Chapter 3

Pathology of the gallbladder and biliary tree

CHAPTER CONTENTS

Ultrasound is an essential first-line investigation in suspected gallbladder and biliary duct disease. It is highly sensitive, accurate and comparatively cheap and is the imaging modality of choice.[1] Gallbladder pathology is common and is asymptomatic in over 13% of the population.[2]

CHOLELITHIASIS

The most commonly and reliably identified gallbladder pathology is that of gallstones (see Table 3.1). More than 10% of the population of the UK have gallstones. Many of these are asymptomatic, which is an important point to remember. When

Table 3.1 Gallstones—clinical features

Often asymptomatic
Biliary colic—RUQ pain, fatty intolerance
+ve ultrasound Murphy's sign (if inflammation is present)
Recurring (RUQ) pain in chronic cholecystitis
Jaundice (depending on degree of obstruction)
Fluctuating fever (if infection is present)

RUQ=right upper quadrant.

scanning a patient with abdominal pain it should not automatically be assumed that, when gallstones are present, they are responsible for the pain. It is not uncommon to find further pathology in the presence of gallstones and a comprehensive upper-abdominal survey should always be carried out.

Gallstones are associated with a number of conditions. They occur when the normal ratio of components making up the bile is altered, most commonly when there is increased secretion of cholesterol in the bile. Conditions which are associated with increased cholesterol secretion, and therefore the formation of cholesterol stones, include obesity, diabetes, pregnancy and oestrogen therapy. The incidence of stones also rises with age, probably because the bile flow slows down.

An increased secretion of bilirubin in the bile, as in patients with cirrhosis for example, is associated with pigment (black or brown) stones.

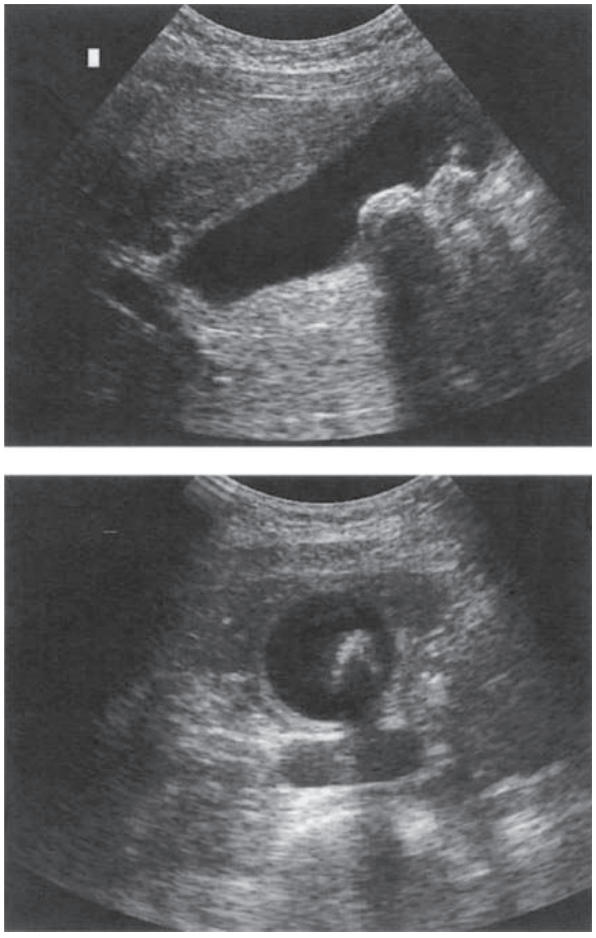

Figure 3.1 (A) Longitudinal section and (B) transverse section images of the gallbladder containing stones with strong distal acoustic shadowing. Note the thickened gallbladder wall.

Ultrasound appearances

There are three classic acoustic properties associated with stones in the gallbladder; they are *highly reflective, mobile* and cast a *distal acoustic shadow*. In the majority of cases, all these properties are demonstrated (Figs 3.1–3.3).

Shadowing

The ability to display a shadow posterior to a stone depends upon several factors:

- The reflection and absorption of sound by the stone. This is fairly consistent, regardless of the composition of the stone.
- The size of the stone in relation to the beam width. A shadow will occur when the stone

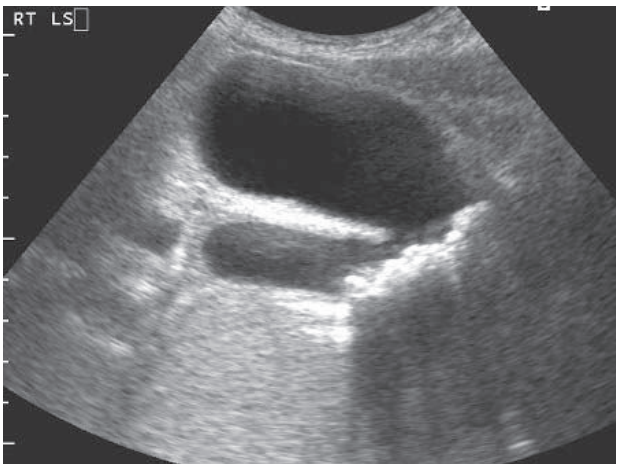

Figure 3.2 Multiple tiny stones combining to form a posterior band of shadow.

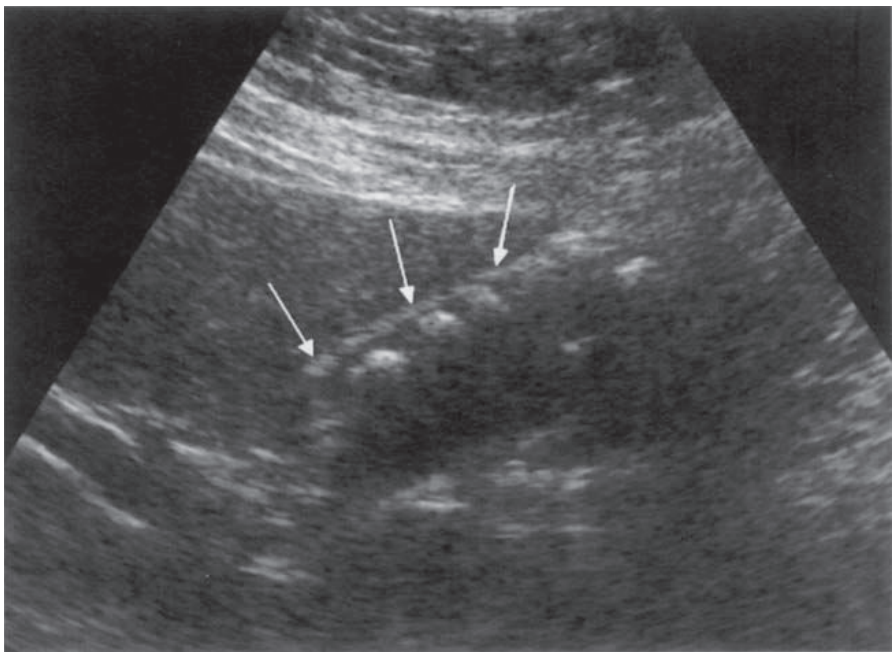

Figure 3.3 Floating stones just below the anterior gallbladder wall.

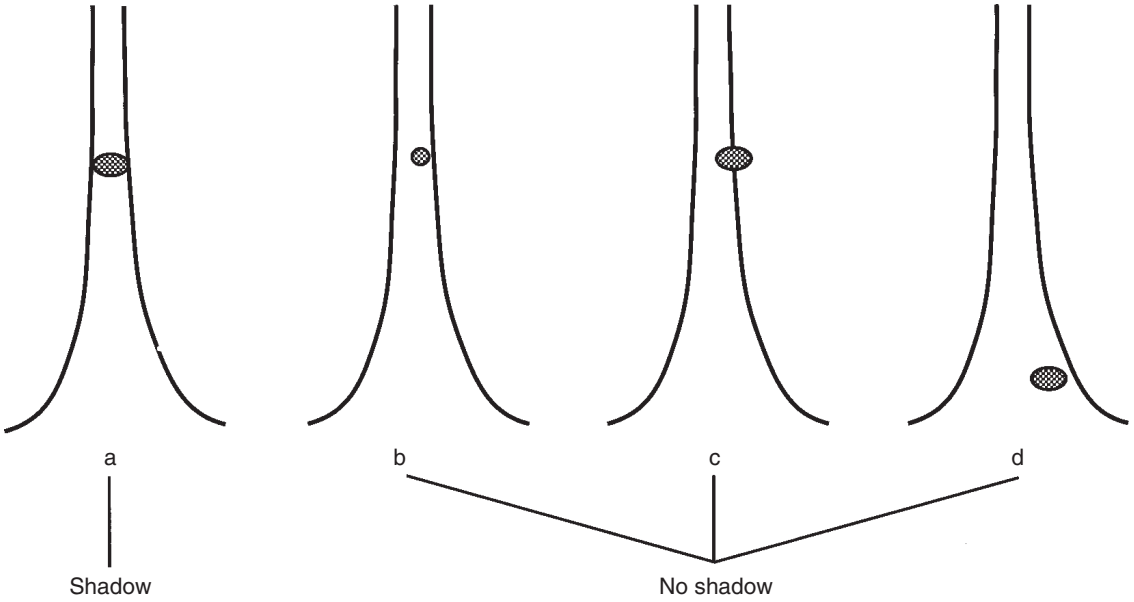

Figure 3.4 (a) A shadow will be displayed from the stone, which occupies the width of the beam. (b) The stone is smaller than the beam. (c) The stone is large, but just out of the beam. (d) The stone is large, but outside the focal zone, where the beam is wider.

fills the width of the beam (Fig. 3.4). This will happen easily with large stones, but a small stone may occupy less space than the beam, allowing sound to continue behind it, so a shadow is not seen. Small stones must therefore be within the focal zone (narrowest point) of the beam and in the centre of the beam to shadow (Fig. 3.5). Higher-frequency transducers have better resolution and are therefore more likely to display fine shadows than lower frequencies.

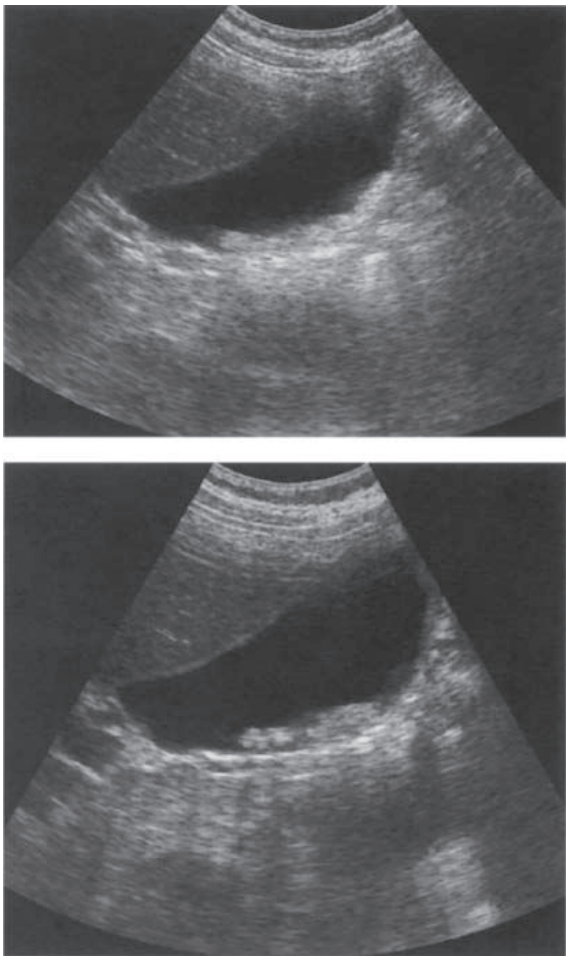

Figure 3.5 (A) The stones are outside the focal zone, and do not appear to shadow well. (B) The focal zone has been moved to the level of the stones, allowing the shadow to be displayed.

- The machine settings must be compatible with demonstrating narrow bands of shadowing. The fluid-filled gallbladder often displays posterior enhancement, or increased through-transmission. If the echoes posterior to the gallbladder are 'saturated' this will mask fine shadows. Turn the overall gain down to display this better (Fig. 3.6). Some image-processing options may reduce the contrast between the shadow and the surrounding tissue, so make sure a suitable dynamic range and image programme are used.
- Bowel posterior to the gallbladder may cast its own shadows from gas and other contents, which makes the gallstone shadow difficult to demonstrate (Fig. 3.7B). This is a particular problem with stones in the common bile duct (CBD). Try turning the patient to move the gallbladder away from the bowel. The shadow cast by gas in the duodenum, which contains reverberation, should usually be distinguishable from that cast by a gallstone, which is sharp and clean.

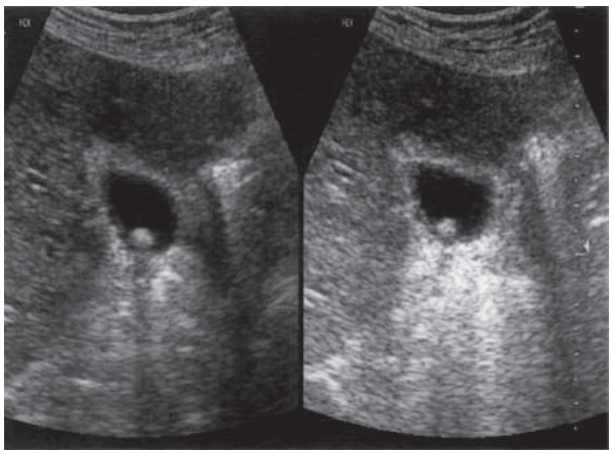

Figure 3.6 The shadow behind the gallstone (left image) is obscured if the time gain compensation is set too high behind the gallbladder (right image).

Reflectivity

The reflective nature of the stone is enhanced by its being surrounded by echo-free bile. In a contracted gallbladder the reflectivity of the stone is often not appreciated because the hyperechoic gallbladder wall is collapsed over it.

Some stones are only poorly reflective, but should still cause a distal acoustic shadow.

Mobility

Most stones are gravity-dependent and this may be demonstrated by scanning the patient in an erect position (Fig. 3.7), when a mobile calculus will drop from the neck or body of the gallbladder to lie in the fundus. Some stones will float, however, forming a reflective layer just beneath the anterior gallbladder wall with shadowing that obscures the rest of the lumen (Fig. 3.3).

When the gallbladder lumen is contracted, either due to physiological or pathological reasons,

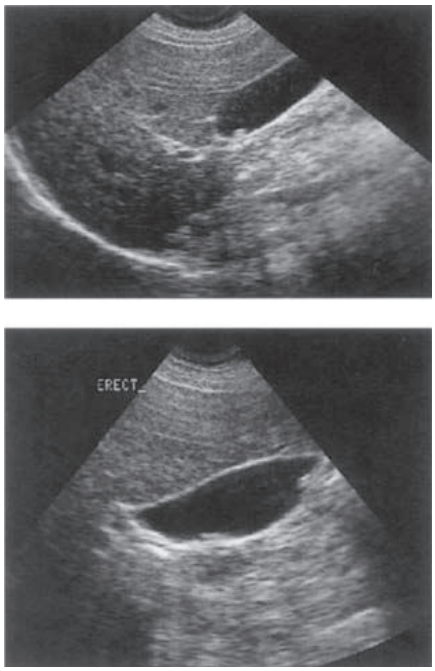

Figure 3.7 (A) Supine and (B) erect views demonstrating movement of the tiny stone into the fundus of the gallbladder. Note how duodenum posterior to the gallbladder masks the shadow in the erect state.

any stones present are unable to move and this is also the case in a gallbladder packed with stones.

Occasionally a stone may become impacted in the neck, and movement of the patient is unable to dislodge it. Stones lodged in the gallbladder neck or cystic duct may result in a permanently contracted gallbladder, a gallbladder full of fine echoes due to inspissated (thickened) bile (Fig. 3.8) or a distended gallbladder due to a mucocoele (see below).

Choledocholithiasis

Stones may pass from the gallbladder into the common duct, or may develop *de novo* within the common duct. Stones in the CBD may obstruct the drainage of bile from the liver, causing obstructive jaundice.

Due to shadowing from the duodenum, ductal stones are often not demonstrated with ultrasound without considerable effort. Usually they are accompanied by stones in the gallbladder and a degree of dilatation of the CBD. In these cases the operator can usually persevere and demonstrate the stone at the lower end of the duct. However, the duct may be dilated but empty, the stone having recently passed.

Stones may be seen to move up and down a dilated duct. This can create a ball-valve effect so that obstruction may be intermittent.

It is not unusual to demonstrate a stone in the CBD without stones in the gallbladder, a phenomenon which is also well-documented following cholecystectomy (Fig. 3.9). This may be due to a single calculus in the gallbladder having moved into the duct, or stone formation within the duct.

It is also important to remember that stones in the CBD may be present *without* duct dilatation and attempts to image the entire common duct

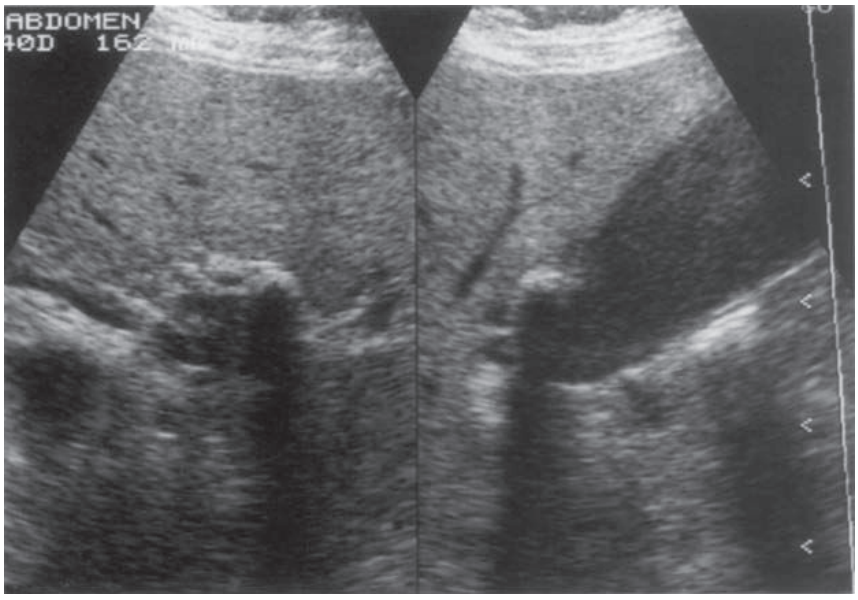

Figure 3.8 Stone impacted in the neck of the gallbladder. The left-hand image is a TS through the neck demonstrating the impacted stone. The right-hand image demonstrates the dilated gallbladder containing fine echoes from inspissated bile.

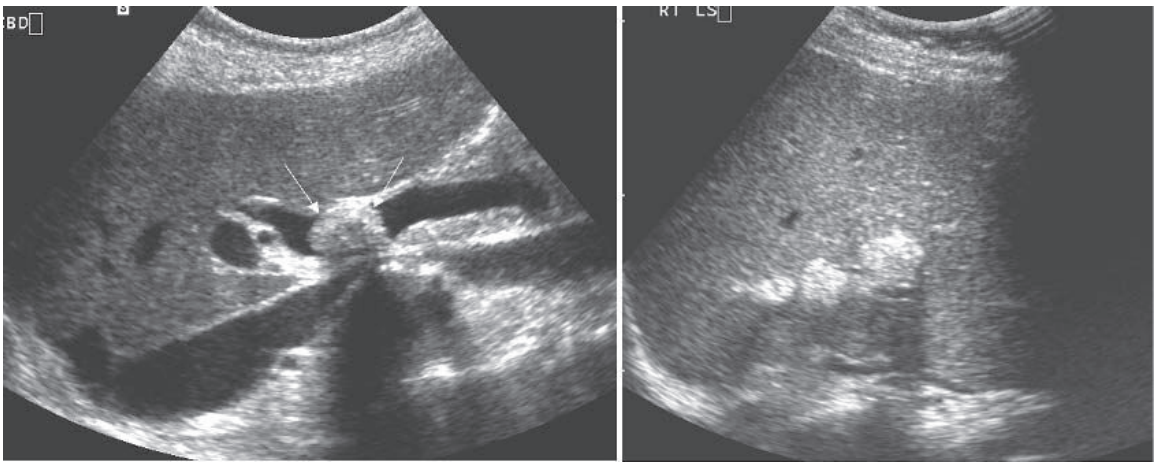

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Figure 3.9 (A) A stone in a dilated common bile duct (CBD) with posterior shadowing. The gallbladder was dilated but did not contain stones. (B) Stone formation in the intrahepatic ducts.

