Point-of-Care Ultrasound and its Applications

Reviewed by:
Dr GN Ramesh
MBBS, MD, DM
Consulting
Gastroenterologist
PVS Memorial Hospital,
Ernakulam, Kerala

Point-of-Care Ultrasound: An Overview

In the medical terminology point-of-care ultrasound (POCUS) is defined as the use of an image-producing ultrasound device for diagnostic and procedural guidance, at the point of care, in real time allowing for direct correlation with signs and symptoms, by the clinician himself.[1]

In the clinical setting, not only that it increases accuracy of diagnoses and aids procedures, it also reduces the time spent on diagnoses, and decreases the overall costs.[2]

Modern POCUS systems can be attached to a cart for ease of movement and portability, carried in laptop-sized housing, attached to a tablet, or even a cell phone. Thus, it can be performed using handheld machines of varying sizes that are considerably more portable than traditional full platform systems.[3]

The Broad Spectrum of POCUS Applications

POCUS use has been widely embraced by emergency medicine (EM) providers and has additionally permeated an array of other specialties such as critical care, trauma, vascular medicine, obstetrics, and rheumatology. It has made relatively low-cost technology available in resource-limited settings globally.[3]

Though POCUS has a broad spectrum of application both as diagnostic exam and as an interventional procedure, its main applications can be broadly categorized into four groups (Figure 1).

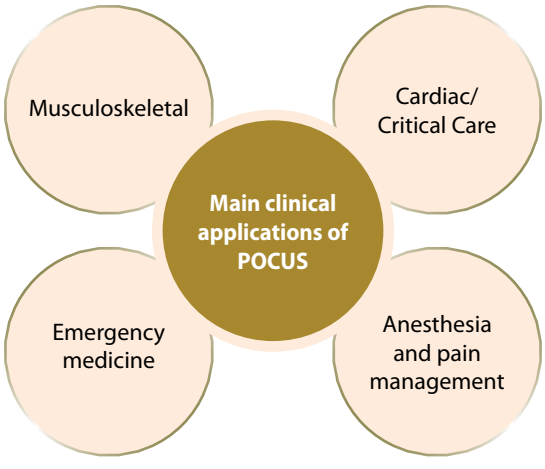
POCUS Use in Musculoskeletal Imaging

POCUS has seen significant growth in musculoskeletal (MSK) applications due to its ability to visualize soft tissue tears in muscles, tendons, ligaments and joint spaces at a high spatial resolution that cannot be seen on X-ray. Detection of foreign bodies or abnormal growths, such as tumors and calcifications, as well as early bone changes, including subclinical synovitis and early bony erosions are a few examples of POCUS in MSK.[4]

POCUS Use in Cardiology

Nobody in the medical world can deny POCUS applications in cardiology, particularly in the emergency medicine. POCUS is now regularly utilized by emergency physicians in the evaluation of patients in cardiac arrest. It is noteworthy to mention that the American Heart Association (AHA) updated its guidelines in 2015 to recommend POCUS use during the management of cardiac arrest. Other cardiac-specific uses of POCUS include triaging chest pain, dyspnea, undifferentiated shock and abdominal/thoracic trauma.[5,6]

Figure 1: Main clinical applications of POCUS



POCUS Use in Emergency medicine (Hospital-based and Urgent care)

The use of POCUS in the Emergency Department has come a long way, from 1994 when the first Emergency Medicine Ultrasound Curriculum was published by Mateer *et al.* to the current times, when it has become a core competency in EM training. Emergency medicine requires quick decision-making in the presence of limited resources. And, here exactly plays ultrasound its most powerful role. Though, it is often an underutilized tool too.[7]

POCUS Use in Anesthesia and Pain Management

In the field of anesthesia, POCUS is increasingly being used for anatomical evaluation prior to the needle insertion. It is providing excellent guidance in cases of difficult venous access, to delineate nerve plexus for chronic nerve blocks and for epidural space identification and regional anesthesia.[8]

POCUS as an Extension of the Physical Examination

Cardiac POCUS has been increasingly adopted by a wide variety of users as an extension of the physical exam and clinical assessment. This can occur once during an outpatient encounter or serially during an inpatient admission.

In the outpatient primary care setting where the symptoms of clinically important cardiac pathology may first be discovered, POCUS examination gives a quick, qualitative initial screen for suspected etiologies. Thus, it helps identify findings that are unsuspected yet of prognostic importance.[3]

- In a recently published study, POCUS-assessed left atrial size in the outpatient setting was shown to be associated with significant 5.5-year mortality (odds ratio 2.4 after adjusting for age), while the absence of this sign in patients under the age of 65 and without diabetes was associated with a 1.2% mortality rate at 5.5 years. This information provided by the POCUS in the physical examination, if used prospectively, would be expected to reduce the cost associated with echocardiography referral by 33%.[3]
- POCUS not only detects important findings likely to be missed on exam but also reduces the cost to refine referral for more expensive high-end echocardiograms.[3]

