POCUS, a non-invasive and child-friendly diagnostic tool that minimizes the need for painful or risky procedures. It provides immediate answers at the bedside, which is particularly crucial in unstable or rapidly deteriorating children, where timely decisions can be lifesaving. By reducing reliance on imaging with ionizing radiation, they also safeguard children from potential long-term health risks associated with repeated cumulative exposure. Moreover, their ability to offer dynamic, real-time assessment enables clinicians to perform repeated serial evaluations, making it easier to monitor disease progression and track treatment response effectively over a period of time.

Children pose unique challenges in clinical care due to their smaller anatomy, evolving physiology, and limited ability to communicate symptoms, which often complicates diagnosis and management. POCUS provides pediatricians with several advantages in this context, including rapid answers at the bedside, which are invaluable in emergency or unstable situations. In addition, it serves as a valuable tool for procedural guidance, improving both accuracy and safety in interventions such as vascular access or fluid drainage.

Internationally, particularly in the Western Countries, pediatric POCUS is now an established part of emergency and acute care practice. The American Academy of Pediatrics clearly recommends that pediatric emergency physicians understand the role, applications, and limitations of POCUS. It also supports structured training, credentialing, and privileging, while emphasizing collaboration with radiology through established protocols for confirmatory imaging, shared interpretation, and escalation of doubtful cases. In India, the widespread issue of female feticide following prenatal sex determination led to the implementation of the strict Pre-Conception and Pre-Natal Diagnostic Techniques (PCPNDT) Act, 1994, which regulates the use of ultrasound machines. Along with other logistical and institutional factors, this regulatory framework has contributed to the limited availability of bedside ultrasound machines for point of care ultrasound, which remain largely confined to tertiary care centers rather than being freely available across all healthcare facilities. Limited awareness about the

utility of POCUS and inadequate trained manpower further hinder its integration into district hospitals and primary health centers, thereby restricting its potential benefits at the grassroots level.

In India, although comprehensive ultrasound services are well established through radiologists and cardiologists, dedicated pediatric POCUS performed by pediatricians, along with structured training and research in this area, remain at an early stage of development. Nevertheless, momentum is growing, with ultrasound increasingly integrated into medical school curricula and a rising number of pediatricians pursuing formal training and certification.



The Unique Context of Pediatric POCUS in India

- ❖ The PCPNDT Act-influences ultrasound accessibility in India, but regulation should not hinder clinical use for children.
- ❖ Pediatric POCUS remains concentrated in tertiary centers due to limited awareness and training.
- ❖ Integration into pediatric residency and certification programs is essential for expanding safe practice.
- ❖ Strengthened research, standardized training, and collaboration with imaging specialists will drive national progress.

FROM STETHOSCOPE TO SOUND WAVES: A NEW DIAGNOSTIC EXTENSION

In the early 19th century, the stethoscope transformed clinical medicine by allowing physicians to “see” into the chest with their ears. Today, POCUS represents a similar leap forward, allowing clinicians to “see” beyond the skin using ultrasound waves. Just as the stethoscope became a universal symbol of the physician, the portable ultrasound probe is fast becoming a symbol of the 21st-century clinician. Point of care ultrasonography in contemporary clinical practice may be aptly conceptualized as “**StethoScan**,” (Fig. 1.1) a theoretical hybrid instrument that extends the traditional physical examination, integrating the stethoscope with real-time ultrasound imaging, while simultaneously functioning as a crucial diagnostic modality.

For pediatricians, incorporating POCUS into the clinical armamentarium does not replace traditional history taking and physical examination; rather, it complements and reinforces them. The integration of clinical reasoning with real-time bedside imaging results in a more comprehensive



Fig. 1.1: StethoScan: Point of care ultrasonography can best be conceptualized as an extension of the physical examination, while also serving as a vital diagnostic tool, much like a stethoscope

Recent advances in ultrasound technology have led to the development and marketing of compact **wireless ultrasound probes** that can be connected directly to smartphones and tablets (**Fig. 1.4**). These portable devices are increasingly becoming affordable, user friendly, and widely accessible, bringing ultrasound

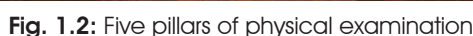


Fig. 1.3: Physician demonstrating all bedside tools available for physical examination and decision making

© Arun Babu Thirunavukkarasu Pediatric Point of Care Ultrasound: CBSPD



Fig. 1.4: Handheld wireless ultrasound probe connected to a smartphone displaying real time ultrasound images

imaging closer to the bedside than ever before. As POCUS becomes integrated into routine clinical practice, it has the potential to revolutionize pediatric healthcare by enabling rapid diagnosis, timely decision making, and improved patient outcomes in diverse clinical settings.

