Gallbladder Stones: Imaging and Intervention[1]

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Imaging of the gallbladder for cholelithiasis and its complications has changed dramatically in recent decades along with expansion of interventional techniques related to the disease. Ultrasonography (US) is the method of choice for detection of gallstones. The characteristic US findings of gallstones are a highly reflective echo from the anterior surface of the gallstone, mobility of the gallstone on repositioning the patient, and marked posterior acoustic shadowing. Oral cholecystography remains an excellent method of gallstone detection, but its role has been limited due to the advantages of US. Most people with cholelithiasis will not experience symptoms or complications related to gallstones. When biliary colic does occur, it is typically caused by transient obstruction of the cystic duct by a stone. The primary imaging modality in suspected acute calculous cholecystitis is usually US or cholescintigraphy. Detection of gallstones alone does not permit a diagnosis of acute cholecystitis; however, secondary US findings provide more specific information. In detection of choledocholithiasis, endoscopic retrograde cholangiopancreatography and magnetic resonance cholangiopancreatography are superior to US. In certain clinical settings, interventional radiologic procedures have become an important alternative to surgery in the treatment of gallstones and their complications; techniques include percutaneous cholecystostomy and gallstone removal.

Abbreviations: CBD = common bile duct, ERCP = endoscopic retrograde cholangiopancreatography

Index terms: Bile ducts, calculi, 76.289 • Cholecystitis, 762.285 • Gallbladder, calculi, 762.289 • Gallbladder, interventional procedures, 762.1228

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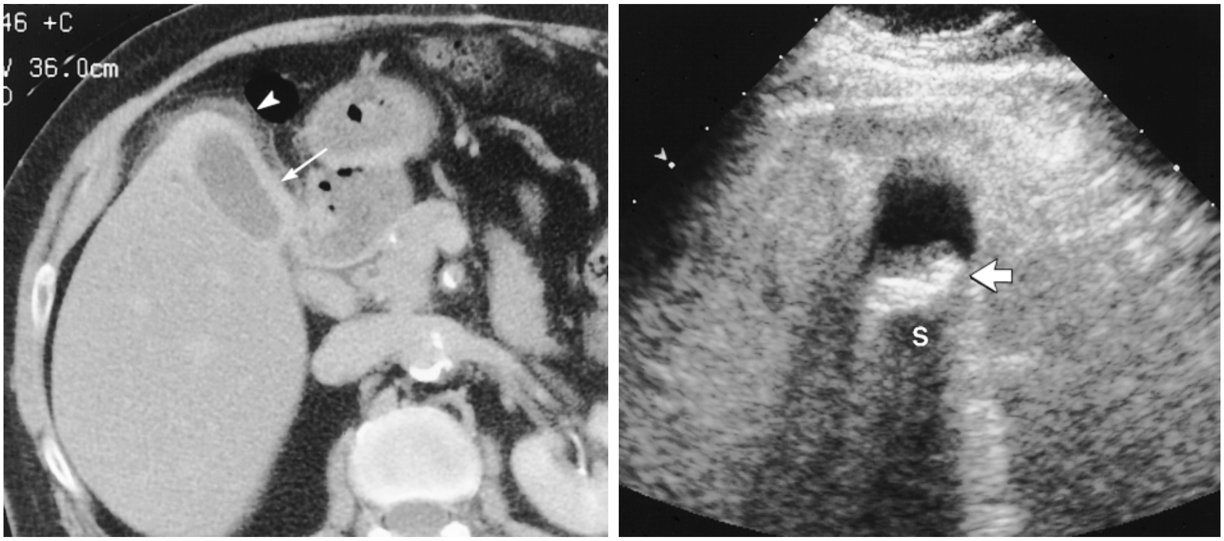


a. **b.**

Figure 1. Acute cholecystitis. **(a)** CT scan shows gallbladder wall thickening (arrow) and pericholecystic inflammation (arrowhead). However, no gallstones are visible. **(b)** Transverse US scan clearly shows gallstones (arrow) and posterior shadowing (*S*).

Introduction

Approximately 25 million adults in the United States have gallstones (1). Women are affected more commonly than men, with nearly 40% of women in the ninth decade of life having gallstones. The prevalence increases with age in both sexes. In brief, the pathogenesis of gallstones is related to supersaturation of bile constituents, most notably cholesterol, and likely related to defects in biliary lipid metabolism. Biliary dysmotility and prolonged intestinal transit also likely play a role (2,3). These factors may be aggravated by diet, a sedentary lifestyle, and a genetic predisposition to stone formation. An increased prevalence of cholelithiasis has been reported in association with obesity, diabetes, use of oral contraceptives, ileal disease, use of certain medications, total parenteral nutrition, cirrhosis, and spinal cord injury (4).

Cholesterol is the main component in approximately 80% of gallstones, with 10% being pure cholesterol. Pigment stones have by definition less than 25% cholesterol, and the major component is calcium bilirubinate. Calcium carbonate is a less common constituent (5). As stones degenerate, nitrogen gas may collect in central fissures; this process may produce the classic "Mercedes-Benz" sign on plain radiographs.

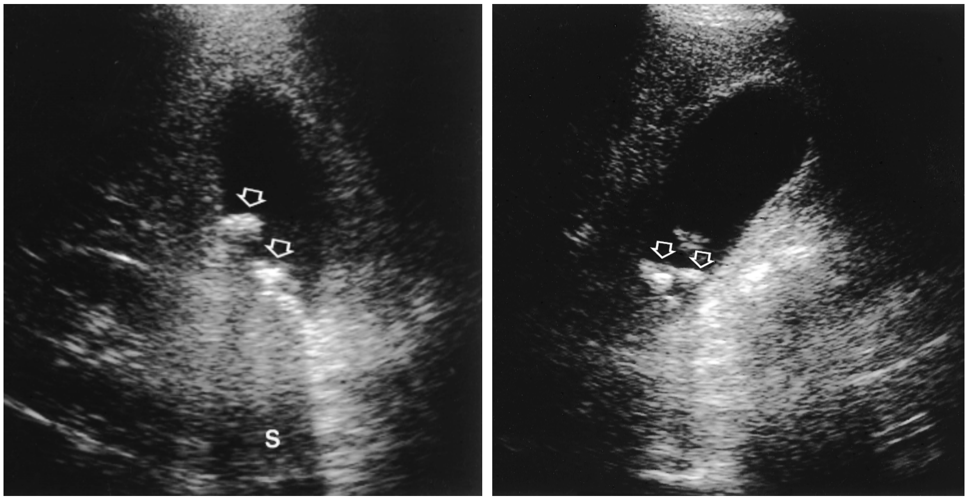
Approximately 15%–20% of gallstones contain enough calcium to be visible on plain radiographs (1). Therefore, plain radiography is a poor screening examination for gallstones. Oral cholecystography was introduced in 1924 and remained the mainstay of radiographic diagnosis of gallbladder disease for decades. Although still used, oral cholecystography has largely been replaced by ultrasonography (US) for evaluation of cholelithiasis and its associated complications, most notably acute cholecystitis.

Hepatobiliary scintigraphy, computed tomography (CT), endoscopic retrograde cholangiopancreatography (ERCP), and magnetic resonance (MR) imaging have essentially no role as primary imaging modalities for detection of gallstones but are important in the evaluation of associated complications (eg, acute cholecystitis [Fig 1], pancreatitis, and biliary obstruction).

In this article, we review the imaging of cholelithiasis and complications of cholelithiasis and provide an update on current radiologic interventions for cholelithiasis.