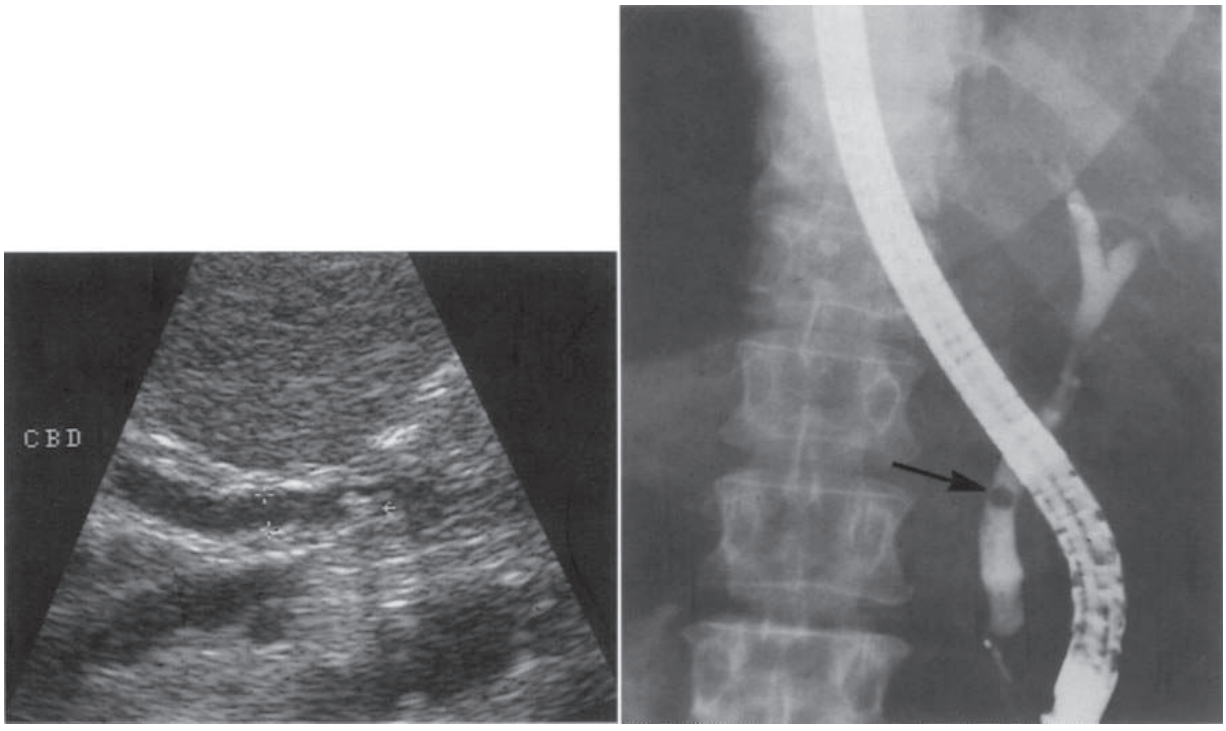

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Figure 3.10 (A) Small stone in the CBD causing intermittent obstruction. At the time of scanning, the CBD was normal in calibre at 5 mm. The duct walls are irregular, consistent with cholangitis. (B) Endoscopic cholangiopancreatography (ERCP) of a stone in a normal-calibre (5 mm) duct.

with ultrasound should *always* be made, even if it is of normal calibre at the porta (Fig. 3.10).

Other ultrasound signs to look for are shown in Table 3.2.

Possible complications of gallstones are outlined in Figure 3.11A. In rare cases, stones may perforate the inflamed gallbladder wall to form a fistula into the small intestine or colon. A large stone

Table 3.2 Gallstones—other ultrasound signs to look for

Acute or chronic cholecystitis
Complications of cholecystitis, e.g. pericholecystic collection
Stone impacted in the neck of gallbladder—mucocoele, hydrops
CBD stones
Biliary obstruction—dilatation of the CBD and/or intrahepatic ducts
Pancreatitis
Other causes of RUQ pain unrelated to stones

CBD = common bile duct.

passing into the small intestine may impact in the ileum, causing intestinal obstruction (Fig. 3.11B).

Biliary reflux and gallstone pancreatitis

A stone may become lodged in the distal common bile duct near the ampulla. If the main pancreatic duct joins the CBD proximal to this, bile and pancreatic fluid may reflux up the pancreatic duct, causing inflammation and severe pain.

Reflux up the common bile duct may also result in ascending cholangitis, particularly if the obstruction is prolonged or repetitive. Cholangitis may result in dilated bile ducts with mural irregularity on ultrasound, but endoscopic retrograde cholangiopancreatography (ERCP) is usually superior in demonstrating intrahepatic ductal changes of this nature.

Bile reflux is also associated with anomalous cystic duct insertion (Fig. 3.12), which is more readily recognized on ERCP than ultrasound.

Further management of gallstones

ERCP demonstrates stones in the duct with greater accuracy than ultrasound, particularly at the lower end of the CBD, which may be obscured by duodenal gas and also allows for sphincterotomy and stone removal.

Laparoscopic cholecystectomy is the preferred method of treatment for symptomatic gallbladder disease in an elective setting and has well-recognized benefits over open surgery in experienced

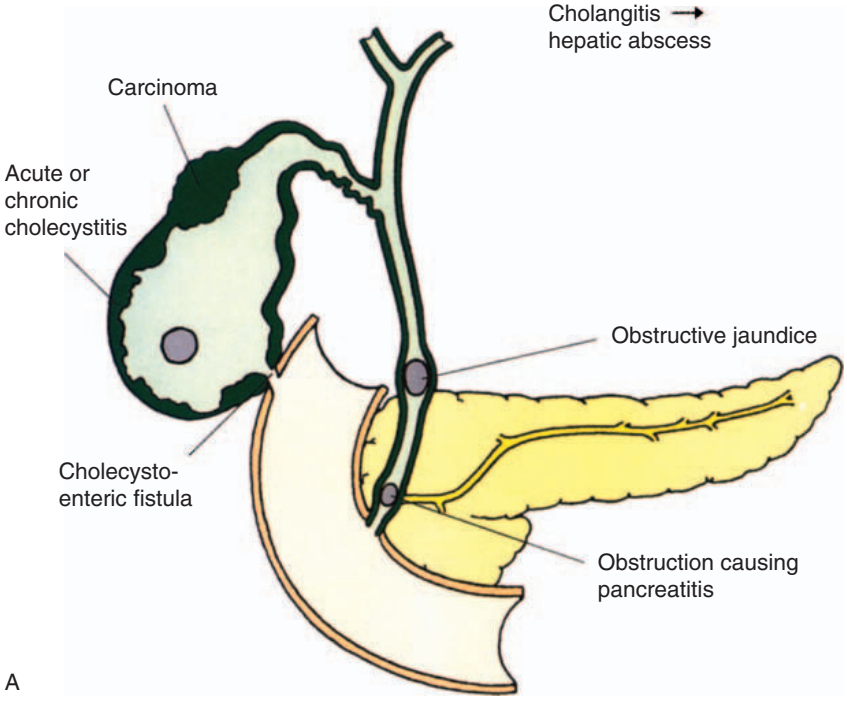
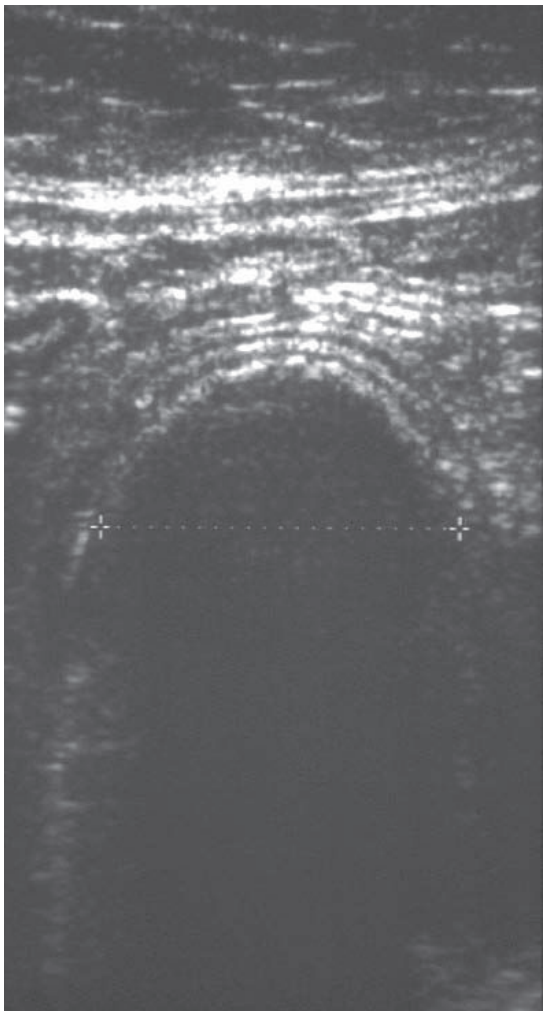


Figure 3.11 (A) The possible complication of gallstones.

(Continued)



B

Figure 3.11 cont'd (B) Gallstone Ileus.

hands. Acute cholecystitis is also increasingly managed by early laparoscopic surgery, with a slightly higher rate of conversion to open surgery than elective cases.[3] Laparoscopic ultrasound may be used as a suitable alternative to operative cholangiography to examine the common duct for residual stones during surgery.[4] Both ultrasound and cholescintigraphy are used in monitoring postoperative biliary leaks or haematoma (Fig. 3.13).

Other, less common options include dissolution therapy and extracorporeal shock wave lithotripsy (ESWL). However, these treatments are often only partially successful, require careful patient selection and also run a significant risk of stone recurrence.[5]

ENLARGEMENT OF THE GALLBLADDER

Because of the enormous variation in size and shape of the normal gallbladder, it is not possible to diagnose pathological enlargement by simply using measurements. Three-dimensional techniques may prove useful in assessing gallbladder volume[6] but this is a technique which is only likely to be clinically useful in a minority of patients with impaired gallbladder emptying.

An enlarged gallbladder is frequently referred to as *hydropic*. It may be due to obstruction of the cystic duct (see below) or associated with numerous disease processes such as diabetes, primary sclerosing cholangitis, leptospirosis or in response to some types of drug.

A pathologically dilated gallbladder, as opposed to one which is physiologically dilated, usually assumes a more rounded, tense appearance.

Mucocoele of the gallbladder

If the cystic duct is obstructed, usually by a stone which has failed to pass through to the CBD, the normal flow of bile from the gallbladder is interrupted. Chronic cystic duct obstruction causes the bile to be replaced by mucus secreted by the lining of the gallbladder, resulting in a mucocoele. The biliary ducts remain normal in calibre.

If the gallbladder looks dilated, make a careful search for an obstructing lesion at the neck; a stone in the cystic duct is more difficult to identify on ultrasound as it is not surrounded by echo-free bile (Fig. 3.8).

Mirizzi syndrome

Mirizzi syndrome is a rare cause of biliary obstruction in which the cystic duct is obstructed by a stone, which in combination with a surrounding inflammatory process compresses and obstructs the common hepatic duct, causing distal biliary duct dilatation. This is associated with a low insertion of the cystic duct into the common hepatic duct. Occasionally a fistula forms between the hepatic duct and the gallbladder due to erosion of the duct wall by the stone. Ultimately this may lead to gallstone ileus—small-bowel obstruction resulting from migration of a large stone through

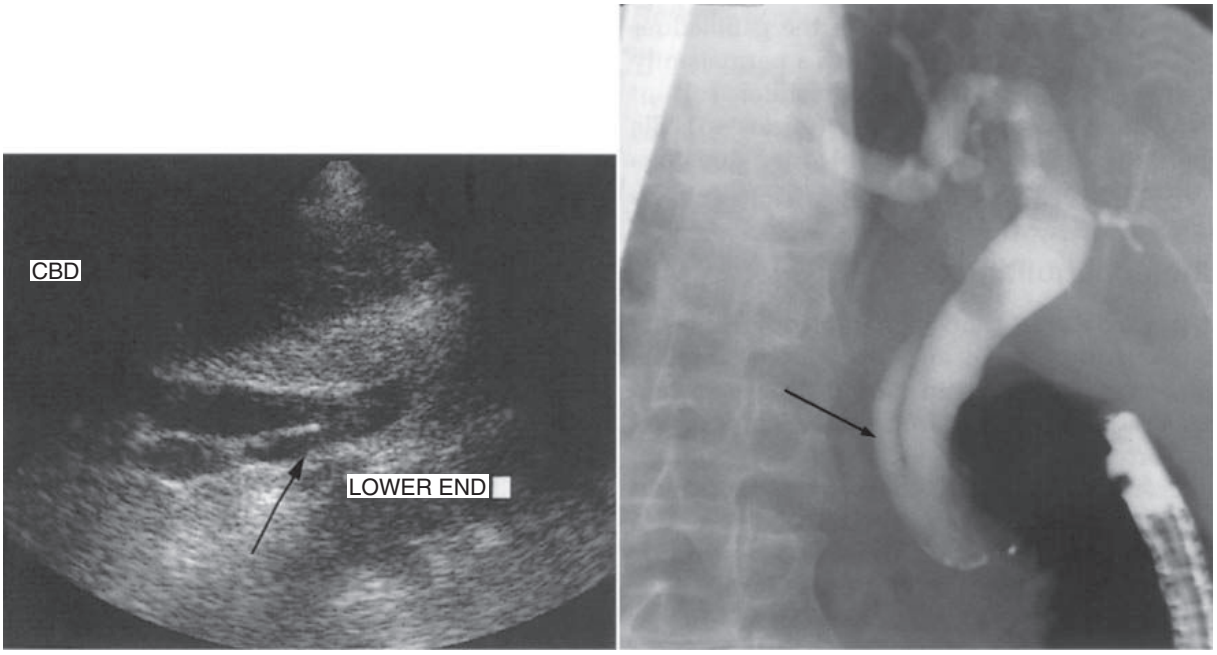


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Figure 3.12 (A) Anomalous insertion of the cystic duct (arrow) into the lower end of the CBD. (B) Appearances of case in (A) are confirmed on ERCP. A stone is also present in the duct.

the cholecystoenteric fistula (Fig 3.11B). If the condition is not promptly diagnosed, recurring cholangitis leading to secondary biliary cirrhosis may result.

On ultrasound the gallbladder may be either enlarged or contracted and contain debris. A stone impacted at the neck may be demonstrated together with dilatation of the intrahepatic ducts with a normal-calibre lower common duct (Fig. 3.14). The diagnosis, however, is difficult, and ERCP is generally the most successful modality. Although rare, it is an important diagnosis as cholecystectomy in these cases has a higher rate of operative and post-operative complications.[7]

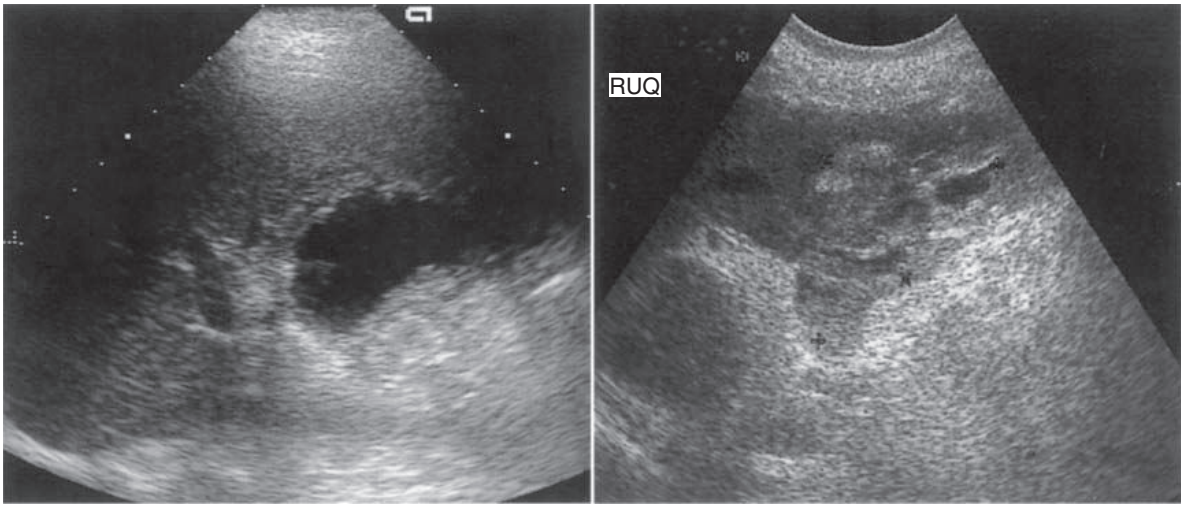

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Figure 3.13 (A) Postoperative bile collection in the gallbladder bed. (B) Hyperechoic, irregular mass in the gallbladder bed which represents a resolving haematoma after laparoscopic cholecystectomy.

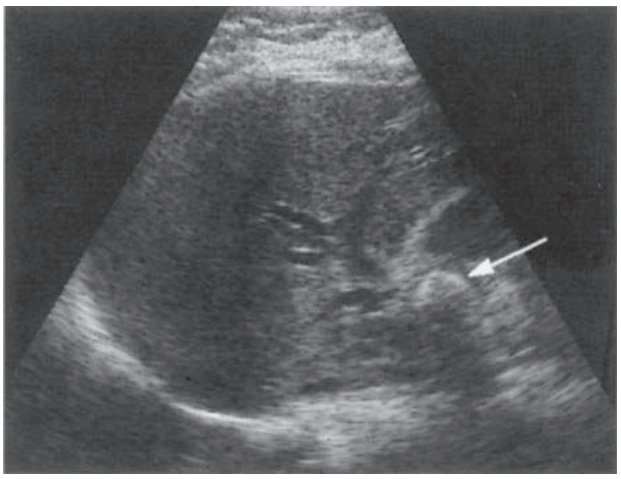

Figure 3.14 Mirizzi syndrome: a large stone in the neck of the gallbladder (arrow) is compressing the bile duct, causing intrahepatic duct dilatation. The lower end of the CBD remains normal in calibre.

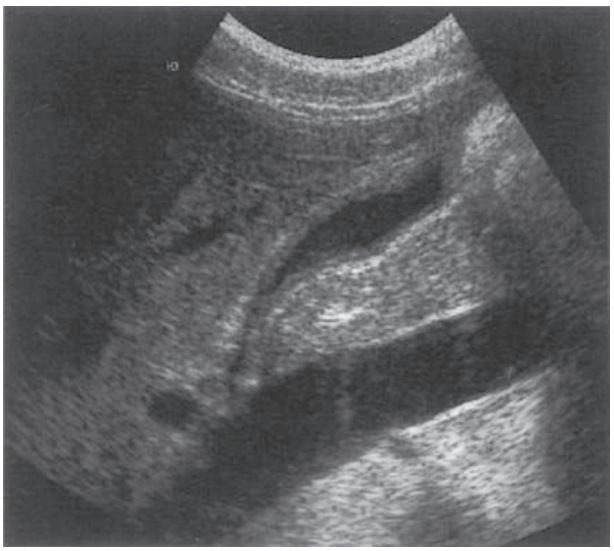

Figure 3.15 Postprandial, contracted gallbladder, with consequently thickened wall.

