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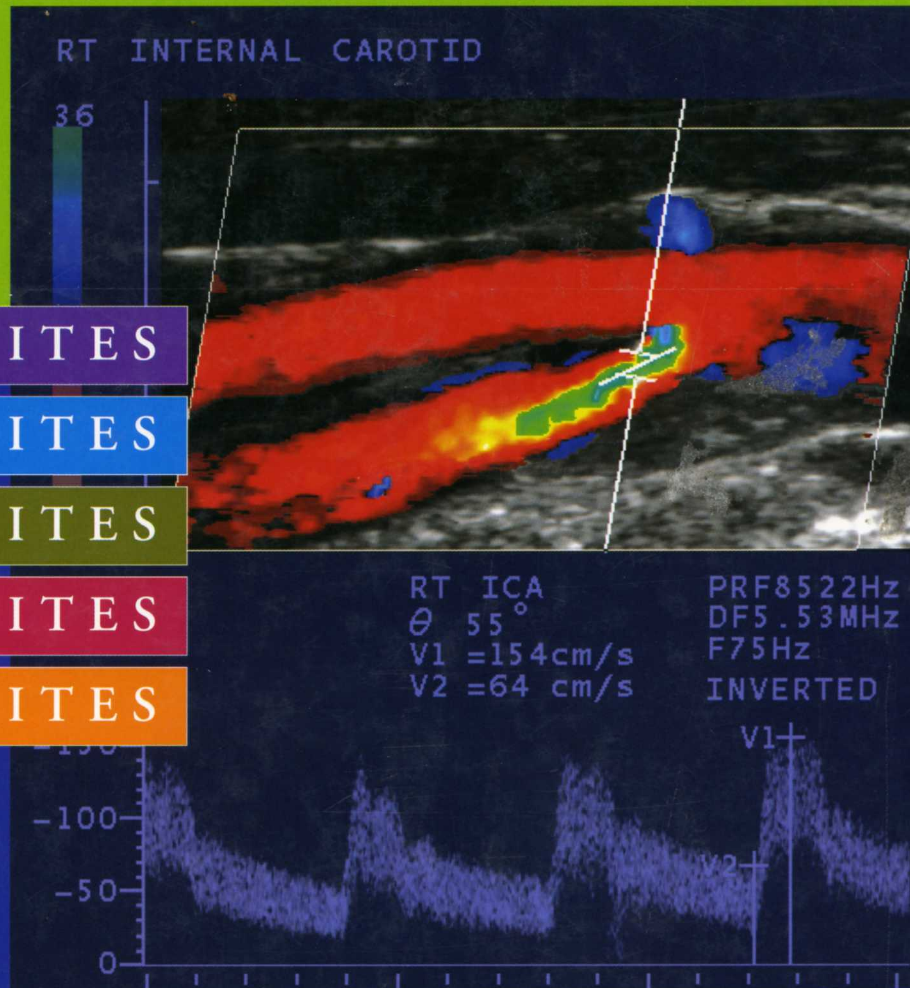

Ultrasound

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CHAPTER 2

Gallbladder

ANATOMY

The gallbladder is a long oval organ that is positioned beneath the liver immediately adjacent to the interlobar fissure (Fig. 2-1). The fissure can be a useful landmark for locating small contracted gallbladders or gallbladders that are completely filled with stones. Likewise, the gallbladder can be used as a landmark for identifying the junction between the left and right lobes of the liver. The upper limit of normal for the transverse dimension of the gallbladder is 4 cm. The length of the gallbladder is more variable but generally does not exceed 10 cm. The normal upper limit for the gallbladder wall thickness is 3 mm. When the gallbladder contracts, the echogenic mucosa and the hypoechoic muscularis become apparent and the wall may appear thickened (Fig. 2-2). However, even with gallbladder contraction, the wall usually remains less than 3 mm thick. See Table 2-1 for the characteristics of a normal gallbladder.

Variations in shape of the gallbladder are common. There are frequently one or more junctional folds in the gallbladder neck, and occasionally there are folds throughout the gallbladder (Fig. 2-3A and B). When the gallbladder fundus folds on itself, it is referred to as a phrygian cap (see Fig. 2-3C). Gallbladder folds may mimic septations, but it should be possible to demonstrate a change in the outer contour of the gallbladder. Septations are rare and generally appear thinner than folds. They separate the gallbladder into segments that communicate through a small pore (Fig. 2-4).

Variations in the location of the gallbladder are also rare; intrahepatic gallbladders are probably the most frequently recognized. Most intrahepatic gallbladders are located immediately above the interlobar fissure (Fig. 2-5). Gallbladder duplication is another rare congenital anomaly that may be complete (Fig. 2-6A) or partial (see Fig. 2-6B). Agenesis of the gallbladder has also been reported.

TECHNIQUE

Ideally, patients should fast 8 hours after midnight before a gallbladder sonogram to ensure adequate gallbladder distention and to reduce upper abdominal bowel gas. A recent meal makes the examination harder to perform and interpret and decreases diagnostic sensitivity. However, in most cases diagnostic information can be obtained even in non-fasting patients, so a recent meal is not an absolute contraindication to performing a gallbladder sonogram.

Most gallbladder examinations start with the patient in the supine position using a 3- to 5-MHz sector transducer. The gallbladder should be scanned from both a subcostal and intercostal approach whenever possible. Often one approach will display a pathologic process and/or diminish artifacts better. When scanning from a subcostal view, a deep inspiration will usually allow better visualization. Frequently there are artifactual low-level echoes in the gallbladder lumen resulting from reverberations. They can often be eliminated by scanning from a more lateral and superior approach (often

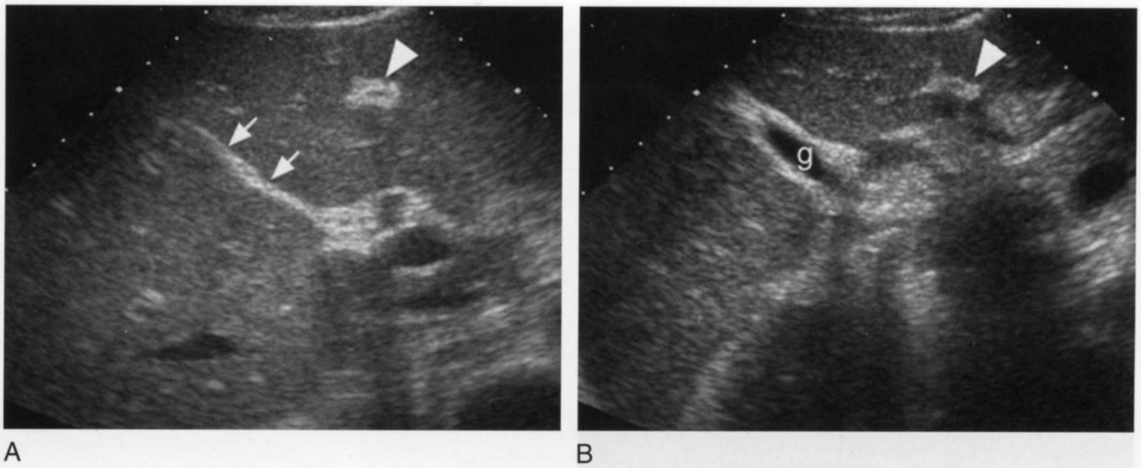


Figure 2-1 Relationship of gallbladder to interlobar fissure. **A,** Transverse view shows the ligamentum teres *(arrowhead)* and the interlobar fissure *(arrows)*. **B,** Transverse view slightly inferior to part A shows a contracted gallbladder (g) located immediately inferior to the interlobar fissure.

from an intercostal space) and using more of the liver as a window. Scans should routinely be obtained with the patient in a variety of positions (left posterior oblique, left lateral decubitus, prone, upright) to document mobility of intraluminal structures, such as stones and sludge, and nonmobility of polyps and tumors. In some patients the gallbladder may be hard to see in the prone position. Nevertheless, stones that fall into the fundus when the patient is prone can be seen on real-time imaging, falling back into the neck as the patient rolls from a prone to a supine position. Upright views can be obtained in the sitting position, although it is usually easier to scan with the patient standing. Although it is important to visualize the entire gallbladder, seeing the gallbladder neck is especially important, because stones can be missed if the entire neck is not visualized, if a stone is positioned behind a junctional fold, or if the stone is impacted in the neck of the organ (Fig. 2-7). It is also important to ensure that abnormalities in the fundus are not obscured by bowel gas.

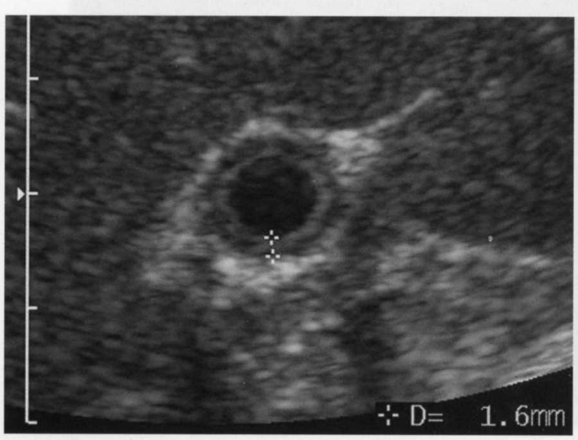


Figure 2-2 Contracted gallbladder. Transverse view shows the echogenic mucosal layer and the hypoechoic muscular layer. Despite apparent thickening, the wall measures only 1.6 mm thick *(cursors)*.

GALLSTONES

Gallstones are present in up to 10% of the population. In North America, 75% are cholesterol and 25% are pigment. The majority of gallstones are asymptomatic (silent). Surgery is seldom performed on silent stones because they become symptomatic at a rate of only 2% per year. Symptoms rarely develop after an asymptomatic period of 10 to 15 years.

The most common symptom of gallstones is biliary colic, which manifests as acute right upper quadrant or epigastric pain lasting for up to 6 hours and ending when the stone disimpacts from the gallbladder neck or passes completely through the cystic duct. Gallstones may also cause nonspecific dyspeptic symptoms.

Table 2-1 Characteristics of the Normal Gallbladder

Characteristic	Appearance
Location	Inferior to interlobar fissure Between left and right lobe
Size	<4 cm transverse <10 cm longitudinal
Wall thickness	<3 mm
Lumen	Anechoic

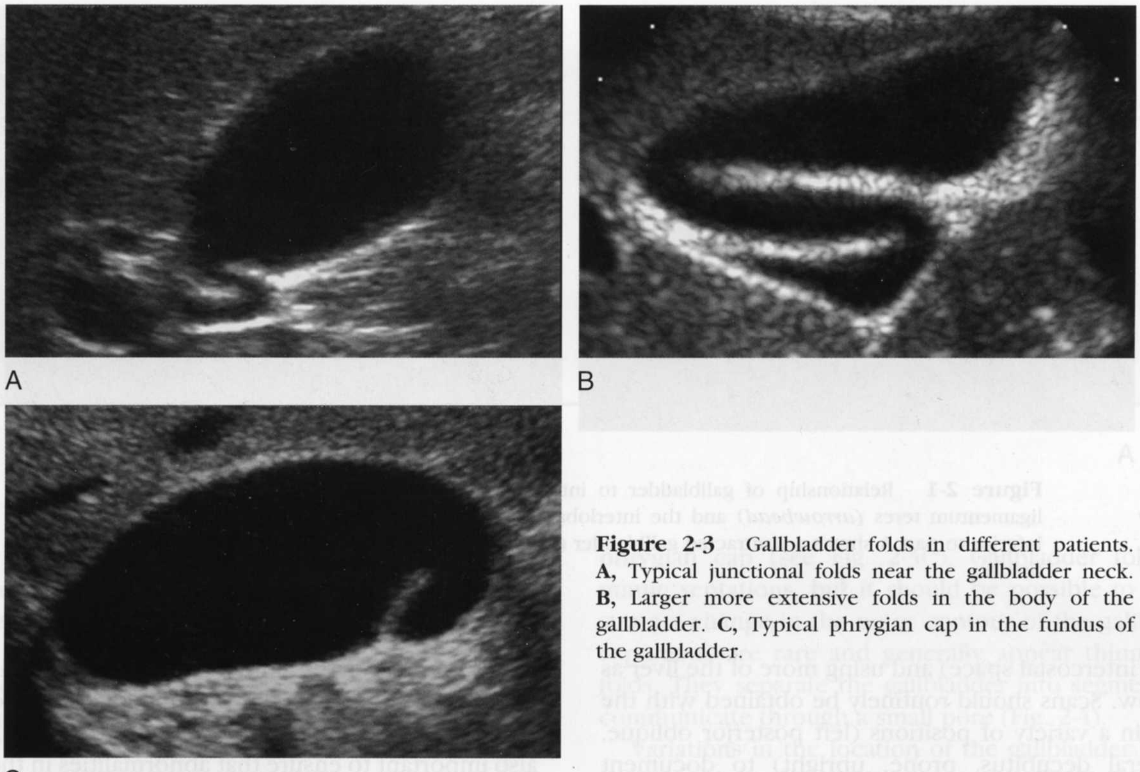


Figure 2-3 Gallbladder folds in different patients. **A,** Typical junctional folds near the gallbladder neck. **B,** Larger more extensive folds in the body of the gallbladder. **C,** Typical phrygian cap in the fundus of the gallbladder.