In this evolving landscape, familiarity with the principles and applications of POCUS is no longer an optional skill but an essential competency for pediatric healthcare providers. Clinicians who develop proficiency in POCUS will be better equipped to deliver efficient, evidence based, and patient centered care. As the ultrasound probe increasingly becomes an extension of the physical examination, training in the fundamentals of POCUS is crucial for pediatricians to remain relevant in modern clinical practice.



POCUS: The Future Stethoscope

- ❖ POCUS in current practice represents a “Stethoscope 2.0 - StethoScan” revolution, extending the physician’s eyes into the body.
- ❖ As devices become AI-assisted and pocket-sized, every pediatrician may carry one alongside a stethoscope in the near future.
- ❖ It enhances diagnostic precision, procedural confidence, and family trust through immediate visualization.
- ❖ POCUS signifies the shift from uncertainty to clarity, making pediatric care safer, faster, and smarter.

POCUS in pediatrics is still on its journey toward widespread integration, with many novel applications yet to be standardized or fully discovered. While pediatric-specific POCUS guidelines are often based on moderate to

low-quality evidence, the field is rapidly growing due to the clear face validity and practical advantages of real-time, bedside imaging. For the practicing pediatrician, ultrasound offers the extraordinary ability to transform signs, symptoms, and clinical impressions into dynamic visual data that directly guide diagnosis and management.

The use of ultrasound is not without challenges. Any new technology in medicine carries concerns about safety, training, and effective integration, and POCUS is no different. Learning ultrasound requires mastery over knowledge, technical skills, and interpretative ability, which demands considerable time and training infrastructure. Despite this, its culture of safety and accuracy justifies the effort. Ultrasound not only replaces some traditional imaging modalities that involve radiation, but also improves procedural safety, reduces complications, and enhances provider diagnostic accuracy. Medico-legal literature increasingly highlights that failure to perform POCUS when clinically indicated, particularly in emergency situations, may increase liability by causing diagnostic delays, underscoring the central role of timely and appropriate POCUS use in modern clinical practice.

Ultrasound in pediatrics is also built upon a foundation of long-standing expertise across medical specialties. While POCUS for children may seem relatively new, radiology and cardiology have established decades of evidence supporting its efficacy. Emerging applications in critical care, neonatology, and subspecialties such as shock management or surfactant decision-making in neonatal respiratory distress demonstrate its expanding scope. Beyond efficacy, ultrasound is patient-centered, offering individualized care in a world where algorithms and standardized pathways are often built around populations. By tailoring diagnostics and therapeutics to the needs of a single child at the bedside, ultrasound aligns clinical decisions with precision and personal relevance.

Ultrasound technology is also timely, efficient, and increasingly equitable. Pocket-sized portable ultrasound devices allow rapid, repeatable bedside evaluation, enable ongoing adaptation of management, and shorten hospital stays while improving family satisfaction. By reducing reliance on centralized imaging systems and minimizing systemic biases embedded in healthcare practices, ultrasound provides a more just and accessible tool for diverse patient populations. By providing objective visual information through the same black and white pixels for every patient, POCUS may help promote more equitable care across social and economic barriers. Given this breadth of impact, on safety, timeliness, efficiency, and patient-centered care, it is clear that ultrasound is not only worth the effort but also essential to the future of pediatric medicine. This book is dedicated to guiding healthcare providers through this journey, to harness the true potential of pediatric POCUS in transforming clinical practice for children everywhere.

The role of POCUS is rapidly expanding across pediatric subspecialties, with applications that enhance diagnosis and management in diverse clinical settings. In emergency medicine, it enables rapid identification of conditions

such as pneumothorax, pericardial effusion, or intussusception, while in critical care it proves invaluable for guiding vascular access, assessing cardiac function, and evaluating fluid status. Pediatricians use POCUS for bedside confirmation of pneumonia, detection of pleural effusions, and bladder volume assessment, whereas in neonatology it is essential for cranial imaging, evaluating lung disease in respiratory distress, and guiding intravenous line placement. Pediatric cardiologists also rely on POCUS for functional evaluation of ventricular performance and assessment of pericardial pathology. This versatility underscores its adaptability to the unique clinical demands of each subspecialty, while maintaining a patient-centric approach that is especially important in children.



