Acute cholecystitis is the most common cause of acute pain in the right upper quadrant (RUQ), and urgent surgical removal of the gallbladder is the treatment of choice for uncomplicated disease. However, cross-sectional imaging is essential because more than one-third of patients with acute RUQ pain do not have acute cholecystitis. In addition, patients with complications of acute cholecystitis, such as perforation, are often best treated with supportive measures initially and elective cholecystectomy at a later date. Ultrasound (US) is the primary imaging modality for assessment of acute RUQ pain; US is both sensitive and specific in demonstrating gallstones, biliary dilatation, and features that suggest acute inflammatory disease. Occasionally, additional imaging modalities are indicated. Computed tomography is valuable, especially for confirming the extent and nature of the complications of acute cholecystitis. Magnetic resonance cholangiopancreatography is helpful in complicated ductal disease (eg, recurrent pyogenic cholangiohepatitis) when more detailed diagnostic information is required for treatment planning, whereas endoscopic retrograde cholangiopancreatography is used when biliary intervention is required (eg, treatment of choledocholithiasis). Successful imaging with all modalities requires familiarity with both the characteristic and the unusual features of a wide variety of pathologic conditions. In addition, potential pitfalls must be recognized and avoided.

©RSNA, 2004
Introduction
Patients presenting to the emergency department with abdominal pain localized to the right upper quadrant constitute a recognized patient population in whom acute cholecystitis is a prime diagnostic consideration. Although hepatobiliary disease in general and acute cholecystitis in particular may be the explanation for the patient’s symptoms, the clinical picture is often confusing and imaging is generally indicated early in an effort to reach a specific diagnosis. The primary treatment of acute cholecystitis is laparoscopic cholecystectomy. There is evidence that surgery in acute cholecystitis leads to better outcomes, and many surgeons prefer early cholecystectomy. However, more than one-third of patients suspected of having acute cholecystitis after initial clinical evaluation are ultimately proved to have a different diagnosis. In one study of 52 patients with acute right upper quadrant pain suspected of having acute cholecystitis, the diagnosis was confirmed in only 34.6%, whereas 32.7% had chronic cholecystitis and 32.7% had normal gallbladders (1).

Ultrasound (US) is the primary imaging modality used to evaluate acute right upper quadrant pain. In our experience, it is an accurate, safe, relatively inexpensive, and readily accessible imaging modality for investigating these patients. It is highly sensitive and specific for the detection of gallstones and biliary dilatation. As early as 1982, the accuracy of US (88%) was shown to be similar to that of scintigraphy with hepato-iminodiacetic acid (HIDA) (85%) in 91 patients suspected of having acute cholecystitis (2). In many practices, US has since replaced scintigraphy for these patients. Not only will US more easily demonstrate complications of acute cholecystitis, such as gangrenous and emphysematous change, but also it will frequently demonstrate an alternate diagnosis as the cause of the patient’s symptoms if the gallbladder is normal. Finally, scintigraphy is time-consuming, often requiring up to 4 hours for differentiation of acute from chronic cholecystitis (3). Many authors therefore suggest that nuclear imaging for the diagnosis of acute cholecystitis be reserved for patients with the rare equivocal sonogram (1,4,5).

US is also superior to computed tomography (CT) as the initial imaging investigation for assessment of biliary disease causing acute right upper quadrant pain. This view is supported by a study by Harvey et al (6) where CT was the initial imaging study in 57 patients, and CT findings resulted in underdiagnosis or misdiagnosis in eight of 11 patients with acute biliary disease. Follow-up US performed within 48 hours of the CT suggested the correct diagnosis and provided additional clinical information in seven of these eight patients. In addition, US findings resulted in altered clinical management in six of the 11 patients with acute biliary disease. US was the initial imaging study in 66 patients, and US findings were suggestive of biliary disease or the correct diagnosis in seven of seven patients with acute biliary disease. Follow-up CT within 48 hours of the US examination did not result in altered clinical treatment in any of these seven patients.

Although US is an excellent modality for the initial evaluation of the patient with acute right upper quadrant pain and will often suffice to direct treatment decisions, there are situations where additional imaging may be required. In general terms, CT is an excellent second choice. It will frequently provide a better overview of the scope and extent of disease where visibility with US is limited (eg, open wounds, surgical dressings, and obesity) and will complement the US findings in more complex cases. The combination of US and magnetic resonance (MR) imaging or MR cholangiopancreatography provides excellent potential for diagnosis of acute biliary ductal disease. On the other hand, endoscopic retrograde cholangiopancreatography (ERCP) with papilotomy is the treatment of choice for patients shown to have choledocholithiasis at US and may also be a helpful adjunct to intravenous fluids and antibiotics in treating patients with ascending cholangitis shown to have biliary dilatation at US.