Imaging of Cholelithiasis

US remains the method of choice for detection of gallstones, offering several advantages: high sensitivity and accuracy (>95%) (6), noninvasiveness, the option of performing a bedside examination, lack of ionizing radiation, relatively low



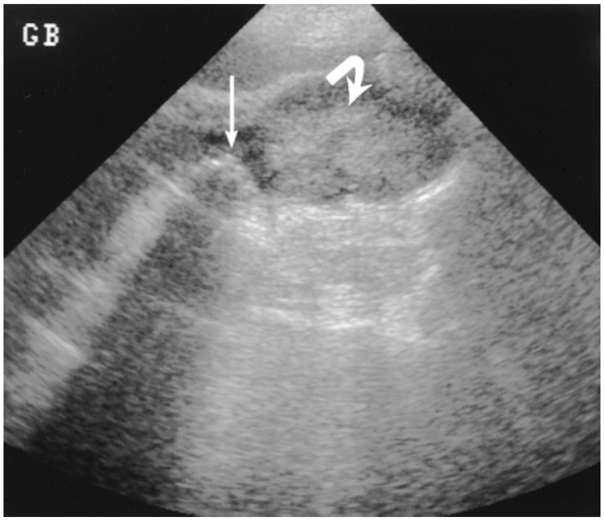
a. b.

Figure 2. Typical US appearance of gallstones. **(a)** Oblique US scan shows highly reflective echoes within the gallbladder (arrows), which indicate gallstones. Note the marked posterior shadowing (*S*). **(b)** Oblique US scan obtained after repositioning the patient shows mobility of the gallstones (arrows).

Table 1
Differential Diagnosis of a Gallbladder Mass Seen at US

Diagnosis	Comments
Stone	Echogenic mass with shadowing, usually mobile The mass is occasionally adherent (ie, nonmobile)
Cholesterol polyp	Unifocal form of cholesterolosis Nonmobile, nonshadowing mass
Adenomyomatosis	May occur as focal mass(es), but most typically occurs as segmental mural thickening “Ring-down” artifacts may be seen and are attributable to debris and cholesterol crystals trapped in Rokitansky-Aschoff sinuses
Tumefactive sludge	Mobile echogenic mass without shadowing
Congenital fold or septum	…
Gallbladder carcinoma	May completely fill the gallbladder lumen 75% of patients have gallstones
Miscellaneous	Includes metastasis (eg, from melanoma), adenoma (including adenomatous polyp, papilloma), ectopic pancreas, hematoma

cost, and the ability to evaluate adjacent organs. The characteristic findings of gallstones at US are a highly reflective echo from the anterior surface of the gallstone, mobility of the gallstone on repositioning the patient (typically in a decubitus position), and marked posterior acoustic shadowing (Fig 2). The latter finding is extremely important in regard to the specificity of the technique because nonshadowing structures are considerably less likely than shadowing structures to represent gallstones (7) (Table 1) (Figs 3, 4). When the gallbladder is filled with stones, the resulting appearance is termed the *wall-echo-shadow*



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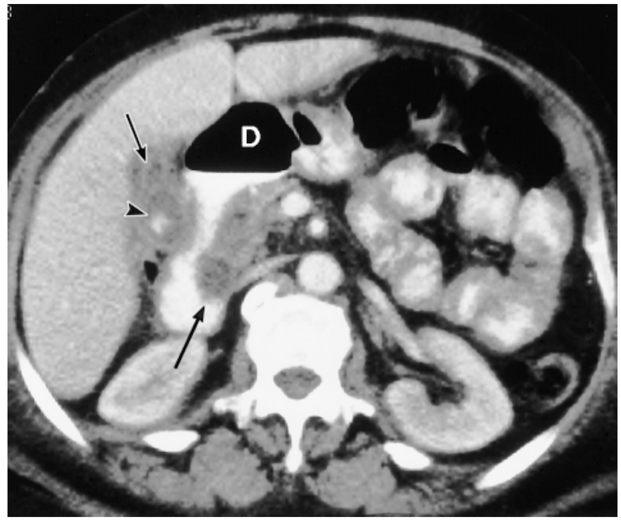

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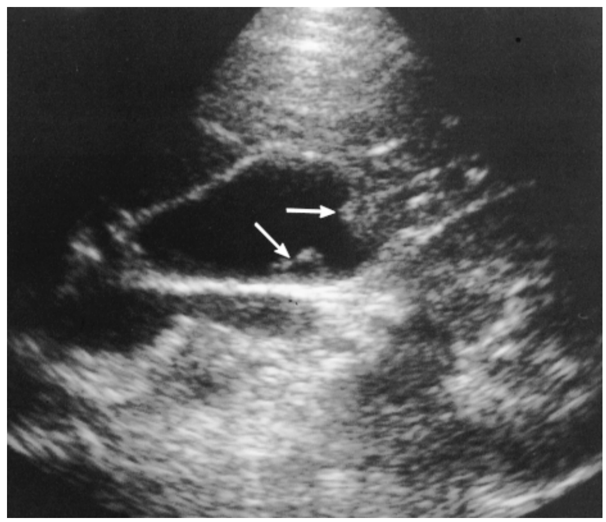


4.

Figures 3, 4. **(3)** Gallbladder mass that should not be confused with gallstones at US. **(a)** Longitudinal US scan shows an echogenic mass (curved arrow) filling the gallbladder lumen with evidence of gallstones as well (straight arrow). Note the lack of shadowing by the majority of the mass. **(b, c)** CT scans show a gallstone (arrowhead) and an enhancing mass (arrows) located in the gallbladder fossa, partially surrounding the duodenum (*D*). Gallbladder carcinoma was found at surgery. **(4)** Gallbladder masses that should not be confused with gallstones at US. Longitudinal US scan shows two nonshadowing, nonmobile echogenic masses in the gallbladder (arrows), which represent metastatic melanoma.

sign (8) (Fig 5). The anterior wall of the gallbladder is echogenic, below which is a thin, dark line of bile; finally, there is a highly echogenic line of superficial stones with associated posterior shadowing. The deeper stones and posterior gallbladder wall are not visible.

Oral cholecystography remains an excellent method of gallstone detection, with sensitivities close to those of US (9). Furthermore, oral cholecystography allows better determination of the number and size of gallstones than US and can demonstrate cystic duct patency. Gallbladder contractility can be determined by administration of a fatty meal and reimaging. However, oral cholecystography has several disadvantages relative to US: (*a*) adjacent organs cannot be evaluated, (*b*) nonvisualization of the gallbladder is nonspecific and can be attributable to multiple

