Diaphragmatic Laceration After Penetrating Trauma

Direct Visualization and Indirect Findings on Focused Assessment With Sonography for Trauma in the Emergency Department

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Rupture of the diaphragm usually occurs from blunt or penetrating trauma to the abdomen or chest and is found in up to 5% of patients with trauma.[1,2] In the acute setting, the diagnosis is often missed because of nonspecific clinical and radiographic signs and symptoms.[1–3] Problems often arise later in the clinical course because of the inability of the diaphragm to heal spontaneously and subsequent bowel or organ herniation through a persistent defect.[4–6]

In addition to radiography and computed tomography (CT), focused assessment with sonography for trauma (FAST) is another imaging modality now routinely used in many acute care trauma centers.[7–9] One of the staples of FAST is the detection of free pericardial or intra-abdominal fluid in the unstable patient.[7–9] More recently, an extension of the FAST examination to include evaluation for acute hemothorax and pneumothorax (extended focused assessment with sonography for trauma [E-FAST]) has been proposed, which also comprises imaging of the diaphragm.[10] Several investigations showed high accuracy of bedside sonography for these common pulmonary injuries, but surprisingly there are only a few publications showing the utility of FAST or E-FAST for detecting diaphragmatic trauma.[11–17]

We present a case of a diaphragmatic laceration from an abdominal stab wound diagnosed with E-FAST. The direct and indirect sonographic findings of this phrenic injury and potential utility of this technique in acute trauma imaging are discussed.

Abbreviations
CT, computed tomography; E-FAST, extended focused assessment with sonography for trauma; FAST, focused assessment with sonography for trauma

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Case Report

A 23-year-old man was brought to the emergency department trauma bay for multiple stab wounds. On physical examination, he was alert, oriented, hemodynamically stable with a respiratory rate of 32 breaths per minute, and very pale. His examination showed stab wounds to the left anterior chest, right chest, base of the right anterior neck, and right upper abdomen. Multiple lacerations were noted on both hands. His airway was patent, and on chest auscultation he had regular heart tones and breath sounds over the right lung but no breath sounds over the left thorax. The stab wound over the left chest appeared

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deep and extending into the chest cavity. An immediate left thoracostomy released a large gush of air and drained 100 mL of blood, restoring breath sounds.

Parallel to the chest tube procedure, an initial bedside FAST examination was performed with an M-Turbo machine (SonoSite Inc, Bothell, WA) and both a large curvilinear probe with a 5–2 MHz frequency and a sector probe with a 4–2 MHz frequency. It showed no pericardial effusion, excellent left ventricular function with a bicuspid aortic valve, no notable free fluid in the abdomen, and no large pneumothorax on the right. Subsequent portable chest radiography showed an expanded lung on the left and a small apical pneumothorax on the right with mild atelectasis at the right lung base (Figure 1). The trauma evaluation proceeded with intravenous contrast-enhanced CT of the neck, chest, abdomen, and pelvis using a multislice helical CT scanner (Somatom Sensation 16; Siemens Medical Solutions, Erlangen, Germany) and 100 mL of the contrast agent iopamidol, 300 mgI/mL (Isovue-300; Bracco Diagnostics Inc, Princeton, NJ). The CT studies were interpreted as having negative CT angiographic findings in the neck; chest CT findings were negative for pericardial fluid but showed small bilateral apical pneumothoraces measuring 4 mm on the right and 7 mm on the left and a small right hemothorax with mild atelectasis at the lung base. Computed tomography of the abdomen and pelvis depicted a small anterior liver laceration measuring 2.9 cm with a very small amount of free fluid adjacent to the liver surface (Figure 2). No other injuries were identified, including on sagittal and coronal reconstruction views. After returning from CT, the patient remained hemodynamically stable with normal oxygen saturation while receiving supplemental oxygen but showed persistent tachypnea.

Another bedside sonographic examination was performed, including extended views of the thorax and lung (E-FAST). The sonographic evaluation of the heart was unchanged. Sonography of the right upper abdomen revealed a minuscule amount of free fluid at the interface of the gallbladder with the liver and kidney (Figure 3 and Video 1) and a small amount of free intraperitoneal fluid at the dome of the liver inferior to the diaphragm (Figure 4 and Videos 2 and 3). In these views, the diaphragm contour appeared interrupted, and free fluid was found inferior and superior to the diaphragm, including isoechoic-appearing material in the immediate supraphrenic space. Also, pulmonary atelectasis was observed at the right lung base with large numbers of air bronchograms. Positive lung gliding was observed, but diaphragmatic motion

Figure 1. Portable anteroposterior chest radiograph showing a small pneumothorax on the right (arrow) with some right lung lower lobe atelectasis and a chest tube in place on the left.