The spectrum of diseases that may manifest as acute right upper quadrant pain includes acute cholecystitis and its complications, gangrene and perforation; gallbladder torsion; mimics of acute cholecystitis; choledocholithiasis; biliary colic caused by hemobilia; hepatic artery aneurysm; ascending cholangitis; liver abscess; recurrent pyogenic cholangiohepatitis; and complications of liver masses, such as rupture and hemorrhage. The operator must be familiar with the characteristic and unusual appearances of these conditions and must be aware of potential pitfalls that can mimic them.

Acute Cholecystitis
Acute cholecystitis occurs in approximately one-third of patients who have gallstones (7). Ninety percent to 95% are due to calculous obstruction of the gallbladder neck or cystic duct leading to increased intraluminal pressure and distention. Inflammation may result from chemical injury of the mucosa by bile salts and/or superimposed infection. Gallbladder ischemia and transmural necrosis may occur if the obstruction persists. The differential diagnosis for acute cholecystitis is extensive and includes choledocholithiasis, pancreatitis, peptic ulcer disease, acute hepatitis, liver abscess, liver neoplasm with complication, pneumonia, and heart disease.
The most sensitive US finding in acute cholecystitis is the presence of cholecystolithiasis in combination with maximal tenderness over the sonographically localized gallbladder (sonographic Murphy sign). In one study of 497 patients, Ralls et al (8) showed this combination of findings to have a positive predictive value of 92%. In our experience, the presence of a tensely distended gallbladder is also very helpful, and we are somewhat reluctant to entertain the diagnosis of acute cholecystitis in its absence. Lack of this finding will at least prompt us to look more carefully for another cause for the patient’s pain. Finally, every effort should be made to demonstrate the obstructing stone in the gallbladder neck or cystic duct (Figs 1, 2). Success will often depend on various maneuvers including the use of different acoustic windows (eg, subcostal and intercostal) to assess the cystic duct and altering the patient’s position (eg, supine, decubitus, sitting, and standing) to demonstrate lack of movement of an impacted stone in the gallbladder neck. Both gallbladder wall thickening (>3 mm) and pericholecystic fluid are secondary findings that are neither sensitive nor specific for acute cholecystitis. There are reports in the literature of improving sensitivity and specificity when making the diagnosis of acute cholecystitis with color and power Doppler US (9). However, we rarely include Doppler US as part of the routine examination when considering this diagnosis, relying instead on the gray-scale appearances and a positive or negative sonographic Murphy sign to confirm or refute the clinical impression.

A potential problem when evaluating the gallbladder with US is the presence of tumefactive sludge within the gallbladder lumen. This appearance may raise the possibility of gallbladder cancer. Doppler US may be helpful by demonstrating blood flow in a polypoid neoplasm, whereas no flow will be detected in tumefactive sludge. In the asymptomatic patient, the problem may also be resolved by repeating the study after a fatty meal or after a period of a few days to weeks. In the acute setting, however, this distinction becomes more urgent as many of these patients may be candidates for early cholecystectomy. Laparoscopic cholecystectomy should not be performed if gallbladder cancer is a consideration because of...
the high recurrence rates (Fig 3). Open cholecystectomy should be performed in this situation with consideration given to resection of segments V and IVB of the liver. Additional imaging with triphasic CT can therefore be helpful (Fig 4). The absence of an enhancing mass at CT suggests that gallbladder cancer is not present.

Acalculous cholecystitis accounts for 5%–10% of all cases of acute cholecystitis and occurs most commonly in patients in the intensive care unit. Predisposing factors include trauma, mechanical ventilation, hyperalimentation, the postoperative state, diabetes mellitus, vascular insufficiency, prolonged fasting, burns, and the postpartum state. These conditions share the propensity to produce gallbladder ischemia. Acalculous cholecystitis carries high morbidity and mortality rates partly because of difficulty and delay in making the diagnosis. These patients are challenging to assess clinically, and the sonographic features are nonspecific. Scintigraphy has the propensity to give false-positive results in this patient population. As a result, image-guided cholecystostomy tube placement is therefore often performed to decompress the gallbladder if there is a high index of suspicion and the gallbladder is distended at US.