Sonography has assumed an important role in evaluating the gallbladder because it is the most sensitive means of detecting gallstones. Multiple studies have documented sensitivities of greater than 95% and positive and negative predictive values that are close to 100%. Even in obese patients, sonography is the best way to detect stones.

Gallstones appear as mobile, echogenic, intraluminal structures that cast acoustic shadows (Fig. 2-8). Shadowing occurs because of sound beam absorption by the stone. Demonstration of shadowing is important in distinguishing stones from other intraluminal abnormalities. Shadowing primarily depends on the size of the stone. Stones smaller than 3 mm may not cast a

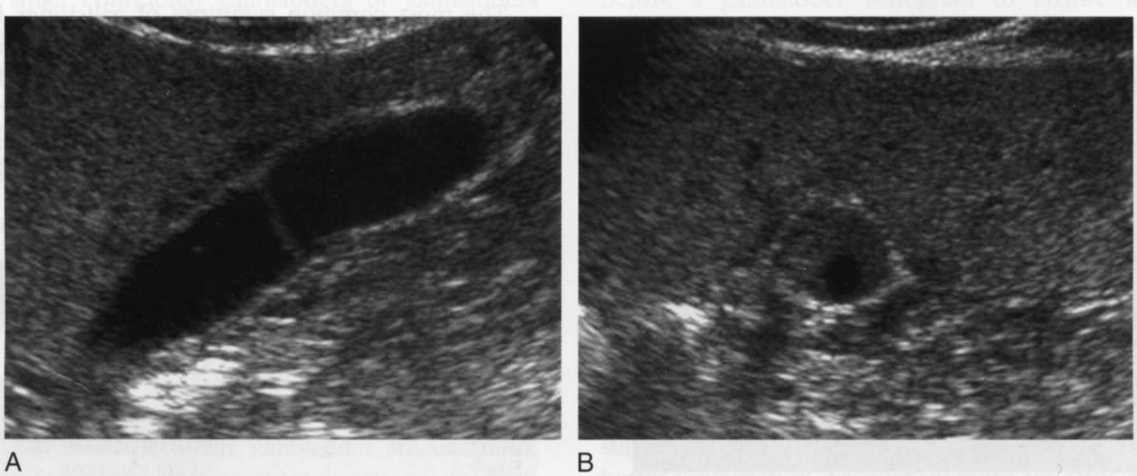


Figure 2-4 Septated gallbladder. **A,** Longitudinal view shows a thin septation in the body of the gallbladder with little deformation of the outer gallbladder contour. **B,** Transverse view through the septation shows a small, round defect in the periphery of the septation that allows for communication between the two segments of the gallbladder.

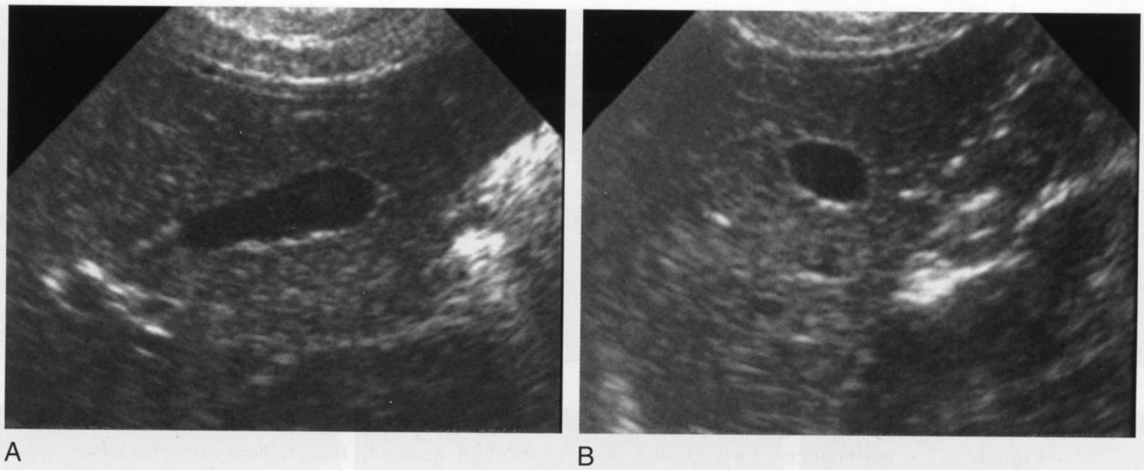


Figure 2-5 Intrahepatic gallbladder. **A,** Longitudinal view of the liver shows a gallbladder completely surrounded by hepatic parenchyma. **B,** Transverse view of the gallbladder shows similar findings.

detectable shadow. In contrast, shadowing is largely independent of stone composition. In particular, calcification is not necessary for shadow production. To a large degree, all stones appear similar on sonography.

Technical factors need to be optimized to demonstrate shadowing from small stones. Because sound absorption increases at higher frequencies, non-shadowing stones may be converted into shadowing stones by switching to a higher-frequency transducer (Fig. 2-9A and B). Another important factor is the focal zone. Because the beam profile is narrowest at the focal zone, it should be set at the depth of the stone so that the stone will absorb a greater percentage of the sound beam (see Fig. 2-9C and D). If there are multiple small stones, shadowing may be best demonstrated by positioning the patient so that the stones are clumped together (see Fig. 2-9E and F).

The major differential considerations are gallbladder polyps and sludge balls (Table 2-2). Polyps are small soft tissue structures that are adherent to the gallbladder wall. They do not move or shadow. Sludge balls (tumefactive sludge) are almost always mobile but do not produce a shadow. In addition, sludge balls are usually quite a bit larger than non-shadowing stones.

A gallbladder completely filled with stones is harder to recognize than when it is filled with bile. All that is apparent is an echogenic shadowing structure in the right upper quadrant that could potentially be confused with a gas-filled loop of bowel. If an identifiable gallbladder is seen elsewhere, then the problem is solved.

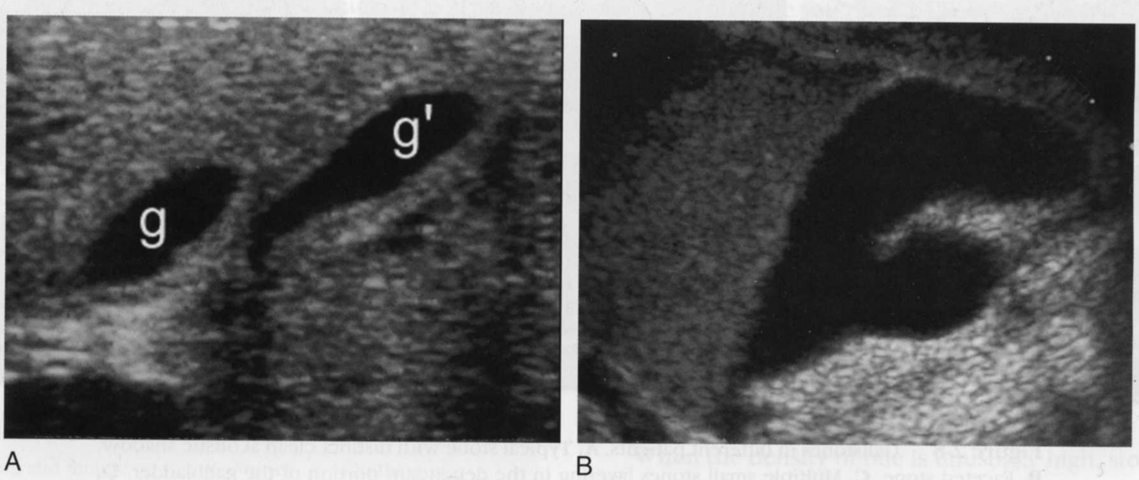
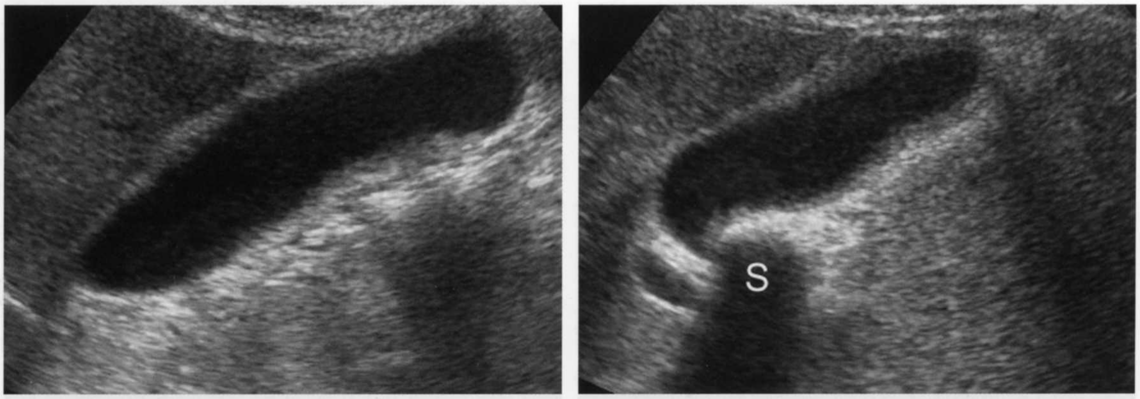
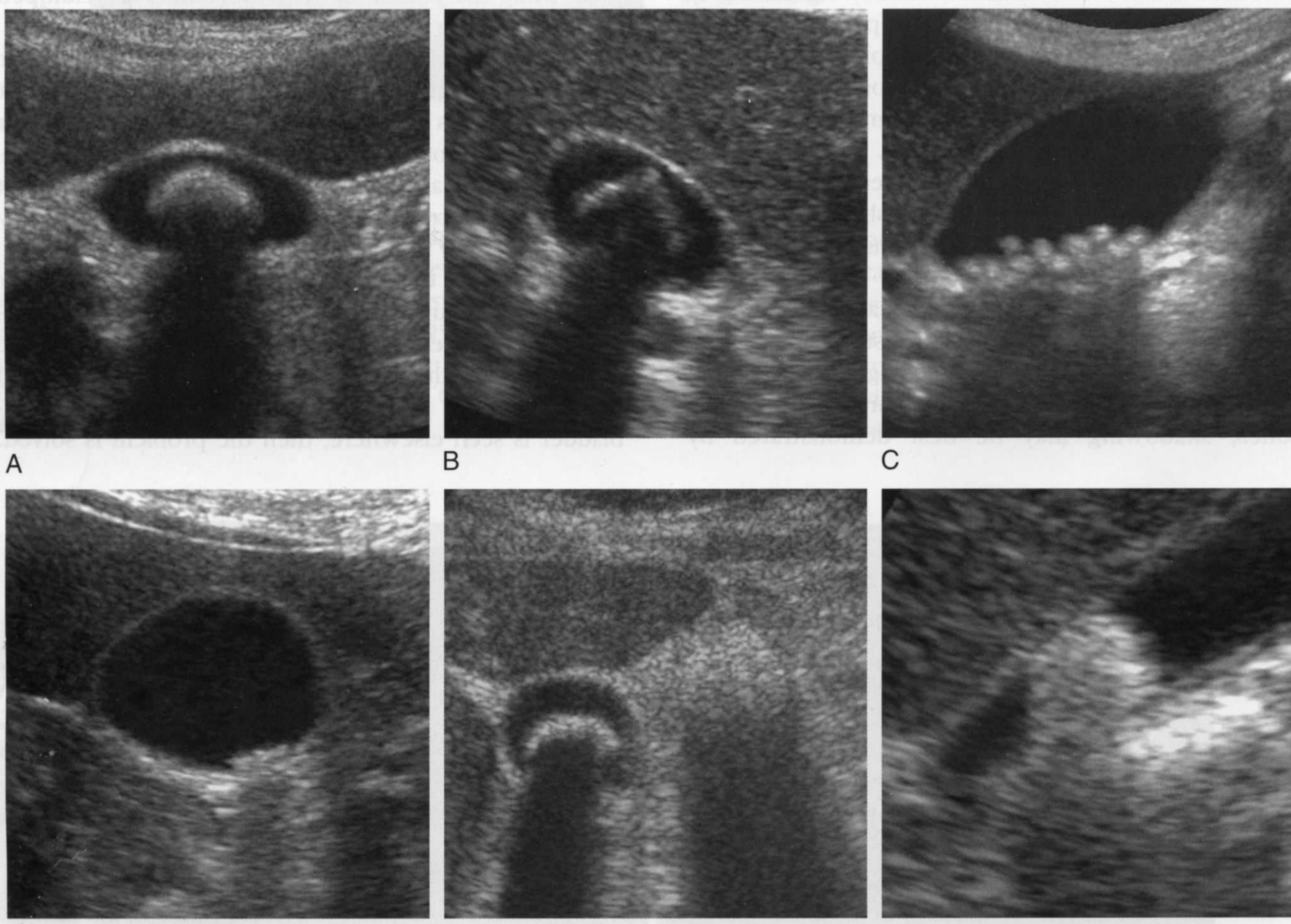