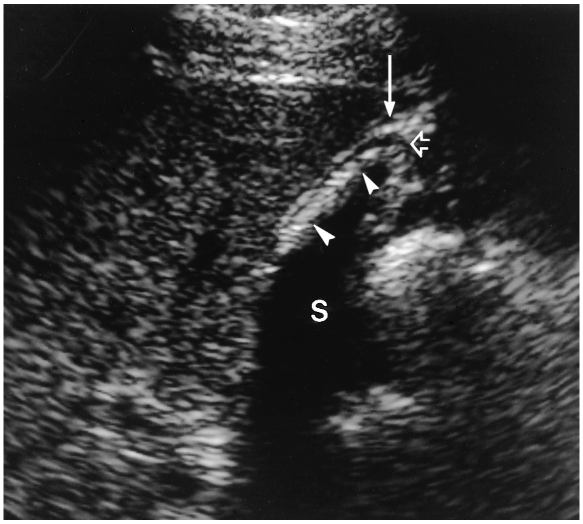
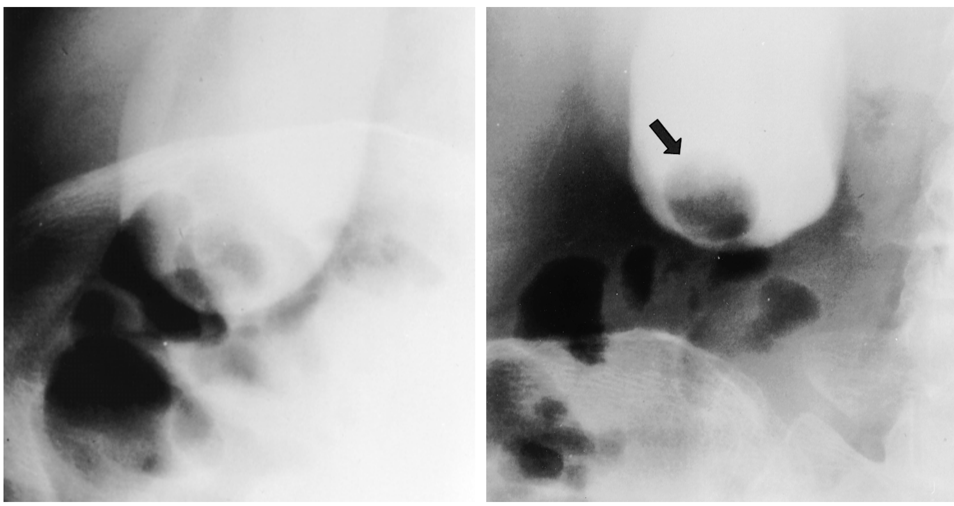


Figure 5. Wall-echo-shadow sign. Longitudinal US scan of a gallbladder filled with gallstones shows the classic wall-echo-shadow sign. The anterior wall of the gallbladder is echogenic (solid arrow). A thin layer of bile immediately underneath the anterior wall is seen as a black line (open arrow), and the most superficial gallstones are seen as an echogenic layer beneath the bile (arrowheads). Intense shadowing (*S*) obscures the deeper stones and the posterior gallbladder wall.



a. **b.**

Figure 6. Bowel gas obscuring gallstones. **(a)** Frontal upper right spot image from initial oral cholecystography shows bowel gas superimposed over the lower aspect of the gallbladder. **(b)** Oral cholecystogram obtained after repositioning the patient clearly shows a large gallstone in the fundus of the gallbladder (arrow).

factors, (*c*) patients are exposed to ionizing radiation, and (*d*) bowel gas can obscure the gallbladder and yield false-positive or false-negative results (Fig 6). The role of oral cholecystography has been limited due to the advantages of US in detecting gallstones and related disease. Oral cholecystography remains useful in certain circumstances, such as in patients being considered for orally administered bile acid therapy or contact dissolution. In these patients, oral cholecystography can allow accurate determination of stone size, composition, and burden and provide information on gallbladder contractility (10).

Complications of Cholelithiasis

Most people with cholelithiasis will not experience symptoms or complications related to gallstones. When biliary colic does occur, it is most often caused by transient obstruction of the cystic duct by a stone. The pain typically lasts 1–3 hours and is often accompanied by nausea and vomiting. When the stone falls back into the gallbladder or passes into the common bile duct

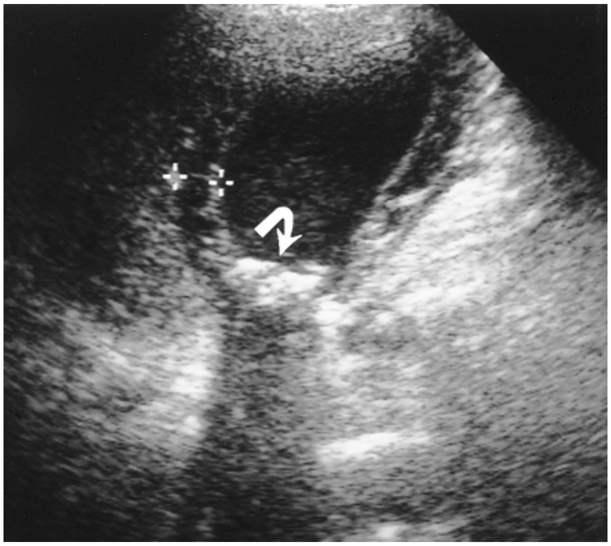
Table 2
Complications of Cholelithiasis

Complication	Comments
Biliary colic	Typically caused by transient obstruction of the cystic duct Pain lasts 1–3 hours, with or without nausea or vomiting Subsides when the stone falls back into the gallbladder or passes into the CBD
Choledocholithiasis	Persistent blockage at the level of the ampulla of Vater is a common cause of jaundice
Acute cholecystitis	A stone is impacted in the neck of the gallbladder or in the cystic duct in 95% of cases
Gallbladder perforation	Typically seen in the setting of acute cholecystitis A pericholecystic or, less commonly, intrahepatic abscess may result and may be amenable to percutaneous drainage in certain clinical settings; however, therapy almost invariably requires surgery
Pancreatitis	…
Biliary strictures	…
Cholangitis	…
Biliary fistula	Gallstone ileus Bouveret syndrome
Mirizzi syndrome	Obstruction of the CBD or hepatic duct Caused by a gallstone lodged in the cystic duct, with associated inflammation compressing adjacent ducts
Porcelain gallbladder	Associated with gallstones in 95% of cases Gallbladder carcinoma develops in 22% of cases

Note.—Most patients with cholelithiasis are asymptomatic and will remain so.

Table 3
Imaging of Acute Cholecystitis

Imaging Modality	Comments
US	Generally accepted method of initial imaging Gallstones are found in approximately 95% of patients The Murphy sign (focal tenderness directly over the gallbladder) is absent in most cases of gangrenous cholecystitis Gallbladder wall thickening (≥3 mm) Pericholecystic fluid Gallbladder enlargement (nonspecific)
Hepatobiliary scintigraphy	Also highly sensitive in diagnosis of acute cholecystitis Does not provide information on adjacent organs Highly valuable as a follow-up study when US results are equivocal Nonvisualization of the gallbladder in the presence of bowel activity is diagnostic
CT	Useful as an adjunctive imaging modality when US results are equivocal or the clinical setting suggests disease of adjacent organs (eg, pancreatitis or duodenitis) Can demonstrate gallbladder wall thickening, gallstones (depending on composition), pericholecystic inflammation, and pericholecystic abscess
MR cholangiopancreatography	Scant literature at present Gallstones (seen as a signal void) are detected with a sensitivity of approximately 90%–95% Pericholecystic high signal intensity is seen on heavily T2-weighted images in approximately 91% of cases of acute cholecystitis, with an overall accuracy of 89% CBD stones can be detected with much greater sensitivity than with US



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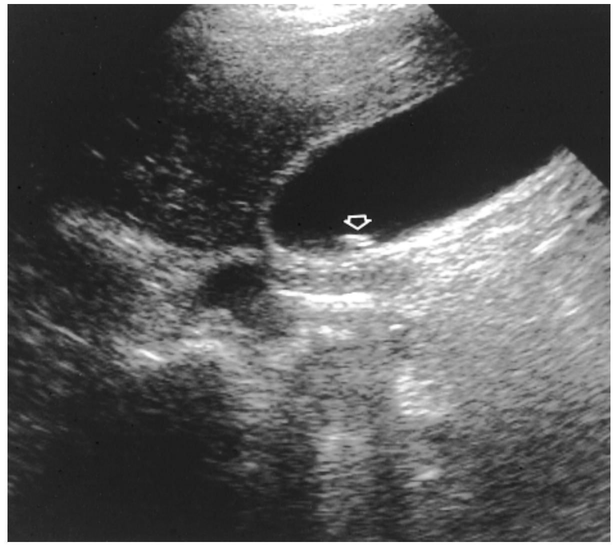