**Figure 3.** Recurrent gallbladder cancer in a 57-year-old man. Axial CT scan shows recurrent tumor at the site of the right upper quadrant port (arrow). There was also evidence of tumor recurrence at the site of the umbilical port (not shown).

**Figure 4.** Acute cholecystitis in a 64-year-old woman with pain and fever. (a) Sagittal sonogram shows stones (arrowheads) embedded in heterogeneous material. Abdominal CT was performed to rule out gallbladder cancer. (b) Axial CT scan shows a distended gallbladder with stones, wall thickening, and edema (arrowheads). A breach in the enhancing mucosa (arrow) suggests early, focal gangrene. No enhancing mass was seen at comparison with the unenhanced images (not shown). Acute cholecystitis was confirmed at surgery.

**Figure 5.** Gangrenous cholecystitis in a 38-year-old man with polyarteritis nodosa and vague abdominal pain. Sagittal sonogram shows sloughed membranes (arrows) and sludge or pus layered in the gallbladder. The diagnosis was confirmed at urgent cholecystectomy.
Complications of Acute Cholecystitis

Gangrenous Cholecystitis

Increased intraluminal pressure may produce gallbladder wall ischemia and ultimately necrosis, resulting in gangrenous cholecystitis. It complicates acute cholecystitis in 2%–38% of cases (10). Perforation is more common than in uncomplicated cholecystitis, leading to increased morbidity and mortality. As the gallbladder necroses, clinical symptoms and signs may become more generalized. The abdominal pain may be diffuse in up to 50% of patients (11) possibly because of more generalized peritonitis with inflammation of the parietal peritoneum.

In the symptomatic patient, the presence of asymmetric gallbladder wall thickening or intraluminal membranes should be viewed with suspicion for gangrenous change (Fig 5). The sonographic Murphy sign may be negative in up to 66% of cases (11), probably because of denervation of the gallbladder wall by gangrenous changes. At CT, findings with the highest specificity for gangrenous cholecystitis are gas in the wall or lumen (100%), intraluminal membranes (99.5%), irregular or absent wall (97.6%), and abscess (96.6%) (12). Because of the increased risk of perforation (up to 10%) (10), early cholecystectomy should be performed if gangrenous cholecystitis is likely.

Emphysematous Cholecystitis

Emphysematous cholecystitis is a rare condition associated with the presence of gas-forming bacteria in the gallbladder wall and lumen. Cholecystolithiasis is often absent. It is more common in men than women (7:3) (13), and 40% of the patients are diabetic. There is a fivefold increased risk of gangrene and perforation. Emphysematous cholecystitis is a surgical emergency and is treated definitively with cholecystectomy. Percutaneous cholecystostomy may be used as a temporizing procedure in critically ill patients.

The appearance at US may be characteristic. Intraluminal gas appears as a nondependent hyperechoic focus with ring-down or comet-tail artifact. The gas may move with changes in the patient’s position. Intramural gas appears as an arclike echogenic interface with posterior reverberation artifact (14) (Fig 6). Care must be taken to distinguish this appearance from a gallbladder packed with stones (Fig 7) or calcification.
in the gallbladder wall (porcelain gallbladder). In difficult cases, CT is most sensitive for confirming gas in the gallbladder wall or lumen (15). It also allows distinction between gas and wall calcification, as is seen with porcelain gallbladder. CT should also be performed in patients with acute right upper quadrant pain in whom the gallbladder is not definitely identified at sonography because a gas-filled gallbladder may be mistaken for gas-filled bowel with dire consequences.
Gallbladder Perforation

Gallbladder perforation is a serious complication of acute cholecystitis and may occur in up to 10% of cases. There is an associated mortality rate of 19%–24%. Early detection reduces morbidity and mortality. There are three categories of gallbladder perforation as classified by Niemeier (16): acute, subacute, and chronic. Acute perforation results in generalized peritonitis and has the worst prognosis. Subacute perforation is generally contained, resulting in pericholecystic abscess. Chronic perforation may result in an internal biliary fistula, often to the duodenum or common bile duct. Most perforations are subacute, accounting for 60% of all cases. Chronic perforation accounts for 30%, and acute perforation accounts for 10%.

