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The Portable Powerhouse: A Review of Current Applications of Point-of-care Ultrasound in Emergency Medicine

Jerome Bruce Hoke [1]

[1] Department of Emergency Medicine, University Hospitals, Cleveland Medical Center, Case Western Reserve School of Medicine, Cleveland, Ohio, USA

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ABSTRACT

Point-of-care ultrasound (POCUS) is used by Emergency Department (ED) providers to screen patients for significant medical decompensations. This article seeks to review POCUS's many applications in the ED. Embedded are two cases that illustrate the power of POCUS to quickly identify and monitor life threats. The review ends with a discussion contextualizing the subjective role of POCUS in providing patient-centered care.

Introduction

Ultrasound technology has improved drastically over the decades; from static scanners that took up a third of a specialized exam room in the 1950s, to dynamic scanners with linear and phase arrays introduced in the 1970s,[1] to most Emergency Departments (EDs) having at least one portable cart-based high fidelity point-of-care ultrasound (POCUS) machine available for use at all times. Enthusiasm and engagement in POCUS education in residency only continues to grow, with a 46.9% increase in imaging acquisition numbers by residents between 2013 and 2022.[2] The days in which we all swap out our stethoscopes for a POCUS machine to perform our initial heart and lung exams may yet be close at hand. Indeed, POCUS allows providers to rapidly gather real time data regarding fluid status and pathology in critically ill patients to overlay onto the clinical framework of the traditional history and physical.

A recent comprehensive 2023 American College of Emergency Physicians (ACEP) update emphasizes that POCUS is much more than just an extension of the physical exam.[3] It drastically improves diagnostic accuracy in a wide variety of clinical settings, helping vascular surgeons better assess for aortic pathology,[4] ED providers differentiate between cellulitis and abscesses,[5] and pediatric ED providers assess for bowel intussusception[6,7] and pyloric stenosis.[8] POCUS also improves procedural success rates and limits adverse effects in vascular access,[9-11] incision and drainage,[12] paracentesis,[13,14] and nerve blocks.[15,16] Cutting-edge applications of POCUS are also being investigated and promoted in academic sites, including transcranial doppler to assess for midline shift from intracranial mass effect or vasospasm from a subarachnoid hemorrhage,[17] and transesophageal echocardiography to assess for reversible causes and confirm high-quality CPR in critically ill intubated patients.[18-20]

In high acuity patient care settings, POCUS findings often drastically change the trajectory of a diagnostic and therapeutic approach early in the patient presentation. An Extended Focused Assessment with Sonography in Trauma (E-FAST) exam in a penetrating trauma patient can assist in answering whether they require a thoracic, pericardial, or abdominal intervention.[21] A Rapid Ultrasound for Shock and Hypotension (RUSH) exam in an unstable medical patient can help guide resuscitative management by quickly delineating between different shock states.[22] POCUS can be used to raise or lower pre-test probability in diagnostic algorithms to allow selective use of Computed Tomography (CT) imaging. Serial POCUS imaging can assist with monitoring for response to interventions. The following two cases seek to illustrate POCUS's diagnostic utility in this regard.

Case 1.

A patient in her 80s recently presented to the ED complaining of shortness of breath that had progressively worsened over the previous three weeks with a new oxygen requirement of 8 liters per minute (LPM). During our initial conversation, the patient shared that she had not seen a doctor since her Obstetrician visits 60 years earlier when she was pregnant with her now adult children. I expected on ultrasound to find a "shred sign" and dynamic bronchograms consistent with pneumonia super-imposed on a viral upper respiratory infection. Instead, I found diffuse B lines and a dilated right heart with normal left ventricular systolic function, collapsible inferior vena cava and no pleural effusions. My resident questioned, "Do we think this is the usual hypoxic differential of heart failure, pulmonary embolism, versus pneumonia?" I said, "No, this is likely different. I think this is interstitial lung disease and pulmonary hypertension. So, even though the lactate is elevated, we are going to minimize fluid boluses." Two hours later, CT confirmed my initial diagnosis made 5 minutes into patient evaluation and pulmonary hypertension specialists were involved early in patient's care in the inpatient setting.

Case 2

In another recent ED patient encounter, my colleague treated a patient presenting with hypotension and severe chest pain. On initial evaluation, my colleague could not find a dissection flap in cardiac, suprasternal, or abdominal views, but the aortic outflow tract on the parasternal long view appeared to be mildly dilated. This prompted him to prioritize emergent CT angiography imaging to confirm his clinical concern for an aortic dissection and allow for rapid vascular surgery consultation. As he returned to the patient's bedside, her vitals acutely worsened, and he found she had developed a pericardial effusion. Informed by the dynamic change from his earlier POCUS, my colleague was empowered to explain to the patient and family what was happening and the poor prognostic outcome. He did not have to hypothesize based on physical exam, mentation, or vital signs. He could watch the pathology progressing and provide his patient with an understanding of her experience and ultimate outcome.

Discussion

Point-of-care ultrasound facilitates busy ED providers, stretched thin by documentation expectations and high patient volumes, to be present at the bedside. It allows them to provide high-quality, precision patient care; answering patient questions regarding their pathology in ways that talking them through a static chest x-ray or CT scan does not. A patient can see and appreciate their lungs displacing the diaphragm with each breath and fluid above or below it. The patient can see the squeeze of their heart and the size, thickness, and movement of its chambers and valves. A woman and her loved ones can see the developing fetus in her uterus. POCUS invites the patient into their care decisions as an active, informed participant.

Whether an academic or community emergency provider, outpatient clinician, or inpatient hospitalist/critical care specialist, we are all medical and healthcare educators to our patients. POCUS allows us to teach the public and patients what is going on inside of their bodies. We can then use this data to make time-sensitive, patient-centered life-saving decisions, sometimes without the need for supplemental or complementary lab-work or advanced imaging.

Artificial Intelligence (AI), being newer in its clinical application trajectory, is sometimes described as a "black box". With AI, the drivers of data outputs can be unclear,

and the weight of data inputs can be unknown. Over the last half-decade, there have been multiple attempts to develop high-level AI algorithms to improve image interpretation and quality assurance of operations. There remain significant concerns regarding generalizability and reliability of findings. Simple deep learning algorithms perform excellently in well-defined clinical measures such as hip dysplasia in pediatrics[23] or bladder volume estimations.[24] Unfortunately, more complex algorithms continue to output unreliable interpretations in more nuanced clinical questions such as lung pathology or cardiac function.[25] POCUS is the opposite of a black box. POCUS generates literal black and white information at the bedside, bringing transparency to interactions between patients and their providers.

Conclusion:

As the complexities of modern medical care continue to increase, POCUS provides an essential tool to answer relevant clinical questions and improve outcomes in bedside procedures.

Conflicts of Interest Statement:

The author has no conflicts of interest to declare.

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