THE CONTRACTED OR SMALL GALLBLADDER

Postprandial

The most likely cause is physiological and due to inadequate preparation. The normal gallbladder wall is thickened when contracted, and this must not be confused with a pathological process. Always enquire what the patient has recently eaten or drunk (Fig. 3.15).

Pathological causes of a small gallbladder

Most pathologically contracted gallbladders contain stones.

When the gallbladder cannot be identified, try scanning transversely through the gallbladder fossa, just caudal to the porta hepatis. Strong shadowing alerts the sonographer to the possibility of a contracted gallbladder full of stones. The reflective surface of the stones and distal shadowing are apparent and the anterior gallbladder wall can be demonstrated with correct focusing and good technique (Fig. 3.16).

Do not confuse the appearances of a previous cholecystectomy, when bowel in the gallbladder fossa casts a shadow, with a contracted, stone-filled gallbladder.

A less common cause of a small gallbladder is the *microgallbladder* associated with cystic fibrosis (Fig. 3.17). The gallbladder itself is abnormally small, rather than just contracted. Cystic fibrosis also carries an increased incidence of gallstones because of the altered composition of the bile and bile stasis and the wall might be thickened and fibrosed from cholecystitis.

PORCELAIN GALLBLADDER

When the gallbladder wall becomes calcified the resulting appearance is of a solid reflective structure causing a distal shadow in the gallbladder fossa (Fig. 3.18). This can be distinguished from a gallbladder full of stones where the wall can usually be seen anterior to the shadowing (Fig 3.16).

A porcelain gallbladder probably results from a gallbladder mucocoele—a long-standing obstruction of the cystic duct, usually from a stone. The bile inside the non-functioning gallbladder is gradually replaced by watery fluid, the wall becomes fibrotic and thickened and ultimately calcifies.

There is an association between porcelain gallbladder and gallbladder carcinoma, so a prophylactic cholecystectomy is usually performed to pre-empt malignant development.[8]

The shadowing from the anterior gallbladder wall obscures the gallbladder contents, and can mimic bowel in the gallbladder fossa. A plain X-ray also clearly demonstrates the porcelain gallbladder.

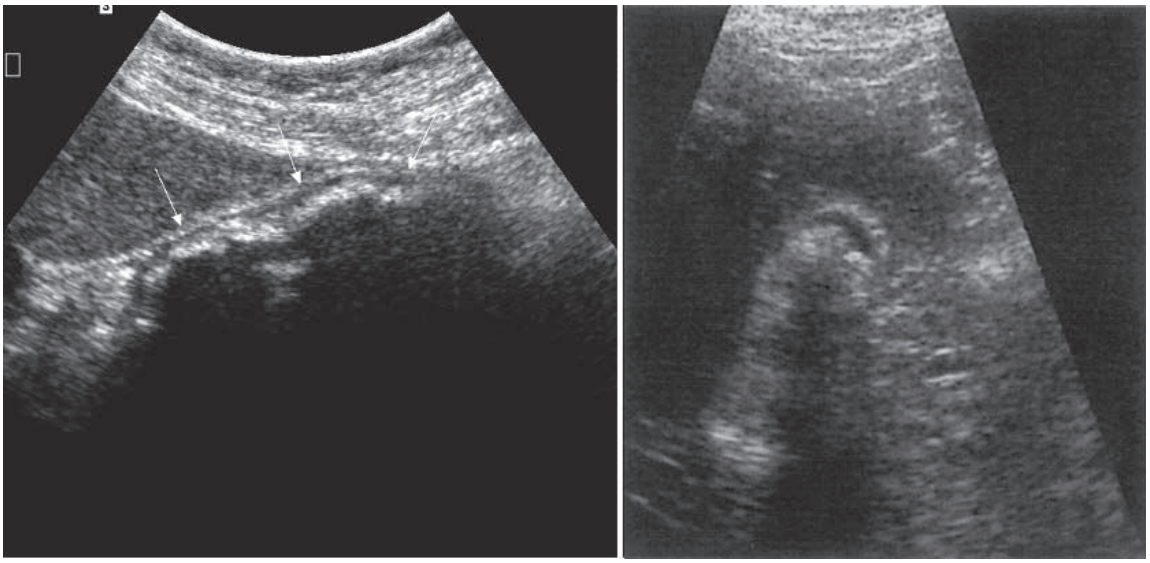

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Figure 3.16 (A) The gallbladder lumen is filled with stones, causing dense shadowing in the gallbladder fossa. The thickened gallbladder wall can be demonstrated separately (arrows) from the reflective surface of the stones. (B) A small layer of bile is visible between the stones and the anterior gallbladder wall.

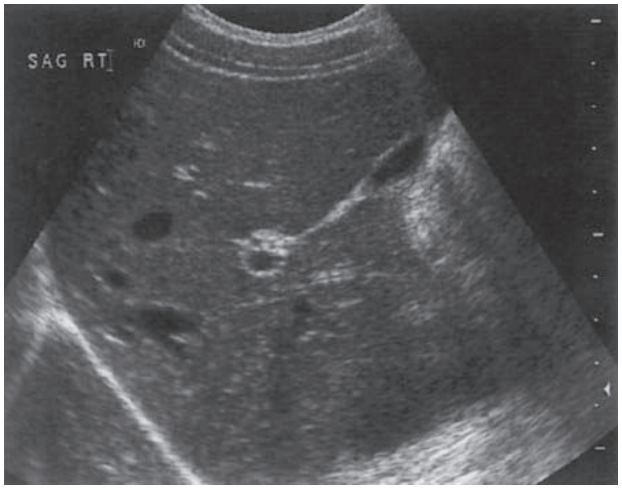


Figure 3.17 Microgallbladder in cystic fibrosis.

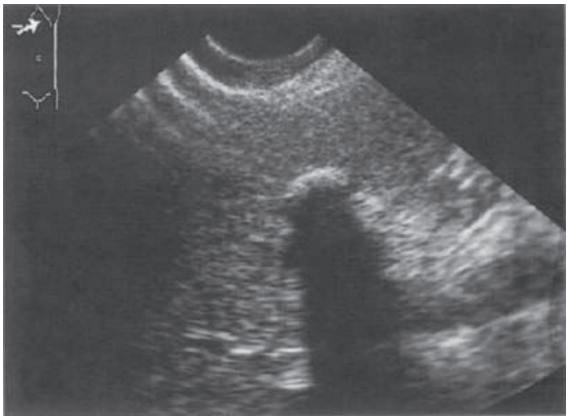


Figure 3.18 TS of a porcelain gallbladder demonstrating a calcified wall with strong acoustic shadowing.

HYPERPLASTIC CONDITIONS OF THE GALLBLADDER WALL

Adenomyomatosis

This is a non-inflammatory, hyperplastic condition which causes gallbladder wall thickening. It may be mistaken for chronic cholecystitis on ultrasound.

The epithelium which lines the gallbladder wall undergoes hyperplastic change, extending diverticula into the adjacent muscular layer of the wall. These diverticula, or sinuses (known as Rokitansky–Aschoff sinuses), are visible within the wall as fluid-filled spaces (Fig. 3.19), which can bulge eccentrically into the lumen, and may contain echogenic material or even (normally pigment) stones.

The wall thickening may be focal or diffuse, and the sinuses may be little more than hypoechoic

'spots' in the thickened wall, or may become quite large cavities in some cases.[9]

Deposits of crystals in the gallbladder wall frequently result in distinctive 'comet-tail' artefacts.

Often asymptomatic, this may present with biliary colic although it is unclear whether this is caused by co-existent stones. Its distinctive appearance allows the diagnosis to be made easily, whether or not stones are present.

Cholecystectomy is performed in symptomatic patients, usually those who also have stones. Although essentially a benign condition, a few cases of associated malignant transformation have been reported, usually in patients with asso-

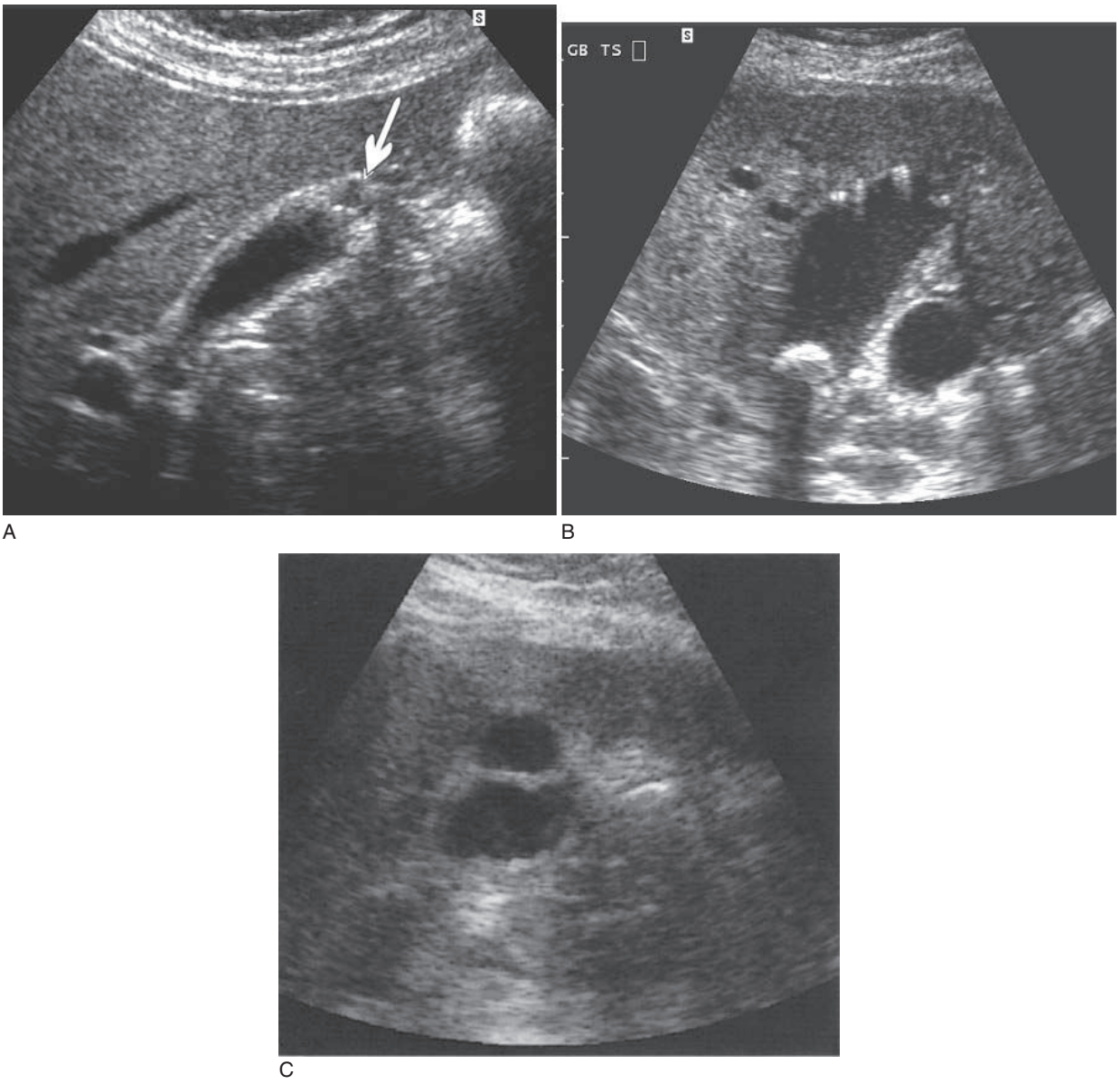


Figure 3.19 Adenomyomatosis: (A) LS demonstrating a thickened gallbladder wall with a small Rokitansky-Aschoff sinus (arrow) at the fundus. (B) TS demonstrating a stone and comet-tail artifacts from within the wall due to crystal deposits. (C) TS through a more advanced case of adenomyomatosis with a large Rokitansky–Aschoff sinus, giving the appearance of a 'double lumen'.

ciated anomalous insertion of the pancreatic duct.[10]

Polyps

Gallbladder polyps are usually asymptomatic lesions which are incidental findings in up to 5% of the population. Occasionally they are the cause of biliary colic. The most common type are cholesterol polyps. These are reflective structures which project into the gallbladder lumen but do not cast an acoustic shadow. Unless on a long stalk they will remain fixed on turning the patient and are therefore distinguishable from stones (Fig. 3.20).

There is an association between larger adenomatous gallbladder polyps and subsequent carcinoma, especially in patients over 50 years of age, so cholecystectomy is often advised (Fig. 3.20C). Smaller polyps of less than 1 cm in diameter may be safely monitored with ultrasound.[11] In particular, gallbladder polyps in patients with primary sclerosing cholangitis have a much greater likelihood of malignancy (40–60%).[12]

Cholesterolosis

Also known as the 'strawberry gallbladder', this gets its name because of the multiple tiny nodules on the surface of the gallbladder mucosal lining.

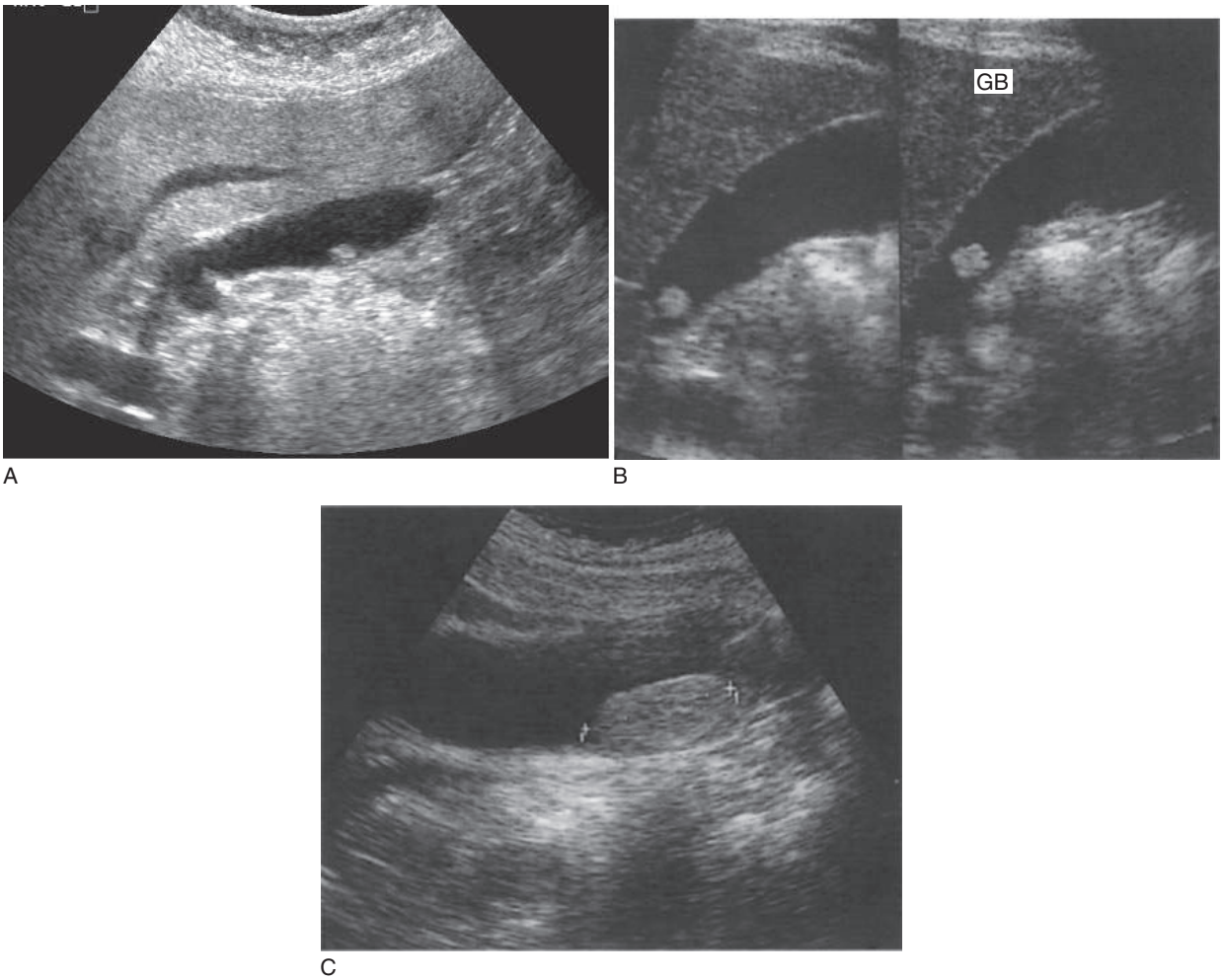


Figure 3.20 (A) Small polyp in the gallbladder lumen—no posterior shadowing is evident. (B) A gallbladder polyp on a stalk moves with different patient positions. (C) Large, fleshy gallbladder polyp.

These nodules are the result of a build-up of lipids in the gallbladder wall and are not usually visible on ultrasound. However in some cases, multiple polyps also form on the inner surface, projecting into the lumen, and are clearly visible on ultrasound (Fig. 3.21). Cholesterolosis may be asymptomatic, or may be accompanied by stones and consequently requires surgery to alleviate symptoms of biliary colic.

INFLAMMATORY GALLBLADDER DISEASE

Cholecystitis is usually associated with gallstones; the frictional action of stones on the gallbladder wall causes some degree of inflammation in almost all cases. The inner mucosa of the wall is injured, allowing the access of enteric bacteria. The inflammatory process may be long-standing and chronic, acute or a combination of acute inflammation on a chronic background.

Acute cholecystitis

Acute inflammation of the gallbladder presents with severe RUQ pain localized to the gallbladder area. The pain can be elicited by (gently!) pressing the gallbladder with the ultrasound transducer—a positive ultrasound Murphy's sign. (This sign, although a useful pointer to acute inflammation, is not specific and can frequently be elicited in other conditions, such as chronic inflammatory cases.)

On ultrasound, the gallbladder wall is thickened greater than 2 mm. This is not in itself a specific sign (see Table 3.3), but characteristically the thickening in acute cholecystitis is symmetrical, affecting the entire wall, and there is an echo-poor 'halo' around the gallbladder as a result of oedematous changes (Fig. 3.22). This is not invariable, however, and focal thickening may be present, or the wall may be uniformly hyperechoic in some cases. Pericholecystic fluid may also be present, and the inflammatory process may spread to the adjacent liver.

Colour or power Doppler can be helpful in diagnosing acute cholecystitis and in differentiating it from other causes of gallbladder wall thickening. Hyperaemia in acute cholecystitis can be demonstrated on colour Doppler around the thickened wall[13] (Fig. 3.23). In a normal gallbladder, colour Doppler flow may be seen around the gallbladder neck in the region of the cystic artery but not elsewhere in the wall. The increased sensitivity of power Doppler, as opposed to colour

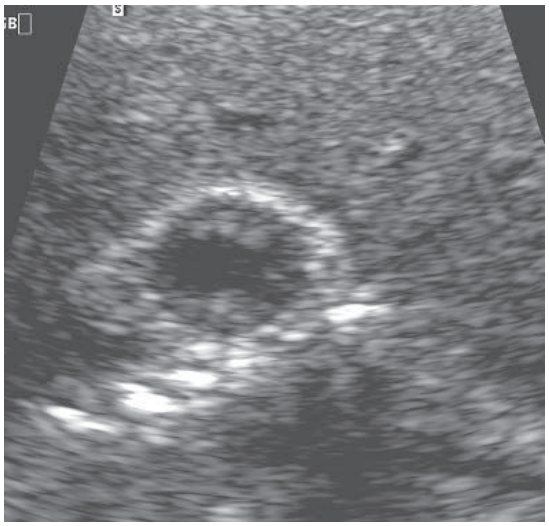


Figure 3.21 Cholesterolosis TS of the gallbladder demonstrating multiple tiny polyps in the gallbladder.