Both US and CT are comparable in their ability to show the defect in the gallbladder wall (Fig 8). In one study of 23 patients, US helped diagnose the defect in the gallbladder wall in 16 (70%). Eighteen patients in this series underwent both US and CT, with US demonstrating the defect in 11 of these cases (61%) and CT demonstrating the defect in 14 (78%). This difference did not reach statistical significance (17).

Cholecystoenteric Fistula

The gallbladder has a close anatomic relationship to the duodenum and the proximal transverse colon. As a result, inflammation of the gallbladder may lead to chronic perforation and fistulous communication to either of these structures. A cholecystoduodenal fistula is by far the more common. Once a fistula is established, air may pass from the bowel into the gallbladder and stones may pass from the gallbladder into the bowel. As these stones pass through the bowel they may cause mechanical obstruction, most often in the ileum (gallstone ileus) (18) (Fig 9) but also at other levels including the duodenum (Bouveret syndrome) (18) (Fig 10).

Figure 9. Gallstone ileus in a 46-year-old woman. (a) Axial CT scan shows a fistulous communication (arrowhead) between the gallbladder and the duodenum, both of which are filled with air. Note the dilated loops of the proximal small intestine (BL). (b) Axial CT scan obtained inferiorly to a shows gallstones in a distal ileal loop (arrow). The stones are the cause of the obstruction.
Figure 10. Duodenal obstruction by a gallstone (Bouveret syndrome) in an 85-year-old woman.
(a) Transverse oblique sonogram of the gallbladder fossa shows gas (arrowhead) with reverberation artifact (arrows).
(b) Sagittal sonogram obtained adjacent to the gallbladder fossa shows a large, fluid-filled structure (D). This structure demonstrated active peristalsis, which suggested that it was the duodenum. A gallstone (arrow) is seen within the structure.
(c) Axial CT scan shows a fistulous communication (arrow) between the air-filled gallbladder and the distended, fluid-filled duodenum.
(d) Axial CT scan obtained inferiorly to c shows a gallstone (arrow) in the third part of the duodenum. This large stone is the one seen on the sonogram (b).
(e) Axial CT scan obtained inferiorly to d shows an additional large, laminated stone (arrow) that obstructs the jejunum. This stone was not seen at US.
There may be difficulty identifying the gallbladder with US, as it is often air-filled and contracted from chronic inflammation. US may show evidence of bowel dilatation and will often demonstrate an obstructing stone in the bowel. However, CT will more accurately demonstrate the fistula and the level of bowel obstruction.

**Gallbladder Torsion**

Gallbladder torsion is a rare cause of acute abdominal pain with only limited case reports in the literature. It is usually seen in elderly patients, so it may become more common as the population ages. The majority of patients are female (84%). It is most commonly acalculous (>67%). Mobility of the gallbladder because of a long or absent mesentery ("floating gallbladder") predisposes to torsion, which may be either complete (>180°) or incomplete (<180°). Complete torsion is likely to result in vascular compromise and gangrene of the gallbladder, whereas incomplete torsion may only obstruct the cystic duct and blood supply to the gallbladder wall may be maintained. A high index of suspicion is required to make this diagnosis preoperatively.

US may show a distended, tender gallbladder with an abnormal orientation remote from the gallbladder fossa (Fig 11). CT and MR imaging may help confirm the diagnosis (19) and may show tapering and twisting of the cystic duct.

**Mimics of Acute Cholecystitis**

Sympathetic thickening of the gallbladder wall occurring secondary to an acute inflammatory process in the right upper quadrant, including acute pancreatitis, perforated duodenal ulcer, hepatitis, right-sided diverticulitis, and even acute right-sided pyelonephritis, may cause confusion when assessing the gallbladder for acute cholecystitis (20). Edema of the gallbladder wall from a systemic condition (eg, congestive heart failure, hypoalbuminemia) may also be problematic.

Because many of these diagnoses mimic the presentation of acute cholecystitis, the diagnostic imager requires a high level of awareness in order to avoid mistakes (Figs 12–14). Gallstones may or may not be present. The patient may be tender in the right upper quadrant; however, an important point is that this tenderness is often remote from the sonographically localized gallbladder (Fig 15). We also find lack of tense gallbladder distention a useful “flag” to prompt us to consider an alternate diagnosis (Fig 16). Careful assessment of the right upper quadrant may then yield additional findings (eg, free air) that facilitate making the correct diagnosis.