The Power of Bedside Imaging

- ❖ POCUS bridges the gap between clinical examination and diagnostic imaging at the bedside.
- ❖ It empowers pediatricians to make rapid, evidence-based decisions without delays from formal imaging.
- ❖ Real-time assessments improve safety, reduce radiation exposure, and guide timely interventions.
- ❖ It transforms clinical reasoning into dynamic visualization, seeing beyond what is felt or heard.

COMPREHENSIVE ULTRASOUND VS. POCUS

A comprehensive ultrasound, typically performed by expert radiologists, is a systematic survey that may be less adaptable to immediate clinical priorities and can delay time-sensitive care. In contrast, POCUS is focused, problem-oriented, and performed at the bedside by the treating clinician. For example, in a child with suspected pericardial tamponade, POCUS can confirm the diagnosis within seconds at the bedside, the point of care, guiding urgent intervention before a formal radiology exam is feasible. Similarly, in smaller clinics or rural practices with limited imaging access, POCUS empowers pediatricians to make timely, evidence-informed decisions.

However, it is critical to remember that POCUS is best used as a “rule in” tool, it can confirm many urgent diagnoses but may not reliably exclude them. Findings should be integrated into the overall clinical picture and supplemented with further imaging by expert radiologist when appropriate.

Conventional ultrasound examinations are comprehensive studies performed in radiology or cardiology departments by specialists and require patient transport, formal reporting, and are less amenable to frequent repetition. In contrast, POCUS is a focused, goal-directed bedside examination performed by the treating clinician using portable or handheld devices, can be repeated as clinical conditions evolve, is integrated into routine clinical assessment, and supports timely decision-making while retaining clinician responsibility for image acquisition, interpretation, and documentation. **Table 1.1** highlights the

key differences between conventional ultrasonography (USG) and point of care ultrasound (POCUS).

POCUS is not an alternative for comprehensive ultrasound assessment by radiologists. While POCUS is a powerful bedside tool that enhances pediatric care, it is important to emphasize that it is not a substitute for comprehensive ultrasound assessments performed by radiologists or cardiologists. POCUS is designed to provide focused, real-time information that can guide immediate clinical decisions, particularly in urgent or resource-limited situations. However, complex or detailed evaluations, such as in-depth anatomical studies, advanced cardiac assessments, or precise measurements, remain within the domain of imaging specialists, whose expertise ensures accuracy and comprehensive interpretation. Thus, POCUS should be viewed as a complementary tool that augments, rather than replaces, formal imaging.

For a pediatrician, acquiring proficiency in POCUS is far more than learning a new diagnostic tool and it represents a paradigm shift in clinical practice and decision-making. Mastery of this skill brings greater diagnostic confidence, enabling clinicians to confirm or exclude critical conditions within minutes at the bedside. It also enhances procedural precision by allowing safer, image-guided interventions that reduce complications. Beyond improving patient safety, POCUS supports better resource utilization by minimizing unnecessary referrals, transfers, or additional imaging studies, which is particularly valuable

Table 1.1: Comparison of conventional ultrasound (USG) and POCUS

Aspect	Conventional ultrasound examination	POCUS (point of care ultrasound)
Location	Performed in radiology (USG room) or cardiology (Echo lab) department	Performed at the bedside (pediatric ward, ICU, emergency or OPD)
Operator	Done by radiologists or cardiologists, who are not directly responsible for the patient's ongoing care	Performed by the treating clinician managing the patient
Scope	Comprehensive examination, covering the entire requested region in detail	Focused, goal-directed scan, limited to answering specific clinical questions
Frequency of use	Limited repeatability due to logistic and scheduling constraints and distance from bedside	Can be repeated easily at the bedside as the patient's clinical status evolves with no need for transport
Reporting	Formal written/printed, signed reports are mandatory with greater medicolegal implications	POCUS is an extension of the clinical examination and typically does not require a separate signed report, resulting in fewer medicolegal implications. Findings are documented within the clinical record, and the clinician performing the scan remains responsible for image acquisition, interpretation, documentation, and subsequent clinical decisions
Equipment	Stationary or portable ultrasound systems in radiology	Portable or handheld ultrasound devices are available in pediatric wards, ICUs, and emergency units and can be moved to the bedside as needed

in resource-limited settings. Ultimately, this additional skillset provides professional distinction, positioning the pediatrician as a comprehensive frontline diagnostician who can integrate real-time imaging into holistic patient care. Importantly, acquiring POCUS skills requires commitment to structured training, practice, and ongoing quality assurance to ensure accuracy and patient safety. The skill becomes most impactful when embedded in an evidence-based, ethically sound clinical framework.