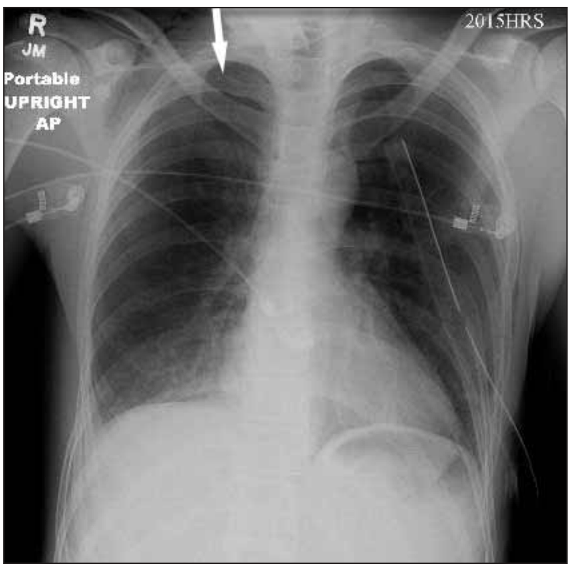
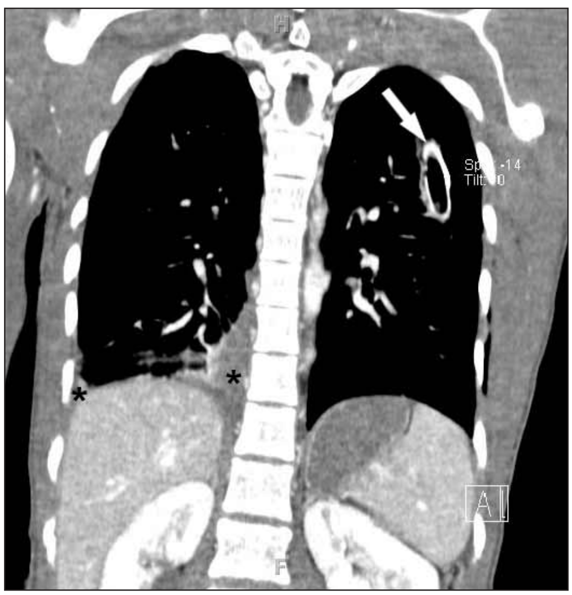


Figure 2. Sagittal chest CT. Arrow indicates chest tube on the left; and asterisks, hemothorax on the right.



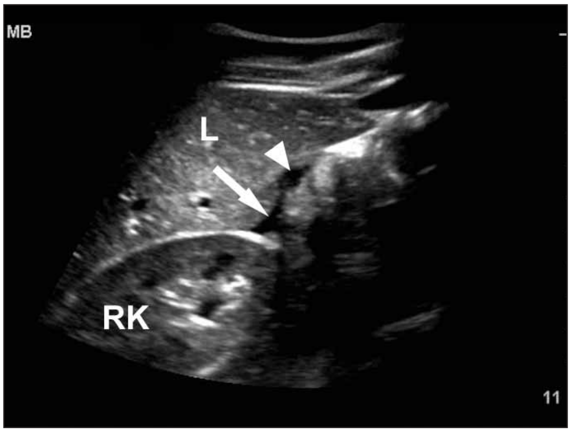


Figure 3. Right upper quadrant abdominal sonogram from a lateral oblique position approximately at the midaxillary line. Arrow indicates small amount of free intra-abdominal fluid; arrowhead, gallbladder; L, liver; and RK, right kidney.

appeared very limited or abolished (Figure 4 and Videos 2 and 3). Further sonographic examination of the liver and diaphragm revealed a liver laceration through the dome of the liver extending into the diaphragm with a diaphragmatic defect estimated at about 4 cm length (Figure 5 and Video 4).

Sonographic findings were discussed with the trauma team at the bedside, and a right thoracostomy tube was placed, draining 100 mL of blood. In light of the negative CT angiographic findings in the neck, the liver laceration detected on CT, and extension of the laceration through the diaphragm with a diaphragmatic defect directly observed on sonography, the patient was taken to the operating room for exploratory laparotomy. During surgery, a 3-cm puncture laceration on the dome of the liver at approximately segment 7 was noted, as well as a 5-cm diaphragmatic laceration (Figure 6). The injuries were repaired, and the patient tolerated the surgical procedure well. After a prolonged hospital course and additional plastic surgery for his hand wounds, the patient was released home in satisfactory condition on hospital day 18.