---

**Figure 11.** Incomplete gallbladder torsion in a 94-year-old woman. (a) Sagittal sonogram of the midabdomen shows a cystic mass (C) with edematous walls anterior to the abdominal aorta (A). (b) Coronal oblique maximum intensity projection CT scan shows that the mass has a beaked neck (arrow), which extends into the gallbladder fossa.
Figures 12–14. (12) Acute viral hepatitis in a 38-year-old woman. Sagittal sonogram of the gallbladder shows a tiny, slitlike lumen (s) with massive “onion peel” edema of the wall (arrowheads). (13) Congestive heart failure in a 56-year-old man. Sagittal sonogram of the gallbladder shows edema of the wall (arrowheads), pericholecystic free fluid (FF), and distention of the inferior vena cava (IVC). (14) Cirrhosis in a 37-year-old man. Sagittal sonogram of the gallbladder shows a thickened wall (arrowheads) and free fluid (FF).

Figure 15. Perforated diverticulitis of the hepatic flexure in a febrile 67-year-old woman. (a) Sagittal sonogram shows a distended gallbladder (GB) with a small amount of pericholecystic fluid (arrow) but no stones. (b) Sagittal sonogram obtained at the site of maximal tenderness shows a thickened hepatic flexure (HF) with an inflamed diverticulum (*), from which extends a linear tract of extraluminal gas (arrow) surrounded by inflamed fat (arrowheads).
It is especially important not to misinterpret gallbladder wall edema secondary to acute hepatitis as representing acute cholecystitis. Some general anesthetics, if given to such a patient for emergent cholecystectomy, may have hepatotoxic effects and can be fatal.

**Choledocholithiasis**

Stones in the common bile duct may manifest with acute right upper quadrant pain and/or jaundice. They may also be discovered as a causative factor in acute pancreatitis or be uncovered incidentally at the time of imaging for some other reason.

US has a sensitivity of 70%–75% for detection of common bile duct stones (Fig 17). In one study, Laing et al (21) found that eight (89%) of nine proximal and 16 (70%) of 23 distal common
bile duct stones were visualized with US. Detection of choledocholithiasis can be substantially improved by scanning the proximal and distal common bile duct separately. The intrapancreatic portion of the bile duct should be assessed first in a transverse plane with the patient in a semierect right posterior oblique position. The proximal duct is best imaged by obtaining parasagittal scans with the patient in a supine left posterior oblique position (22).

If common bile duct stones are visualized with US, then the patient should be referred directly to ERCP for definitive management (papillotomy).

On the other hand, if choledocholithiasis is suspected but cannot be confirmed with US, MR cholangiopancreatography is an excellent choice for further investigation, with a sensitivity of 95% and specificity of 100% (23) (Fig 18). If immediate access to MR cholangiopancreatography is limited, then CT is an alternative to diagnostic ERCP with 80% sensitivity and 100% specificity (24). However, it is mandatory in this scenario that an unenhanced, thinly collimated series through the liver and common bile duct be included in the study to improve detection of stones and to avoid misinterpretation of a common bile duct stone as an enhancing mass (Fig 19). It is also advisable in this situation to give water as an

Figure 18. Choledocholithiasis in a 93-year-old man. Axial MR cholangiopancreatogram shows a stone (arrow) in the distal common bile duct.

Figure 19. Choledocholithiasis in a 69-year-old man. (a) Axial CT scan obtained after intravenous administration of contrast material shows an area of high attenuation in the distal common bile duct (arrow), a finding that raises the possibility of an enhancing mass. The bile ducts were dilated to this level (not shown). (b) Axial CT scan obtained without contrast material at the same level as a shows that the area of high attenuation is a stone (arrow).

Figure 20. Hemobilia in a 47-year-old woman after transjugular liver biopsy. Sagittal sonogram of the bile duct shows a linear, heterogeneous clot (arrow) within the lumen. L = liver.
oral contrast agent, as positive oral contrast agents may obscure stones in the distal common bile duct.

Hemobilia
The classical clinical triad for hemobilia consists of melena, jaundice, and abdominal pain but is seen in less than 50% of patients. Two-thirds of cases are iatrogenic, whereas trauma accounts for 5% (25). It may manifest many weeks after the initial injury. The diagnosis can be made with US (Fig 20), unenhanced CT (high-attenuation clot within the bile ducts), or MR imaging and confirmed with endoscopy (blood from the ampulla of Vater) or angiography. In one review, 43% of cases were managed conservatively and 36% were managed with transarterial embolization (25). The remainder were managed surgically either because of failed transarterial embolization or at the time of laparotomy for other reasons.