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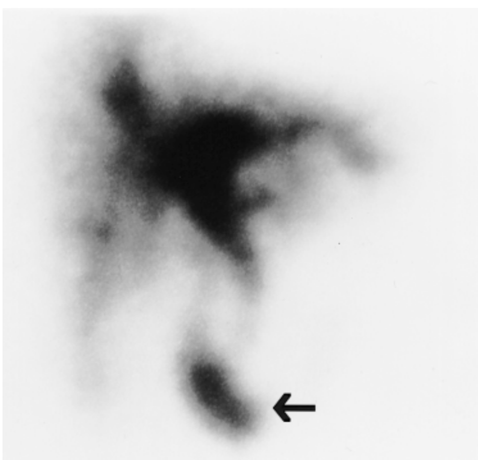


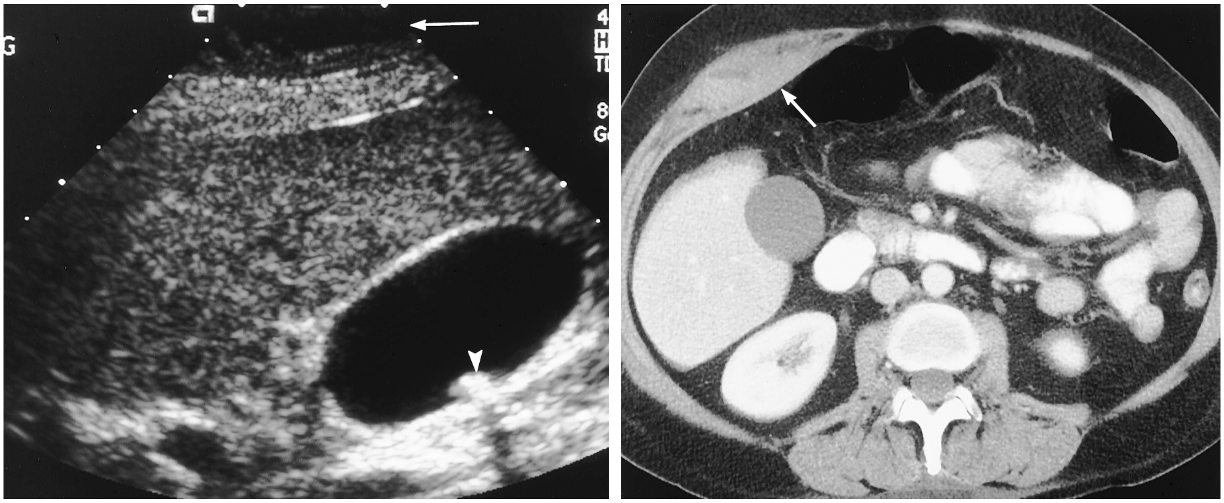
8b.

Figures 7, 8. **(7)** Acute cholecystitis in a patient with right upper quadrant pain. Transverse US scan shows marked thickening (8 mm) of the gallbladder wall (cursors). Mobile gallstones layering dependently are also seen (arrow). There was maximum tenderness during compression with the transducer directly over the gallbladder, a positive Murphy sign. **(8)** Acute cholecystitis. **(a)** Longitudinal US scan shows a nonmobile echogenic focus (arrow) within the gallbladder with subtle shadowing. The patient had recently eaten, which may explain the wall thickening (4 mm). Diagnostic considerations included adherent calculi and cholesterol crystals or polyps. Cholescintigraphy was recommended. **(b)** Cholescintigram obtained after administration of morphine and with the patient in the supine position shows bowel activity (arrow), but the gallbladder is not seen. The diagnosis of acute cholecystitis was confirmed at surgery. Pathologic analysis also revealed a small gallstone and a small focus of ectopic pancreas in the gallbladder wall.

(CBD), the pain usually subsides (Table 2). However, choledocholithiasis can also be accompanied by biliary colic.

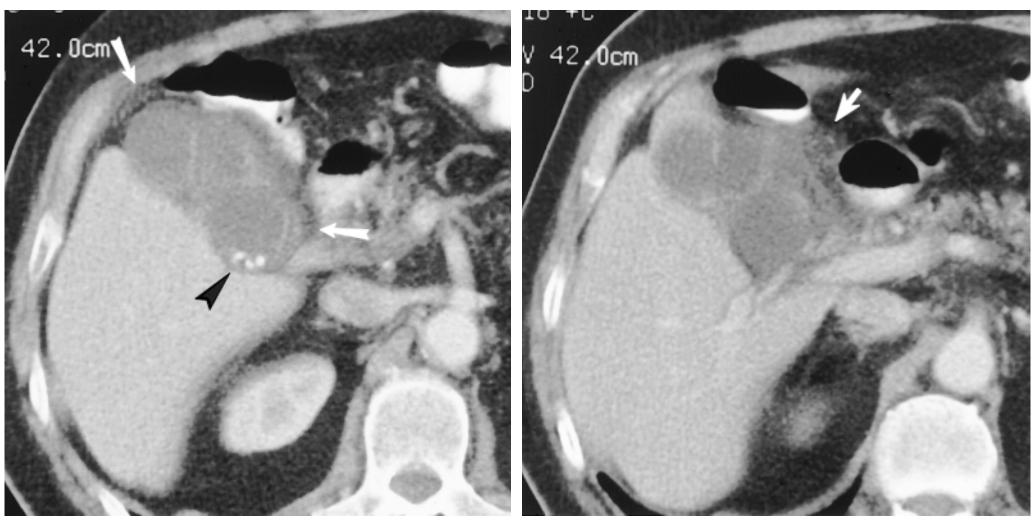
Acute cholecystitis is uncommon in patients with gallstones who were previously asymptomatic; rather, it is more commonly seen in patients who previously experienced bouts of biliary colic (1). The primary imaging modality in suspected acute calculous cholecystitis is usually US (Fig 7) or cholescintigraphy. Both tests offer excellent sensitivity and accuracy. In addition, these tests can be complementary when the results of one or the other are equivocal (Fig 8).

Detection of gallstones alone does not permit a diagnosis of acute cholecystitis. However, secondary US findings provide more specific information (Table 3). Ralls et al (11) found that different combinations of US findings gave the following positive predictive values: (*a*) positive Murphy sign (maximum tenderness during compression with the transducer directly over the gallbladder) plus gallstones, 92%; and (*b*) thickened gallbladder wall (>3 mm) plus gallstones,



a. b.