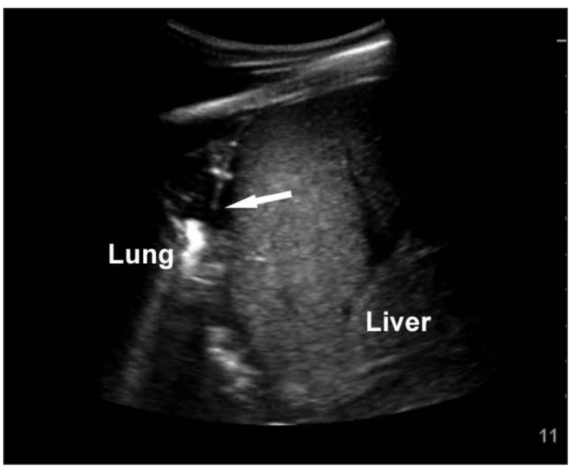


Figure 4. Right upper quadrant abdominal sonogram with the probe in a lateral position at the midaxillary line and pointed toward the dorsal aspect of chest. Arrow indicates the edge of the diaphragmatic defect with periphrenic free fluid and atelectasis.

Discussion

Classic imaging modalities used in acute trauma evaluation, such as plain radiography and CT, are known for their low accuracy in detecting acute traumatic diaphragmatic rupture.[1–4] For instance, the sensitivity of initial plain radiography for diaphragmatic rupture is reported to be as low as 28% to 64%,[18] and that for CT is reported to be 50% to 84%.[19–23] Magnetic resonance imaging is very sensitive for diaphragmatic rupture[24] but rarely feasible in an acute trauma setting.

Sonography, on the other hand, is an additional imaging modality now commonly applied at the bedside during the initial diagnostic trauma workup and is known for its ability to reliably

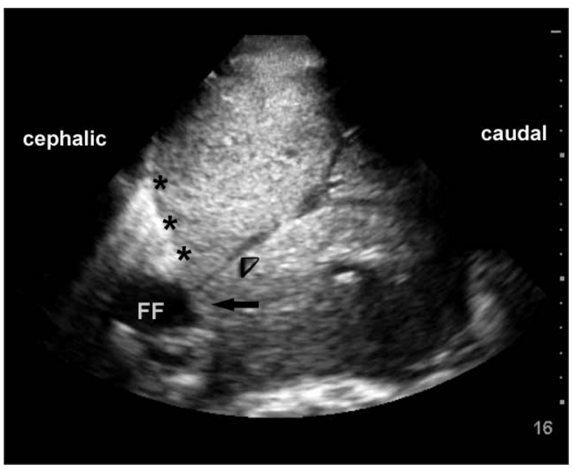


Figure 5. Right upper quadrant abdominal sonogram with the probe in a high lateral position. The lung is shown with atelectasis and movement, with cardiac motion close to the mediastinal structures. Arrow indicates diaphragmatic defect; arrowhead, track of the knife with a liver laceration; asterisks, diaphragm; and FF, free fluid.

Figure 6. Left caudal intraoperative view. Black arrow indicates liver laceration; and white arrow, diaphragmatic laceration.

visualize both hemidiaphragms in outpatient settings.[25–28] It has been shown to effectively visualize the diaphragm and to show motion abnormalities in patients with diaphragmatic paralysis or injury.[26–28] Indeed, over the last 30 years, a limited number of case reports from the inpatient and subacute trauma settings have documented the ability of sonography to directly visualize phrenic defects and secondary signs of diaphragmatic injury such as peridiaphragmatic free fluid, loss of diaphragmatic movement, lung atelectasis, and visualization of intra-abdominal organs in the chest cavity, and sonography has been suggested as an additional imaging modality for diaphragmatic injury.[25–28]

It is surprising then that only 1 group of investigators to date reported the utility of FAST for diagnosing acute diaphragmatic rupture in the emergency department setting.[16] In this interesting case series, M-mode sonography documented the absence of normal respiratory excursion of the diaphragm in patients with blunt trauma. The investigators determined the occurrence of diaphragmatic rupture indirectly from absent phrenic motion on M-mode sonography without documenting the actual anatomic defect.

In our case, we showed the ability of bedside sonography in the acute trauma setting to directly visualize a diaphragmatic defect as well as secondary signs of diaphragmatic rupture previously described, such as decreased phrenic motion with respiratory effort, periphrenic free fluid with hemothorax, and pulmonary atelectasis in the lung area adjacent to the diaphragmatic defect.[14–16]

Although diaphragmatic assessment is not a primary goal of FAST, it is an anatomic landmark frequently evaluated during FAST and E-FAST to distinguish free intra-abdominal from pleural fluid. In this context, increased attention from the sonographer to diaphragmatic continuity and secondary signs of diaphragmatic rupture could increase the currently low rates of detection of diaphragmatic injuries in the acute trauma setting and potentially avoid delayed diagnosis and morbidity. Large prospective trials would be necessary to validate the effectiveness of FAST for acute diaphragmatic injury detection.

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