American Journal of Emergency Medicine (2007) **25**, 838–841

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The American Journal of Emergency Medicine

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Diagnostics

Recognition of pneumoperitoneum using bedside ultrasound in critically ill patients presenting with acute abdominal pain

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Received 5 February 2007; accepted 7 February 2007

Abstract Bedside ultrasound examinations performed by emergency physicians are goal-directed studies meant to answer specific questions. These studies are frequently performed in critically ill patients with undifferentiated abdominal pain who are suspected of having intra-abdominal hemorrhage or a ruptured abdominal aortic aneurysm. Patients presenting with a perforated hollow viscus may have a similar clinical presentation. Although detection of the sonographic findings associated with a perforated hollow viscus is not a current study goal, these findings may be readily apparent during the performance of examinations to detect an abdominal aortic aneurysm or intra-abdominal hemorrhage. Therefore, it is imperative that emergency physicians be familiar with the sonographic findings associated with a perforated hollow viscus. Three illustrative cases are presented with a review of sonographic findings.

1. Introduction

Abdominal pain is often vague and ill defined with many etiologies having similar presentations. Ancillary testing is frequently relied upon to aid in sorting out the differential diagnosis.

Bedside ultrasound is being used with increasing frequency by emergency physicians as goal-directed examinations meant to answer specific questions. In patients with abdominal pain, ultrasound can be used to rapidly determine the presence or absence of an abdominal aortic aneurysm (AAA), gallstones, hydronephrosis, and intra-abdominal hemorrhage.

While these focused studies are being conducted, physicians may come across key sonographic findings that may lead to alternative diagnoses. These incidental findings, which are not related to the focused nature of emergency department (ED) ultrasonography, may sometimes identify a cause for the patient's symptoms.

Perforation of a hollow viscus is a life-threatening cause of abdominal pain. Traditionally, it is diagnosed through the detection of pneumoperitoneum on an upright chest x-ray [1]. Unfortunately, many of these patients are too sick to be positioned upright. Because many patients are initially considered to have other potentially life-threatening conditions, such as intra-abdominal hemorrhage or an abdominal aortic catastrophe, bedside ultrasonography may be the initial imaging study performed. The sonographic findings of a perforated hollow viscus include ring-down artifacts with posterior enhancement that shift with change in patient position, enhancement of the peritoneal stripe, and echogenic free peritoneal fluid [2-9]. These findings may be

0735-6757/$ – see front matter
doi:10.1016/j.ajem.2007.02.004

readily detectable during the performance of the bedside focused assessment with sonography for trauma (FAST) and aorta examinations. Therefore, it is imperative that emergency physicians performing bedside ultrasound be familiar with the sonographic findings associated with perforation of a hollow viscus.

2. Case presentations

2.1. Case 1

A 68-year-old woman with a history of hypertension, myocardial infarction, and type 2 diabetes mellitus presented to the ED with severe upper abdominal pain. The patient stated that she had been experiencing intermittent pain in the mid-epigastric region for the past week. The pain became constant and severe earlier in the day and is now radiating to her back. She denied having fever, chills, or diarrhea, but revealed that she has had numerous episodes of nonprojectile, nonbilious, and nonbloody emesis. Upon examination, the patient had the following results: blood pressure, 90/65 mm Hg; heart rate, 118 beats per minute; respiratory rate, 24 breaths per minute; temperature, 37.1°C. Physical examination revealed the patient to be in severe distress due to the abdominal pain. On abdominal examination, she had hypoactive bowel sounds with diffuse guarding and rebound. A focused bedside ultrasound examination was performed to assess for the presence of an AAA. During bedside ultrasound examination, multiple ring-down artifacts consistent with free air were observed anterior to the liver (Fig. 1) and echogenic free fluid with multiple ring-down artifacts was observed in Morison pouch (Fig. 2). In addition, multiple ring-down artifacts were observed adjacent to the duodenum and pancreas (Fig. 3). The patient was aggressively fluid resuscitated and given broad-spectrum antibiotic coverage; emergent surgical consultation was obtained because of the sonographic findings consistent with a perforated duodenal ulcer. Her supine portable chest radiograph was interpreted by radiology as "suspicious" for the presence of pneumoperitoneum, and it was recommended that computed tomography of the abdomen and pelvis be obtained to better evaluate the radiographic findings. She was taken emergently to the operating room without a computed tomographic scan being performed, and there the presence of a perforated duodenal ulcer was confirmed.