Figure 2-6 Gallbladder duplication in different patients. **A,** Complete duplication of the gallbladder into two separate structures (g, g′). **B,** Partial duplication of the gallbladder into two separate fundal segments.



A B

Figure 2-7 Importance of visualizing entire gallbladder neck. **A,** Longitudinal view of the gallbladder shows an apparently stone-free lumen. **B,** Longitudinal view showing more of the gallbladder neck demonstrates a shadowing stone (S) within a folded segment of the gallbladder neck.



A B C D E F

Figure 2-8 Gallstones in different patients. **A,** Typical stone with distinct clean acoustic shadow. **B,** Faceted stone. **C,** Multiple small stones layering in the dependent portion of the gallbladder. **D,** Very small stones with a faint acoustic shadow layering in the dependent portion of the gallbladder. **E,** Gallstone with a clean acoustic shadow immediately adjacent to a gas-filled loop of bowel with a dirty acoustic shadow. **F,** Unusual gallstone with a dirty acoustic shadow.

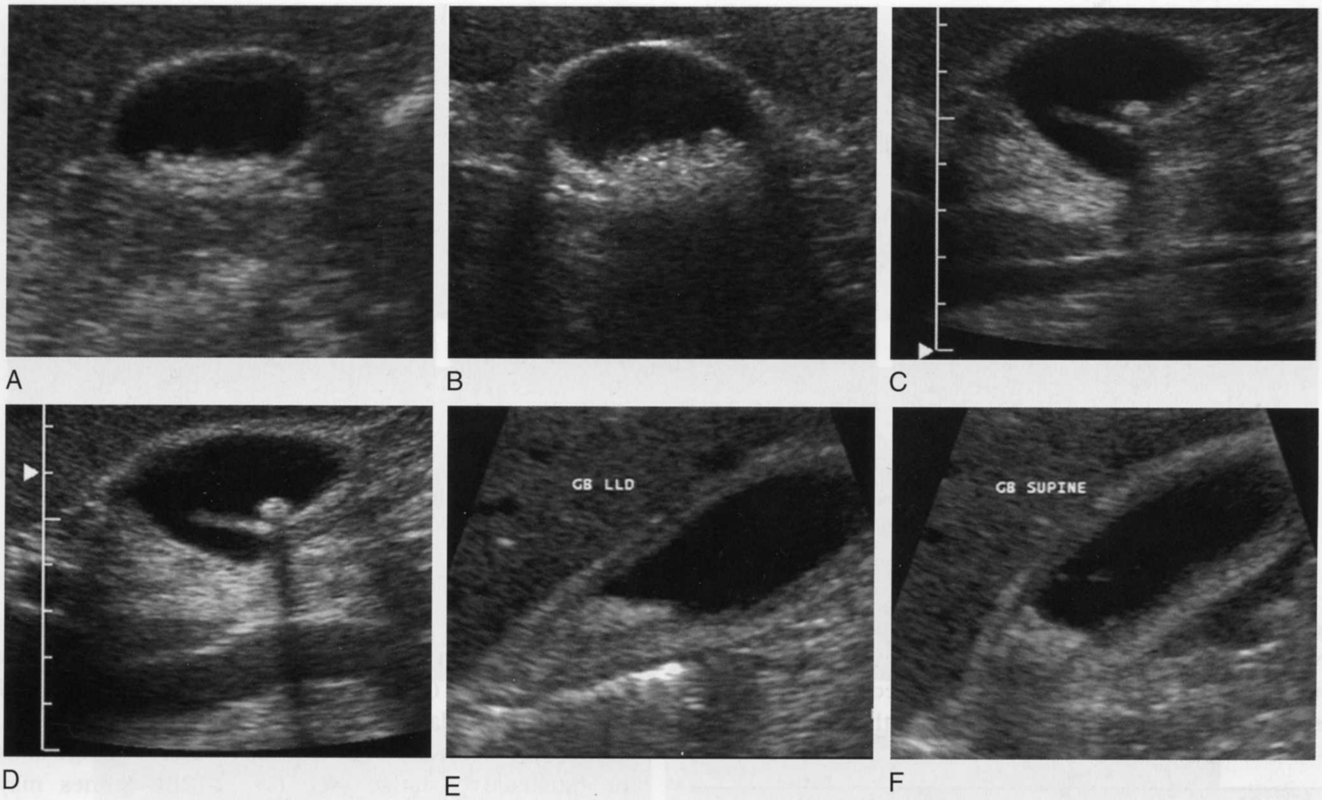


Figure 2-9 Importance of technical parameters in demonstrating gallstone shadowing in different patients. **A,** Transverse view of the gallbladder obtained at 3.6 MHz shows stones but no shadowing. **B,** A similar view obtained at 6.0 MHz shows readily detectable shadowing. **C,** View of the gallbladder with the focal zone placed at the deep aspect of the field of view shows only faint acoustic shadowing from the gallstone. **D,** Another view with the focal zone placed at the level of the gallstone shows distinct acoustic shadowing. **E,** View of the gallbladder with the patient in a left lateral decubitus position shows echogenic material in the neck of the gallbladder but no definite acoustic shadowing. **F,** Similar view but with the patient in the supine position results in consolidation of the material and production of an acoustic shadow confirming that this represents small stones rather than sludge.

If not, the character of the shadow is important. In most cases stones produce a clean shadow and gas produces a dirty shadow (see Fig. 2-8E). Exceptions to this rule occur occasionally (see Fig. 2-8F) and are probably a result of differences in the surface characteristics of gallstones. Another sign that can assist in differentiating a stone-filled gallbladder and gas-filled bowel is the wall-echo-shadow (WES) complex. This consists of three arc-shaped lines followed by a shadow (Fig. 2-10).

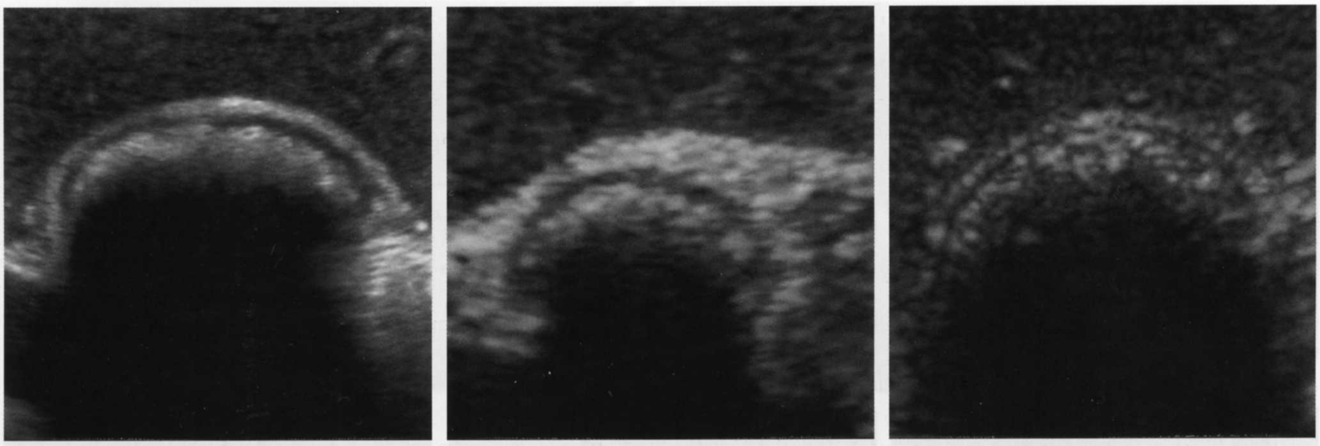
Table 2-2 Intraluminal Abnormalities in the Gallbladder

Ultrasound characteristics	Common	Uncommon
Shadowing and mobile	Stones	Nothing else
Non-shadowing and mobile	Sludge	Stones (<3 mm)
Non-shadowing and nonmobile	Polyps	Sludge

The first line is echogenic and represents pericholecystic fat as well as the interface between the gallbladder wall and the liver. The second line is hypoechoic and represents the gallbladder wall itself. The third is echogenic and arises from the stones. Although a WES complex is a very reliable sign of a stone-filled gallbladder, it is not possible to demonstrate it in every case. Therefore, it is a useful finding when seen but it is not useful when absent.

As mentioned earlier, the vast majority of gallstones fall into the dependent aspect of the gallbladder. When there are multiple small stones arranged in a layer along the dependent gallbladder wall, they might be confused with the wall itself. In such cases, identification of the stones and detection of an acoustic shadow are usually easier on transverse views (see Fig. 2-8D).

When the density of bile is unusually high, stones may float (Fig. 2-11). This occurs when the specific gravity of bile is greater than the specific gravity of the stones and indicates that the floating stones are composed of



A B C

Figure 2-10 Typical examples of the wall-echo-shadow complex in different patients. The complex varies from a very distinct series of arc-shaped lines (**A** and **B**) to less distinct lines (**C**).

cholesterol. One of the most common situations in which the specific gravity of bile increases is when intravenous contrast medium has been injected and there is some degree of vicarious excretion in the gallbladder.

