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The acute abdomen:
Plain radiographic evaluation

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Introduction

With the development of computed tomography, ultrasonography and specialized scintigraphic techniques, conventional radiographic imaging of the abdomen has generally been relegated to a minor position in each of the three clinical entities under discussion in this series. On the other hand, one can make a good case for routinely obtaining radiographs of the abdomen in most patients with an acute abdomen. The information available on the plain radiographs regarding the amount and distribution of intestinal gas, recognition of extraluminal gas collections, significant calcifications, organomegaly and the demonstration of soft tissue masses or fluid collections can be critical in making a specific diagnosis or in suggesting a possible diagnosis. This information may be useful in planning the subsequent workup. In this section, the role of conventional radiography, including plain radiographs and traditional contrast studies of the abdomen, will be discussed in the workup of patients with suspected acute cholecystitis, subhepatic abscess and splenic trauma.

Acute Cholecystitis

Conventional radiographic techniques including plain radiographs and contrast studies have a minor role in the imaging workup of patients suspected of having acute cholecystitis. Oral cholecystography and intravenous cholangiography have no role in the evaluation of a patient with acute right upper quadrant symptoms. A plain radiograph of the abdomen, however, is usually obtained in patients with acute abdominal symptoms and may provide some useful information.

In a patient with abdominal pain, the plain radiographic demonstration of gallstones is an important clue that the gallbladder may be the source of the acute symptoms. Approximately 15% of gallstones are recognizable on plain radiographs (2). The demonstration of gallstones is useful information, although it does not necessarily incriminate the gallbladder as the source of the acute symptoms. Rarely, a soft tissue mass can be detected on plain radiographs in a patient with an obstructed cystic duct and hydrops of the gallbladder (2). In a patient whose symptoms are atypical, an upper gastrointestinal series may be performed in the workup of upper abdominal symptoms. The demonstration of an enlarged gallbladder with compression and spasm of the second portion of the duodenum may first suggest an inflamed gallbladder (3) (Figure 1).

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Figure 1
Acute cholecystitis The enlarged gallbladder resulting from cystic duct obstruction (hydro), causes a pressure deformity (arrows) on the second portion of the duodenum with secondary spasm and fold thickening. These findings suggest acute cholecystitis in a patient complaining of right upper quadrant discomfort.

A rare form of acute cholecystitis which can be specifically diagnosed on plain films is the entity of emphysematous cholecystitis. This form of acute cholecystitis is more common in men than in women, and frequently occurs in diabetics (14). The cystic duct may or may not be obstructed, and it is believed that this form of cholecystitis may occur as a result of ischemia of the gallbladder (12). There is a higher incidence of gangrene and perforation of the gallbladder in emphysematous cholecystitis than with the classic form of cholecystitis, and the mortality rate is higher (14). In spite of this heightened frequency of severe complications, the disease may be surprisingly occult (14).

Radiographically, emphysematous cholecystitis is characterized by demonstration of gas within the wall or within the lumen of the gallbladder or both. In some cases in which the gallbladder has already perforated, the linear outline of the gallbladder can be identified with bubbles of gas outside the gallbladder wall (Figures 2–4). In other patients, there is only gas within the lumen of the gallbladder. In these patients, the possibility of biliary-enteric fistula, resulting from a gallstone eroding into the intestinal tract, or an ulcer penetrating into the common bile duct, needs to be considered as an explanation for the symptoms and for the demonstration of gas in the gallbladder lumen (14).

In our experience, the demonstration of localized ileus, scoliosis, and obliteration of psoas or liver margins is nonspecific and has virtually no radiographic significance in patients suspected of acute cholecystitis.
Emphysematous cholecystitis  

(A&B) An amorphous collection of gas (arrow) is seen within the lumen of the gallbladder. The absence of intramural gas should not dissuade the radiologist from making the correct diagnosis. (C) Computed tomography confirms the plain radiographic findings and, in addition, identifies a pericholecystic fluid collection (open arrow), as well as fluid in the left anterior pararenal space (solid arrow) resulting from pancreatitis.
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Figure 3
Emphysematous cholecystitis (A&B) These figures show obvious intramural and pericholecystic gas collections (arrows) in two different patients.