Pediatrics: The Ideal Ground for POCUS

- ❖ Children benefit most from non-invasive, radiation-free, real-time imaging.
- ❖ POCUS allows repeated assessments for unstable or evolving conditions, enhancing monitoring and treatment.
- ❖ Rapid bedside diagnostics reduce stress, procedural discomfort, and unnecessary transfers.
- ❖ Pediatric anatomy and physiology require tailored scanning; POCUS complements these unique needs.

APPLICATIONS IN PEDIATRICS

Pediatric point of care ultrasound applications can be broadly categorized into procedural guidance and diagnostic assessment, each offering unique benefits in enhancing safety and accuracy of care. As a tool for procedural guidance, POCUS is invaluable in facilitating vascular access, particularly in small or critically ill children where landmark techniques are often challenging, as well as in guiding lumbar punctures and drainage procedures to minimize complications and improve success rates. On the diagnostic side, POCUS serves as a rapid, bedside extension of the clinical examination, enabling lung ultrasound to detect pneumonia or pleural effusions with high sensitivity, focused cardiac evaluations to assess left ventricular function or pericardial effusion, and abdominal scanning to identify free fluid in trauma cases. It also plays a role in everyday practice, such as bladder volume assessment to guide catheterization and cranial ultrasound in neonates for early detection of intraventricular hemorrhage or hydrocephalus. Together, these applications make POCUS a versatile and practical tool that strengthens both diagnosis and interventions in pediatric practice.

Pediatric POCUS applications fall broadly into two categories:

1. **Procedural guidance**, e.g. vascular access, lumbar puncture, drainage procedures.
2. **Diagnostic assessment**, e.g. lung ultrasound for pneumonia or pleural effusion, focused cardiac evaluation, detection of free fluid in trauma, bladder volume assessment, cranial ultrasound in neonates.

Common indications for POCUS ultrasound in children are summarized in **Table 1.2**.

These applications continue to expand as technology improves and new techniques are described. Effective use requires not only technical skill in acquiring images but also the ability to interpret them accurately and apply the findings appropriately.

Table 1.2: Common indications for POCUS ultrasound in children

<i>Diagnostic</i>	<i>Procedural</i>
Respiratory system • ET tube position in intubated children • Lung POCUS for pneumonia/bronchiolitis • Pleural effusion • Pneumothorax • Diaphragmatic POCUS	Respiratory system • Pleural tapping • ICD insertion for pleural effusion/empyema/pneumothorax
Cardiovascular • LV systolic function (Ejection fraction, fractional shortening estimation) • Cardiac output calculation • Pericardial effusion • Cardiopulmonary resuscitation • IVC diameter and collapsibility for volume assessment • VEXUS score	Cardiovascular • Pericardiocentesis • Central line placement • Peripheral venous cannulation
Abdominal • Cholecystitis • Cirrhosis liver • Free fluid abdomen • Appendicitis • Intussusception	Abdominal • Paracentesis
Renal • Renal stone and hydronephrosis • Ureteral stone • Cystitis	Renal • Renal biopsy • Bladder aspiration
Central nervous system • Optic nerve sheath diameter • Neurosonogram in neonates and infants • Transcranial Doppler	Central nervous system • CSF tapping via anterior fontanelle • Lumbar puncture
Musculoskeletal system • Joint effusion	Musculoskeletal system • Joint aspiration • Fracture reduction
Miscellaneous • Extended focused assessment with sonography in trauma (eFAST)	Miscellaneous • Foreign body removal • Spinal anesthesia • Abscess localization and drainage



Pediatric POCUS Applications at a Glance

Section A

- ❖ **Diagnostic use:** Rapid detection of pneumonia, pneumothorax, pericardial effusion, free intra-abdominal fluid, and cranial abnormalities in neonates.
- ❖ **Procedural use:** Image-guided vascular access, pleural or pericardial drainage, lumbar puncture, and abscess localization.
- ❖ **Functional scans:** Assess LV function, preload via IVC collapsibility, and VEXUS grading for fluid status.
- ❖ Its flexible use across systems, respiratory, cardiac, renal, CNS, musculoskeletal, etc makes it indispensable.