Table 3.3 Causes of a thickened gallbladder wall

Physiological
—Postprandial
Inflammatory
—Acute or chronic cholecystitis
—Sclerosing cholangitis
—Crohn's disease
—AIDS
Adjacent inflammatory causes
—Pancreatitis
—Hepatitis
—Pericholecystic abscesses
Non-inflammatory
—Adenomyomatosis
—Gallbladder carcinoma
—Focal areas of thickening due to metastases or polyps
—Leukaemia
Oedema
—Ascites from a variety of causes, including organ failure, lymphatic obstruction and portal hypertension
Varices
—Varices of the gallbladder wall in portal hypertension

Doppler, does enable the operator to demonstrate vascularity in the normal gallbladder wall and the operator should be familiar with normal appearances for the machine in use when making the diagnosis of acute cholecystitis[14] (Fig. 3.24).

Doppler can potentially distinguish acute inflammation from chronic disease.[15] However, false-positive results can be found in cases of pancreatitis and gallbladder carcinoma and the technique does not add significantly to the grey-scale image.

Complications may occur if the acute inflammation progresses (see below) due to infection, pericholecystic abscesses and peritonitis.

Further management of acute cholecystitis

In an uncomplicated acute cholecystitis, analgesia to settle the patient in the short term is followed by the removal of the gallbladder. Open surgery, which is increasingly reserved for the more

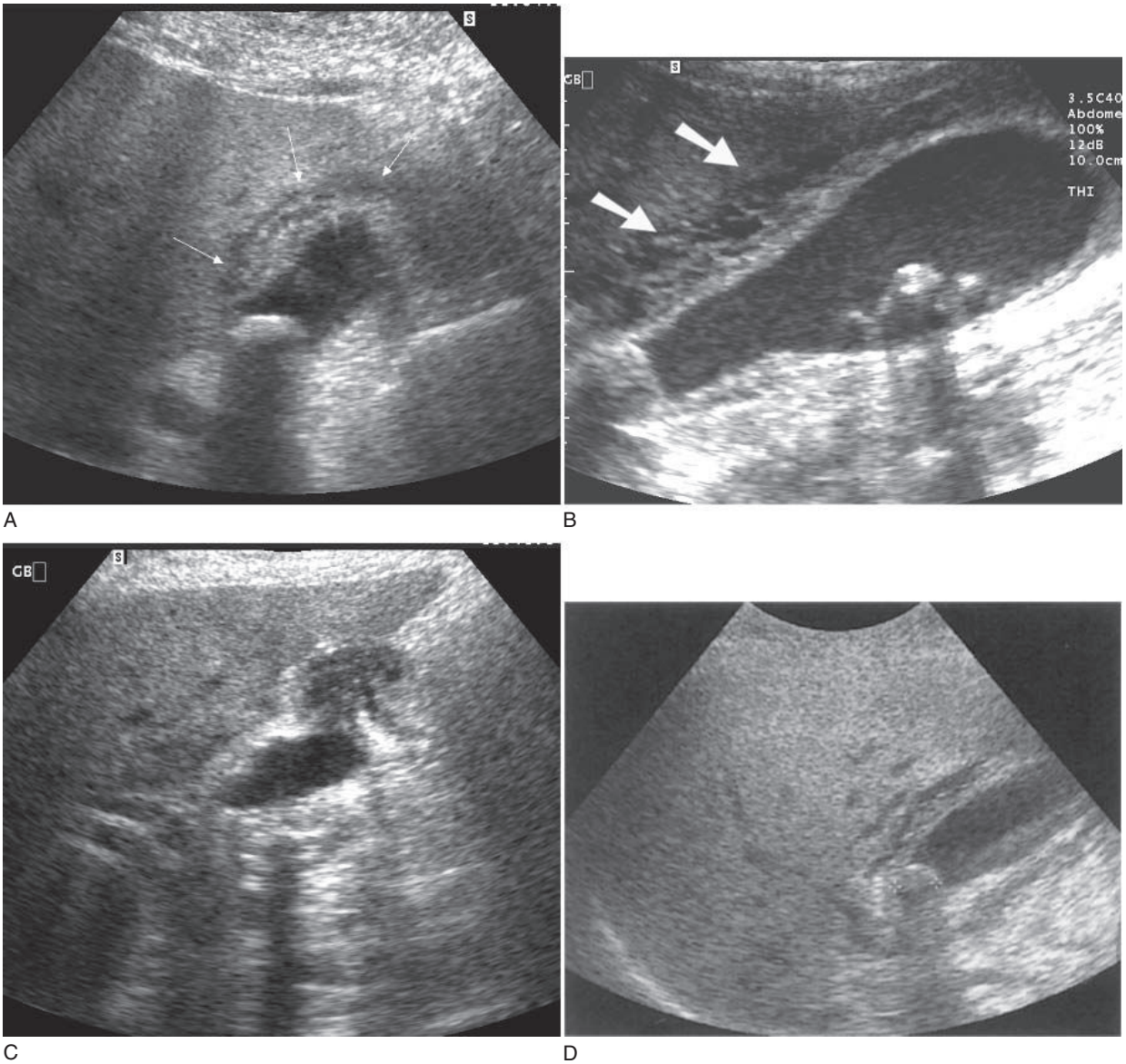
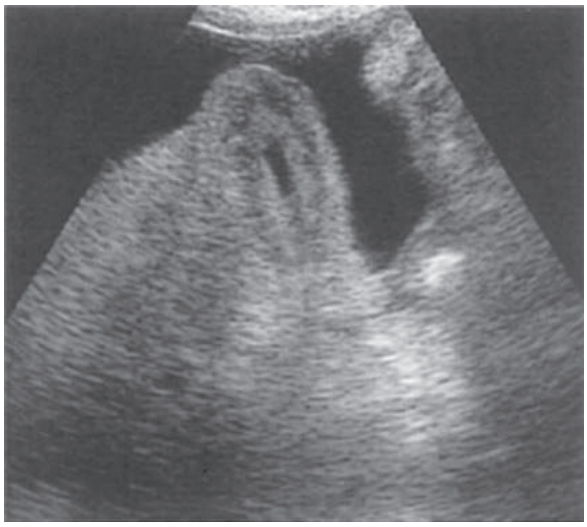


Figure 3.22 Acute cholecystitis: (A) TS of an oedematous, thickened gallbladder wall with a stone. (B) LS with a thickened wall (arrows). Stones and debris are present. (C) and (D) TS and LS demonstrating pericholecystic fluid.

(Continued)



E

Figure 3.22 cont'd (E) Normal gallbladder in the presence of ascites. Oedema may cause the wall to thicken, mimicking an inflammatory process.

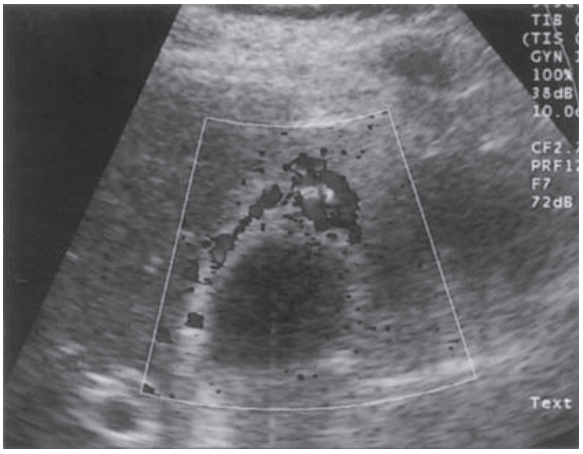


Figure 3.23 Colour Doppler demonstrates hyperaemia in the thickened gallbladder wall in acute cholecystitis.

complex cases, is giving way to the more frequent use of laparoscopic cholecystectomy.

If unsuitable for immediate surgery, for example in cases complicated by peritonitis, the patient is managed with antibiotics and/or percutaneous drainage of pericholecystic fluid or infected bile from the gallbladder, usually under ultrasound guidance. This allows the patient's symptoms to settle and reduces morbidity from the subsequent elective operation.[16]

Hepatobiliary scintigraphy has high sensitivity and specificity for evaluating patients with acute cholecystitis,[17] particularly if the ultrasound examination is technically difficult or equivocal and has the advantage of being able to demonstrate hepatobiliary drainage into the duodenum.

Plain X-ray is seldom used, but can confirm the presence of gas in the gallbladder.

Chronic cholecystitis

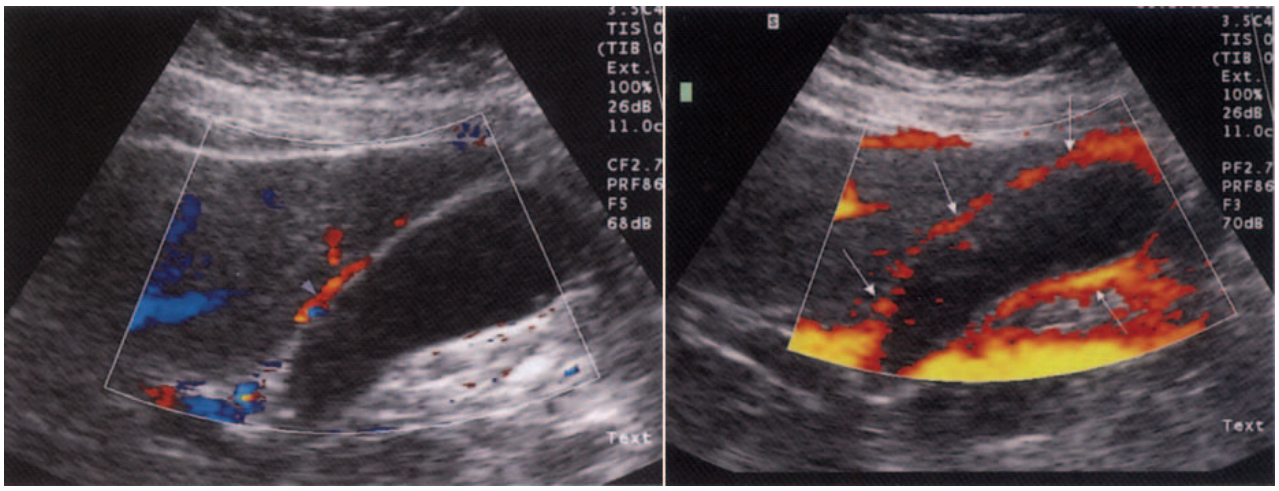
Usually associated with gallstones, chronic cholecystitis presents with lower-grade, recurring right upper quadrant pain. The action of stones on the wall causes it to become fibrosed and irregularly thickened, frequently appearing hyperechoic (Fig. 3.25). The gallbladder is often shrunken and contracted, having little or no recognizable lumen around the stones. Chronic cholecystitis may be complicated by episodes of acute inflammation on a background of the chronic condition.

Most gallbladders which contain stones show at least some histological degree of chronic cholecystitis, even if wall thickening is not apparent on ultrasound.

Acalculous cholecystitis

Inflammation of the gallbladder without stones is relatively uncommon. A thickened, tender gallbladder wall in the absence of any other obvious cause of thickening may be due to acalculous cholecystitis. This condition tends to be associated with patients who are already hospitalized and have been fasting, including post-trauma patients, those recovering from surgical procedures and diabetic patients. It is brought about by bile stasis leading to a distended gallbladder and subsequently decreased blood flow to the gallbladder. This, especially in the weakened postoperative state, can lead to infection. Because no stones are present, the diagnosis is more difficult and may be delayed. Patients with acalculous cholecystitis are therefore more likely to have severe pain and fever by the time the diagnosis is made, increasing the incidence of complications such as perforation.

The wall may appear normal on ultrasound in the early stages, but progressively thickens (Fig. 3.26). Biliary sludge is usually present and a



A B

Figure 3.24 Normal gallbladder wall vascularity. (A) In a normal gallbladder, colour Doppler can demonstrate the cystic artery (arrowhead) but does not demonstrate flow near the fundus. (B) Power Doppler is more sensitive and can demonstrate flow throughout the wall (arrows) in a normal gallbladder; this must not be mistaken for hyperaemia.

pericholecystic abscess may develop in the later stages. A positive Murphy's sign may help to focus on the diagnosis, but in unconscious patients the diagnosis is a particularly difficult one.

Because patients may already be critically ill with their presenting disease, or following surgery, there is a role for ultrasound in guiding percutaneous cholecystostomy at the bed-side to relieve the symptoms.[18]

Chronic acalculous cholecystitis implies a recurrent presentation with typical symptoms of biliary colic, but no evidence of stones on ultrasound. Patients may also demonstrate a low ejection fraction during a cholecystokinin-stimulated hepatic iminodiacetic acid (HIDA) scan. The symptoms are relieved by elective laparoscopic cholecystectomy in most patients, with similar results to those for gallstone disease[19] (although some are found to have biliary pathology at surgery, which might explain the symptoms, such as polyps, cholesterolosis or biliary crystals/tiny stones in addition to chronic inflamation).

Complications of cholecystitis

Acute-on-chronic cholecystitis

Patients with a long-standing history of chronic cholecystitis may suffer (sometimes repeated) attacks of acute inflammation. The gallbladder wall is thickened, as for chronic inflammation, and may become focally thickened with both hypo- and hyperechoic regions. Stones are usually present (Fig. 3.27).

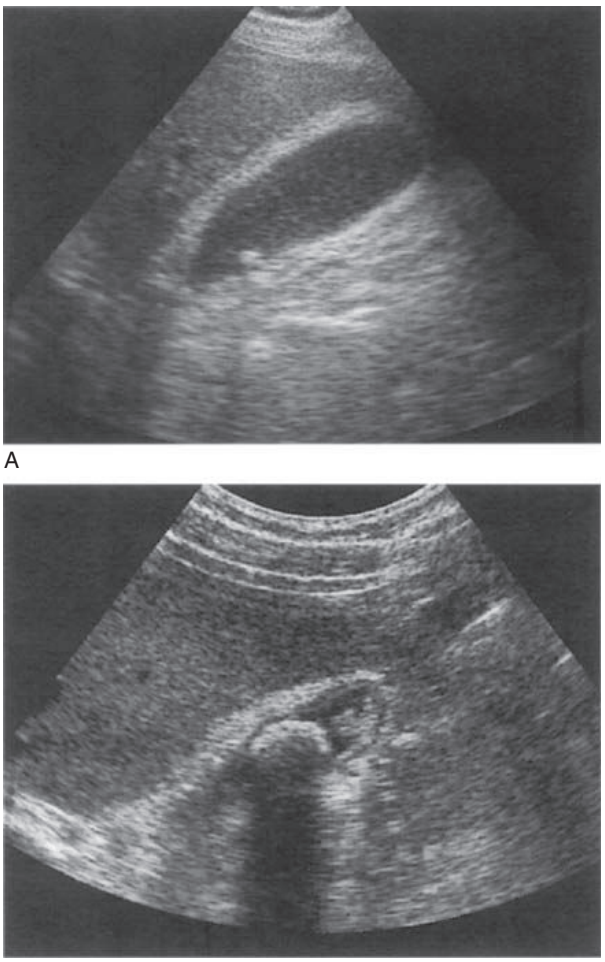
Gangrenous cholecystitis

In a small percentage of patients, acute gallbladder inflammation progresses to gangrenous cholecystitis. Areas of necrosis develop within the gallbladder wall, the wall itself may bleed and small abscesses form (Fig. 3.28). This severe complication of the inflammatory process requires immediate cholecystectomy.

The gallbladder wall is friable and may rupture, causing a pericholecystic collection and possibly peritonitis. Inflammatory spread may be seen in the adjacent liver tissue as a hypoechoic, ill-defined area. Loops of adjacent bowel may become adherent to the necrotic wall, forming a cholecystoenteric fistula.

The wall is asymmetrically thickened and areas of abscess formation may be demonstrated. The damaged inner mucosa sloughs off, forming the appearance of membranes in the gallbladder lumen. The gallbladder frequently contains infected debris

The presence of a bile leak may also be demonstrated with hepatobiliary scintigraphy, using technetium[99], which is useful in identifying a bile



A

B

Figure 3.25 Chronic cholecystitis. (A) A hyperechoic, irregular, thickened wall. The gallbladder contains a small stone and thickened, echogenic bile. It was mildly tender on scanning. (B) The wall is focally thickened anteriorly, and the gallbladder contains a large stone and a polyp in the fundus.

collection which may otherwise be obscured by bowel on ultrasound.

Emphysematous cholecystitis

This is a form of acute gangrenous cholecystitis in which the inflamed gallbladder may become infected, particularly in diabetic patients, with gas-forming organisms. Both the lumen and the wall of the gallbladder may contain air, which is highly reflective, but which casts a 'noisy', less definite shadow than that from stones. Discrete gas bubbles have been reported on ultrasound within the gallbladder wall[20] and may also extend into the intrahepatic biliary ducts.[21]

The air rises to the anterior part of the gallbladder, obscuring the features behind it (Fig. 3.29). This effect may mimic air-filled bowel on ultrasound.

Emphysematous cholecystitis has traditionally had a much higher mortality rate than other forms of cholecystitis, requiring immediate cholecystectomy. However, improvements in ultrasound resolution, and in the early clinical recognition of this condition, suggest that it is now being diagnosed earlier and may be managed more conservatively. The gas in the gallbladder may be confirmed on a plain X-ray (Fig. 3.30), but ultrasound is more sensitive in demonstrating the earlier stages.

Gallbladder empyema

Empyema is a complication of cholecystitis in which the gallbladder becomes infected behind an obstructed cystic duct. Fine echoes caused by pus are present in the bile (Fig. 3.31). These patients are often very ill with a fever and acute pain. A pericholecystic gallbladder collection may result from leakage through the gallbladder wall with subsequent peritonitis. Ultrasound may be used to guide a bedside drainage in order to allow the patient's symptoms to settle before surgery is attempted.[22]

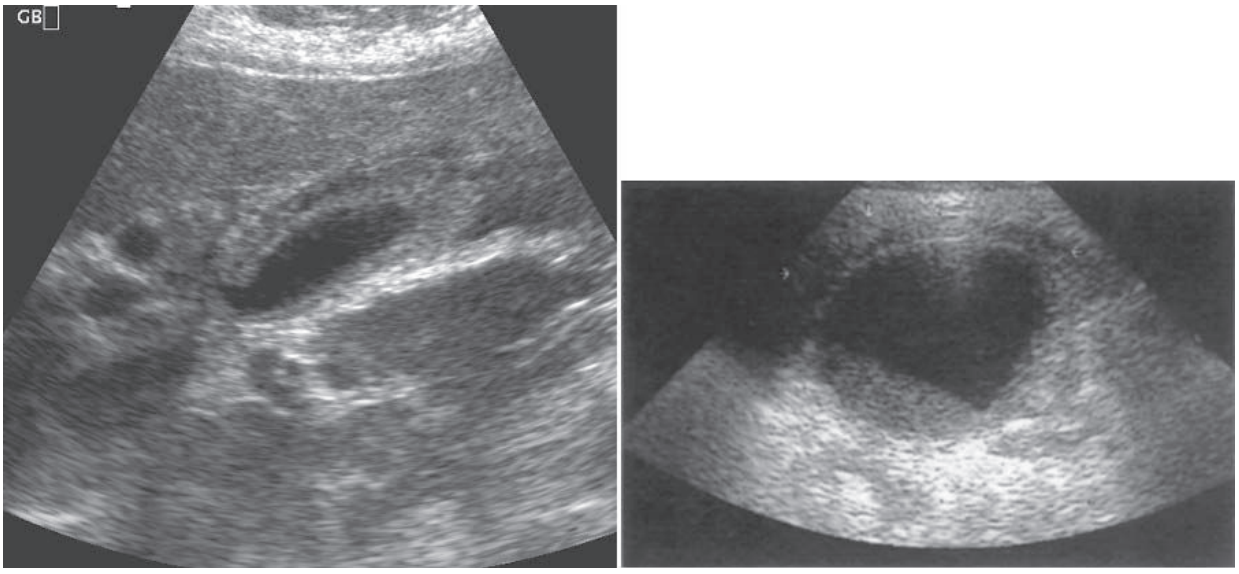
OBSTRUCTIVE JAUNDICE AND BILIARY DUCT DILATATION

Dilatation of all or part of the biliary tree is usually the result of proximal obstruction. Less commonly the biliary tree may be dilated but not obstructed (Table 3.4). The most common causes of obstruction are stones in the common duct or a neoplasm of the bile duct or head of pancreas.