SLUDGE

Sludge consists of calcium bilirubinate granules and cholesterol crystals, often in the setting of thick, viscous bile. It appears as low- to high-level, non-shadowing reflectors in the gallbladder. Typically, sludge localizes in the dependent portion of the gallbladder and forms a bile-sludge level (Fig. 2-12A and B), although it may fill the entire gallbladder lumen (see Fig. 2-12C and D). Sludge may form mass-like aggregates called sludge balls or tumefactive sludge (see Fig. 2-12E). Stones may coexist with sludge, in which case shadowing will be seen (see Fig. 2-12B and D). In some cases the crystalline components of sludge float in the non-dependent portion of the gallbladder lumen (see Fig. 2-12F). This should not be confused with stones. Although typically

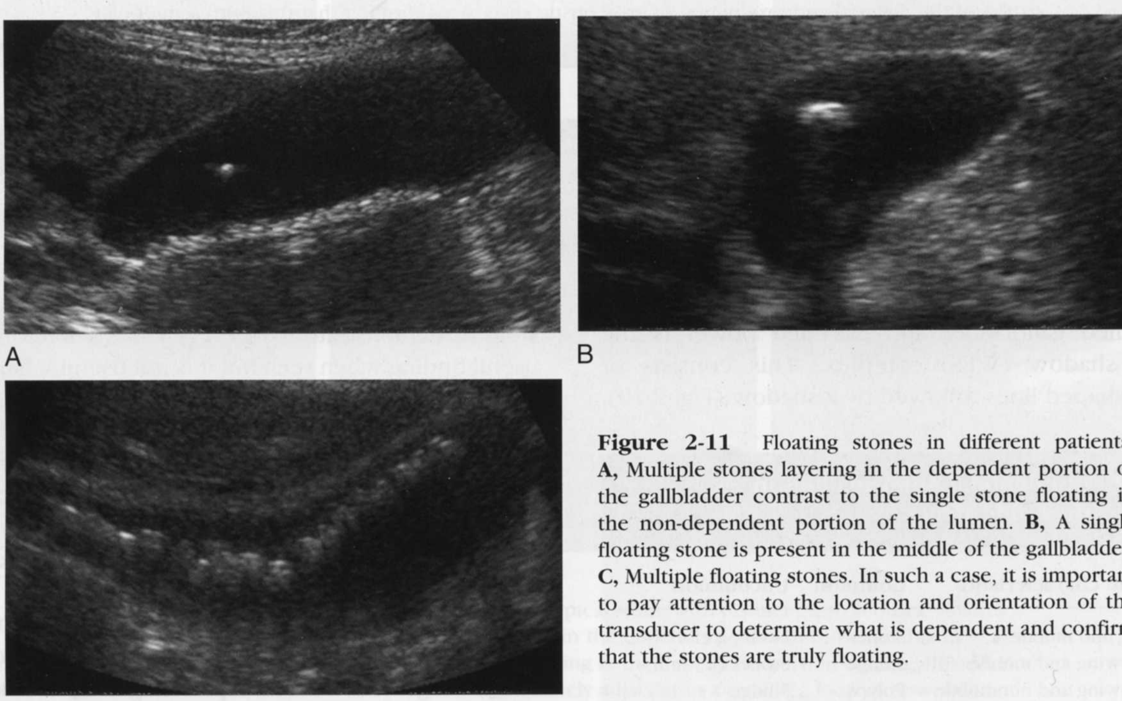


Figure 2-11 Floating stones in different patients. **A,** Multiple stones layering in the dependent portion of the gallbladder contrast to the single stone floating in the non-dependent portion of the lumen. **B,** A single floating stone is present in the middle of the gallbladder. **C,** Multiple floating stones. In such a case, it is important to pay attention to the location and orientation of the transducer to determine what is dependent and confirm that the stones are truly floating.

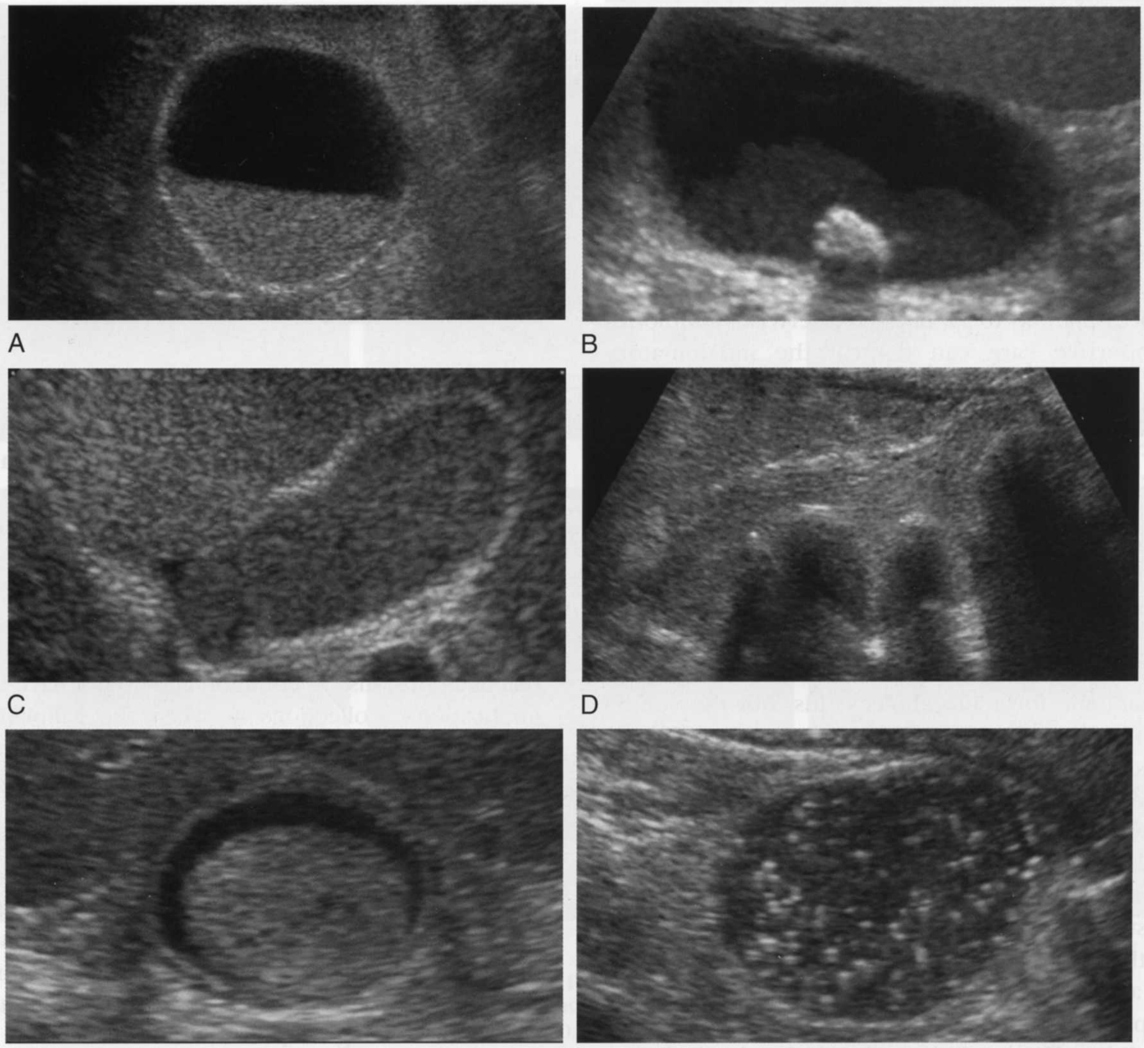


Figure 2-12 Gallbladder sludge in different patients. **A,** Typical echogenic sludge layering in the dependent portion of the gallbladder lumen. **B,** Less echogenic sludge with associated gallstone. **C,** Sludge completely filling the gallbladder lumen. **D,** Sludge completely filling the gallbladder with associated stones. **E,** Sludge ball occupying most of the gallbladder lumen. **F,** Sludge with multiple distinct crystals, many of which demonstrate short comet-tail artifacts.

homogeneous, sludge may have a very inhomogeneous appearance, with prominent hypoechoic regions. It can also form echogenic bands that can be confused with sloughed membranes. The lack of shadowing distinguishes the different forms of sludge from gallstones, and mobility distinguishes sludge from polyps and tumors. In rare cases, it will not be possible to demonstrate mobility of sludge. In such cases a follow-up examination several weeks later is often helpful to demonstrate mobility or a change in appearance and thus excludes gallbladder neoplasm. Color Doppler imaging is also potentially useful in isolated cases because detection of blood flow excludes tumefactive sludge from the differential diagnosis. Lack of detectable flow is not helpful because it can occur in hypovascular tumors in addition to tumefactive sludge. Intraluminal blood and pus can both mimic all of the characteristics of sludge.

The clinical significance of sludge is not entirely clear, but in most patients it can probably be thought of as an asymptomatic dynamic equilibrium between crystal development and elimination. Nonetheless, in a minority of patients it probably represents the early stage of gallstone formation. It is also believed that biliary crystals can cause pancreatitis, and this can make the detection of sludge important in patients with pancreatitis of unknown origin.

ACUTE CHOLECYSTITIS

In the majority of cases, acute cholecystitis occurs from persistent obstruction of the cystic duct or gallbladder neck by an impacted gallstone. If the stone does not spontaneously disimpact or some form of therapy is not initiated, the gallbladder may become necrotic and perforate. Surgery is the treatment of choice and is typically performed at presentation if the duration of symptoms is less than 48 to 72 hours. Otherwise, antibiotics and supportive care can control the inflammatory process and the patient's symptoms so that cholecystectomy can be performed electively.

There are a number of sonographic findings that support the diagnosis of acute cholecystitis and the diagnosis of advanced acute cholecystitis (Boxes 2-1 and 2-2). They include (1) gallstones, (2) gallbladder wall thickening, (3) gallbladder enlargement, (4) pericholecystic fluid, (5) a stone impacted in the gallbladder neck or cystic duct, and (6) focal tenderness directly over the gallbladder. By themselves, none of these findings is pathognomonic for acute cholecystitis, but the combination of several findings in the appropriate clinical setting is highly suggestive. The positive predictive value of gallstones and a positive sonographic Murphy's sign is 92%, whereas the negative predictive value is 95%.

Gallbladder wall thickening greater than or equal to 3 mm occurs in the majority of patients with acute cholecystitis (Fig. 2-13A and B). Unfortunately there are many other causes of wall thickening, and the sonographic appearance of the thickened gallbladder wall is not helpful in distinguishing cholecystitis from other abnormalities. However, irregular, striated sonolucencies in a thickened wall may imply a more advanced case of cholecystitis. Gallbladder enlargement is an important sign of cholecystitis, and the width of the gallbladder is more important than the length (see Fig. 2-13C). As mentioned earlier, gallstones are present in approximately 95% of cases of cholecystitis. In some instances, it is possible to identify the impacted stone that is causing the obstruction in the gallbladder neck or cystic duct (see Fig. 2-13D). However, in many cases non-obstructing stones are seen but the obstructing stone is not. Pericholecystic fluid collections occur in less than 20% of patients with acute cholecystitis. They typically appear as loculated collections in the peritoneal cavity, most frequently near the fundus (see Fig. 2-13E and F). Pericholecystic fluid is important to recognize because it usually indicates more advanced cholecystitis and the need for more urgent intervention. On the other hand, reactive effusions are common and do not have the same implications. Collections between the gallbladder and the liver are also common and probably represent edema in loose areolar tissue rather than pericholecystic fluid.

In addition to pericholecystic fluid collections and irregular striated thickening of the gallbladder wall, other signs of advanced cholecystitis and wall necrosis include focal ulceration of the mucosa, sloughed mucosal membranes, focal bulges of the gallbladder wall, and intramural abscess (Fig. 2-14). All of these abnormalities are rare; and, as mentioned earlier, membranous sludge can simulate sloughed mucosal membranes.

The sonographic diagnosis of acute cholecystitis remains in doubt in some patients. In these patients, hepatobiliary scintigraphy is extremely valuable as a problem-solving technique to exclude or establish the diagnosis of acute cholecystitis. The American College of Radiology states in its appropriateness criteria that patients with suspected acute cholecystitis can be evaluated first with either ultrasound or scintigraphy. However, ultrasound receives a higher rating. There are several reasons for this.