Figure 4
Emphysematous cholecystitis Linear collections of intramural gas (arrows) are seen within this gall-bladder.
Traumatic Rupture of the Spleen

The spleen is the intraabdominal organ that is most often injured in blunt abdominal trauma, but plain radiographic findings suggesting the diagnosis are often absent and usually nonspecific. Patients suffering significant thoracoabdominal trauma usually have a plain radiograph of the chest and abdomen because of the value of these studies in establishing the diagnoses of skeletal injury to the spine or thoracic cage and soft tissue injury to the diaphragm, lungs and pleura. The radiologist should not overlook the opportunity to evaluate these films for signs suggesting splenic injury. If such signs are present, he should suggest the expeditious use of more definitive imaging modalities, including computed tomography, ultrasound, and radionuclide scintigraphy.

RADIOGRAPHIC FINDINGS

The reported frequency with which plain radiographs of the chest and abdomen contribute to the diagnosis of splenic rupture varies markedly, from 90% as stated by Haertel and Ryder (11) to less than 3% in Stivelman’s series (21). Our experience suggests that significant plain radiographic findings are uncommon and rarely diagnostic. Serial films, when available, are sometimes valuable in suggesting splenic trauma or free peritoneal bleeding. The following radiographic findings may be useful in suggesting splenic rupture.

Fractures of the Left Lower Ribs

The demonstration of fractures of the left lower ribs should alert the clinician and radiologist to the possibility of underlying splenic trauma (13). In our experience, this is the most frequent plain radiographic finding in patients with significant splenic trauma, but it is obviously nonspecific (Figure 5).

Figure 5
Rib fracture and subcapsular splenic hematoma In our experience, fracture of a left lower rib (arrow) is the most common finding in splenic trauma. Also notice the splenomegaly which is secondary to a subcapsular hematoma. Associated adynamic ileus is nonspecific, and is rarely helpful in suggesting a precise diagnosis.
Enlargement of the Spleen

Observable enlargement of the spleen on serial radiographs made following blunt abdominal trauma usually indicates splenic laceration, commonly associated with subcapsular hematoma (Figure 6). The enlarging spleen or associated hematoma may displace the gastric air bubble medially (Figure 7). Rarely, a serrated appearance of the lateral aspect of a gas filled stomach is evident on plain radiographs. The enlarging spleen may also displace the splenic flexure of the colon caudally and medially, and there may be elevation of the left hemidiaphragm (9) (Figure 8).

Figure 6
Subcapsular splenic hematoma  Progressive enlargement of the spleen is highly suggestive of splenic injury. This case demonstrates splenomegaly resulting from subcapsular hematoma in a patient with known, recent, blunt abdominal trauma, and a normal abdominal plain radiograph 24 hours earlier.
Figure 7
Subcapsular splenic hematoma  Splenomegaly with medial displacement of the gastric air bubble suggests the diagnosis of subcapsular splenic hematoma in this patient who had suffered blunt abdominal trauma several hours earlier.

Figure 8
Subcapsular splenic hematoma  In this case, massive splenic enlargement developed over a period of six months following abdominal trauma. Arteriography confirmed a subcapsular hematoma. Notice the marked medial displacement of the gastric air bubble and the caudal displacement of the transverse colon. Contrast material is seen within the normal urinary collecting system.
Free Peritoneal Fluid

Free peritoneal fluid following blunt abdominal trauma strongly suggests the presence of intraperitoneal bleeding (11) (Figure 9). This is an important finding suggesting intraabdominal hemorrhage, but in our experience it is infrequently found on abdominal plain films. It is important to know if peritoneal lavage has been performed because incomplete removal of the lavage fluid may be confused with accumulation of peritoneal blood (9). The most frequent radiographic sign of free peritoneal fluid is separation of the flank fat stripe from gas in the descending colon. Normally this separation should not exceed 2 mm (4). Cimmino has reported excellent results using a fluoroscopically monitored air enema to more precisely define widening of this space (5). This technique has not gained widespread acceptance, however, and in our opinion the procedure has been replaced by CT, ultrasound and scintigraphy.

Similar widening of the right paracolic gutter owing to free peritoneal fluid may be evident, especially if the patient is maintained in the right-side-down decubitus position for some time prior to the exposure of the radiograph (8).