The patient with obstructive jaundice may present with upper abdominal pain, abnormal liver function tests (LFTs) (see Chapter 2) and, if the obstruction is not intermittent, the sclera of the eye and the skin adopt a yellow tinge.

Assessment of the level of obstruction

It is possible for the sonographer to work out where the obstructing lesion is situated by observ-



A B

Figure 3.26 (A) Acalculous cholecystitis. The gallbladder wall is markedly thickened and tender on scanning. (B) Gravity-dependent sludge with a thick, oedematous wall. No stones were present.

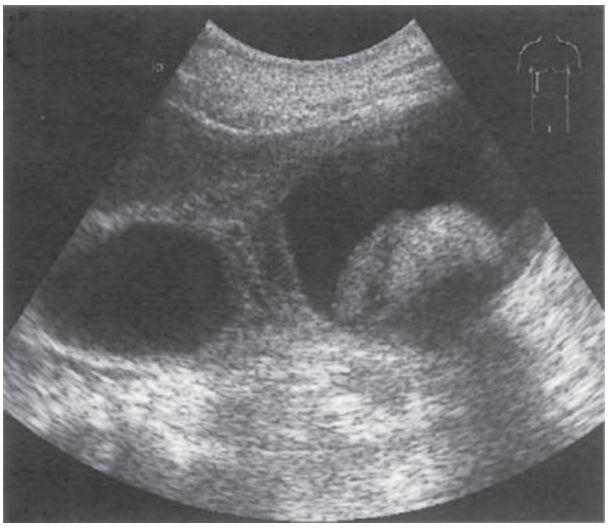


Figure 3.27 Acute on chronic cholecystitis. A patient with known gallstones and chronic cholecystitis presents with an episode of acute gallbladder pain. The wall is considerably more thickened and hyperechoic than on previous scans.

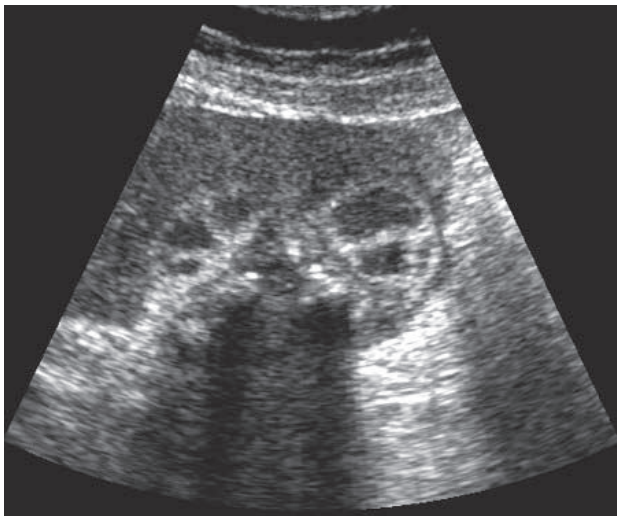


Figure 3.28 Gangrenous cholecystitis. The gallbladder wall is focally thickened and an intramural abscess has formed on the anterior aspect.

ing which parts of the biliary tree are dilated (Fig. 3.32):

- Dilatation of the common bile duct (that is, that portion of the duct below the cystic duct insertion) implies obstruction at its lower end.
- Dilatation of both biliary and pancreatic ducts implies obstruction distally, at the head of the pancreas or ampulla of Vater. This is more likely to be due to carcinoma of the head of pancreas, ampulla or acute pancreatitis than a stone. However, it is possible for a stone to be

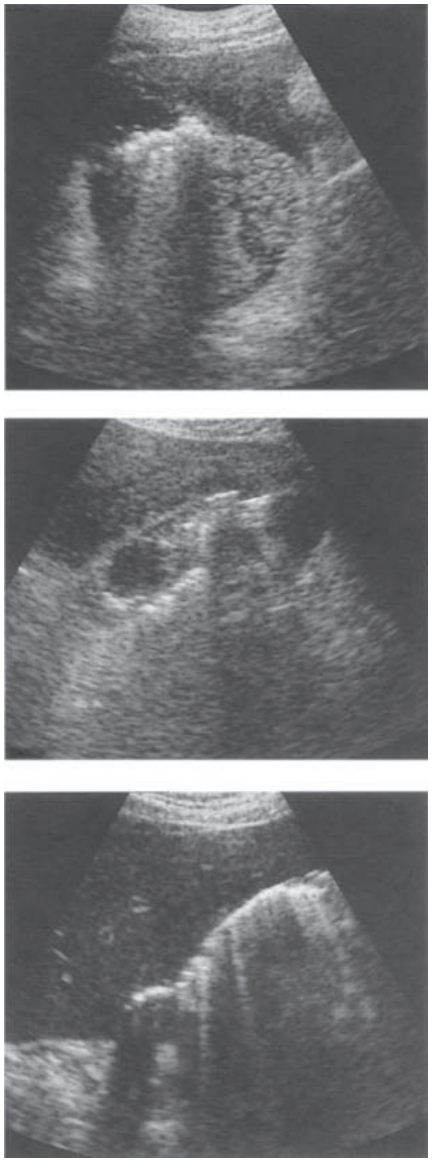


Figure 3.29 Emphysematous cholecystitis. (A) and (B) TS and LS with gas and debris in the gallbladder lumen. (C) Gas in the gallbladder lumen completely obscures the contents.

lodged just distal to the confluence of the biliary and pancreatic ducts.

- Dilatation of the gallbladder alone (that is without ductal dilatation) is usually caused by, obstruction at the neck or cystic duct (Fig. 3.8).

To assess whether the gallbladder is pathologically dilated may be difficult on ultrasound. The sonographer should look at both the size and shape; the dilated gallbladder will have a rounded, bulging shape due to the increase in pressure inside it. A gallbladder whose wall has become fibrosed from chronic cholecystitis due to stones will often lose the ability to distend, so the biliary ducts can look grossly dilated despite the gallbladder remaining 'normal' in size, or contracted.

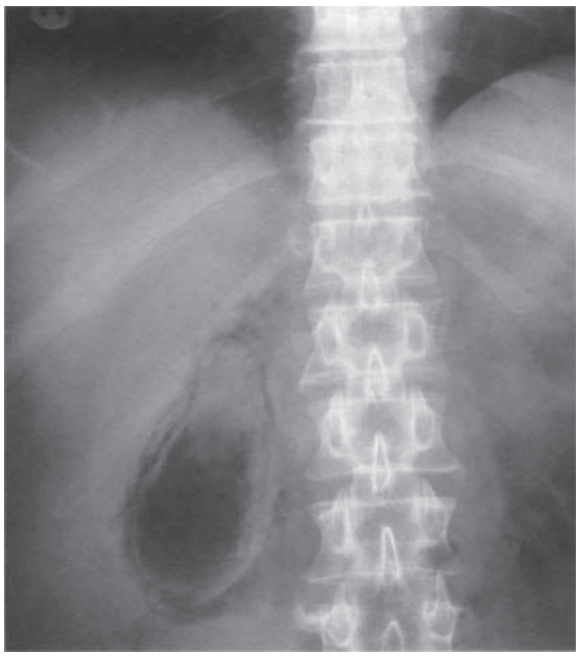


Figure 3.30 X-ray demonstrating gas in the gallbladder in emphysematous cholecystitis.

Early ductal obstruction

Beware very early common duct obstruction, before the duct becomes obviously dilated. The duct may be mildly dilated at the lower end, just proximal to a stone. Likewise intermittent obstruction by a small stone at the lower end of the duct may be non-dilated by the time the scan is performed (Fig. 3.10).

A significant ultrasound feature in the absence of any other identifiable findings is that of thickening of the wall of the bile duct. This represents an inflammatory process in the duct wall, which may be found in patients with small stones in a non-dilated duct, but is also associated with sclerosing cholangitis.[23]

It is sometimes technically difficult in some patients (particularly those with diffuse liver disease) to work out whether a tubular structure on

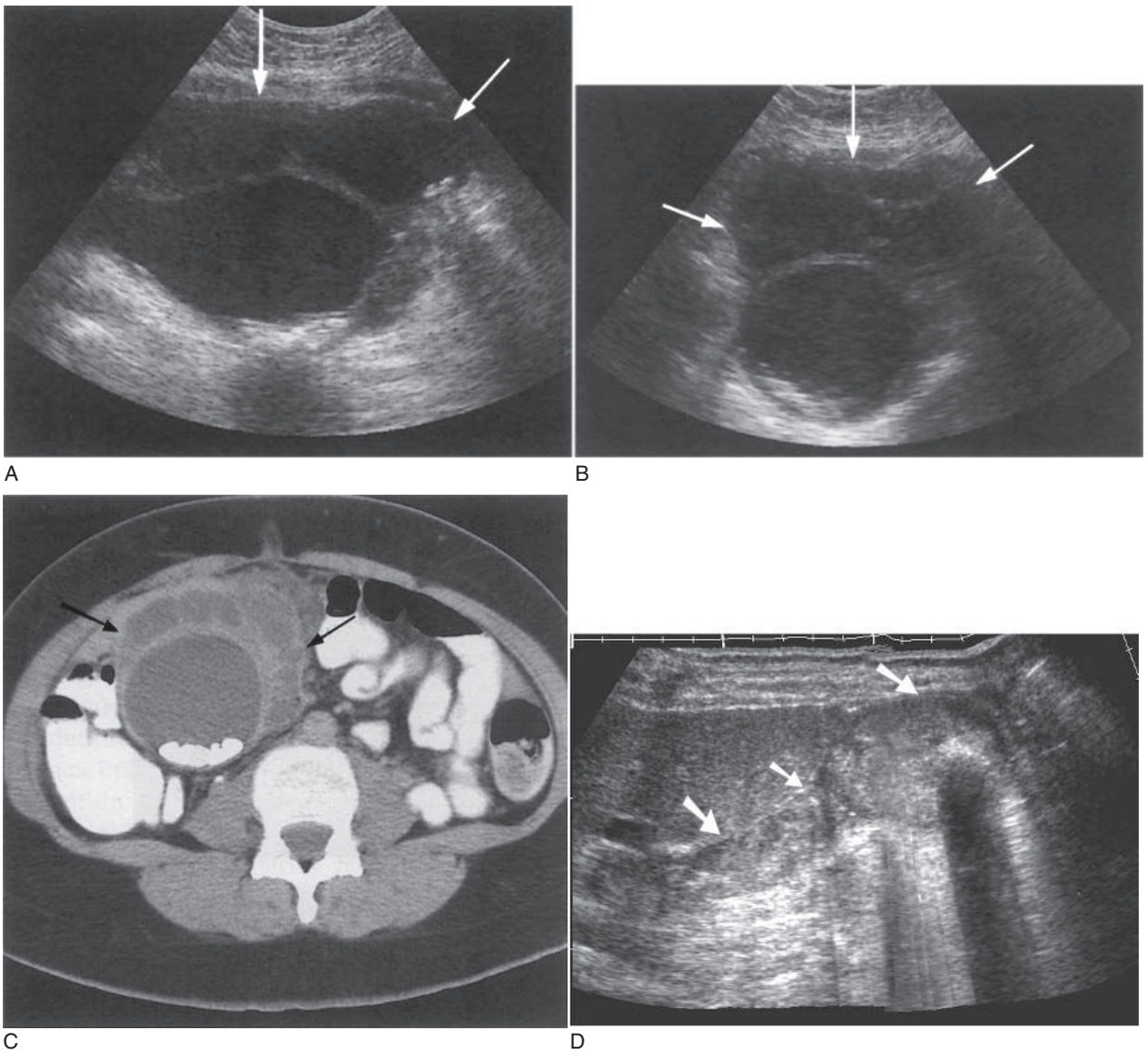


Figure 3.31 Gallbladder empyema. (A) and (B) LS and TS of the same gallbladder. The gallbladder has ruptured, forming a cholecystoenteric fistula which had resealed at surgery. The gallbladder contains pus and stones, with several anterior septations, forming pockets of infected bile which also contained stones (arrows). (C) CT scan confirming the ultrasound appearances. (D) Gallbladder empyema demonstrating a large gallbladder full of pus and stones.

ultrasound represents a dilated duct or a blood vessel. Colour Doppler will differentiate the dilated bile duct from a branch of hepatic artery or portal vein (Fig. 3.33).

Assessment of the cause of obstruction

The numerous causes of biliary dilatation are summarized in Table 3.4. Frequently, ultrasound diagnoses obstruction but does not identify the cause. This is a good case for perseverance by the operator, as the lower end of the CBD is visible in the majority of cases once overlying duodenum has been moved away (Figs 3.9, 3.10 and 33.4). However, ultrasound is not generally regarded as a reliable tool for identifying ductal stones and is frequently unable to diagnose ductal strictures, especially those from benign causes.

Table 3.4 Causes of biliary duct dilatation

Intrinsic
—Stones
—Carcinoma of the ampulla of Vater
—Cholangiocarcinoma
—Stricture (associated with chronic pancreatitis)
—Biliary atresia/choledochal cyst
—Post-liver-transplantation bile duct stenosis (usually anastomotic)
—Parasites
—Age-related or post-surgical mild CBD dilatation
Extrinsic
—Carcinoma of the head of pancreas
—Acute pancreatitis
—Lymphadenopathy at the porta hepatis
—Other masses at the porta, e.g. hepatic artery aneurysm, gastrointestinal tract mass
—Intra-hepatic tumours (obstruct distal segments)
Diffuse hepatic conditions
—Sclerosing cholangitis
—Caroli's disease

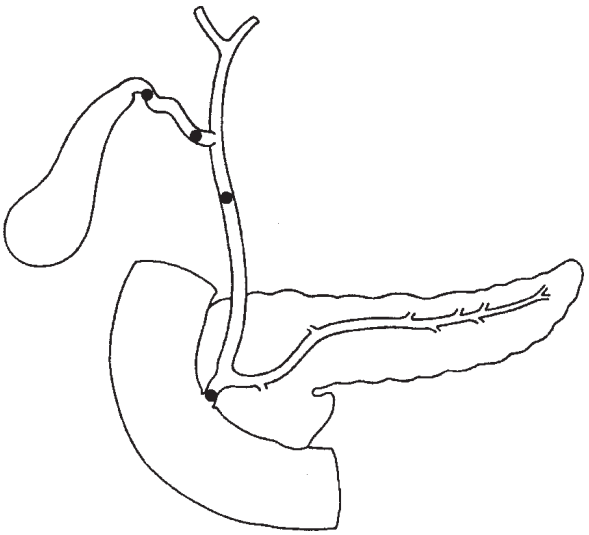
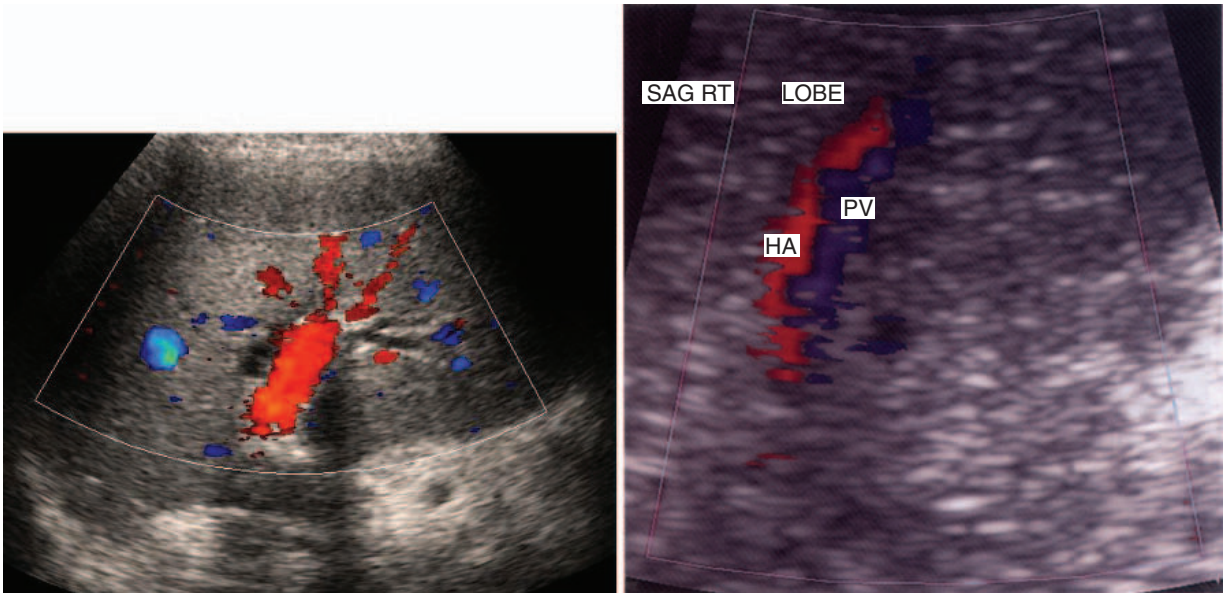


Figure 3.32 Sites of possible gallstone obstruction.

ERCP, although invasive, is a more accurate method of examining the CBD and will often identify strictures or small calculi not visible on ultrasound. It has the advantage of a therapeutic role in addition to its diagnostic capabilities, by allowing the extraction of stones at the time of diagnosis. It is associated with a small risk of complication, however, and its use is therefore increasingly limited in favour of the non-invasive magnetic resonance cholangiopancreatography (MRCP) (Fig. 3.34F). MRCP has been found to be highly effective in the diagnosis of CBD stones[24] and can potentially avoid the use of purely diagnostic ERCP.[25]



A B

Figure 3.33 (A) Dilated biliary ducts do not demonstrate flow on colour Doppler, differentiating them from portal vessels. (B) Originally suspected as a dilated biliary tree, colour Doppler demonstrates that the 'extra tubes' are, in fact, dilated intrahepatic arteries in a patient with end-stage chronic liver disease with reversed portal venous flow.