POCUS in Acute Care Settings: An Insight

Acute care settings need urgent triage and evaluation. It makes POCUS almost embedded in the EM practices. An emergency physician skilled in the use of this technology can optimize patient management by providing timely care, improving diagnostic accuracy, and increasing procedural safety. The American College of Emergency Physicians identify 5 functional clinical categories of POCUS scope of practice in the emergency department setting (Box 1). Included within the 5 categories are 13 core applications for emergency.[7]

Box 1: Five functional clinical categories of POCUS

- **Resuscitative:** POCUS use directly related to an acute resuscitation
- **Diagnostic:** POCUS use in an emergent diagnostic imaging capacity
- **Symptom or sign-based:** POCUS use in a clinical pathway based upon the patient's symptom or sign (both cardiac and non-cardiac POCUS applications)
- **Procedure guidance:** POCUS use as an aid to guide a procedure
- **Therapeutic and monitoring:** POCUS use in therapeutics or physiological monitoring.

Core Applications of POCUS in Emergency

Ultrasound in Trauma

Trauma comprises a major part of all ED visits. Of these, chest and abdominal trauma pose unique challenges for the physicians, particularly in the case of blunt trauma due to their concealed nature. Imaging modalities like CT are not always feasible either due to limited resources or patient instability. In the past, these patients were evaluated by diagnostic peritoneal aspiration (DPA) or lavage (DPL). However, this modality has largely been replaced by focused assessment with sonography for trauma (FAST) due to its ability to provide expedient care, non-invasive nature, cost-effectiveness, and ease-of-

learning with similar accuracy. Besides, with the advent of extended focused assessment with sonography for trauma (EFAST), now thoracic views are also included as part of the exam. It is helping physicians quickly diagnose and treat pneumothorax and hemothorax, as well.[7]

- Healthcare providers performing an EFAST must always be cognizant of its limitations in children, in penetrating trauma, diaphragmatic, hollow viscus and retroperitoneal injuries, pelvic trauma and obstetric patients, among others.[7]
- A negative EFAST in a stable patient does not rule out significant injury and must frequently be followed by serial EFAST exams and/or CT according to the level of clinical suspicion.[7]

First Trimester Pregnancy Ultrasound

When a female patient of reproductive age with acute abdominal pain and/or vaginal bleeding comes in the emergency, all emergency physicians are familiar with the diagnostic challenge that comes along with her. The possibility of the intrauterine pregnancy (IUP) is a critical question that needs to be answered in the patient with a first-trimester pregnancy complicated by abdominal pain and/or vaginal bleeding. Pelvic POCUS can be used to rule out ectopic pregnancy in patients where a definitive sign of IUP is identified. The use of POCUS in first-trimester pregnant patients has demonstrated decreased ED length-of-stay and time-to-ultrasound in the radiology department with a documented increase in patient satisfaction.[7]

Basic Cardiac Ultrasound

In a situation such as a cardiac patient presenting to ED, every passing second is as critical as the patient's failing heart; herein, POCUS saves a lot of time. EPs, with adequate training, have been shown to be as adept as cardiologists at the performance and interpretation of cardiac ultrasound. Its use in appropriate patients has consistently been shown to help narrow down differential diagnoses, diagnose and treat more accurately, and improve outcomes. The use of POCUS to guide resuscitation in pulseless electrical activity arrest has been proposed to help identify possible reversible causes such as cardiac tamponade and massive pulmonary embolism, and therefore, expedite management and improve survival.[7]

Abdominal Vascular US

In patients presenting to ED with abdominal, flank or back pain, an abdominal aortic aneurysm (AAA) is a not-to-miss diagnosis. POCUS diagnoses an AAA when the identified abdominal aorta measures more than 3 cm. A significant percentage of patients do not have clinically evident aortic aneurysms, and due to the time-dependent prognosis of the condition, ultrasound performed by the EP helps improve chances of survival. In spite of these supportive statistics, it must be mentioned that a CT must be performed to rule out AAA in stable patients with suspected AAA.[7]

Biliary Ultrasound

The differential diagnosis in patients presenting with epigastric or right upper quadrant pain, jaundice or even undifferentiated sepsis is broad. POCUS can easily recognize gallstones and acute cholecystitis. Bedside biliary ultrasound can avoid misdiagnosing patients with acute cholecystitis or biliary colic. Thus, it decreases ED length-of-stay, and expedites further management.[7]

Urinary Tract Ultrasound

Complaints secondary to urolithiasis are exceedingly common in emergency. It is seen that ultrasound is a highly useful and often underutilized tool in the evaluation of such patients. In addition to the detection of hydronephrosis, urinary tract ultrasound can also be used to measure bladder volume, an element of particular importance in those with urinary retention. It can also be used in patients in whom urinary tract pathology may be on the list of differential diagnoses, such as those with abdominal pain, hematuria, back pain or groin pain.