1. Approximately 70% of patients with clinically suspected acute cholecystitis will have some other problem, and by showing a normal gallbladder, ultrasound can rapidly exclude cholecystitis in the majority of these patients.
2. Ultrasound is much more likely to identify a specific alternative diagnosis than is biliary scintigraphy.
3. Ultrasound is a relatively inexpensive means of obtaining morphologic information about all of the right upper quadrant organs. This is becoming particularly more important in the era of laparoscopic cholecystectomies because the surgeon has less capability of examining these organs during the operation.

Box 2-1 Sonographic Signs of Acute Cholecystitis

Gallstones
Wall thickening (≥ 3 mm)
Gallbladder enlargement
Pericholecystic fluid
Impacted stone
Sonographic Murphy's sign

Box 2-2 Sonographic Signs of Advanced Acute Cholecystitis

Pericholecystic fluid
Sloughed mucosal membranes
Irregular striated intramural sonolucencies
Wall disruption
Wall ulceration
Focal wall bulge

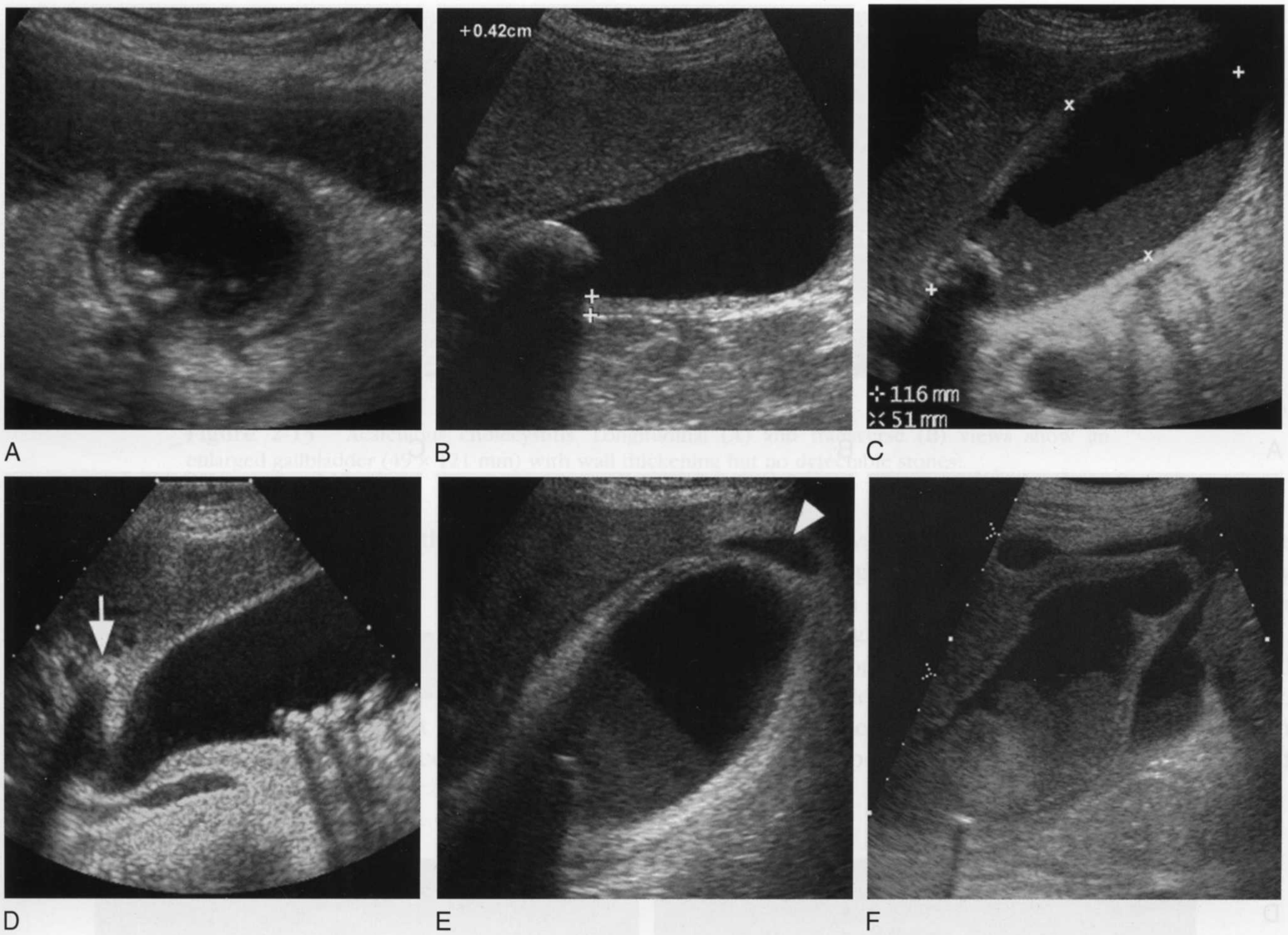


Figure 2-13 Acute cholecystitis in different patients. **A,** Transverse view shows stones, sludge, and gallbladder wall thickening as well as echogenic inflammatory changes in the adjacent fat. **B,** Longitudinal view shows wall thickening (0.42 cm, *cursors*) and a stone in the neck of the gallbladder. **C,** Longitudinal view shows an enlarged gallbladder (116 × 51 mm) with stones and sludge. **D,** Longitudinal view shows a gallstone impacted in the cystic duct *(arrow)* in addition to multiple non-impacted stones in the gallbladder lumen. **E,** Longitudinal view shows wall thickening, sludge, stones, and a small collection of pericholecystic fluid *(arrowhead)* near the gallbladder fundus. **F,** Longitudinal view shows findings similar to that in **E** but more extensive pericholecystic fluid around the gallbladder fundus.

4. The size of the gallbladder, size of the largest stone, status of the gallbladder wall, and presence of biliary dilatation are all important preoperative data that can be obtained with sonography but not with scintigraphy.
5. Most ultrasound examinations that are considered false positive for acute cholecystitis occur in patients with symptomatic gallstones. Because these patients require cholecystectomy anyway, the impact of a preoperative diagnosis of acute cholecystitis is minimal.

Approximately 5% of cases of acute cholecystitis occur in the absence of gallstones and are referred to as acalculous cholecystitis. The etiology is multifactorial and includes ischemia, gallbladder wall infection, chemical toxicity to the gallbladder wall, and cystic duct obstruction. Acalculous cholecystitis occurs predominantly in very sick patients, particularly after major surgery, extensive burns, major trauma, and prolonged total parenteral nutrition. Therefore, the absence of stones is not a reliable means of excluding cholecystitis in this group of patients. Secondary signs must be relied on to make the diagnosis (Fig. 2-15). Unfortunately, most very ill patients have many potential causes of secondary signs, such as gallbladder enlargement and wall thickening. It can also be difficult to assess for tenderness in a semi-responsive patient. Therefore, sonography has significant limitations in the diagnosis of acalculous cholecystitis. Scintigraphy is probably more sensitive than sonography, but it is also prone to false-positive results.

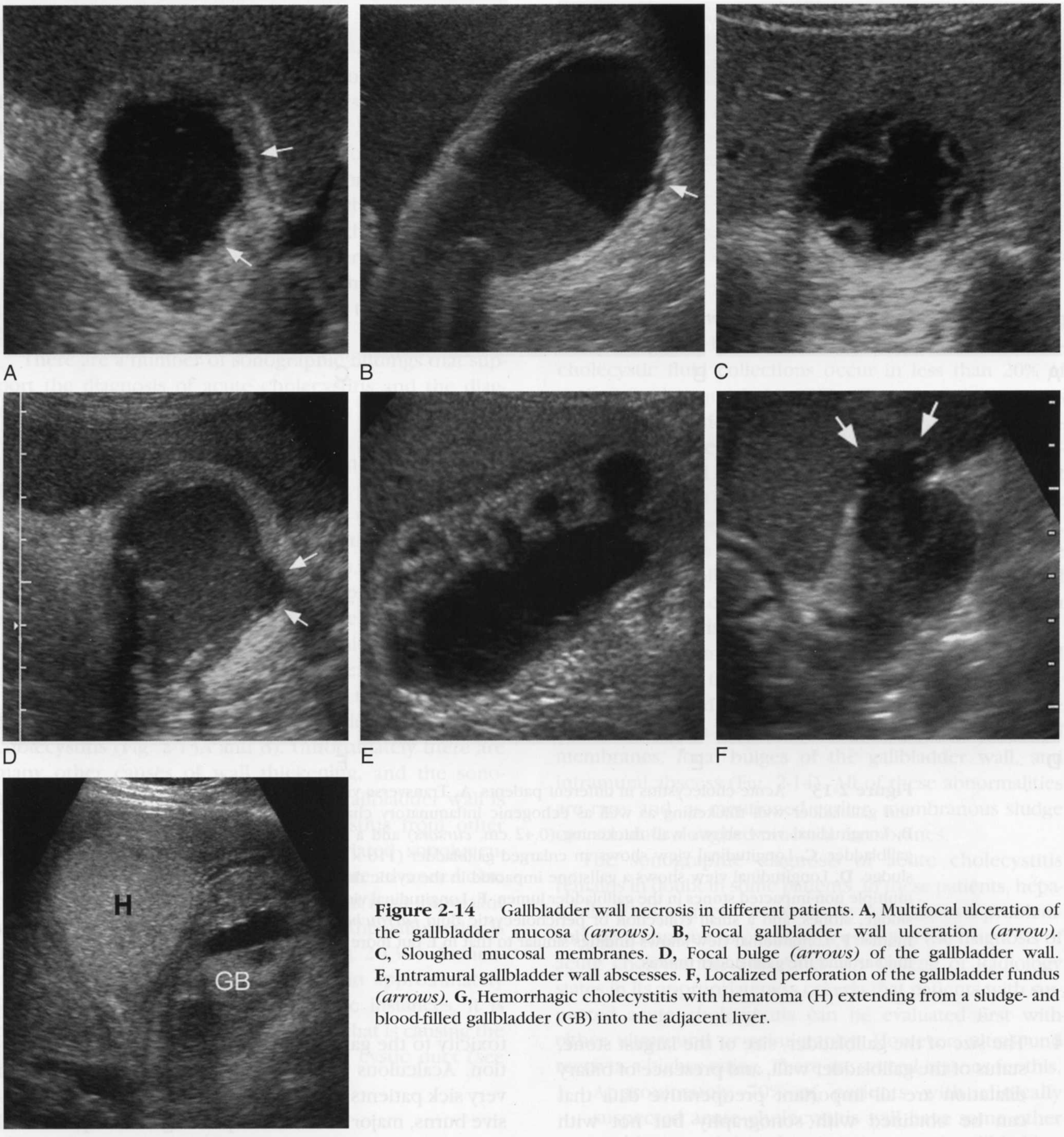


Figure 2-14 Gallbladder wall necrosis in different patients. **A,** Multifocal ulceration of the gallbladder mucosa *(arrows)*. **B,** Focal gallbladder wall ulceration *(arrow)*. **C,** Sloughed mucosal membranes. **D,** Focal bulge *(arrows)* of the gallbladder wall. **E,** Intramural gallbladder wall abscesses. **F,** Localized perforation of the gallbladder fundus *(arrows)*. **G,** Hemorrhagic cholecystitis with hematoma (H) extending from a sludge- and blood-filled gallbladder (GB) into the adjacent liver.