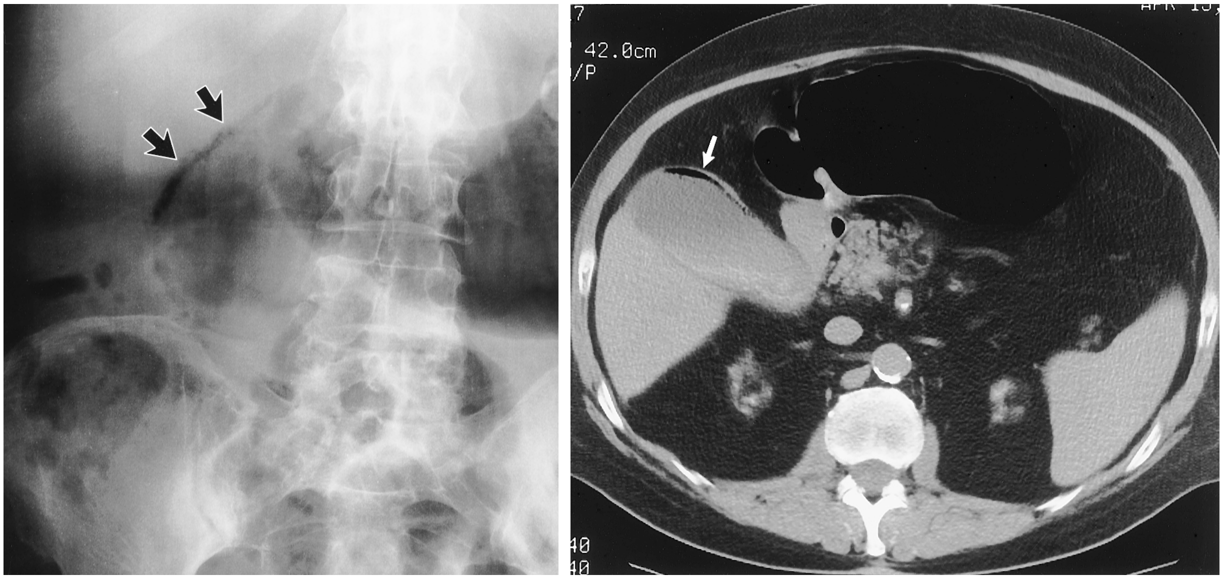
Figure 9. False-positive diagnosis of acute cholecystitis. **(a)** Longitudinal US scan of the gallbladder shows a single gallstone (arrowhead). There was extreme tenderness during compression over the gallbladder, a positive Murphy sign. The thickness of the gallbladder wall is normal. **(b)** CT scan obtained soon afterward shows a normal-appearing gallbladder. However, a hematoma is seen in the right rectus abdominis muscle (arrow), accounting for the tenderness during compression over the gallbladder. Review of the US scan **(a)** revealed a superficial hypoechoic mass at the top of the image (arrow), a finding that corresponds to the hematoma. The patient's symptoms abated when the hematoma resolved.



a. b.

Figure 10. Acute cholecystitis. **(a)** CT scan obtained at the level of the gallbladder shows cholelithiasis (arrowhead), poor definition of the gallbladder wall, and subtle pericholecystic inflammation (arrows). **(b)** CT scan obtained slightly superior to **a** shows more obvious pericholecystic inflammation (arrow).

95%. Therefore, false-positive diagnoses are not common but do occasionally occur (Fig 9). Negative predictive values were also determined, as follows: (*a*) negative Murphy sign and no gallstones, 95%; and (*b*) normal gallbladder wall thickness and no gallstones, 97%. Patients with one of the complications of acute cholecystitis, gangrenous cholecystitis, may demonstrate a positive Murphy sign in only 33% of cases (12). CT can also allow diagnostic imaging of acute cholecystitis (Fig 10) and may be useful when US results are equivocal. In addition, CT can show increased attenuation in adjacent liver tissue during the arterial phase (Fig 11); this finding has been reported in patients with hypervascular gallbladder disease and has been attributed to increased blood flow in the cystic vein (13). However, CT does not allow assessment for



a. **b.**

Figure 12. Emphysematous cholecystitis. **(a)** Plain radiograph shows curvilinear gas collections in the right upper quadrant (arrows), which represent gas within the gallbladder wall. **(b)** CT scan obtained in another patient shows air within the gallbladder wall and the gallbladder lumen (arrow).

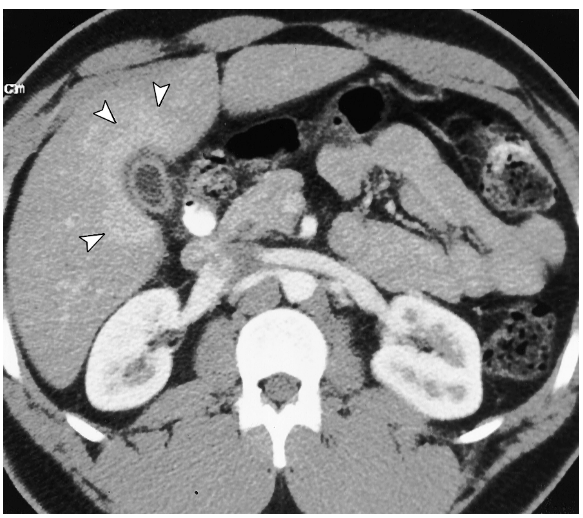


Figure 11. Transient increased attenuation in the liver adjacent to the gallbladder in a patient with pathologically proved acute cholecystitis. Contrast material–enhanced CT scan shows increased hepatic attenuation adjacent to the gallbladder (arrowheads). Note the thickening of the gallbladder wall.

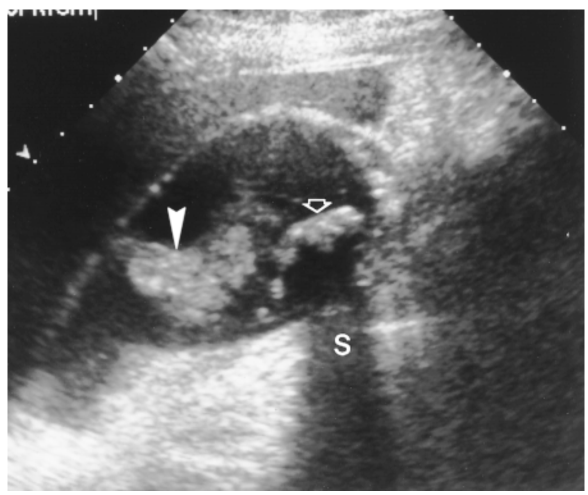
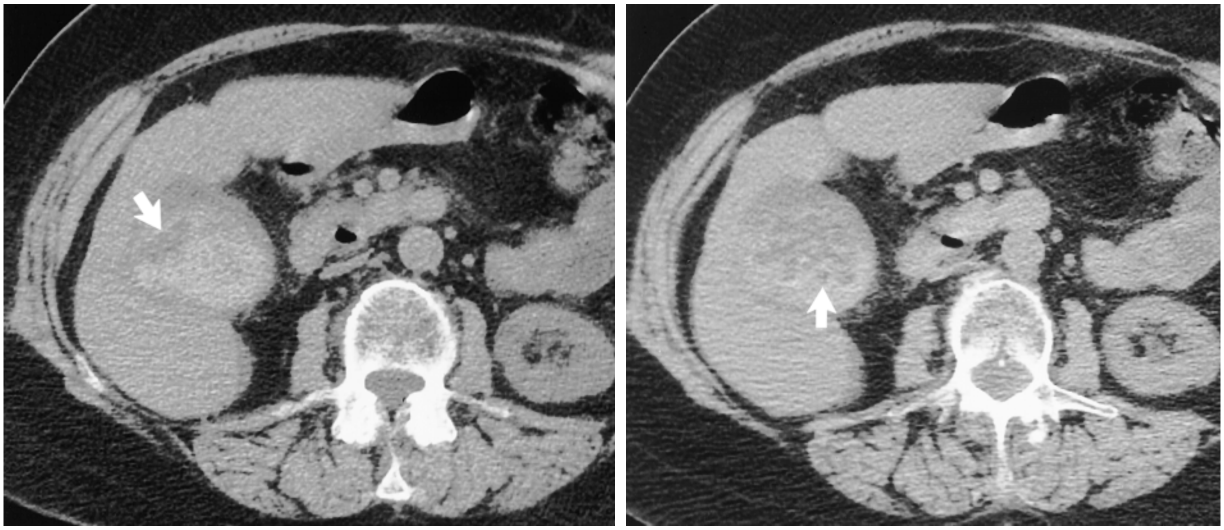


Figure 13. Hemorrhagic cholecystitis. Longitudinal US scan shows mobile foci of increased echogenicity within the gallbladder fossa (arrow) with posterior shadowing (*S*), findings consistent with gallstones. In addition, there are foci of increased echogenicity without shadowing (arrowhead), which correspond to hemorrhage.

the Murphy sign, and noncalcified gallstones are not reliably demonstrated.