- Research supports that in patients with suspected nephrolithiasis, there is a decreased need for subsequent CT scans with the use of ultrasound in the ED, resulting in decreased exposure to ionizing radiation.
- Although CT is superior to ultrasound in terms of sensitivity for nephrolithiasis, an 'ultrasound-first' approach has not revealed any significant differences in terms of serious adverse events, return ED visits or hospital admissions.[7]

Ultrasound for Deep Vein Thrombosis

The most common ED presentations for venous thromboembolism are deep venous thrombosis (DVT) and pulmonary embolism (PE). In patients with suspected DVT, accurate diagnosis is essential to decrease the risk of propagation and development of PE that could lead to significant morbidity and mortality. Experts suggest that only with short training, EPs can use focused ultrasound protocol to accurately diagnose a proximal DVT in the highest probability areas in symptomatic outpatients.

- There is backing from many studies that incorporating POCUS along with pretest probability scoring systems and/or D-Dimer improves the diagnostic accuracy of POCUS.
- Using POCUS to diagnose DVT has been shown to decrease the need for comprehensive scans, decreased time-to-diagnosis, ED length of stay, and the need for return visits.[7]

Lung Ultrasound

Lung POCUS may help in the evaluation of patients presenting to the ED with undifferentiated chest pain, shortness of breath (SOB) or respiratory distress. It assists in the diagnosis of pneumothorax, pleural effusion and pulmonary edema. Ultrasound has a higher sensitivity than the traditional upright anteroposterior chest radiography for the detection of a pneumothorax. Lung ultrasonography has been shown to be superior to chest radiography in the detection of pleural effusions with a sensitivity and specificity of 92 and 93%, respectively. Besides, POCUS is a good diagnostic tool to diagnose acute cardiogenic pulmonary edema.[7]

Soft Tissue Ultrasound

Skin and soft tissue infections are also quite common in the ED. Physical examination findings may be insufficient to differentiate cellulitis from an abscess. Soft tissue ultrasound is one of the easiest ultrasound examinations to perform. It can be used as an adjunct to clinical evaluation of patients presenting to the ED with suspected soft tissue infections. POCUS helps differentiate cellulitis, abscess and necrotizing fasciitis, and therefore, improves the diagnostic accuracy and management.[7]

Musculoskeletal Ultrasound

Musculoskeletal complaints are very common in the ED. The use of POCUS can help EPs diagnose joint effusion, long bone fractures, tendon injury and retained foreign body (FB).

- POCUS can be used to guide arthrocentesis in a safer manner via the shortest route, thus improving success rates and reducing complications.
- It has been shown to accurately diagnose long bone fractures, assist in fracture reduction, determine realignment, and perform hematoma block. In shorter bones and areas close to joints, POCUS is found to be inaccurate in identifying a fracture but might identify indirect signs such as soft tissue swelling and joint effusion.
- EPs can use POCUS to help identify major tendon injuries such as achilles, quadriceps and patellar tendons.
- The evaluation of retained FB can be challenging. Traditional radiography can be used to identify radiopaque FB in soft tissues and muscles. In cases of suspected radiolucent retained FB, POCUS can be used to accurately identify the location and size of FB and assist with its removal.[7]

Bowel Ultrasound

Small bowel obstruction (SBO) is a common cause of acute abdomen. It accounts for about 2% of patients presenting to ED with abdominal pain. Although CT with contrast is considered to be the gold standard for the diagnosis of SBO, it is not the ideal initial imaging modality of choice in all suspected cases, due to its cost and radiation. Abdominal X-ray (AXR) is typically considered the initial imaging modality of choice in all suspected cases of SBO presenting to the ED. However, in the recent years, POCUS has been utilized as a screening imaging modality for suspected cases of SBO; and, it is more accurate, more sensitive, and more specific than AXR.[7]

Ocular Ultrasound

When it comes to ocular emergencies, it is seen that ophthalmology consultation is not available in all the settings. It places considerable burden on the EP to make a rapid decision. Moreover, limited equipment

availability and limited physician training poses additional challenge to assess ocular emergencies, ranging from simple conjunctivitis to sight-threatening diseases. Ocular ultrasound can non-invasively diagnose retinal detachment with high sensitivity, vitreous hemorrhage/ detachment, globe rupture, and lens dislocation.[7]

Ultrasound for Procedure Guidance

POCUS is used to guide various ED procedures such as central venous catheter insertion, difficult peripheral arterial and venous catheter insertion. The use of POCUS for procedure guidance helps improve the success rate and decrease the complication rate and is considered the standard of care for central venous catheter insertion.[7]

Salient Features of POCUS

- POCUS has high accuracy for diagnosing pneumonia and detecting acute decompensated heart failure.
- POCUS confirmation of intrauterine pregnancy rules out an ectopic pregnancy.
- Musculoskeletal POCUS is used to diagnose and guide treatment of many joint and soft tissue conditions. It is as accurate as magnetic resonance imaging in the diagnosis of complete rotator cuff tears.
- Ultrasound guidance improves outcomes in the placement of central venous catheters and fluid drainage from body cavities and lumbar punctures.
- POCUS can accurately diagnose and rule out gallbladder pathology, and is effective for diagnosing urolithiasis.
- Focused cardiac ultrasonography can detect pericardial effusion and decreased systolic function.
- When compared with formal sonography, POCUS is equivalent in screening for abdominal aortic aneurysm and as accurate in diagnosing deep venous thrombosis.[9]

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