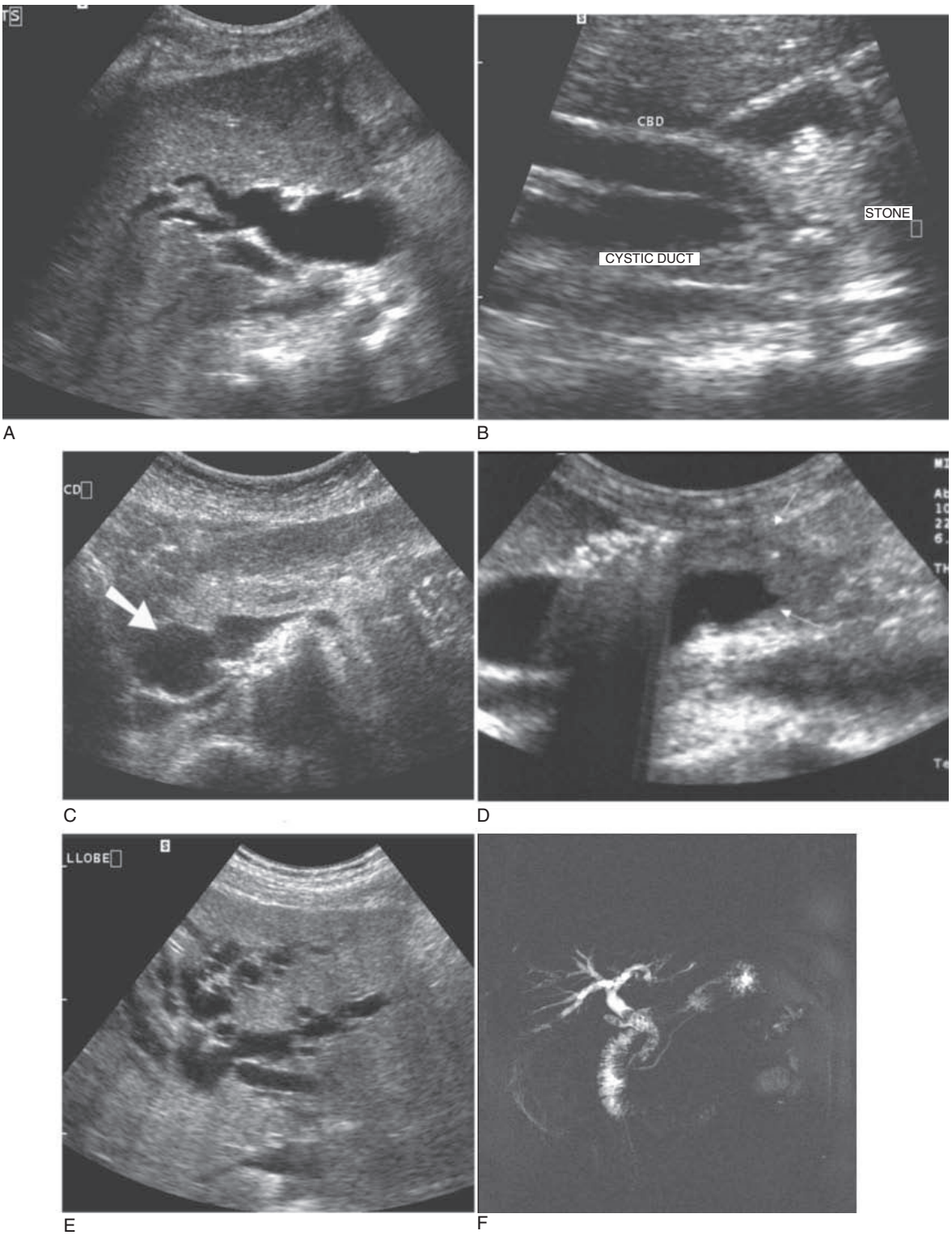


Figure 3.34 (A) Duodenal gas obscures the cause of obstruction at the lower end of this dilated CBD. (B) Patient positioning can move bowel gas away from the duct, demonstrating the cause of obstruction—a stone at the lower end. (C) TS of a dilated CBD in the head of the pancreas (arrow). (D) Dilated CBD with a hypoechoic ampullary carcinoma at the lower end (arrows). (E) Intrahepatic bile duct dilatation. (F) MRCP, post-cholecystectomy, showing stones in the CBD and cystic duct stump.

CT and MRI are useful for staging purposes if the obstructing lesion is malignant. Cholangiocarcinomas spread to the lymph nodes and to the liver and small liver deposits are particularly difficult to recognize on ultrasound if the intrahepatic biliary ducts are dilated.

In hepatobiliary scintigraphy, technetium^{99m}-labelled derivatives of iminodiacetic acid are excreted in the bile and may help to demonstrate sites of obstruction, for example in the cystic duct, or abnormal accumulations of bile, for example choledochal cysts.

Courvoisier's law, to which there are numerous exceptions, states that if the gallbladder is dilated in a jaundiced patient, then the cause is *not* due to a stone in the common duct. The reason for this is that, if stones are or had been present, then the gallbladder would have a degree of wall fibrosis from chronic cholecystitis which would prevent it from distending. In fact there are many exceptions to this 'law' which include the formation of stones in the duct, without gallbladder stones, and also obstruction by a pancreatic stone at the ampulla. Thus:

- Do not assume that obstructive jaundice in a patient with gallstones is due to a stone in the CBD. The jaundice may be attributable to other causes.
- Do not assume that obstructive jaundice cannot be due to a stone in the CBD if the gallbladder does not contain stones. A solitary stone can be passed into the duct from the gallbladder or stones can form within the duct.

Management of biliary obstruction

Management of biliary obstruction obviously depends on the cause and the severity of the condition. Removal of stones in the CBD may be performed by ERCP with sphincterotomy. Elective cholecystectomy may take place if gallstones are present in the gallbladder.

Laparoscopic ultrasound is a useful adjunct to surgical exploration of the biliary tree and its accuracy in experienced hands equals that of X-ray cholangiography. It is rapidly becoming the imaging modality of choice to examine the ducts during laparoscopic cholecystectomy.[26]

Endoscopic ultrasound can also be used to examine the CBD, avoiding the need for laparoscopic exploration of the duct when performed in the immediate preoperative stage.[27]

The treatment of malignant obstruction is determined by the stage of the disease. Accurate staging is best performed using CT and/or MRI. If surgical removal of the obstructing lesion is not a suitable option because of local or distant spread, palliative stenting may be performed endoscopically to relieve the obstruction and decompress the ducts (Fig. 3.35). The patency of the stent may be monitored with ultrasound scanning by assessing the degree of dilatation of the ducts.

Clinical suspicion of early obstruction should be raised if the serum alkaline phosphatase is elevated, (often more sensitive in the early stages than a raised serum bilirubin). In the presence of ductal dilatation on ultrasound, further imaging, such as CT or MRCP, may then refine the diagnosis.

Intrahepatic tumours causing biliary obstruction

Focal masses which cause segmental intrahepatic duct dilatation are usually intrinsic to the duct itself, for example cholangiocarcinoma.

It is also possible for a focal intrahepatic mass, whether benign or malignant, to compress an adjacent biliary duct, causing subsequent obstruction of that segment. This is not, however, a common cause of biliary dilatation and occurs most usually with hepatocellular carcinomas.[28] Most liver metastases deform rather than compress adjacent structures and biliary obstruction only occurs if the metastases are very large and/or invade the biliary tree. A hepatocellular carcinoma or metastatic deposit at the porta hepatis may obstruct the common duct by squeezing it against adjacent extrahepatic structures. Benign intrahepatic lesions rarely cause ductal dilatation, but occasionally their sheer size obstructs the biliary tree.

Choledochal cysts

Most commonly found in children, this is associated with biliary atresia, in which the distal 'blind' end of the duct dilates into a rounded, cystic mass in response to raised intrahepatic pressure.

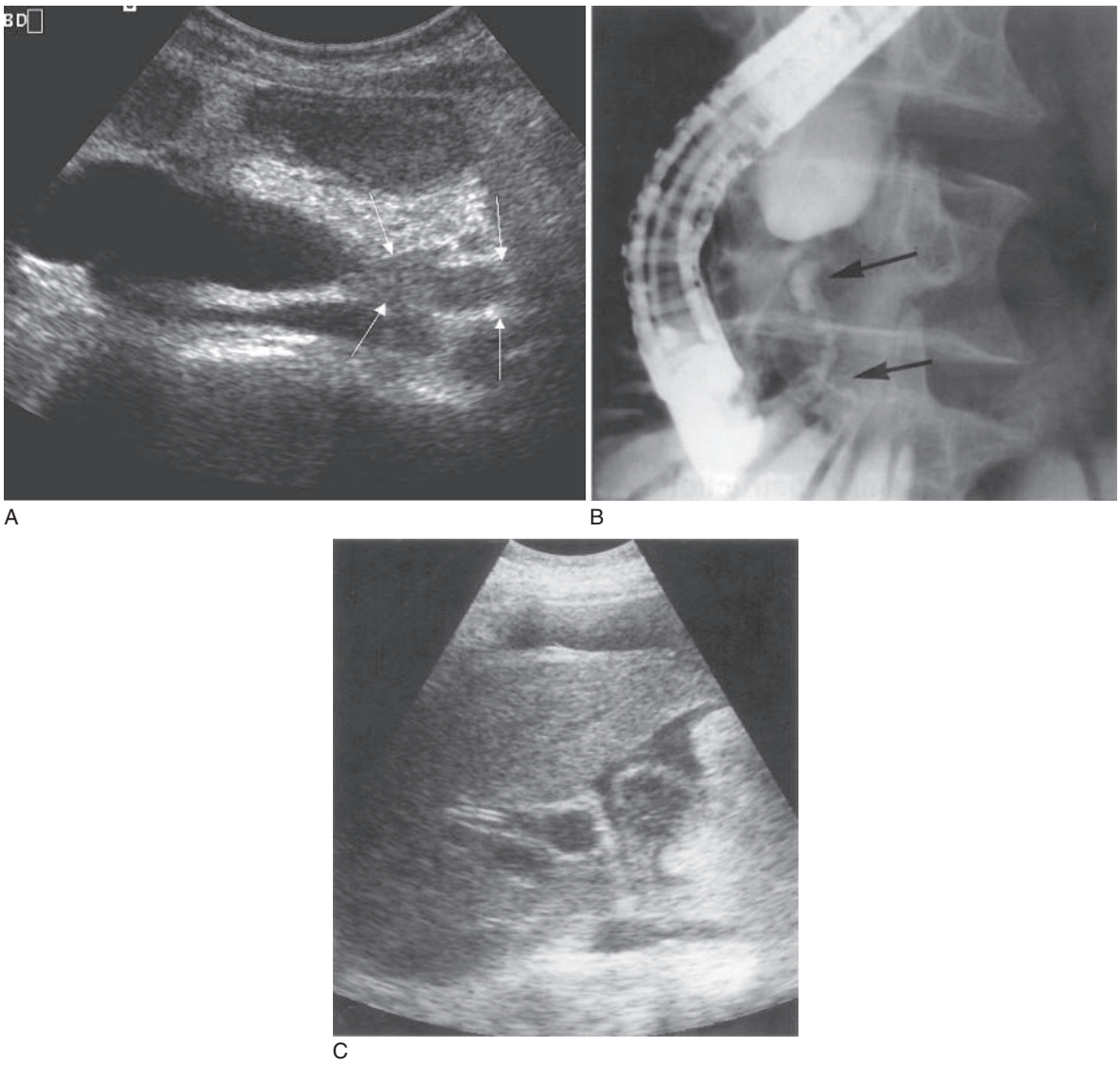


Figure 3.35 (A) This dilated CBD is obstructed by a mass (*arrows*) invading the lower end. (B) ERCP demonstrates a tight, malignant stricture, and can be used to position a palliative stent. (C) Stent in the CBD of a patient with a cholangiocarcinoma and malignant ascites. Decompression of the dilated biliary tree has been achieved, and ultrasound can be used to monitor the patency of the stent.

Choledochal cysts in adults are rare, and tend to be asymptomatic unless associated with stones or other biliary disease. They are sometimes associated with an anomalous insertion of the CBD into the pancreatic duct. The mechanism of the subsequent choledochal cyst formation is unclear, but it is thought that the common channel, which drains into the duodenum, is prone to reflux of pancreatic enzymes into the biliary duct. This can cause a biliary stricture, with subsequent proximal dilatation of the duct, forming a choledochal cyst[29] [Fig. 3.36].

Less commonly the dilatation is due to a non-obstructive cause in which the biliary ducts themselves become ectatic and can form diverticula. This may be due to a focal stricture of the duct which causes reflux and a localized enlargement of the duct proximal to the stricture. (See also *Caroli's disease*, below (Fig. 3.42.)

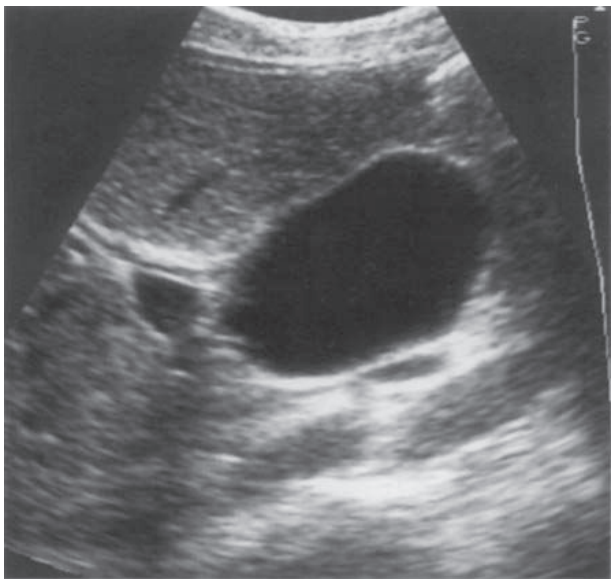


Figure 3.36 Choledochal cyst. (These can sometimes be difficult to distinguish from a gallbladder, particularly if large.)

Complications of choledochal cysts include cholangitis, formation of stones and progression of the condition to secondary biliary cirrhosis, which may be associated with portal hypertension.

It may be difficult to differentiate a choledochal cyst, particularly if solitary, from other causes of hepatic cysts. The connection between the choledochal cyst and the adjacent biliary duct may be demonstrated with careful scanning.

Cholangitis

Cholangitis is an inflammation of the biliary ducts, most commonly secondary to obstruction.

It is rarely possible to distinguish cholangitis from simple duct dilatation on ultrasound, although in severe cases the ductal walls appear irregular (Fig. 3.10A) and debris can be seen in the larger ducts (Fig. 3.37).

The walls of the ducts may appear thickened. Care should be taken to differentiate this appearance from tumour invasion and further imaging is often necessary to exclude malignancy.

Bacterial cholangitis is the most common form, due to bacterial infection which ascends the biliary tree. Bacterial cholangitis is also associated with biliary enteric anastomoses. It may be complicated by abscesses if the infection is progressive and untreated. Small abscesses may be difficult to diagnose on ultrasound, as they are frequently isoechoic and ill-defined in the early stages and biliary dilatation makes evaluation of the hepatic parenchyma notoriously difficult.

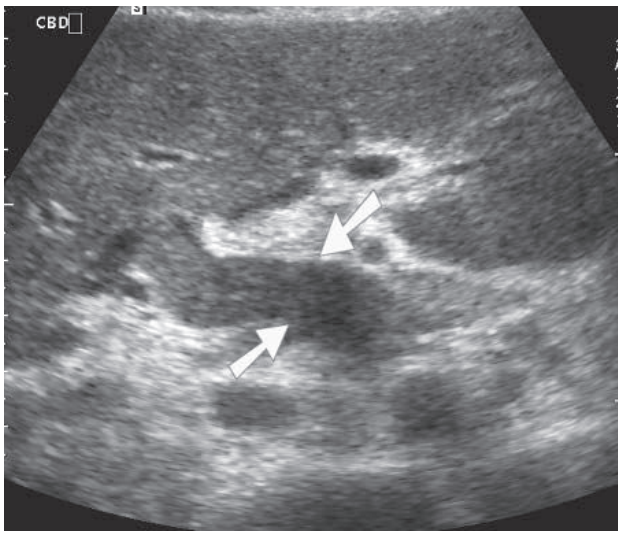


Figure 3.37 Cholangitis with debris present in the dilated CBD (*arrows*).

Contrast CT will often identify small abscesses not visible on ultrasound, and MRCP or ERCP demonstrates mural changes in the ducts.

Other forms of cholangitis include:

- Primary sclerosing cholangitis, a chronic, progressive cholestatic disease, which exhibits ductal thickening, focal dilatation and strictures (see p. 67).
- AIDS-related cholangitis which causes changes similar to that of primary sclerosing cholangitis.
- Recurrent pyogenic cholangitis (Oriental cholangiohepatitis) which is endemic in Southeast Asia and is associated with parasites and malnutrition. Intrahepatic biliary stones are also a feature of this condition.

BILIARY DILATATION WITHOUT JAUNDICE

Postsurgical CBD dilatation

In patients who have had cholecystectomy associated with previous dilatation of the CBD it is common to find a persistent (but non-significant) mild dilatation of the duct postoperatively. The serum alkaline

phosphatase and bilirubin levels should be normal in the absence of pathology. Because stones may be found in the duct postoperatively, it is important to differentiate non-obstructive from truly obstructive dilatation in a symptomatic patient (Fig. 3.38). If in doubt, the patient may be rescanned at a suitable interval to assess any increase in ductal diameter.

Focal obstruction

Intrahepatic tumour, such as cholangiocarcinoma, may obstruct a segment of the biliary tree whilst the remainder of the liver and biliary tree appears normal. Focal duct dilatation should trigger the operator to examine the proximal area of dilatation for a possible mass. Such tumours may be present before jaundice is clinically apparent.

Pitfalls

Patients with cirrhosis and portal hypertension may have dilated hepatic arteries which can mimic the appearances of dilated ducts. Colour or power Doppler will readily differentiate between these, as the bile duct lacks a Doppler signal. Pneumobilia (air in the ducts) casts a distal acoustic shadow, and may therefore obscure ductal dilatation.

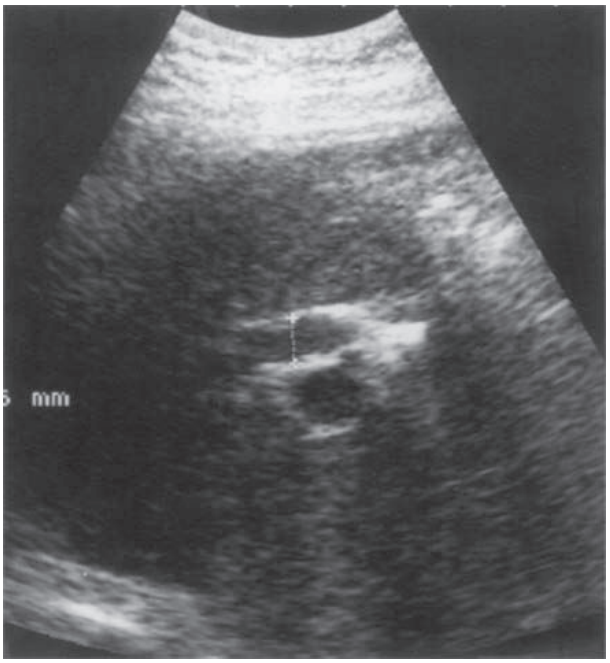


Figure 3.38 Biliary dilatation following laparoscopic cholecystectomy, due to a surgical clip across the CBD.

OBSTRUCTION WITHOUT BILIARY DILATATION

Early obstruction

It is possible to scan a patient at the time of recent onset of obstruction from a stone before the ducts have had time to dilate, leading to a false-negative diagnosis. If clinical suspicion persists, a rescan is frequently useful in these cases.

Occasionally, stones have a ball-valve effect in the duct, causing intermittent obstruction which may not demonstrate ductal dilatation on the ultrasound scan.

Fibrosis of the duct walls

There are a number of chronic pathological conditions which cause the walls of the ducts to become fibrotic and stiff. These include primary sclerosing cholangitis (see below), hepatitis and other chronic hepatic diseases leading to cirrhosis. The liver itself becomes rigid and this prevents biliary dilatation. In such cases the lack of dilated bile ducts does not necessarily imply an absence of obstruction.

OTHER BILIARY DISEASES

Primary sclerosing cholangitis (PSC)

PSC is a chronic hepatobiliary disease in which the walls of the bile ducts become inflamed, causing narrowing. It occurs predominantly in young men (with a 2:1 male to female ratio) and is characterized by multiple biliary strictures and bead-like dilatations of the ducts. The aetiology of PSC remains unclear but is associated with inflammatory bowel disorders or may be idiopathic.

Clinical features include jaundice, itching and fatigue. Some 25% of patients also have gallstones, which complicates the diagnosis. Approximately 70% of patients affected also have ulcerative colitis.