In the supine position, blood in the pelvis may be identified above the bladder (8), and has been called the "dog ears" sign (Figure 9). In our experience, this sign is rarely of much clinical value. Fluid filled loops of small bowel may have an identical appearance and the presence of this sign generally indicates a large amount of fluid that can be more accurately identified by other methods and imaging techniques.

Figure 9
Pelvic fluid collection—"Dog Ears"  Large amounts of free peritoneal fluid can accumulate in the pelvis and present as soft tissue masses in the paravesicle space (arrows). These fluid collections have been called "dog ears" and strongly suggest free intraperitoneal blood in a patient with known recent abdominal trauma.

Obliteration of Psoas and Renal Outlines

Obliteration of the psoas outlines and renal outlines is also extremely nonspecific and difficult to evaluate radiographically. Definite obliteration of these fat lines suggests retroperitoneal injury and is probably an indication for computed tomography.

Abnormal Gas Collections

Significant ileus is frequently encountered in patients with blunt abdominal injuries, but it is entirely nonspecific and of little value in suggesting specific visceral injury.
Subhepatic Abscess

Intraabdominal abscess remains an important clinical problem with a mortality rate of approximately 30% (1), in spite of better antibiotics, improved drainage techniques, and more accurate localization with the newer imaging modalities before attempting drainage. This discussion will be limited to the diagnosis of subhepatic abscesses, the majority of which occur in patients who have recently undergone surgery or sustained trauma (18, 22). In the postoperative patient, physical findings are difficult to evaluate, and fever is often attributed to pulmonary or urinary infection. Postoperative abscesses may be clinically occult; a surprising number of patients with sizable intraabdominal abscesses demonstrate few clinical signs and symptoms (10, 20). Many patients who continue to have abdominal pain and ileus in the postoperative period will have more or less routine abdominal radiographs. These conventional radiographic images of the abdomen may provide the first indication that a postoperative abscess is present. This is especially true when clinical signs or symptoms are partially masked by antibiotics, steroids, immunosuppressive therapy, or chemotherapy (20).

ANATOMIC CONSIDERATIONS

The subhepatic space is one of the most common sites for abscess accumulation. Meyers and Whalen have precisely defined the normal anatomic spaces and pathways by which free peritoneal fluid disseminates (16, 17). Free peritoneal fluid may reach the subhepatic space via the right paracolic gutter from either the subdiaphragmatic space or the pelvis. The subhepatic space is the most dependent region in the upper abdomen when a patient is in the supine position (23). Meyers refers to this region as the “sewer” of the upper abdomen, for it is the most frequent site for the accumulation of infected peritoneal fluid (15, 16).

Anatomically, the subhepatic space is bounded anteriorly by the posterior surface of the right lobe of the liver, posteriory by the right kidney, medially by the second portion of the duodenum, and laterally by the right paracolic gutter. Anterior and posterior subdivisions of this space have been defined, but the posterior compartment (Morison’s pouch) is more often the site of infection. The epiploic foramen (Foramen of Winslow) connects Morison’s pouch with the lesser sac. This communication is rarely patent in the presence of infection; and a lesser sac abscess, therefore, is rarely associated with infection in the subhepatic space. Concurrent infection in the right subphrenic space is commonly present owing to its communication with the subhepatic space via the right paracolic gutter (16).

The close relationship of the gallbladder, the duodenal bulb, and the hepatic flexure of the colon to the subhepatic space is important, and subhepatic abscess may result from surgery, perforation or other diseases involving any of these organs.

RADIOGRAPHIC CONSIDERATIONS

Though the obvious role of computed tomography, ultrasound, and improved scintigraphic techniques has resulted in less emphasis on plain radiography, there are several studies that demonstrate that plain abdominal radiographs are surprisingly accurate in detecting upper abdominal abscesses. Connell et al. reported radiographic findings either diagnostic or suspicious for upper abdominal abscess in 71% of patients on plain radiographs alone. The addition of contrast studies of the gastrointestinal tract improved the diagnostic accuracy to 88% in those patients who received contrast examinations (6). Similar results have been reported by Fataar and Schulman (7).

The most important plain radiographic finding to suggest the diagnosis of a subhepatic abscess is the demonstration of a loculated pocket of extraluminal gas in the subhepatic space (Figure 10A). The fact that the pocket of gas is extraluminal may be subtle, and it may be very difficult to differentiate extraluminal abscess gas from normal intraluminal gas. Many patients with a subhepatic abscess will have an associated ileus which may compound the problem (20).