Emphysematous cholecystitis is another unusual form that tends to occur in elderly men. Because it is caused by ischemia, it occurs more often in diabetics and is often not associated with gallstones. The gas that develops results from infection with gas-forming organisms and can occur in the gallbladder wall and/or lumen. Perforation of the gallbladder is five times more likely with emphysematous cholecystitis than with gallstone-induced cholecystitis; thus, the distinction is clinically significant. Sonographically, emphysematous cholecystitis usually manifests as very bright reflections from a non-dependent portion of the gallbladder wall (Fig. 2-16A). The associated acoustic shadow is usually dirty (see Fig. 2-16B) and in many cases has a demonstrable

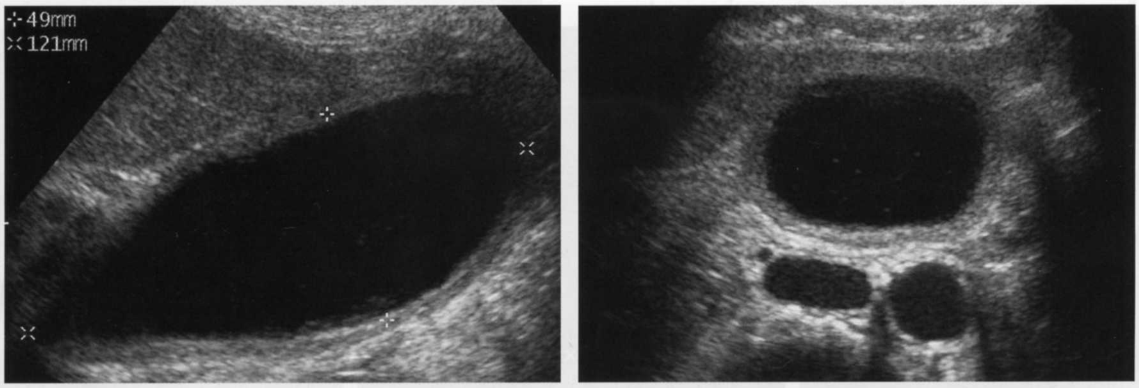
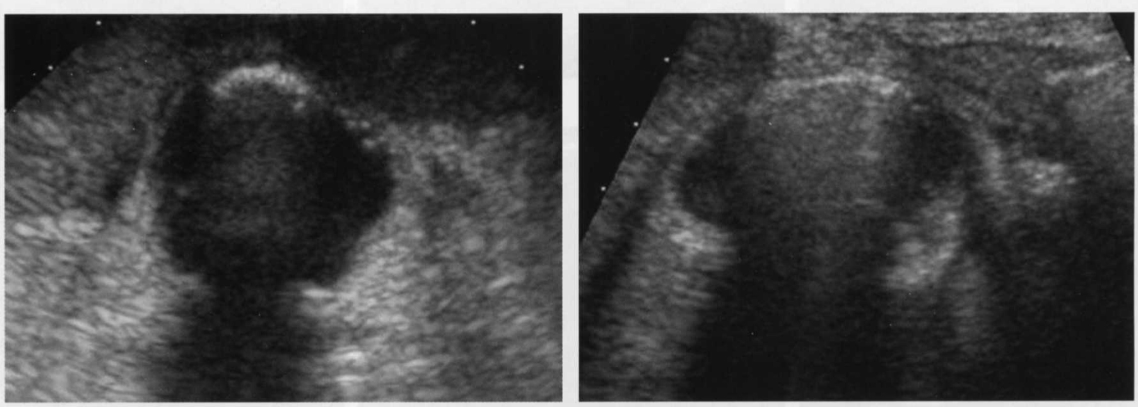


Figure 2-15 Acalculous cholecystitis. Longitudinal (**A**) and transverse (**B**) views show an enlarged gallbladder (49 × 121 mm) with wall thickening but no detectable stones.

ring-down artifact (see Fig. 2-16C) that is a reliable sign of gas.

CARCINOMA

Gallbladder cancer is the fifth most common gastrointestinal malignancy. It probably occurs because of chronic irritation of the gallbladder wall by stones. Therefore, the vast majority of gallbladder cancers are associated with gallstones and develop more commonly in women than in men. The 5-year survival rate for patients with gallbladder cancer is less than 20%, although the prognosis for patients with tumor confined to the gallbladder wall is much better. Unfortunately, up to 80% of these patients have direct tumor invasion of the liver or portal node involvement at the time of diagnosis.



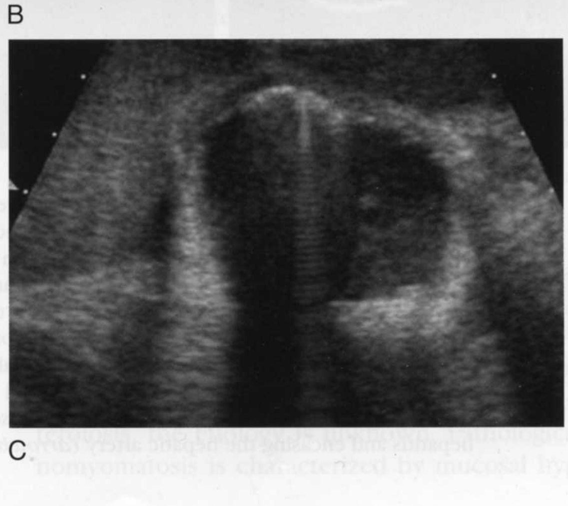


Figure 2-16 Emphysematous cholecystitis. **A** to **C**, Three different views show typical findings of bright reflectors arising from the non-dependent portion of the gallbladder with associated dirty shadowing. A ring-down artifact arising from the gas is shown in **C**.

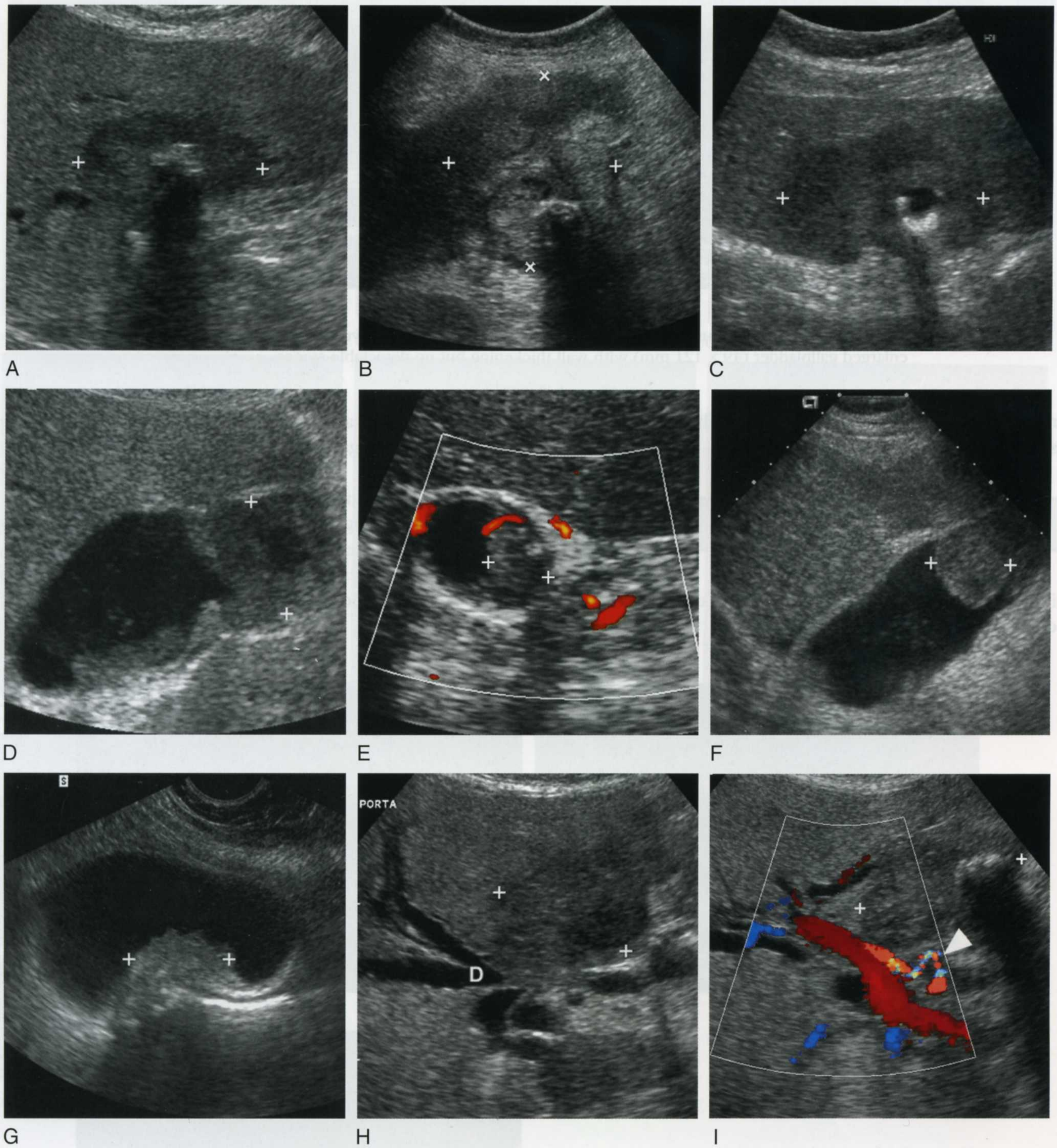


Figure 2-17 Gallbladder carcinoma in different patients. **A,** Homogeneous hypoechoic mass *(cursors)* obliterating the gallbladder lumen and engulfing a gallstone. **B,** Large heterogeneous mass *(cursors)* obliterating the gallbladder lumen and engulfing a gallstone. **C,** Homogeneous mass *(cursors)* partially obliterating the gallbladder lumen. **D,** Focal thickening of the gallbladder wall *(cursors)* in the region of the fundus. **E,** Focal thickening *(cursors)* of the medial aspect of the gallbladder wall. **F,** Large polypoid mass *(cursors)* in the gallbladder fundus. **G,** Smaller sessile polypoid mass *(cursors)* in the body of the gallbladder. **H,** Hypoechoic mass *(cursors)* in the gallbladder fossa invading the porta hepatis and causing bile duct obstruction with dilated intrahepatic bile ducts (D). **I,** Hypoechoic mass *(cursors)* engulfing a gallstone and invading the porta hepatitis and encasing the hepatic artery *(arrowhead).*

Box 2-3 Sonographic Appearance of Gallbladder Cancer

Mass centered on gallbladder fossa with associated stones
Eccentric irregular wall thickening
Bulky intraluminal polypoid mass
Infiltration of adjacent liver or vessels
Periportal and/or peripancreatic lymphadenopathy
Bile duct obstruction

The most common sonographic appearance for gallbladder cancer is a soft tissue mass centered in the gallbladder fossa that completely (Fig. 2-17A and B) or partially obliterates the lumen (see Fig. 2-17C). Identification of gallstones within the mass can help to confirm that the origin of the mass is the gallbladder rather than adjacent organs. Fifteen to 30 percent of gallbladder cancers appear as focal or diffuse gallbladder wall thickening (see Fig. 2-17D and E). In the vast majority of these cases the thickening is irregular, asymmetric, and eccentric. The least common form of gallbladder cancer is a polypoid intraluminal mass (see Fig. 2-17F and G). This form is almost always larger than a centimeter (usually much larger). Size is therefore a good way to distinguish cancer from gallbladder polyps. The sonographic findings in gallbladder cancer are reviewed in Box 2-3.

The differential diagnosis for gallbladder masses includes tumefactive sludge (see Fig. 2-12C), inflammatory wall thickening, polyps (Fig. 2-18), metastases (Fig. 2-19), and focal adenomyomatosis (Fig. 2-20D). The causes of gallbladder masses are reviewed in Box 2-4. When the diagnosis of cancer is in doubt, detection of metastatic disease in the regional lymph nodes or peritoneal cavity, or invasion of adjacent organs, especially the liver, bile ducts, or vessels (Fig. 2-17H and I, can be very useful.

POLYPS

Cholesterolosis is a condition in which triglycerides, cholesterol precursors, and cholesterol esters are deposited within the lamina propria of the gallbladder. Although the cause is unknown, cholesterolosis does not appear to be related to serum lipid level, atherosclerosis, diabetes, cholesterol stones, or hyperconcentration of cholesterol in the bile.