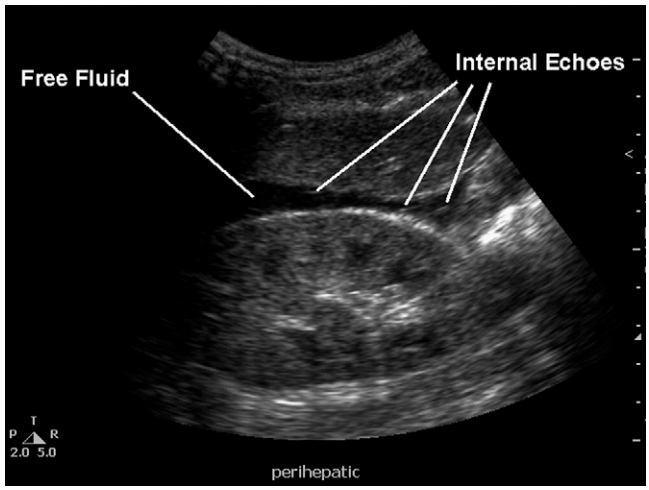

Fig. 2 Perihepatic window demonstrates free fluid with internal echoes in Morison pouch.

2.2. Case 2

A 75-year-old man with a history of hypertension, myocardial infarction, poorly controlled type 2 diabetes mellitus, peripheral vascular disease, and mild chronic obstructive pulmonary disease presented to the ED with a complaint of severe abdominal pain. The patient stated that

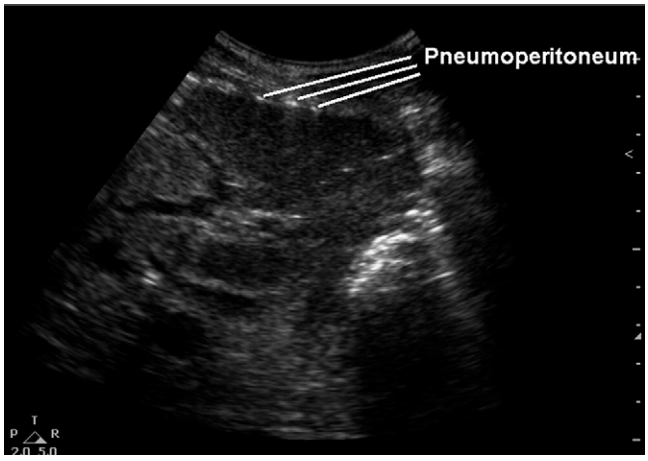

Fig. 1 Sagittal image of the liver demonstrates pneumoperitoneum as echogenic lines anterior to the liver with posterior ring-down artifacts.

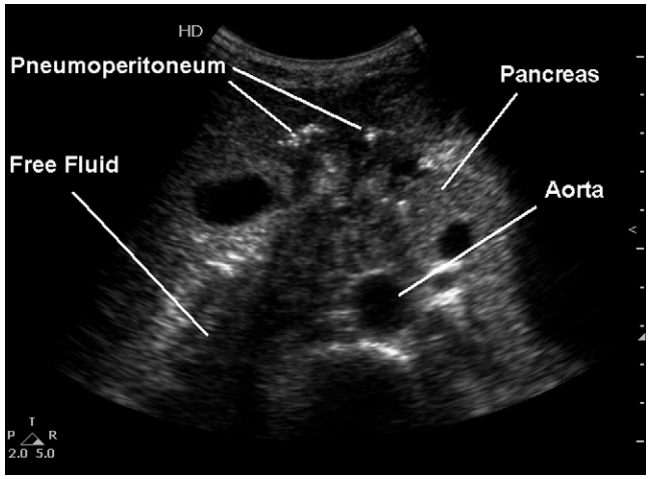

Fig. 3 Transverse image of the pancreas with free fluid and pneumoperitoneum noted.