TRAINING, COMPETENCY, AND SAFETY

Competent POCUS use involves three integrated skills:

1. **Image acquisition:** Obtaining clear, diagnostic-quality images.
2. **Image interpretation:** Understanding what the images reveal and their limitations.
3. **Clinical integration:** Applying findings to guide management in the patient's overall context.

Structured, hands-on training is essential. Supervised scanning, standardized documentation, and multidisciplinary review help maintain quality and safety. Collaboration with pediatric radiologists and cardiologists strengthen POCUS programs, prevents redundancy, and fosters research and education.

Indian pediatricians can pursue formal POCUS certification which are being offered by many institutes, which require a combination of course participation, supervised examinations, and independent practice. The recent inclusion of basic ultrasound competencies in pediatric residency means that future pediatricians will graduate with foundational scanning skills.



Integration, Training, and Safety

- ❖ Competency = Skills acquisition + interpretation + clinical integration.
- ❖ Structured training, supervised scans, and documented credentialing are central to safe practice.
- ❖ Collaboration with radiologists and supervised mentorship minimize errors and promote quality assurance.
- ❖ Misuse stems from poor training, not the tool itself. Hence continuous learning ensures safe, effective deployment.

CHALLENGES AND RESPONSIBILITIES

While POCUS offers immense benefits, its misuse or over-reliance can be harmful. Inadequate training, poor image acquisition, or misinterpretation can lead to diagnostic errors. Therefore, the pediatricians aspiring to master POCUS must also adopt the mindset of a lifelong learner, continuously refining skills, adhering to competency guidelines, and understanding the limits of their expertise.

The rapid adoption of point of care ultrasound marks a fundamental shift in the way medicine is practiced, and in pediatrics within India, three priorities are particularly critical to harness its full potential. First, there is a need to advance structured training programs that equip pediatricians with the knowledge and skills to use POCUS safely and effectively, ensuring it complements rather than compromises patient care. Second, strengthening research that evaluates its impact on patient outcomes, such as reduced radiation exposure, faster diagnosis, and improved cost-effectiveness will provide the evidence base necessary to guide policy and practice. Finally, fostering strong

collaboration between frontline pediatric clinicians and imaging specialists will be essential for quality assurance, standardization, and innovation, ensuring that POCUS evolves as a reliable and integrated component of pediatric healthcare delivery. With sustained effort, clinician-performed ultrasound could become a core competency of pediatric care in India, just as it already is in other countries.

Pediatric point of care ultrasound represents a rapidly evolving domain with immense potential for clinical research, particularly in bridging diagnostic accuracy with bedside applicability. Unlike adult populations, pediatric patients often present with unique anatomical and physiological characteristics that demand tailored imaging approaches, making research in this field both necessary and impactful. There is significant scope to investigate the role of POCUS in early detection of critical illnesses, optimization of emergency and intensive care workflows, and reduction of radiation exposure in children. Furthermore, studies focusing on validating standardized protocols, developing age- and size-specific reference values, and assessing long-term outcomes of POCUS-guided management can transform pediatric care practices globally. With increasing portability of ultrasound devices, collaborative multicentric pediatric research initiatives can generate robust evidence to support guideline development, advance training frameworks, and establish POCUS as an indispensable component of child health care.

CONCLUSION

As portable devices become smaller, more affordable, and AI-assisted interpretation becomes mainstream, POCUS is poised to become a standard competency for pediatricians worldwide. In the near future, a generation of pediatricians may graduate considering POCUS as indispensable as their stethoscope.

This book aims to equip pediatricians with the knowledge, protocols, and practical tips needed to integrate POCUS seamlessly into everyday practice. The chapters ahead will cover foundational principles, system-specific applications, procedural guidance, and quality assurance frameworks to ensure safe and effective use. In essence, POCUS empowers pediatricians to merge clinical skill with immediate visual evidence, transforming uncertainty into clarity, and hesitation into decisive action, all in the best interest of the child.

POCUS is more than just another diagnostic tool, it is a game changer in pediatric practice. By providing real-time bedside insight into anatomy and pathology, it enhances diagnostic accuracy, speeds decision-making, and improves procedural safety.

Just as the stethoscope became an indispensable extension of the physician's hands and ears, POCUS is becoming an extension of the physician's eyes, allowing pediatricians to quite literally *see* the problem at the point of care. Mastering this skill set not only improves patient care but also positions the pediatrician at the forefront of modern, efficient, and child-centered medicine.

ADDITIONAL READING

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