Complications of acute cholecystitis include the following: (*a*) Emphysematous cholecystitis is characterized by gas-forming organisms, which cause gas to collect in the wall and lumen of the gallbladder, and is commonly seen in diabetic patients (Fig 12). Gallstones are found in only approximately 50% of cases of emphysematous cholecystitis; instead, the pathogenesis is related to small-vessel disease (eg, diabetes). (*b*) Hemorrhagic cholecystitis is characterized by significant intraluminal hemorrhage, and abundant nonshadowing echoes are often seen in the gallbladder lumen at US (Figs 13, 14). (*c*) Pericholecystic abscess is the result of a perforation of the



a. **b.**

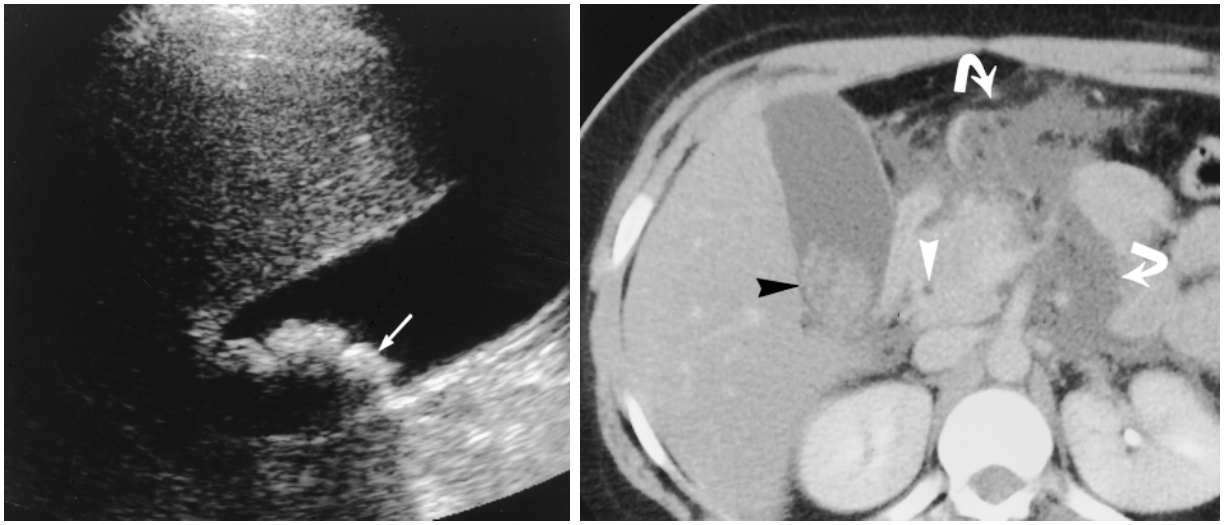
Figure 14. Hemorrhagic cholecystitis. CT scans show diffuse increased attenuation in the gallbladder lumen, which represents hemorrhage, surrounding multiple round areas of decreased attenuation, which represent gallstones (arrow). Note the subtle pericholecystic inflammation.

a. **b.**

Figure 15. Hepatic abscess related to acute cholecystitis. **(a)** Transverse US scan shows a hypoechoic mass (arrow) in the liver near the gallbladder (*GB*). Note the thickening of the gallbladder wall (arrowhead). Cholelithiasis was present as well (not shown). **(b)** CT scan shows a low-attenuation lesion in the liver adjacent to the gallbladder with subtle peripheral enhancement (arrow). The diagnosis of acute cholecystitis with perforation and an intrahepatic abscess was confirmed at surgery.

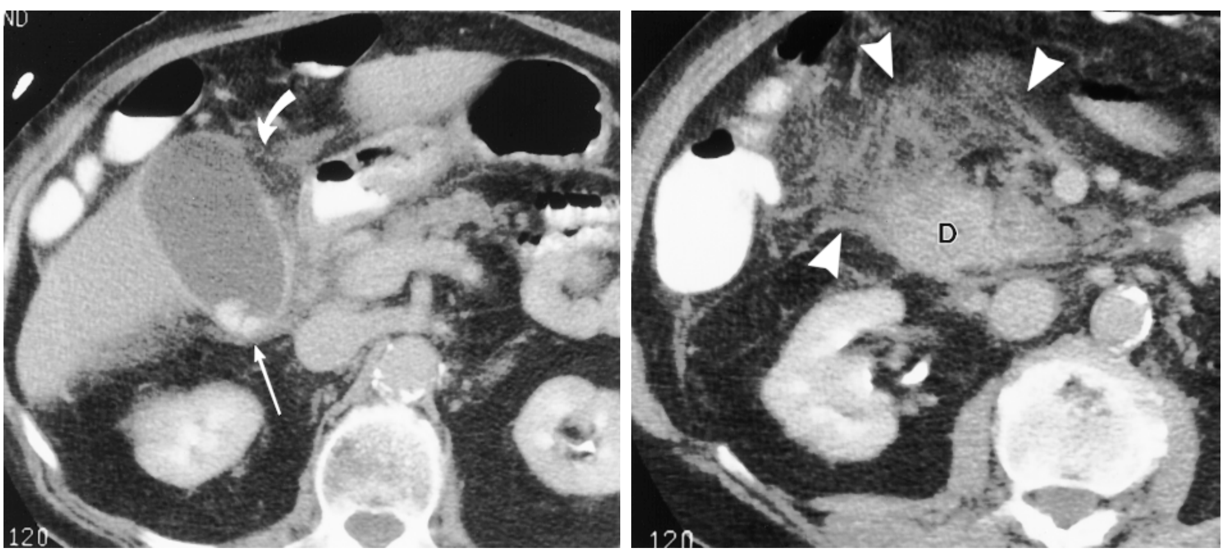
gallbladder wall and is usually seen as a fluid collection with internal echoes near the fundus of the gallbladder. Intrahepatic abscesses can also occur (Fig 15).

Further complications of cholelithiasis include pancreatitis (Fig 16), duodenitis (Fig 17), biliary fistula (Fig 18), gallstone ileus (Fig 19), and Mirizzi syndrome, in which inflammation related to a stone impacted in the cystic duct causes narrowing of the CBD and subsequent biliary obstruction. Cholelithiasis is found in at least



a. b.

Figure 16. Gallstone pancreatitis in a 20-year-old woman with no history of alcohol abuse. **(a)** Longitudinal US scan shows multiple gallstones within the gallbladder (arrow); however, there was no evidence of acute cholecystitis. The pancreas and CBD are poorly visualized. US is commonly performed in this setting to evaluate for gallstones as a possible cause of pancreatitis. **(b)** Follow-up CT scan shows cholelithiasis (black arrowhead) and extensive peripancreatic inflammation (arrows). Note the normal-sized distal CBD (white arrowhead). Given the patient's age, lack of history of alcohol abuse, and clinical presentation, a diagnosis of gallstone pancreatitis was made. The patient underwent cholecystectomy and has been symptom free for over 1 year.



a. b.

Figure 17. Acute cholecystitis and duodenitis. **(a)** CT scan shows cholelithiasis (straight arrow), gallbladder wall thickening, and pericholecystic inflammation (curved arrow). **(b)** CT scan obtained inferior to **a** shows extensive inflammation (arrowheads) extending to and involving the proximal duodenum (*D*). Surgery revealed gangrenous cholecystitis and extensive duodenitis.