he has been vomiting for the past 4 days, but denies any chest pain, difficulty in breathing, gastrointestinal bleeding, fever, or chills. Physical examination revealed a very sick-looking man who was in severe distress due to pain, with the following vital signs: blood pressure, 88/52 mm Hg; heart rate, 104 beats per minute; respiratory rate, 28 breaths per minute; temperature, 37.4°C. Abdominal examination revealed hypoactive bowels with diffuse tenderness and guarding that was worse in the mid-epigastric and right upper quadrant. A bedside ultrasound examination of the aorta revealed no sonographic evidence of an AAA, and a bedside ultrasound examination of the gallbladder revealed no sonographic evidence of cholelithiasis or cholecystitis. During the bedside examination, it was noted that the patient had echogenic free fluid containing ring-down artifacts within Morison pouch. Free air and complex fluid were noted adjacent to the duodenum. Although the patient was resuscitated, emergent surgical consultation was obtained because of the presence of sonographic findings consistent with a perforated duodenal ulcer. After 2 L of intravenous fluids, the patient's blood pressure improved to 142/72 and his heart rate decreased to 84 beats per minute. The initial supine chest x-ray (CXR) was interpreted by radiology to have no definitive findings of pneumoperitoneum. An upright CXR was performed after the patient's vital signs improved with fluid resuscitation, and it revealed the presence of pneumoperitoneum under the right hemidiaphragm. The patient was taken to surgery where the diagnosis of a perforated duodenal ulcer was confirmed.

2.3. Case 3

A 47-year-old man with a history of peptic ulcer disease presented to the ED with upper abdominal pain unrelieved with Nexium. The patient had been experiencing both mid-epigastric and right upper quadrant abdominal pain for the past 3 weeks, and was prescribed Nexium (Astra-Zeneca, Wilmington, DE) by his primary care physician. He had been intermittently vomiting for the past 2 days but denied gastrointestinal bleeding, chest pain, difficulty breathing, or fever. The pain was acutely worse earlier in the day and had persisted throughout the day. He was afebrile and had stable vital signs, except for his heart rate, which was recorded at 112 beats per minute. Physical examination revealed the patient to be in severe distress because of upper abdominal pain. Abdominal examination revealed diffuse tenderness and rebound, with the predominance of tenderness in the epigastric region. A portable CXR could not be immediately obtained due to the presence of numerous trauma patients within the ED. A bedside ultrasound was performed, which revealed echogenic free fluid in Morison pouch and the presence of free air anterior to the liver. Portable CXR obtained subsequent to completion of the bedside ultrasound revealed the presence of pneumoperitoneum. Emergent surgical consultation was obtained and the patient was taken emergently to the operating room, where the diagnosis of a perforated gastric ulcer was made.

3. Discussion

Abdominal pain is often vague and ill defined with many etiologies having similar presentations. Ancillary testing is frequently relied upon to aid in sorting out the differential diagnosis. It is essential that these patients be rapidly evaluated and correctly diagnosed to minimize morbidity and mortality. Bedside ultrasound is now being used by emergency physicians with increasing frequency to evaluate patients with a variety of potentially life-threatening conditions and may therefore be the first imaging study performed in the ED evaluation.

Perforation of a hollow viscus is a life-threatening condition, and the diagnosis is traditionally based on evidence of pneumoperitoneum on an upright CXR. Experimental studies have shown that as little as 1.0 mL air can be detected in upright, supine, and lateral decubitus plain radiographs [1,10]. In cases where the determination of pneumoperitoneum can be made on plain radiographs, the diagnosis is straightforward. However, in a clinical study, the diagnosis could only be established in 56% of cases with supine radiographs because of interpretive difficulties [11].