Most cases of cholesterolosis are of the planar variety and produce no detectable changes in the appearance or thickness of the gallbladder wall on ultrasound or other imaging tests. It is sometimes referred to as strawberry gallbladder because the mucosa bears a resemblance to the surface of a strawberry. A minority of cases of cholesterolosis are of the polypoid variety and can be detected by imaging tests such as ultrasound (see Fig. 2-18). Cholesterol polyps are by far the most common type of gallbladder polyp. They are not true neoplasms but rather enlarged papillary fronds filled with lipid-laden macrophages, and they are attached to the wall by means of a slender stalk. The stalk is rarely seen so they typically appear as a mass that is adjacent to the wall but barely attached to the wall. This is referred to as the "ball on the wall" sign. There are usually multiple polyps, although it is not uncommon to detect only the largest one sonographically. Cholesterol polyps are usually 5 mm or less and only rarely get bigger than 10 mm. They can be distinguished from gallbladder stones by their lack of a shadow and nonmobile nature and from sludge balls by their lack of mobility. Their small size and multiplicity help to distinguish them from true neoplasms of the gallbladder wall. Other types of gallbladder polyps occur but are less common than cholesterol polyps. These include adenomas, papillomas, leiomyomas, lipomas, and neuromas. These lesions are true neoplasms and are almost always solitary and are usually larger than cholesterol polyps (see Fig. 2-18E). Larger polyps may have detectable blood flow on color Doppler imaging (see Fig. 2-18F).

Metastatic disease to the gallbladder is very uncommon but can produce multiple polypoid lesions. Melanoma has the greatest tendency to spread to the gallbladder (see Fig. 2-19), and detection of gallbladder polyps should be viewed with a high level of suspicion in patients with a history of melanoma. Generally there will be other evidence of metastatic disease in the liver, lymph nodes, or elsewhere in the abdomen.

It has been well established that polypoid lesions of the gallbladder wall that are 5 mm or less require no further evaluation or therapy. Lesions that are between 5 and 10 mm should be monitored to ensure their stability, realizing that the yield of follow-up studies will be very low. If small polyps are multiple, they are almost certainly cholesterol polyps and can be ignored. Lesions that are larger than 10 mm should probably be removed because of the possibility of cancer and the low risk of cholecystectomy. It should be recognized that most polyps that are just slightly larger than 10 mm will still be benign, but as polyps enlarge, the risk of malignancy increases progressively.

ADENOMYOMATOSIS

Adenomyomatosis is one of two forms of hyperplastic cholecystoses (cholesterolosis is the other). Like cholesterolosis, the etiology is unknown. Pathologically, adenomyomatosis is characterized by mucosal hyperplasia

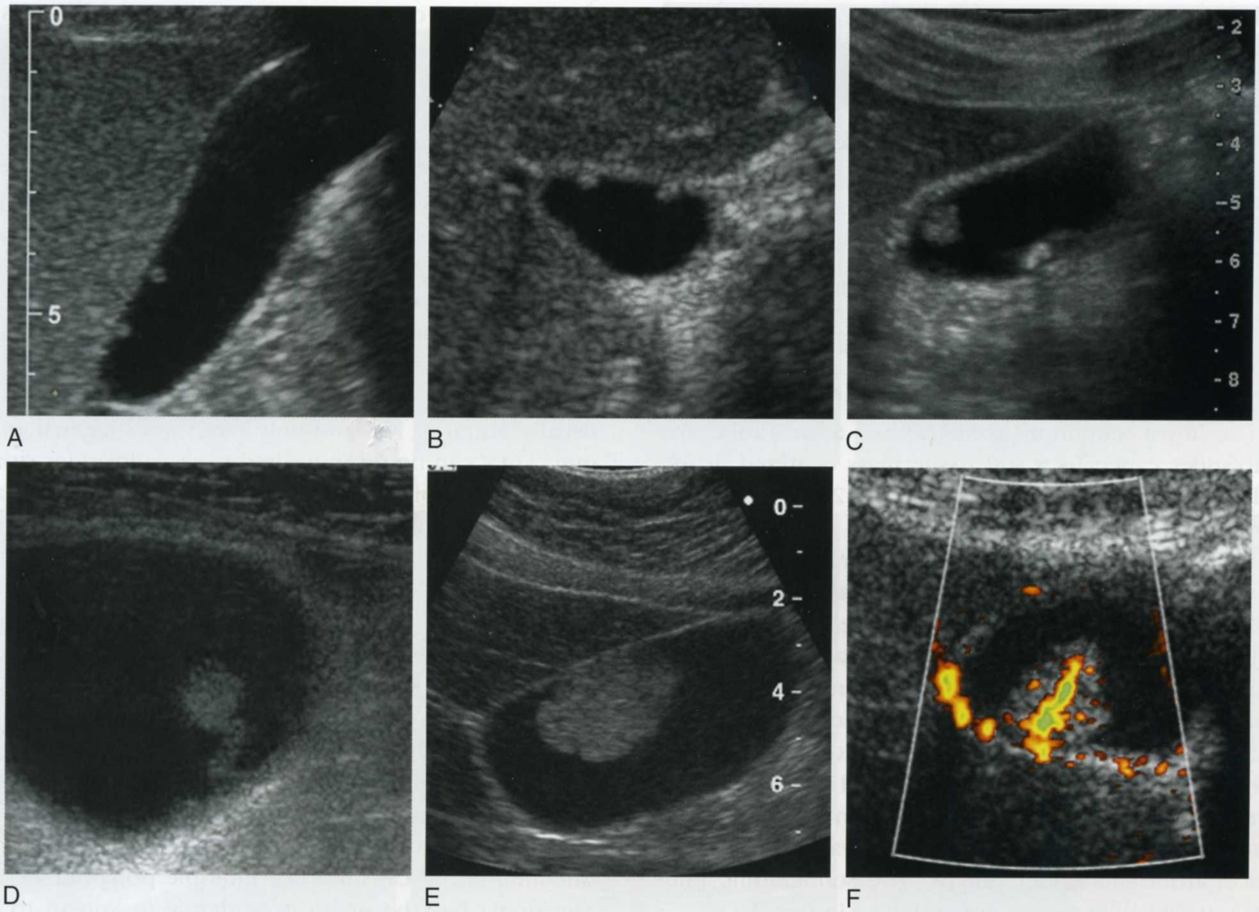


Figure 2-18 Gallbladder polyps in different patients. Longitudinal (**A**) and transverse (**B**) views show two small (<5 mm) non-shadowing polypoid defects along the non-dependent portion of the gallbladder typical of cholesterol polyps. **C,** Oblique view shows a stone in the dependent portion and a non-shadowing polypoid filling defect in the non-dependent portion. This is slightly larger than expected for a typical cholesterol polyp but demonstrates the typical "ball on the wall" sign. **D,** Unusual case showing the stalk of a cholesterol polyp. **E,** Three-centimeter polyp that was pathologically proven to represent an adenoma. **F,** Color Doppler view shows the vascular pedicle of a polyp, which helps to distinguish this from tumefactive sludge.

Figure 2-19 Metastatic melanoma. Longitudinal view of the gallbladder shows several polypoid lesions in a patient with widely metastatic melanoma. Gallbladder wall edema is also present owing to portal hypertension caused by diffuse liver metastases.

and thickening of the muscular layer of the gallbladder. Mucosal herniations into the muscular layer are called Rokitansky-Aschoff sinuses, and they frequently contain cholesterol crystals. Adenomyomatosis is unrelated to gallstones and occurs equally in men and women.

Sonographically, the cholesterol crystals deposited in the Rokitansky-Aschoff sinuses result in bright reflections and short comet-tail artifacts arising from the gallbladder wall (see Fig. 2-20A to C). The comet-tail artifact is the most obvious finding in many cases of adenomyomatosis and is almost exclusively seen along the near wall of the gallbladder. This does not reflect focal disease but instead occurs because the artifact is only visible when it is displayed in the anechoic background of intraluminal bile behind the near wall and not visible in the echogenic background of the tissues deep to the back

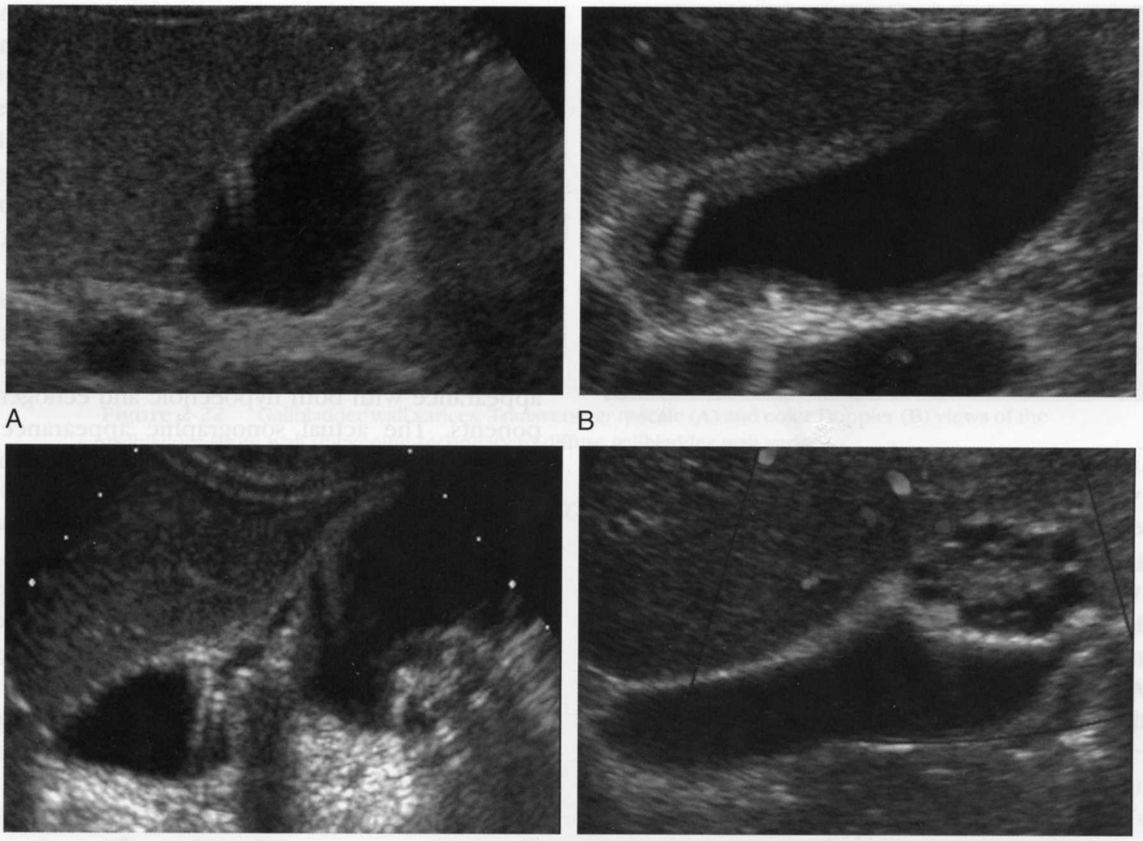


Figure 2-20 Adenomyomatosis in different patients. **A,** Typical example showing comet-tail artifacts from the superficial wall of the gallbladder but no other abnormalities. **B,** Focal thickening of the gallbladder wall near the gallbladder neck with associated comet-tail artifacts. **C,** Focal segmental wall thickening in the midportion of the gallbladder with associated waisting of the gallbladder contour and comet-tail artifacts. Stones are present in the fundal segment. **D,** Focal mass in the fundus of the gallbladder with multiple cystic spaces owing to unusually large Rokitansky-Aschoff sinuses.

wall. Rarely, large Rokitansky-Aschoff sinuses will be resolved as cystic or hypoechoic spaces in the gallbladder wall. Adenomyomatosis may also appear as diffuse wall thickening, focal segmental annular thickening (see Fig. 2-20C), or a localized mass (see Fig. 2-20D). In many cases ultrasound will show such characteristic findings that the diagnosis is unequivocal. However, when the diagnosis of adenomyomatosis is in doubt, an oral cholecystogram can be obtained because it may demonstrate the Rokitansky-Aschoff sinuses and establish the diagnosis more definitively.