Hepatic Artery Aneurysm
Hepatic artery aneurysms are rare vascular lesions. They may be found incidentally at the time of abdominal imaging or may manifest more acutely as jaundice and/or abdominal pain (26). They are often well seen with US (Fig 21). It is essential to interrogate all cystic masses in the porta hepatis with Doppler US to assess for blood flow. CT angiography is replacing conventional angiography for pre-embolization and/or preoperative planning in such cases.

Ascending Cholangitis
Ascending cholangitis results from infection of an obstructed biliary system, most commonly due to common bile duct stones. It is less often caused by biliary strictures from other causes such as trauma or primary sclerosing cholangitis. Patients with cholangitis are febrile, often have abdominal pain, and are jaundiced. A minority of patients present in septic shock. There is usually leukocytosis and abnormal liver function.

The hallmark sonographic finding of ascending cholangitis is thickening of the walls of the bile ducts in the appropriate clinical setting (Fig 22). US may also demonstrate biliary dilatation with
stones and/or pus and/or debris within the common bile duct (Fig 23). Treatment includes fluid resuscitation and antibiotics. Biliary decompression is required when patients do not rapidly respond to conservative therapy. An endoscopic approach is currently favored over percutaneous procedures because of a lower risk of complication (27).

Liver Abscess

Acute abdominal pain and fever are the most common presenting symptoms of liver abscess, and right upper quadrant tenderness is the most common clinical sign. The onset may be insidious. Pyogenic abscesses may result from direct extension of bacteria from the biliary system in patients with suppurative cholangitis. Other sources of infection include the gastrointestinal tract (appendicitis, diverticulitis) via the portal vein, subacute bacterial endocarditis and osteomyelitis via the hepatic artery, and direct contiguous spread. No source can be found in up to 50% of cases. Most of these abscesses are due to anaerobic infection. The differential diagnosis for pyogenic liver abscess includes amebic and echinococcal infection.

US is diagnostic for liver abscess in over 90% of cases (28). The sonographic appearances are varied. Frankly purulent abscesses appear cystic with the fluid ranging from anechoic to highly echogenic (Fig 24). There may be internal septations or stranding. Occasionally, gas may be noted. It is not unusual for liver abscesses to have a more solid appearance at US (Fig 25), and it is important to interpret this appearance in light of the clinical presentation. CT may be very complementary in this situation by demonstrating areas of liquefaction (low attenuation), which may not yet be evident with US. US is also a readily available, portable, safe, and cost-effective means for guiding percutaneous drainage.
Recurrent Pyogenic Cholangiohepatitis

Recurrent pyogenic cholangiohepatitis (Oriental cholangiohepatitis) is extremely common in Asia, where an association with the liver fluke Clonorchis sinensis is postulated (29). It can also occur in any patient with prolonged biliary stasis. It is characterized by recurrent attacks of abdominal pain, fever, and jaundice caused by intrahepatic bile duct strictures and calculi. The stones are typically soft and puttylike in texture. The lateral segment of the left lobe and the posterior segment of the right lobe are most commonly involved (30). There is an increased prevalence of cholangiocarcinoma.

The US appearance may initially present a confusing picture (Fig 26). The dilated ducts in the involved segments may be filled with echoogenic material with little or no acoustic shadow, creating a disorganized appearance. An important feature is marked liver atrophy of the involved segments, resulting in the segmental bile ducts being positioned very close to the liver capsule. As a result, the calculi may be overlooked or be mistaken for gas in a bowel loop adjacent to the liver. Unenhanced CT gives an excellent overview of the segmental atrophy and helps confirm the intrahepatic stones. MR cholangiography has become the standard of reference for documenting the extent of this disease and developing a road map for planning surgical and/or interventional treatment (30).

Painful Liver Neoplasms

Any large liver mass may cause right upper quadrant discomfort because of pressure on the liver capsule. However, the development of acute pain generally results from a complication such as rupture or hemorrhage. There are often other symptoms and signs such as hypotension or falling hemoglobin level that will help suggest the correct diagnosis. The most common liver masses that
bleed are hepatic adenoma and hepatocellular carcinoma. Knowledge of the patient profile is critical for distinguishing between these two possibilities. Other masses that bleed include vascular liver metastases, for example, from renal cell carcinoma and neuroendocrine tumors.