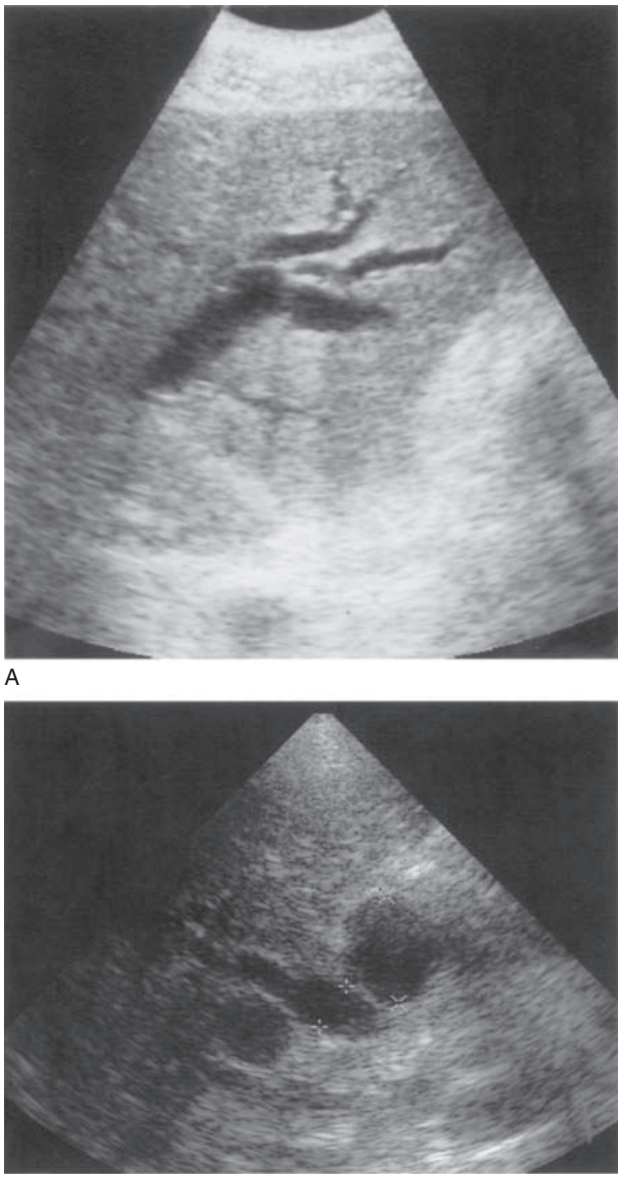
It is progressive gradual fibrosis which eventually obliterates the biliary tree. Untreated, this eventually leads to hepatic failure. PSC has a strong association with cholangiocarcinoma, and it is this, rather than hepatic failure, which may lead to death. In the absence of malignancy, however, hepatic transplant has a 70–90% 5-year survival rate.[30]

Ultrasound appearances

The ultrasound appearances in PSC may be normal or may demonstrate a coarse, hyperechoic texture throughout the liver. Ductal strictures may cause downstream dilatation in some segments (Fig. 3.39) and in some cases there is marked biliary dilatation, but in the majority of patients the biliary ducts are prevented from dilatation by the surrounding fibrosis and so appear unremarkable on ultrasound. MRCP is superior at demonstrating intrahepatic ductal strictures. Mural thickening, particularly in the CBD, may be demonstrated with careful, high-resolution scanning[31] (Fig. 3.40).

Ultrasound also demonstrates the effects of portal hypertension in advanced disease. The gallbladder may also have a thickened wall and can be dilated.[32]

Due to the association between PSC and cholangiocarcinoma, which may be multifocal, a careful search must be made for mass lesions. Because the ultrasound appearances may be those of a coarse, nodular liver texture, it is difficult to identify small cholangiocarcinomas and colour or power Doppler may be an advantage here (Fig. 3.41). This diagnosis is an important one, because the patient's prognosis and management are affected by the presence of cholangiocarcinomata. If no masses are identified, the prognosis is good and includes the endoscopic removal of stones to relieve symptoms, endoscopic stenting of main duct strictures to relieve jaundice and subsequent liver transplant to pre-empt the formation of carcinoma. However, if carcinoma is already present, 5-year survival falls to 10%.



A

B

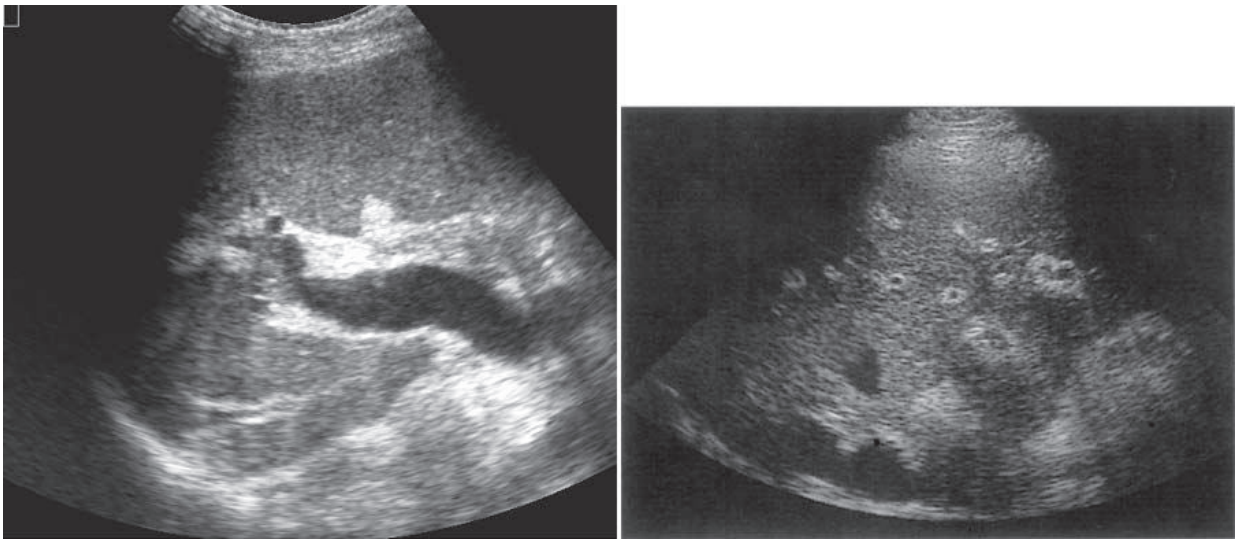
Figure 3.39 (A) Localized biliary dilatation due to a ductal stricture in a patient with primary sclerosing cholangitis (PSC). (B) Coarse-textured liver with a dilated CBD in PSC. A small choledochal cyst is present just anterior to the lower CBD.

Caroli's disease (congenital intrahepatic biliary dilatation)

This is a rare, congenital condition in which the bile ducts are irregularly dilated with diverticula-like projections. These diverticula may become infected and may separate off from the biliary duct, forming choledochal cysts (Fig. 3.42).

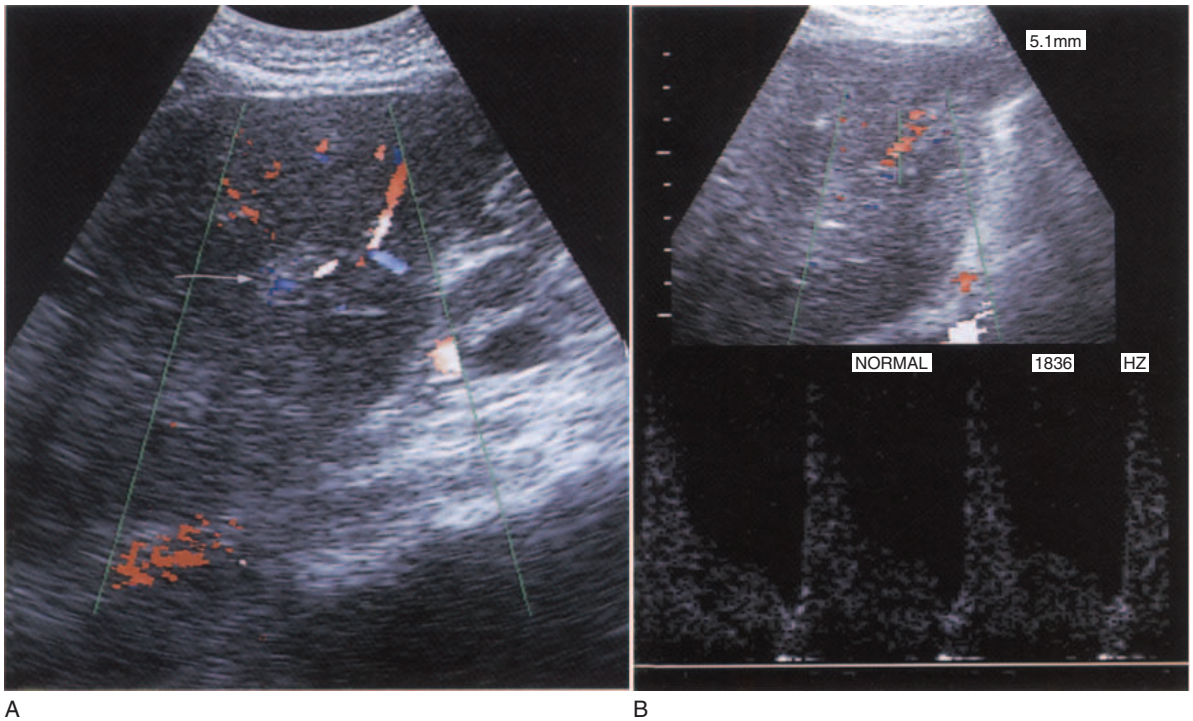
In most cases, the entire hepatobiliary system is affected to some degree. Sufferers may present in early childhood, with symptoms of portal hypertension, [33] or may remain well until adulthood, presenting with cholangitis. It is generally thought to be an autosomal recessive inherited condition and the prognosis is poor. Medical control of associated portal hypertension with varices can improve the quality of life.

In a few cases, the disease is confined to one or two segments of the liver, in which case a cure can be effected with hepatic resection.[34] The extrahepatic biliary tree is often unaffected.



A B

Figure 3.40 PSC. Hyperechoic mural thickening of the biliary tree can be seen in (A) the CBD and (B) the intrahepatic ducts.



A B

Figure 3.41 PSC. (A) A tiny, suspicious, hyperechoic focal lesion (arrow) demonstrates increased flow on colour Doppler. (B) The spectral waveform confirms vigorous arterial flow in this small cholangiocarcinoma.

The ultrasound appearances are usually of widespread intrahepatic duct dilatation, with both saccular and fusiform biliary ectasia. Because it is also associated with biliary stone formation, the diagnosis is often not clear. The dilatation is also associated with cholangitis and signs of infection may be present in the form of debris within the ducts. Sometimes, frank choledocal cysts can be located.

Advanced disease is associated with portal hypertension and, in some cases, cholangiocarcinoma.[35]

Parasites

Parasitic organisms, such as the *Ascaris* worm and liver fluke, are extremely rare in the UK. However, they are a common cause of biliary colic in Africa,

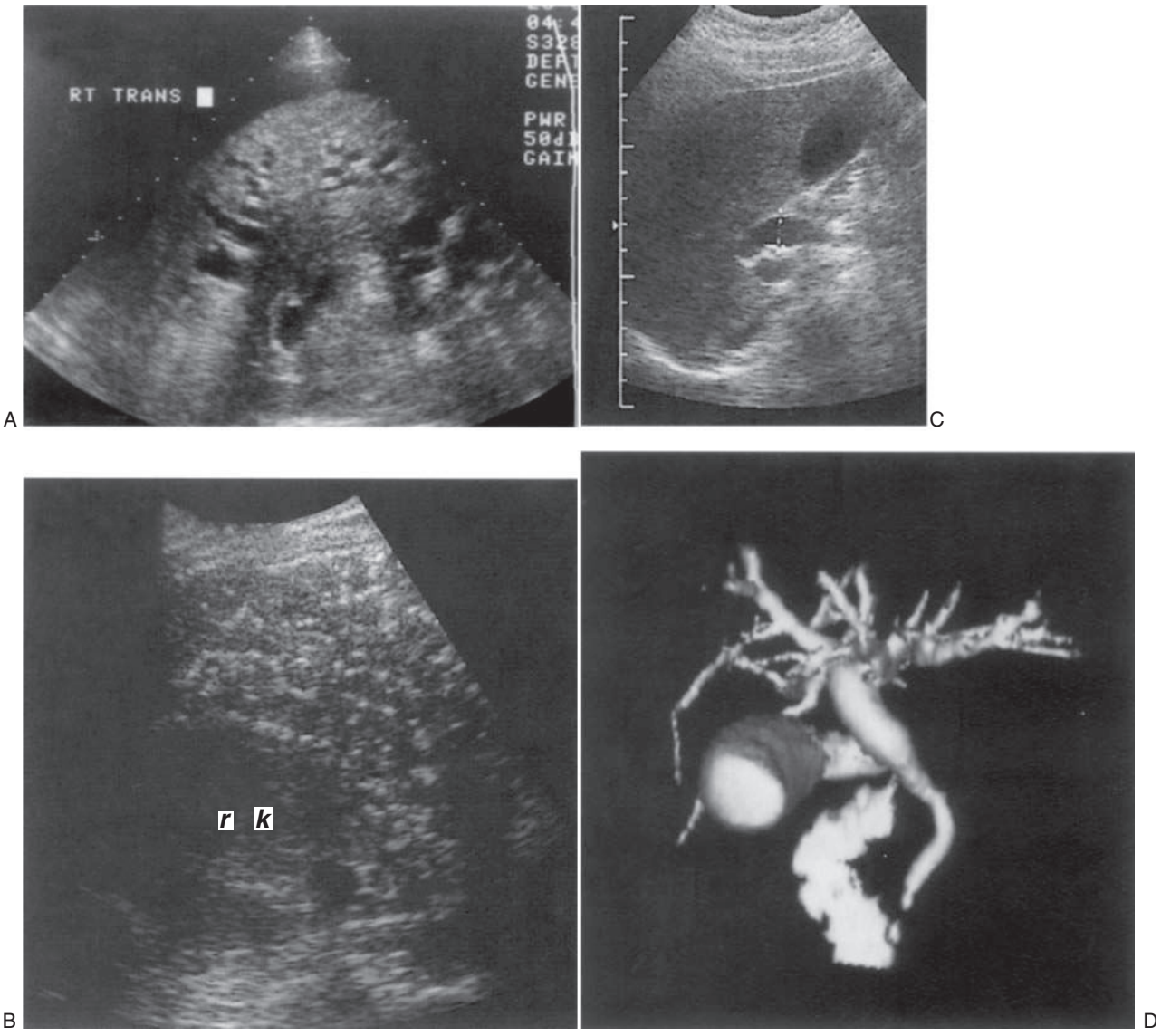


Figure 3.42 Caroli's disease. (A) Dilated biliary tree and ascites. (B) TS of a different patient with end-stage disease. The grossly abnormal liver texture contrasts with the right kidney. (C) A small section of focal CBD dilatation persisted in a symptomatic patient, with normal-calibre distal CBD. This was confirmed on ERCP and thought to be a dyskinetic segment, causing biliary reflux, but was later diagnosed as a mild form of Caroli's. (D) 3D CT reconstruction of the case in (C), confirming the ultrasound appearances. Note the tiny ectatic 'pouchings' of the intrahepatic ducts characteristic of Caroli's.

the Far East and South America. The hyperechoic linear structures in the gallbladder lumen should raise the sonographer's suspicion in patients native to, or who have visited these countries. Impacted worms in the biliary ducts may mimic other ductal masses.[36]

They are a rare cause of obstructive biliary dilatation (Fig. 3.43).

Patients may present with acute cholangitis or abdominal pain and vomiting. Endoscopic management is frequently highly effective.[37]

ECHOGENIC BILE

Biliary stasis

Fine echoes in the bile within the gallbladder are not uncommon on an ultrasound scan. This is commonly due to the inspissation of bile following prolonged starving, for example following surgery (Fig. 3.44). These appearances disappear after a normal diet is resumed and the gallbladder has emptied and refilled.

It occurs when the solutes in the bile precipitate, often due to hypomotility of the gallbladder, and can commonly be seen following bone marrow transplantation and in patients who have undergone prolonged periods (4–6 weeks) of total parenteral nutrition.[38]

Prolonged biliary stasis may lead to inflammation and/or infection, particularly in postoperative patients and those on immunosuppression (Fig. 3.44B). Its clinical course varies from complete resolution to progression to gallstones. However, following the resumption of oral feeding, the gallbladder may contract and empty the sludge into the biliary tree causing biliary colic, acute pancreatitis and/or acute cholecystitis.[39] For this reason, cholecystectomy may be considered in symptomatic patients with biliary sludge.

The fine echoes may form a gravity-dependent layer and may clump together, forming 'sludge balls'. To avoid misdiagnosing sludge balls as polyps, turn the patient to disperse the echoes or

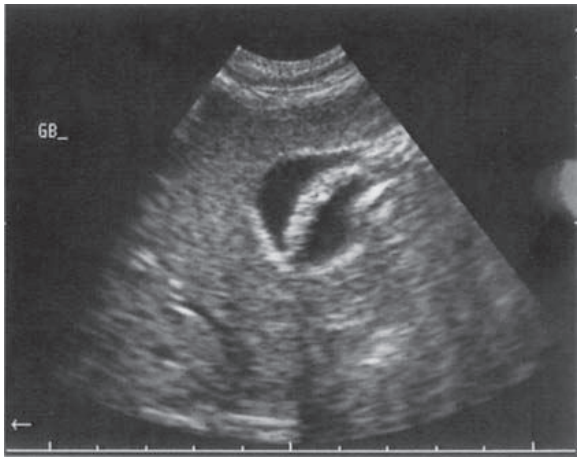
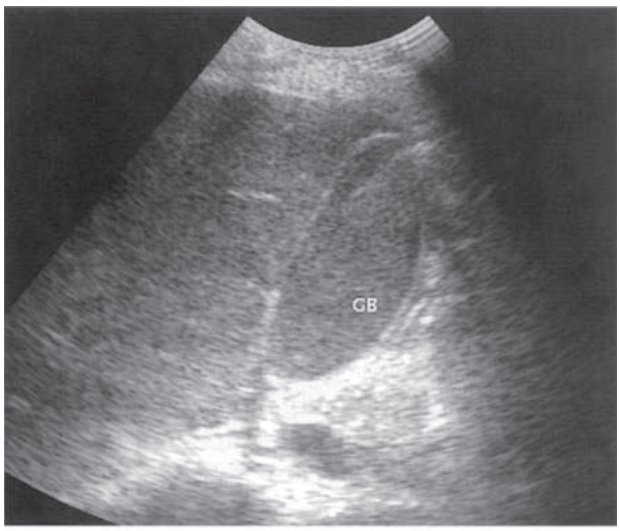


Figure 3.43 *Ascaris* worm in the gallbladder.



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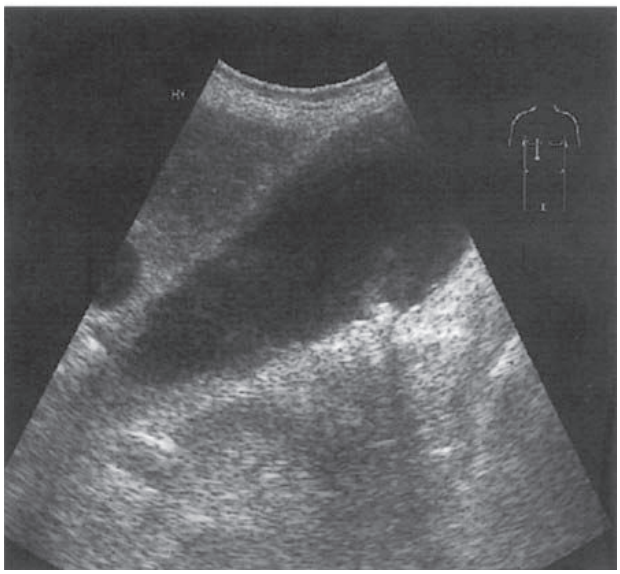


B

Figure 3.44 (A) Inspissated bile in the normal gallbladder of a fasting patient. (B) Gravity-dependent biliary sludge with a small stone.

rescan after the patient has resumed a normal diet.

Biliary stasis is associated with an increased risk of stone formation.[40]

Biliary crystals

Occasionally, echogenic bile persists even with normal gallbladder function (Fig. 3.45). The significance of this is unclear. It has been suggested that there is a spectrum of biliary disease in which gallbladder dysmotility and subsequent saturation of the bile lead to the formation of crystals in the bile and also in the gallbladder wall, leading eventually to stone formation.[41] Pain and biliary colic may be present prior to stone formation and the presence of echogenic bile seems to correlate with the presence of biliary crystals.[42]

Biliary crystals, or 'microlithiasis' (usually calcium bilirubinate granules) have a strong association with acute pancreatitis[43] and its presence in patients who do not have gallstones is therefore highly significant.