Although not recognized as a current study goal with bedside ultrasound, sonographic findings of pneumoperitoneum may be readily detected during the performance of these focused, bedside studies. A 1984 study by Nirapathpongporn and colleagues [12] first described the sonographic detection of pneumoperitoneum with ultrasound. A recent study by Chen and colleagues [6] found that ultrasonography is a more sensitive modality than plain radiography for the diagnosis of pneumoperitoneum. They found that ultrasonography demonstrated a sensitivity of 93%, a specificity of 64%, and a positive predictive value of 97% for the diagnosis of pneumoperitoneum, whereas plain radiography demonstrated a sensitivity of 79%, a specificity of 64%, and a positive predictive value of 96% [6].

The sonographic diagnosis of a perforated hollow viscus is also primarily made through the detection of pneumoperitoneum [4,5,7,13]. To determine the presence of pneumoperitoneum, the patients should first be scanned in supine position with attention concentrated on the epigastric region and the right upper quadrant. In the supine position, air will tend to accumulate anterior over the liver and in the epigastrium [2,4,5,7]. A 2- to 5-MHz curvilinear transducer will most commonly be used to scan these patients. In difficult cases, a linear-array transducer may be more sensitive for the detection of pneumoperitoneum because of the higher resolution in the near field where the air will tend to accumulate.

Sonographically, air will appear as echogenic areas with posterior reverberation artifacts (Figs. 2 and 3) [5,7].

The presence of air within the bowel will have an identical sonographic appearance to that of free peritoneal air. Therefore, in some cases, it may be difficult to determine the exact location of the air collection. Scans of the hepatic region may resolve any doubt because any free air here will be separate from the bowel (Fig. 1). Chilaiditi syndrome, where colonic gas is interposed between the liver and the abdominal wall over the right hypochondrium, is the exception here.

In cases where the bowel lumen cannot be definitively identified and there is no free air in the hepatic region, the patient should be placed in the left lateral decubitus position [14]. Reverberation artifacts caused by pneumoperitoneum will demonstrate the shifting phenomenon that consists of the shifting of the reverberation artifacts after displacement of air in the peritoneal cavity because of the change in patient positioning [14]. Because free air will move to the least dependent area, a patient in the left lateral decubitus position will have free air noted around the hepatic parenchyma where it can be easier to diagnose.

In cases where it is difficult to differentiate pulmonary air from free intraperitoneal air in the hepatic region because of the appearance of a continuous line of reverberation artifacts, the patient should be evaluated during inspiration and expiration. During inspiration the pulmonary and free intraperitoneal air will overlap, but during expiration the pulmonary and free intraperitoneal air will appear separate [2].

Enhancement of the peritoneal stripe with the presence of pneumoperitoneum has been demonstrated in both human and animal studies [9]. The presence of even minute amounts of pneumoperitoneum against the anterior peritoneal wall will result in an enhancement of its appearance. Patients with ascites may demonstrate the presence of air bubbles within the ascitic fluid [2].

In addition to detecting the presence of pneumoperitoneum, ultrasonography may also demonstrate other findings not typically found on plain radiographs [2,6]. The presence of echogenic fluid with or without reverberation artifacts due to the presence of free gastric contents may be detected with ultrasound (Fig. 2). Morison's pouch will be a common location of such fluid. The underlying cause of the pneumoperitoneum may be detected with ultrasound. Lee and colleagues [2] were able to identify the site of perforation in 4 of 5 patients in their case series. Three of the patients had a perforated duodenal ulcer, whereas the other patient had a perforated gastric neoplasm.

Bedside ultrasound can be a useful modality in the critically ill patient. This case series demonstrates its use in patients with perforated hollow viscus. This technique may be considered by emergency physicians with training and expertise in abdominal ultrasound.

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