**Hepatic Adenoma**

Hepatic adenomas are rare. They are most commonly seen in women of reproductive age using oral contraceptive pills. Men and women taking androgen-containing steroids are also at increased risk, particularly if taking large doses for prolonged periods. Another high-risk group is patients with type 1 glycogen storage disease, in whom lesions are more often multiple. Hepatic adenomas may occasionally undergo malignant transformation (31).

Most patients with adenomas are asymptomatic. However, large and multiple adenomas are more prone to complication, classically spontaneous rupture or hemorrhage. Life-threatening hemorrhage is more likely if the adenoma is in a subcapsular location and ruptures into the peritoneal cavity. The presence of a heterogeneous liver mass with internal hemorrhage and/or hemoperitoneum is suggestive of this diagnosis in the correct clinical setting (32) (Fig 27). If rupture is suspected with US, CT with the inclusion of an unenhanced series is most helpful for confirmation.

**Hepatocellular Carcinoma**

Hepatocellular carcinoma is a very common tumor worldwide, and its prevalence is increasing in North America. Risk factors include cirrhosis, often due to chronic hepatitis C virus or hepatitis B virus infection or alcoholism. In persons infected with hepatitis B or hepatitis C virus in whom hepatocellular carcinoma develops, there is a latency period of 1–3 decades. As the prevalence of alcoholic liver disease is declining, it is likely that the increasing prevalence of hepatocellular carcinoma in North America is related to high hepatitis C and hepatitis B virus transmission rates in the 1960s and 1970s (33).

It is estimated that spontaneous hemorrhage and/or rupture of hepatocellular carcinoma occurs in up to 10% of cases (34). Intraperitoneal rupture of hepatocellular carcinoma has a dismal prognosis. US will frequently show a heterogeneous, vascular liver mass with evidence of cirrhosis, manifested by a nodular liver and lobar redistribution (atrophy of the right lobe and segment IV with hypertrophy of segments I, II, and III). The presence of an echogenic “rind” around the liver at US is suggestive of acute hemoperitoneum (Fig 28). Triphasic CT may add additional information for preoperative planning if the patient is in stable condition. In addition, high-attenuation free fluid in the peritoneal cavity, if present, will help confirm the hemoperitoneum.

**Cavernous Hemangioma**

Cavernous hemangiomas are the most common benign liver tumors, occurring in 7%–10% of the general population. They are more common in women (male-to-female ratio, 1:5). The vast majority are small and asymptomatic. There are only sporadic case reports in the literature of hemorrhage and rupture of cavernous hemangiomas. These invariably involve giant cavernous hemangiomas (>10 cm) and usually occur in association with minor trauma or pregnancy (35,36). There are very few reports of spontaneous rupture.
US will show a large, heterogeneous mass in a liver of normal background morphology with evidence of free fluid or hemoperitoneum. The sonographic appearance will be indistinguishable from that of a ruptured hepatic adenoma (Fig 29). Contrast-enhanced CT or MR imaging will show the typical peripheral nodular enhancement pattern, which will suggest the correct diagnosis.

Figure 28. Ruptured hepatocellular carcinoma in a 70-year-old man with hepatitis B. (a) Sagittal sonogram of the liver shows a large mass (M), which is exophytic from segment V. (b) Sagittal sonogram of the right lobe of the liver shows an echogenic rind (arrows) anterior to the liver, a finding suggestive of acute hemoperitoneum.

Figure 29. Ruptured cavernous hemangioma in a 48-year-old woman. (a) Sagittal sonogram of the liver shows a large, heterogeneous mass (M) in the right lobe. (b) Arterial phase CT scan of the abdomen shows that the mass (M) has peripheral nodular enhancement (arrow), which is typical of a cavernous hemangioma. There was fluid of high attenuation in the pelvis (not shown), a finding suggestive of hemoperitoneum. (c) Photograph obtained during surgery shows the lesion, which was confirmed to be a cavernous hemangioma.
Conclusions

The spectrum of conditions that may manifest as acute right upper quadrant pain was shown with emphasis on the most appropriate and effective imaging investigation. Noninvasive determination of the explanation for the patient’s symptomatology is the expected standard (37) so that surgical intervention can be promptly selected for those patients with early acute cholecystitis or with other surgical conditions such as ruptured liver tumors and gallbladder torsion.

Acknowledgments: We thank Korosh Khalili, MD, FRCPC, for providing the images of gallbladder torsion and Murray Asch, MD, FRCPC, for providing the intraoperative photographs.

References