Obstructive causes of biliary stasis

Pathological bile stasis in the gallbladder is due to obstruction of the cystic duct (from a stone, for example) and may be demonstrated in a normal-sized or dilated gallbladder. The bile becomes viscous and hyperechoic. The biliary ducts remain normal in calibre. Eventually the bile turns watery and appears echo-free on ultrasound; this is known as a mucocoele (see above) (Fig. 3.8).

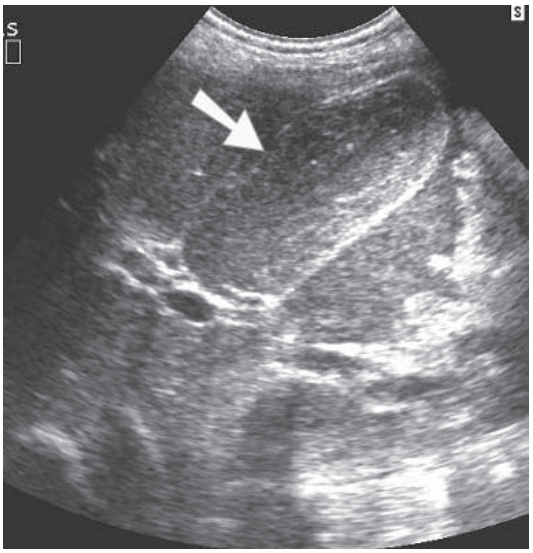


Figure 3.45 Biliary crystals.

Bile stasis within the ducts occurs either as a result of prolonged and/or repetitive obstruction or as a result of cholestatic disease such as primary biliary cirrhosis (PBC) (Chapter 4) or PSC. This can lead to cholangitis.

Haemobilia

Blood in the gallbladder can be the result of gastrointestinal bleeding or other damage to the gallbladder or bile duct wall, for example iatrogenic trauma from an endoscopic procedure.

The appearances depend upon the stage of evolution of the bleeding. Fresh blood appears as fine, low-level echoes. Blood clots appear as solid, non-shadowing structures and there may be hyperechoic, linear strands.[44]

The history of trauma will allow the sonographer to differentiate from other causes of haemobilia and echogenic bile, particularly those associated with gallbladder inflammation, and there may be other evidence of abdominal trauma on ultrasound such as a haemoperitoneum.

Pneumobilia

Air in the biliary tree is usually iatrogenic and is frequently seen following procedures such as ERCP, sphincterotomy or biliary surgery. Although it does not usually persist, the air can remain in the biliary tree for months or even years and is not significant.

It is characterized by highly reflective linear echoes (Fig. 3.46), which follow the course of the biliary ducts. The air usually casts a shadow which is different from that of stones, often having reverberative artefacts and being much less well-defined or clear. This shadowing obscures the lumen of the duct and can make evaluation of the hepatic parenchyma difficult.

Pneumobilia may also be present in emphysematous cholecystitis, an uncommon complication of cholecystitis in which gas-forming bacteria are present in the gallbladder (see above), or in cases where a necrotic gallbladder has formed a cholecystoenteric fistula.

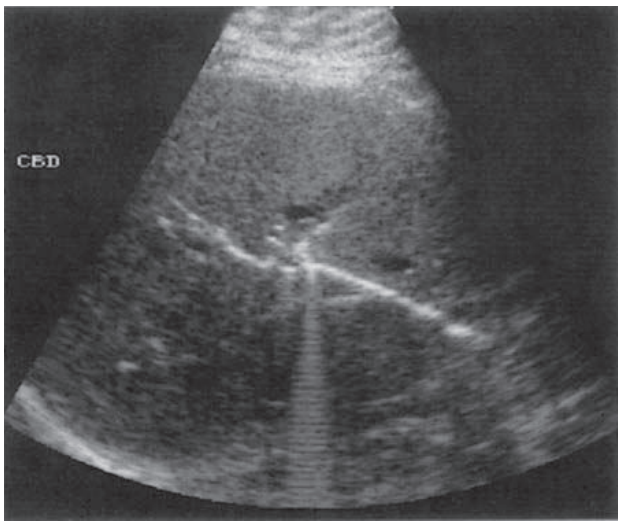


Figure 3.46 Air in the biliary tree following surgery. Note the 'reverberative' shadow.

Rarely, multiple biliary stones form within the ducts throughout the liver and can be confused with the appearances of air in the ducts.

MALIGNANT BILIARY DISEASE

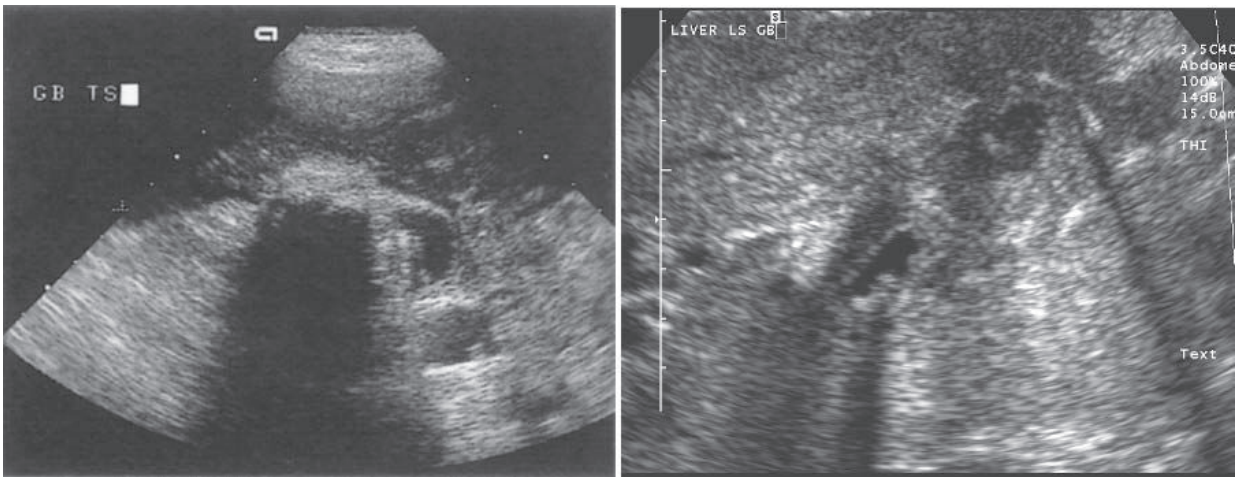
Primary gallbladder carcinoma

Cancer of the gallbladder is usually associated with gallstones and a history of cholecystitis. Most often, the gallbladder lumen is occupied by a solid mass which may have the appearance of a large polyp. The wall appears thickened and irregular and shadowing from the stones may obscure it posteriorly. A bile-filled lumen may be absent, further complicating the ultrasound diagnosis (Fig. 3.47). In a porcelain gallbladder (calcification of the gallbladder wall), which is associated with gallbladder carcinoma, the shadowing usually obscures any lesion in the lumen, making the detection of any lesion present almost impossible.

Particular risk factors for gallbladder carcinoma include large stones, polyps of over 1 cm in size, porcelain gallbladder and, occasionally, choledochal cyst due to anomalous junction of the pancreatobiliary ducts.[8]

The carcinoma itself is frequently asymptomatic in the early stages, and patients tend to present with symptoms relating to the stones. It is a highly malignant lesion which quickly metastasizes to the liver and portal nodes and has a very poor prognosis, with a curative surgical resection rate of around 15–20%.

Doppler may assist in differentiating carcinoma from other causes of gallbladder wall thickening,[45] but further staging with CT is usually necessary. Ultrasound may also demonstrate local spread into the adjacent liver.



A B

Figure 3.47 Gallbladder carcinoma. (A) TS, containing stones, debris and irregular wall thickening. (B) A different patient, demonstrating a grossly thickened hypoechoic wall with a contracted lumen.

Cholangiocarcinoma

This is a malignant lesion arising in the wall of the bile duct (Fig. 3.48). It is obviously easier to recognize from an ultrasound point of view when it occurs in and obstructs the common duct, as the subsequent dilatation outlines the proximal part of the tumour with bile. Cholangiocarcinoma may occur at any level along the biliary tree and is frequently multifocal.

A cholangiocarcinoma is referred to as a *Klatskin tumour* when it involves the confluence of the right and left hepatic ducts. These lesions are often difficult to detect on both ultrasound and CT. They are frequently isoechoic, and the only clue may be the proximal dilatation of the biliary ducts (Fig. 3.49).

Although rare, the incidence of cholangiocarcinoma seems to be increasing and it is strongly associated with PSC, a disease of the biliary ducts which predominantly affects young men (see above).

Multifocal cholangiocarcinoma may spread to the surrounding liver tissue and carries a very poor prognosis for long-term survival. In a liver whose texture is already altered by diffuse disease it may be almost impossible to identify these lesions before they become large. A pattern of dilated ducts distal to the lesion is a good clue (Figs 3.50 and 3.51).

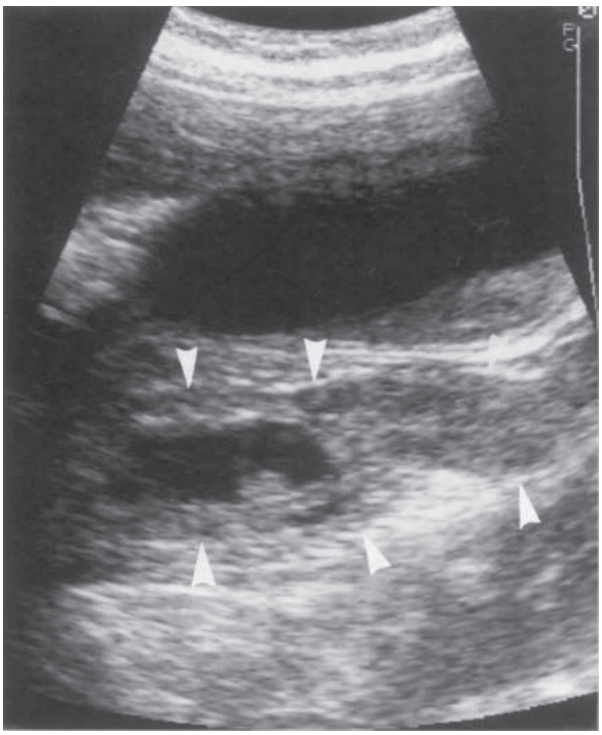
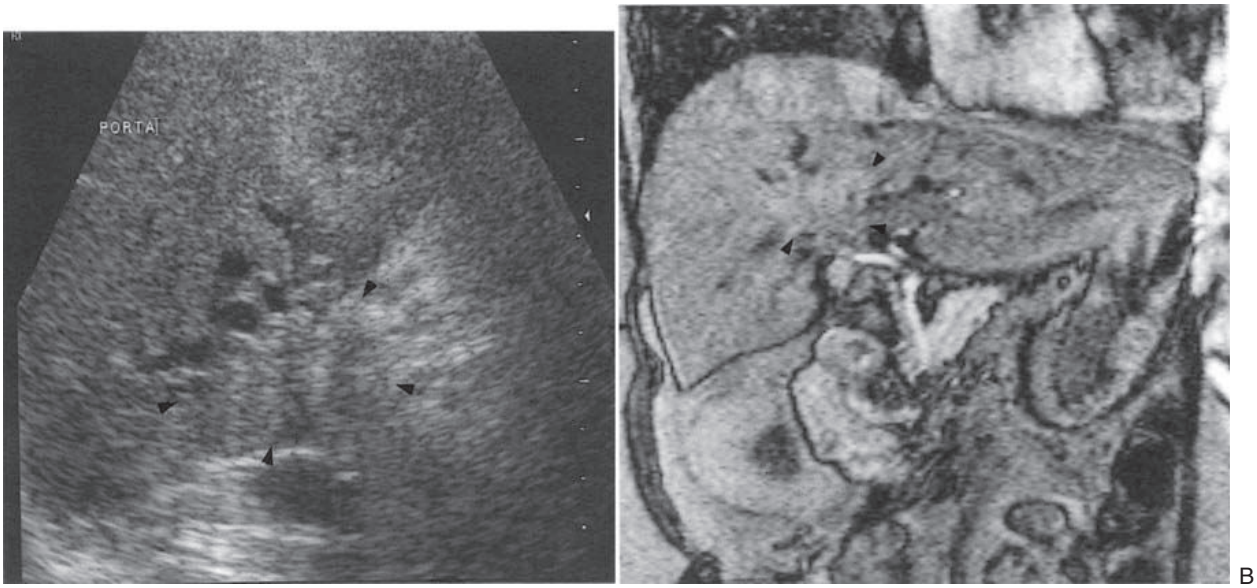


Figure 3.48 The distal CBD has a thickened wall (arrowheads), and the lumen is filled with tumour at the lower end. (Gallbladder anterior.)



A B

Figure 3.49 Cholangiocarcinoma. (A) Irregular mass at the porta, causing biliary obstruction—a Klatskin tumour. (B) MRI of the same patient, confirming the mass at the porta.

Management of the patient with cholangiocarcinoma

These patients have a poor prognosis, as the lesions usually present with jaundice due to invasion and obstruction of the duct. They spread to surrounding tissues, including the portal vein and lymph nodes, metastasize to the liver, and can be multifocal, particularly with PSC.

Staging of the disease is performed with CT or MRI. Endoscopic ultrasound can outline invasion into the biliary duct and laparoscopic ultrasound can pick up peritoneal or local spread.

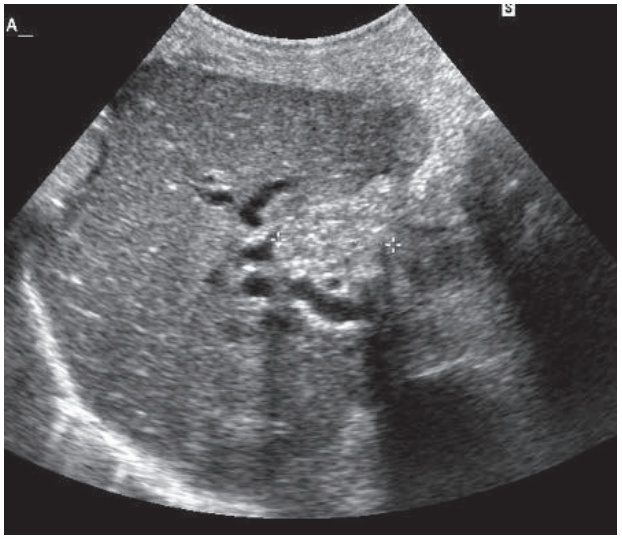


Figure 3.50 Focally dilated ducts distal to a hyperechoic cholangiocarcinoma (calipers).

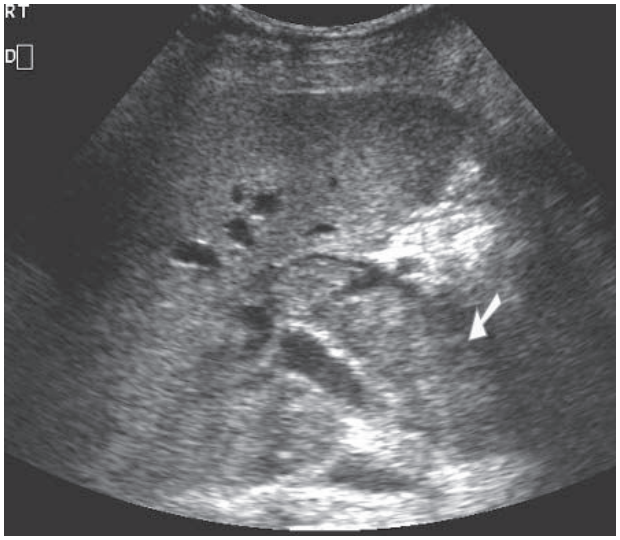
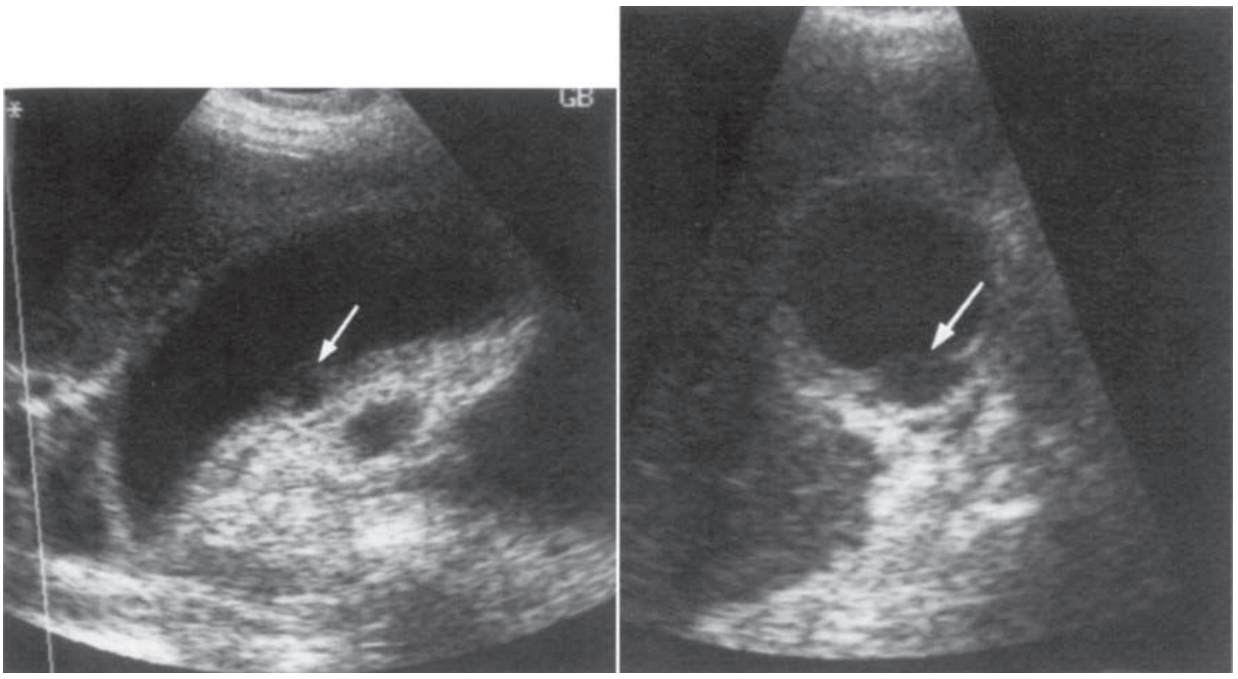


Figure 3.51 Cholangiocarcinoma invading the CBD (arrow).



A B

Figure 3.52 Metastases in the gallbladder wall (A) LS and (B) TS from advanced ovarian carcinoma.

Surgical resection of the tumour is becoming more successful in patients with single lesions.[46] Palliation is frequently the only feasible option and the insertion of a stent, either percutaneously or endoscopically, to bypass the obstructing lesion and assist drainage of the liver will relieve the symptoms and often allows the patient to return home for some months.

Other treatment options, such as chemotherapy, have limited success, although transplantation is increasingly regarded as an option in some cases. Despite improvements in treatment, only a minority of patients survive beyond twelve months after the initial diagnosis.

Gallbladder metastases

Metastases from other primaries may occasionally be deposited within the gallbladder wall (Fig. 3.52), usually as a late presentation of the disease process. Often, other metastatic deposits, for example in the liver and lymph nodes, may raise suspicion of gallbladder metastases in an irregularly thickened gallbladder wall.

The ultrasound appearances are of focal thickening and polyp-like lesions in the wall of the gallbladder. This may mimic primary gallbladder carcinoma but knowledge of a previously diagnosed primary, for example melanoma, lung or breast carcinoma, will point towards the diagnosis.

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