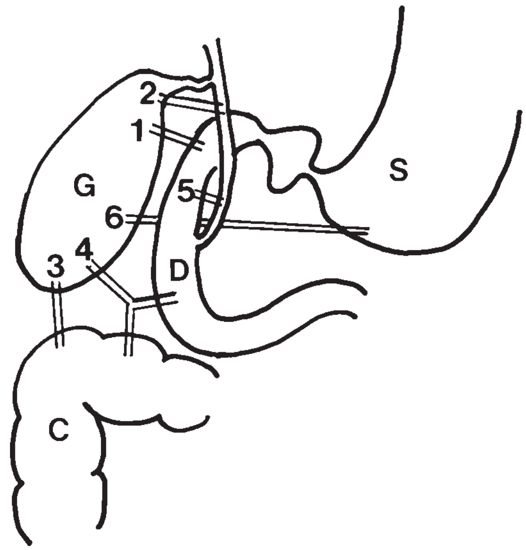


Figure 18. Biliary fistula. Diagram shows the routes by which gallstones can erode into adjacent hollow visceral organs. Most commonly, the gallstones migrate into the duodenum (*D*), but any of the routes shown are possible. Gallstones larger than 2.5 cm in diameter can lodge in the terminal ileum, leading to gallstone ileus; this entity is reported to account for 20% of intestinal obstructions in patients over the age of 65 years. Occasionally, the gallstone lodges more proximally in the intestine. Bouveret syndrome is a rare form of proximal obstruction caused by a large gallstone that has usually migrated through route 1. The gallstone then becomes lodged in the duodenum, most often at the level of the bulb, resulting in a gastric outlet obstruction. *C* = colon, *G* = gallbladder, *S* = stomach.

two-thirds of patients with gallbladder carcinoma and is frequently associated with cholecystitis, thus suggesting that chronic irritation is a causative factor (15).

Choledocholithiasis is another complication of gallstones. Although CBD stones can be demonstrated at US (Fig 20), US has proved to be relatively insensitive in detection of CBD stones, with sensitivities ranging from 22% to 75% (16–18). Traditionally, ERCP has been the standard of reference for detection of CBD stones and evaluation of suspected biliary obstruction (Fig

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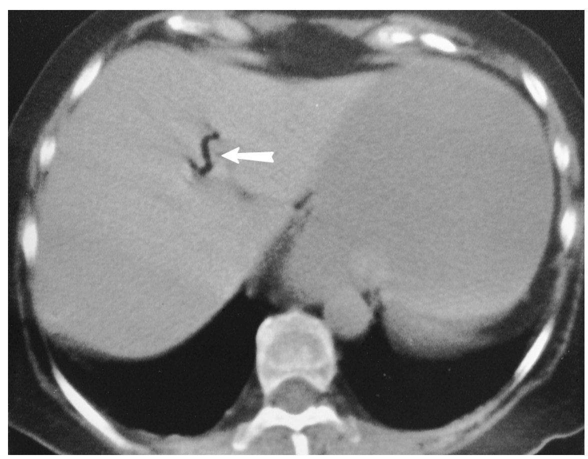
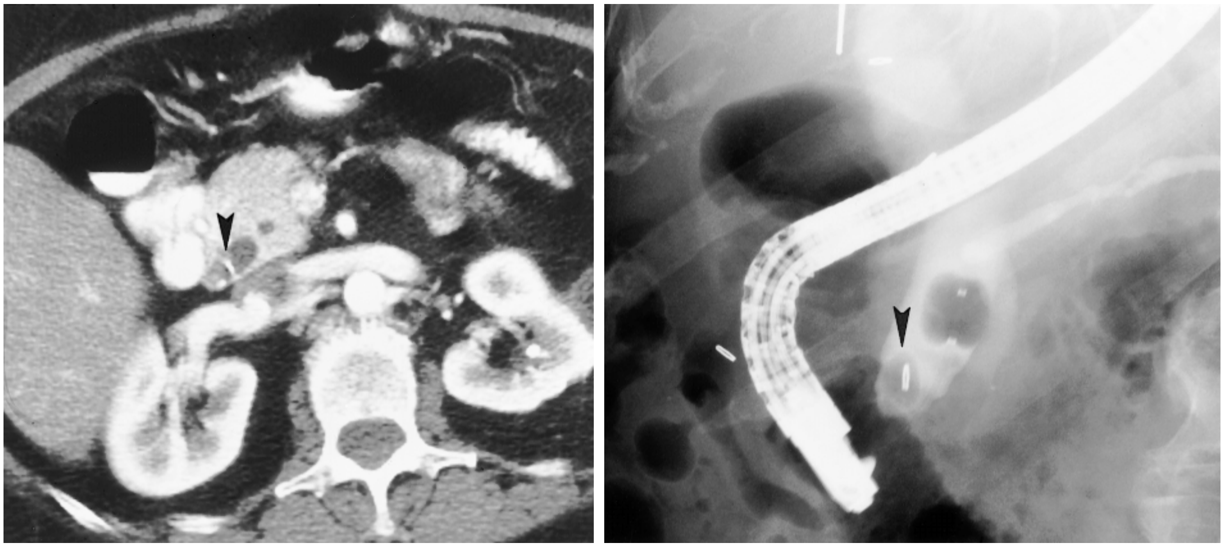


b.

Figure 19. Gallstone ileus. **(a)** Image from a small-bowel follow-through study shows a dilated small intestine and at least two intraluminal filling defects (arrows). Also, contrast material opacifies a communication with the biliary tree (arrowhead). **(b)** CT scan shows air in the biliary tree (arrow) as a result of the choloenteric fistula. (Reprinted, with permission, from reference 14.)



a. b.

Figure 21. Choledocholithiasis. **(a)** CT scan obtained through the distal CBD shows a metallic clip and an adjacent area of soft-tissue attenuation in the region of the CBD (arrowhead). **(b)** ERCP image shows a mobile round filling defect (arrowhead) surrounding a metallic clip within a markedly dilated CBD. At endoscopy, a stone that had formed around the surgical clip and caused intermittent biliary obstruction was removed.

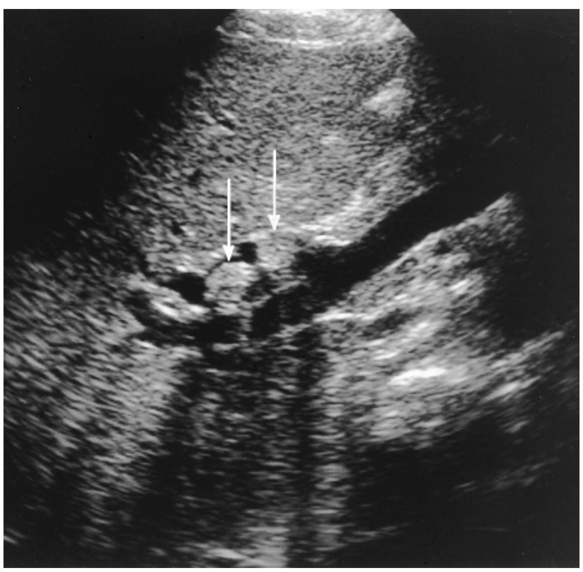


Figure 20. CBD stones. Longitudinal US scan shows two relatively large gallstones (arrows) within a dilated CBD.

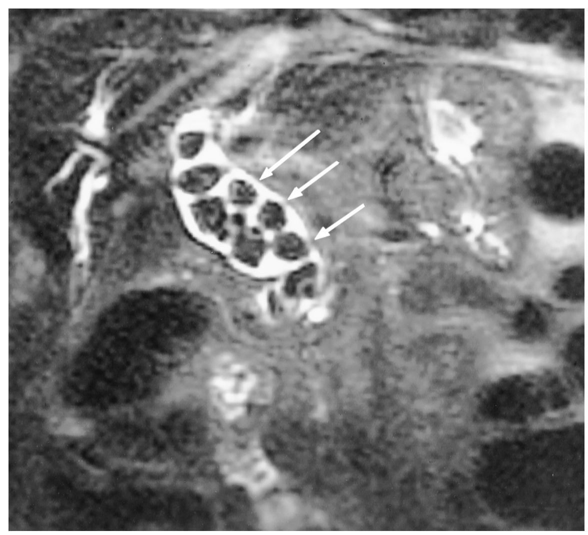


Figure 22. CBD stones in a patient who had undergone cholecystectomy. Coronal single-shot fast spin-echo MR cholangiopancreatogram shows multiple gallstones (arrows) within a markedly dilated CBD (30 mm wide).

