Critical Diagnoses in Bedside Ultrasonography

a report by
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Bedside ultrasound has arrived. After decades of use in Europe, bedside ultrasound has finally been adopted as an essential tool in academic emergency departments in the US, and is now a mandatory component of emergency medicine residency training. Community emergency departments are rapidly following the trend.[1] With improving experience and technology, the number of applications for bedside ultrasound increases; however, the primary applications are still for those patients with potentially life-threatening diagnoses. It is for these critical patients that the immediate results of ultrasound are the most useful in guiding treatment. This review will focus on several critical diagnoses that can be made by the emergency clinician trained in bedside ultrasonography in three patient presentations: trauma, undifferentiated hypotension (UDH), and abdominal pain.

Trauma

The most widely accepted and well-studied application of bedside ultrasound is in the setting of trauma, where ultrasound has enabled practitioners to view inside 'the black box' of the torso and identify areas of internal hemorrhage. Focused assessment with sonography for trauma (FAST) has been shown to be a rapid, accurate, and non-invasive diagnostic tool for the detection of free fluid, and has nearly obviated the use of invasive diagnostic peritoneal lavage. Clinical indications for the FAST examination include all blunt or penetrating torso trauma cases where there is a suspicion of internal hemorrhage. As the technical details have been described elsewhere, here we briefly summarize four critical diagnoses that can be made with bedside ultrasound for a trauma patient.

The initial investigations with the FAST examination focused primarily on the use of bedside ultrasound in the detection of free peritoneal fluid.[2] While ultrasound is inferior to abdominal computed tomography (CT) in the detection of parenchymal injury, it is >95% sensitive and specific for the presence of significant hemoperitoneum.[3] The primary application of the FAST examination is in the hemodynamically unstable patient, in whom the detection of free fluid generally necessitates immediate laparotomy.[4] In hemodynamically stable patients, a positive FAST examination prompts more aggressive resuscitation efforts while the patient is prepared for definitive CT study. This may assist in effective triage of emergency department resources.

In the trauma setting, the FAST exam has been shown to have a sensitivity of 81–100% and a specificity of 100% for diagnosis of hemothorax when clinical course is the gold standard.[5–7] Ultrasound has superior sensitivity and specificity to supine chest radiography, and may mean that unnecessary thoracostomy for severe pulmonary contusion is avoided. Like chest radiography, sensitivity is poor compared with chest CT, but missed hemothoraces are small and likely to be clinically insignificant.[8] In addition, time required for ultrasound versus radiography in one study was one versus 14 minutes, highlighting the potential for rapid diagnosis and intervention.[6] In an unstable trauma patient, detection of a pleural fluid collection on the FAST examination requires immediate thoracostomy in addition to aggressive fluid and blood-product resuscitation.

With the subxiphoid view of the heart, the FAST examination allows a rapid assessment for pericardial fluid, and is highly sensitive and specific in the hands of emergency clinicians. Although one study showed the potential to misinterpret epicardial fatpads as fluid in challenging cases, a parasternal long window can be obtained for confirmation.[9] The presence of 'echocardiographic' or 'impending' tamponade with right atrial or right ventricular diastolic collapse allows for intervention prior to hemodynamic compromise.[10] In both blunt and penetrating chest trauma, the use of bedside echocardiography can expedite the diagnosis of cardiac injury, allow for rapid thoracotomy, or transfer to the operating room, and has been associated with decreased mortality.[11–13]

The extended FAST (EFAST) exam adds bilateral anterior thoracic sonography to the FAST exam to evaluate for pneumothorax with the absence of normal 'lung-sliding' and 'comet-tail' artifact. Compared with supine chest radiography, with CT or clinical course as the gold standard, bedside sonography has superior sensitivity (49–99 versus 27–75%), similar specificity (95–100%), and greater rapidity of application.[14–16] Several recent prospective studies have validated its use in the setting of trauma resuscitation, and have also shown that ultrasound can provide an accurate estimation of pneumothorax size. Although radiography or CT scanning is generally feasible, immediate bedside detection of a pneumothorax confirms what are often ambiguous physical findings in unstable patients, and guides immediate chest decompression. In addition, in the patient undergoing positive-pressure ventilation, the detection of an otherwise 'occult' pneumothorax prior to CT scanning may prevent development of a tension pneumothorax and deterioration in the radiology suite.

Undifferentiated Hypotension

In patients presenting with pulseless electrical activity (PEA) or UDH, bedside ultrasound is indicated and may facilitate rapid diagnosis and treatment of reversible life-threatening conditions. A protocol for patients presenting with PEA or UDH, initially termed the undifferentiated hypotensive protocol (UHP), was described in 2001. The UHP exam involves a cardiac view to assess cardiac function, a hepatorenal view for abdominal fluid (as in the FAST exam), and transverse views of the abdominal aorta.[17] A randomized trial of this protocol showed it decreased time to diagnosis and quickly narrowed the differential diagnoses in such patients.[18] This protocol can be extended with

additional echocardiographic views, allowing estimation of central venous pressure.[19] Below we review three critical diagnoses that can be made with bedside ultrasound in hypotensive patients.