Box 2-4 Causes of Gallbladder Masses

COMMON	UNCOMMON
Polyps	Metastases
Adenomyomatosis	Chronic cholecystitis
Gallbladder cancer	
Tumefactive sludge	

GALLBLADDER WALL THICKENING

As mentioned previously, the normal upper limit for the gallbladder wall is 3 mm. A large number of processes can result in a thickened gallbladder wall (Box 2-5). In addition to acute cholecystitis, gallbladder cancer, and adenomyomatosis, other abnormalities related to the biliary tract that can thicken the gallbladder wall are AIDS cholangiopathy and sclerosing cholangitis.

A large number of non-biliary processes can also cause gallbladder wall thickening due to edema (Fig. 2-21).

Box 2-5 Causes of Gallbladder Wall Thickening

BILIARY	NON-BILIARY
Cholecystitis	Hepatitis
Adenomyomatosis	Pancreatitis
Cancer	Heart failure
AIDS cholangiopathy	Hypoproteinemia
Sclerosing cholangitis	Cirrhosis
	Portal hypertension
	Lymphatic obstruction

Interestingly, non-biliary-related edema of the gallbladder wall usually produces more marked thickening than does acute cholecystitis. Hypoproteinemia (from cirrhosis, nephrotic syndrome, etc.), congestive heart failure, venous congestion from portal hypertension, lymphatic obstruction from portal lymph node disease, and adjacent inflammatory processes such as pancreatitis are all potential causes. Hepatitis is another cause of gallbladder wall thickening that is often overlooked, despite the fact that it can cause marked thickening (see Fig. 2-21C). This may be due to the adjacent inflammation of the liver or excretion of the virus in the bile and direct infection of the gallbladder. Hepatitis also frequently causes gallbladder contraction. Gallbladder varices can also occur in patients with portal hypertension and can simulate wall thickening on gray-scale imaging but should be readily distinguishable on color Doppler imaging (Fig. 2-22).

Most non-biliary causes of gallbladder wall thickening produce concentric thickening that may be uniform in echogenicity or may have a regular or irregular layered appearance with both hypoechoic and echogenic components. The actual sonographic appearance of the thickened wall is not helpful in distinguishing acute cholecystitis from non-biliary thickening. However, in most cases the clinical setting and the presence or absence of a sonographic Murphy's sign can help to make the diagnosis. In some instances, associated sonographic signs can be very useful. For instance, heart failure often produces abnormally pulsatile portal venous flow and cirrhosis produces secondary signs of portal hypertension and a nodular liver surface.

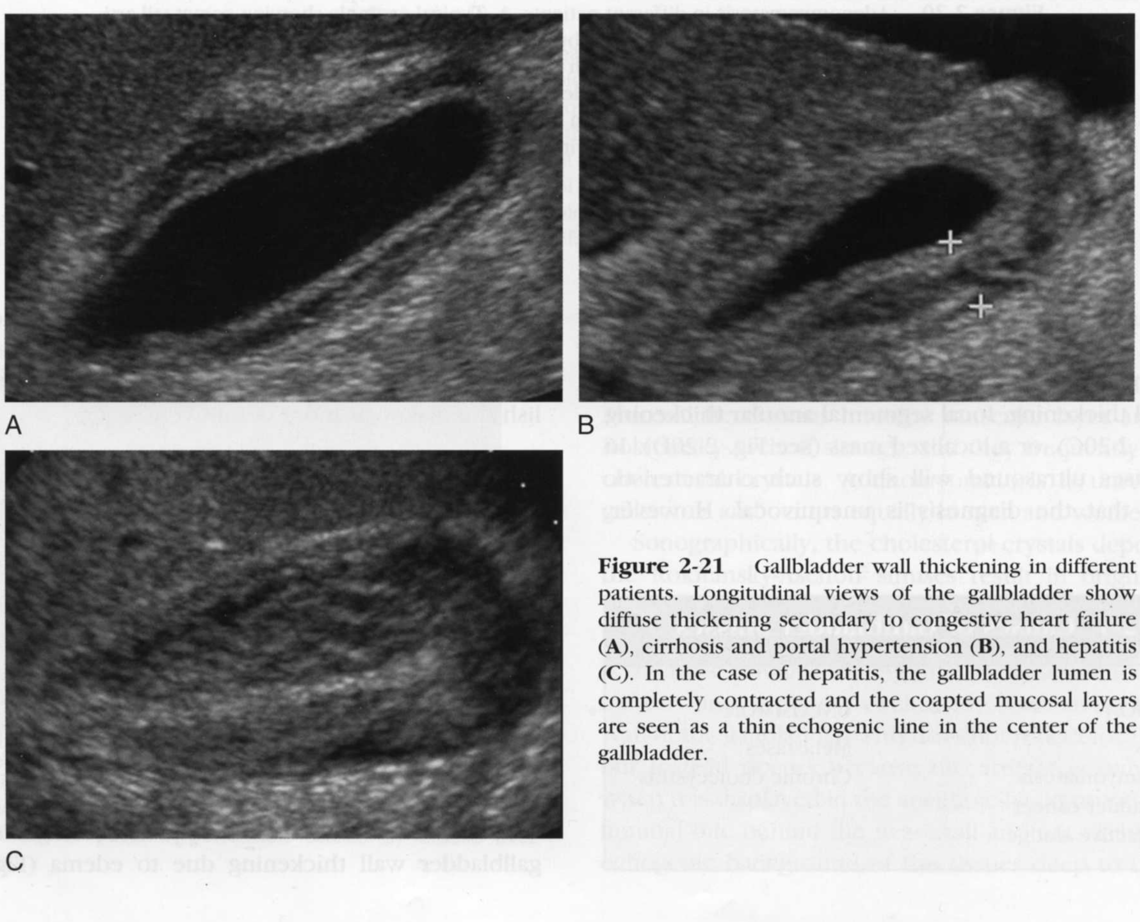
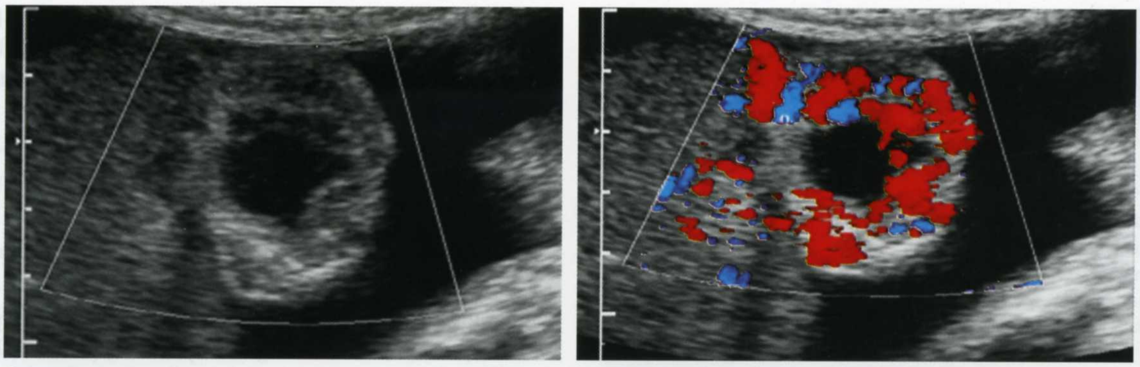


Figure 2-21 Gallbladder wall thickening in different patients. Longitudinal views of the gallbladder show diffuse thickening secondary to congestive heart failure (**A**), cirrhosis and portal hypertension (**B**), and hepatitis (**C**). In the case of hepatitis, the gallbladder lumen is completely contracted and the coapted mucosal layers are seen as a thin echogenic line in the center of the gallbladder.



A B

Figure 2-22 Gallbladder wall varices. Transverse gray-scale (**A**) and color Doppler (**B**) views of the gallbladder show wall thickening secondary to diffuse gallbladder wall varices.

PORCELAIN GALLBLADDER

Extensive calcification of the gallbladder produces a brittle bluish wall that has led to the term *porcelain gallbladder*. It is associated with chronic gallbladder inflammation, and 95% of the cases have gallstones. The clinical significance of porcelain gallbladder is the increased risk of gallbladder carcinoma. Estimates of this risk range from 13% to 61%. Because many uncomplicated and occult cases of porcelain gallbladder probably never come to clinical attention, the true incidence of carcinoma in this condition is probably overestimated in the literature. Nonetheless, most authorities would still recommend prophylactic cholecystectomy unless there are medical contraindications to surgery.

When the gallbladder wall is heavily calcified and the wall is diffusely involved, it will appear as an echogenic arc with dense posterior shadowing (Fig. 2-23A). Less extensive calcification will produce only partial shadowing so that the back wall of the gallbladder remains visible (see Fig. 2-23B). In early cases, only segments of the gallbladder wall may be affected. Given the increased risk of gallbladder carcinoma, whenever wall calcification is detected, a careful search should be made for evidence of malignancy (see Fig. 2-23C).

The major differential diagnosis for porcelain gallbladder is an entirely stone-filled gallbladder and

A B C

Figure 2-23 Porcelain gallbladder in different patients. **A,** Transverse view shows an echogenic superficial gallbladder wall with complete shadowing of the remainder of the gallbladder lumen and back wall. **B,** Longitudinal view of the gallbladder shows an echogenic superficial wall with shadowing of the deep gallbladder wall in the region of the fundus but sound penetration and visualization of the back wall in the body of the gallbladder *(arrows).* **C,** Large mass *(cursors)* caused by gallbladder carcinoma that has engulfed displaced areas of echogenic gallbladder wall calcification as well as a gallstone *(arrow).*

Table 2-3 Causes of Shadowing from Gallbladder Fossa

	Shadow	Wall-Echo-Shadow Complex	Back Wall
Gallbladder full of stones	Usually clean	Often	Not seen
Porcelain gallbladder	Variable	Rare	May be seen
Intramural gas	Usually dirty	Rare	May be seen

emphysematous cholecystitis. If a wall-echo-shadow complex is seen, then it is almost certainly a stone-filled gallbladder. If the back wall of the gallbladder is visible, then a gallbladder filled with stones can be excluded. If ring-down artifact is detected, emphysematous cholecystitis can be diagnosed. In cases where it is not possible to distinguish these three possibilities sonographically, abdominal radiographs and/or CT will be helpful. Table 2-3 summarizes the causes of shadowing from the gallbladder fossa.

Key Features

- Gallstones appear as mobile, dependent, shadowing echogenic structures in the gallbladder lumen. Sonography is the most accurate means of detecting gallstones.
- The wall-echo-shadow complex is a sign of a completely stone-filled gallbladder.
- Sonography is the method of choice in the initial evaluation of patients with suspected acute cholecystitis. Findings include gallstones, wall thickening, gallbladder enlargement, impacted stone, pericholecystic fluid, and a sonographic Murphy sign.
- Gallbladder cancer typically presents late as a mass obliterating the gallbladder and engulfing gallstones. Wall thickening and intraluminal masses are less common findings.
- Cholesterolosis is a benign, usually asymptomatic condition that may produce cholesterol polyps, which are usually small and are the most common polypoid lesion of the gallbladder wall. They appear as a non-mobile, non-shadowing "ball on the wall."
- Adenomyomatosis is a benign, usually asymptomatic condition that may produce focal or diffuse wall thickening. Cholesterol crystals deposited in Rokitansky-Aschoff sinuses are a characteristic finding.
- Gallbladder wall thickening is a nonspecific finding with a lengthy differential diagnosis. Extensive wall thickening is usually due to systemic edema-forming states rather than cholecystitis.
- Calcification of the gallbladder wall places a patient at a significantly increased risk of gallbladder cancer.

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