21). However, MR cholangiopancreatography is also excellent for detection of CBD stones (Fig 22), with a sensitivity and accuracy approximately equal to those of ERCP: 88%–95% and 89%–96%, respectively (19–21). Although the spatial resolution of MR imaging may be somewhat limited for detection of small stones (eg, <3 mm in diameter) (22), at some institutions it has begun to replace ERCP for imaging of suspected CBD disorders in patients in whom intervention is not anticipated, and it is likely that this trend will continue (20).

Table 4
Nonsurgical and Percutaneous Management of Biliary Stones and Related Disease

Management Technique	Comments
Nonsurgical management	
Percutaneous management	…
Extracorporeal shock wave lithotripsy	Limited use due to cost, stone recurrence, and small number of cases suitable for procedure
Oral dissolution therapy	Reserved for symptomatic high-risk surgical candidates with cholesterol stones Stones often recur
Percutaneous management	
Percutaneous cholecystostomy and gallbladder drainage	…
Percutaneous gallbladder ablation	Uncommonly used technique
Contact dissolution therapy	Requires percutaneous cholecystostomy Cholesterol solvents such as methyl-*tert*-butyl ether or ethyl propionate are administered into the gallbladder lumen Reserved for large, noncalcified gallstones Cumbersome technique with problems related to leakage and retrieval of the agent Uncommonly used technique
Intervention for related disease	Biliary drainage Stent placement in stricture Balloon dilation of stricture Manipulation of retained cystic duct or CBD stones

Current Radiologic Interventions for Cholelithiasis

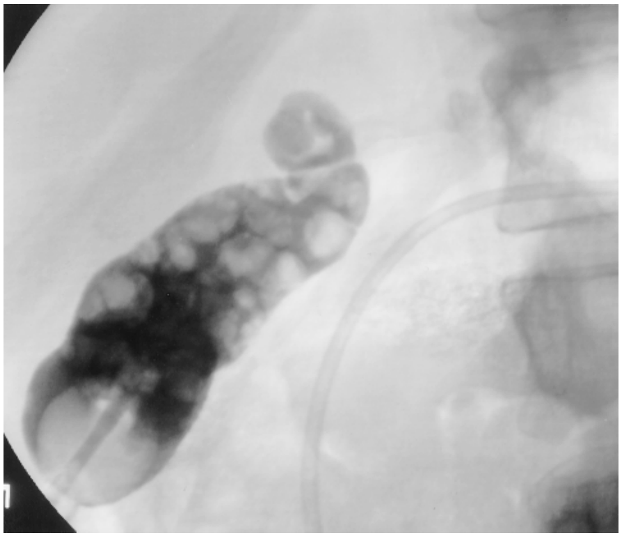
Although laparoscopic cholecystectomy is the treatment of choice for symptomatic gallstones, several nonsurgical techniques such as percutaneous contact dissolution have been developed for treatment of gallstones (Table 4) (23,24). Unfortunately, most of these techniques have been largely abandoned due to the relatively frequent recurrence of gallstones. However, one radiologic interventional procedure that has evolved and continues to serve a role in management of cholelithiasis and its complications is percutaneous cholecystostomy.

The clinical setting in which percutaneous cholecystostomy is most often performed is acute cholecystitis in a patient who is a poor surgical risk. This procedure allows decompression of the inflamed gallbladder and provides a potential route for stone extraction. The tract chosen depends on the anatomy and whether stone extraction is planned. A transhepatic route is associated with less risk of bile leakage, whereas a subhepatic or transperitoneal route is preferred for stone extraction through a larger tract.

The gallbladder is visualized with US guidance or fluoroscopy after oral administration of contrast medium. The gallbladder can then be entered by using the Seldinger technique, with tract dilation and catheter placement over a guide wire, or a direct trocar technique. Gallstones can be removed with baskets and graspers (Fig 23). Although success rates for percutaneous stone removal are high, the potential for gallstone recurrence remains, and there is a slightly increased risk of gallbladder carcinoma related to chronic inflammation.

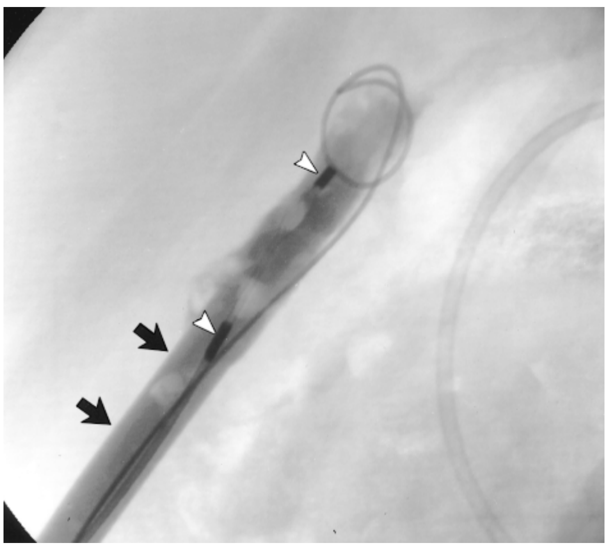
Conclusion

With recent and ongoing improvements in MR imaging techniques, advances in US equipment, and an increasing spectrum of percutaneous biliary interventions, radiologists will continue to play an integral role in diagnosis and treatment of gallstone-related diseases.

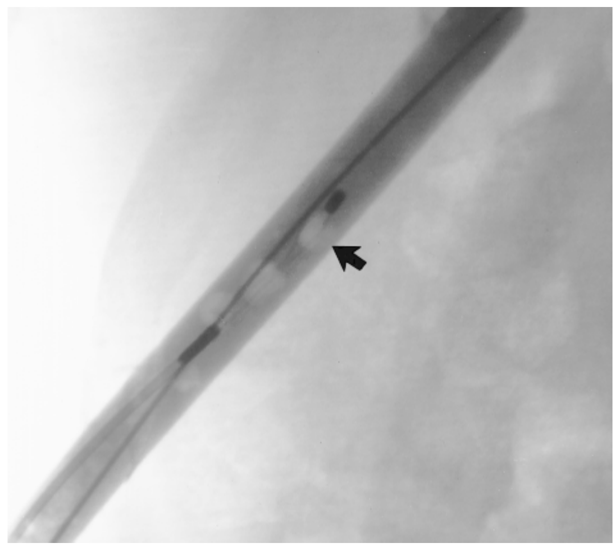


a.

Figure 23. Cholecystostomy and percutaneous stone removal in an elderly patient whose condition was too unstable for cholecystectomy. A Foley catheter was surgically placed within the gallbladder. **(a)** Oblique percutaneous cholecystogram obtained after injection of contrast material via the catheter shows multiple filling defects consistent with gallstones. The surgeons subsequently requested percutaneous stone removal. **(b)** Image obtained with the patient in the supine position shows a large sheath (arrows), which was exchanged for the catheter over a guide wire. A basket catheter has been advanced into the sheath. Arrowheads indicate the basket. **(c)** Image shows sequential removal of gallstones with the grasping technique. Arrow indicates a stone within the basket.



b.



c.

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