In addition to assessment of pericardial effusion and tamponade, bedside echocardiography allows estimation of left ventricular function and central venous pressure with good agreement with formal echocardiography.[20] In the hypotensive patient, the appearance of a hyperdynamic heart with small chambers and a flat inferior vena cava (IVC) would suggest hypovolemic shock, while an enlarged heart with low ejection fraction and dilated IVC would suggest cardiogenic shock, providing key information to guide resuscitation. Findings of right ventricular strain with an underfilled left ventricle, although neither sensitive nor specific, suggest pulmonary embolism, and may expedite definitive studies. In PEA, bedside ultrasonography may also reveal agonal contractions or cardiac standstill on arrival to the emergency department, the latter of which should prompt cessation of resuscitation efforts.[21]

As in the FAST exam, the focused and limited assessment with sonography in hypotension (FLASH) exam looks for free fluid in the abdomen. It should be noted that ultrasound cannot reliably distinguish blood from ascitic fluid. Given that the prevalence of hemoperitoneum outside a trauma setting (e.g. due to ectopic pregnancy, hemorrhagic ovarian cyst, or spontaneous splenic rupture) is likely to be lower than that of ascites, the detection of abdominal free fluid in an unstable non-trauma patient has ambiguous implications. Ultrasound-guided paracentesis following the discovery of abdominal free fluid can quickly differentiate ascites from blood, and would provide a key branch point in the resuscitation.[22]

Whether in the outpatient or emergency settings, bedside ultrasound has been shown to be accurate for the diagnosis of abdominal aortic aneurysm (AAA) (diameter >3cm) compared with CT.[23] Adequate transverse sonographic views of the abdominal aorta from the celiac axis to the iliac bifurcation can be obtained in over 90% of emergency department patients in whom the diagnosis is being considered.[24] Rupture, when it occurs, is generally retroperitoneal, and is not well evaluated by ultrasound. Free abdominal fluid found with AAA may, in rare cases, represent hemoperitoneum, but more frequently represents ascites, as aortic free wall rupture generally causes rapid intraperitoneal exsanguination and death. In the occurrence of hemodynamic instability and pain, the bedside sonographic finding of AAA is consistent with rupture and requires immediate surgical repair. Timely diagnosis is critical, as mortality for ruptured AAA is approximately 50% and is directly related to speed of diagnosis and definitive intervention.

Abdominal Pain

Patients with abdominal pain often present diagnostic dilemmas, with a differential diagnosis that is broad and highly dependent on age and gender. Bedside ultrasound has found regular application in the evaluation of the biliary tract, but this rarely involves a critical diagnosis. As AAA and abdominal trauma have already been discussed, here we review two other critical diagnoses that can be made with bedside ultrasound in patients with abdominal pain.

In adult patients with acute abdominal pain, the diagnosis of perforated viscous is generally sought with plain radiography or CT imaging. However, plain radiography is insensitive for smaller amounts of free air, and CT scanning is time-consuming and often delayed for several hours pending administration of oral contrast. In 1999 the enhancement of the peritoneal stripe sign (EPSS) was described in an animal model and post-operative human volunteers. A recent prospective study of 600 emergency department patients with abdominal pain found that EPSS was 100% sensitive in detecting the 21 cases of pneumoperitoneum with only three false-positives, compared with a 42% sensitivity of upright chest radiography.[25] In addition to the benefits of rapid diagnosis, the exam is performed in the supine position and is well suited to critically ill patients. While this application is not yet regularly taught to most emergency sonographers, it deserves more attention and further research.

In women of reproductive age with abdominal pain or hemodynamic instability (among other presenting symptoms), one of the critical diagnoses that must immediately be identified or excluded is ruptured ectopic pregnancy. With bedside ultrasound, images may be obtained rapidly even prior to availability of urine pregnancy results, and research has shown that use of bedside abdominal and endovaginal ultrasonography decreases the time to diagnosis and the incidence of adverse outcomes.[26,27] Visualization of a definitive intrauterine pregnancy with a yolk sac and/or fetal pole essentially excludes ectopic pregnancy in the patient not undergoing fertility therapy. Findings of probable ectopic pregnancy include free fluid in the hepatorenal space, pelvic free fluid with associated pelvic mass, or direct visualization of a tubal ring or extrauterine gestation.[28] Hemodynamic instability or a significant amount of free fluid suggest rupture and require immediate surgical intervention, while others may be candidates for medical treatment.

This review has briefly touched on several critical diagnoses that can be made with bedside ultrasonography. This tool allows for prompt recognition, effective triage, and expeditious management of a diverse array of clinical entities. As experience with this modality increases, we will likely see more specific indications for its application, as well as applications that have not yet been conceived. ■

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