Extraluminal gas may appear as a mottled lucency resembling stool in the colon. Less commonly emphasized in the radiologic literature, but equally as common in our experience, is the demonstration of a homogeneous abscess gas collection. Such a collection can sometimes be differentiated from intraluminal gas by a featureless wall which is devoid of any mucosal pattern (19) (Figure 11). Because the pocket of gas in an abscess is loculated and may contain pus, an air fluid level can frequently be demonstrated. Normally, there is no gas containing viscus above the hepatic flexure, so when a gas pocket is identified which is clearly superior to the stool or gas filled hepatic flexure, the presence of extraluminal gas can be strongly suggested. Occasionally, subhepatic abscess gas may be difficult to differentiate from normal gas within the duodenal bulb or loop, and a limited gastrointestinal series is useful in making this distinction (Figure 10B).
Figure 10
Subhepatic abscess  (A) Loculated, amorphous gas collection (arrows) might lie in the duodenum. (B) An upper gastrointestinal series proves the extraluminal nature of the gas collection (arrows) which, in fact, lies in the subhepatic space.
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Figure 11
Subhepatic abscess—perforated duodenal stump

(A) Notice the gas collection (arrow) superolateral to the second portion of the duodenum. The homogeneous character of the gas, without any mucosal features, strongly suggests that the gas collection is extraluminal. (B) This contrast study demonstrates a perforation of the duodenal stump following a Billroth II procedure.

11A

11B
Abscesses that do not contain gas are rarely demonstrable on plain radiographs of the abdomen. In contrast examinations of the upper gastrointestinal tract or colon, an abscess may be demonstrable as a soft tissue mass displacing or indenting the hepatic flexure or duodenal loop (Figure 12). A more important contribution of the contrast examination is the demonstration of the site of perforation or anastomotic leak which may be the underlying cause of a postoperative or spontaneous abscess (6) (Figures 13 and 14).

Subhepatic abscesses alone are rarely associated with right pleural effusions, lower lobe atelectasis or other changes in the lung base. These radiographic signs are more likely to be present if a subhepatic abscess is associated with a subdiaphragmatic abscess (17). Scoliosis and loss of fat planes, as demonstrable on plain radiographs, are rarely of much value.

**Figure 12**

**Subhepatic abscess**  (A) Extrinsic compression of the superior aspect of the hepatic flexure (arrows) is due to the mass effect of a subhepatic abscess. (B) This upper gastrointestinal study demonstrates an extrinsic mass effect on the lateral aspect of the second portion of the duodenum (arrow).
Figure 13
Subhepatic abscess—blown duodenal stump  This is another example of a blown out duodenal stump following a Billroth II procedure. The radiograph demonstrates gas and extravasated contrast material in the subhepatic space (arrows).

Figure 14
Subhepatic abscess—perforated duodenal ulcer  Contrast studies are frequently helpful not only in identifying extraluminal gas collections, but also in revealing the cause of the abscess. This case demonstrates extravasation of contrast material into the subhepatic space as a result of a perforated duodenal ulcer (arrow). Gas can also be seen within the subhepatic space, cephalad to the duodenal bulb.
Summary

There is still a significant role for plain radiographs of the abdomen in the workup of patients with an acute abdomen, and we believe that radiographs of the abdomen are a reasonable place to start the imaging evaluation of these patients.

In patients suspected of having acute cholecystitis, the demonstration of opaque gallstones or of an obvious soft tissue mass in the region of the gallbladder is obviously important. In the rare patient with emphysematous cholecystitis, the demonstration of gas in the wall or lumen of the gallbladder, or both, can be diagnostic.

Specific plain radiographic findings of splenic trauma are unusual, but plain radiographs may demonstrate rib fractures or other skeletal injuries that raise one's index of suspicion with respect to the possibility of splenic rupture. Plain radiographs may also demonstrate splenic enlargement or free peritoneal fluid. These findings strongly suggest splenic trauma.

Plain radiographs of the abdomen in a postoperative patient may demonstrate gas in a subhepatic abscess that has not been suspected clinically. Any loculated collection of gas above the proximal transverse colon is an indication for further imaging evaluation. Contrast studies of the gastrointestinal tract can define leaks and perforations that cannot be diagnosed preoperatively by any other technique.

References