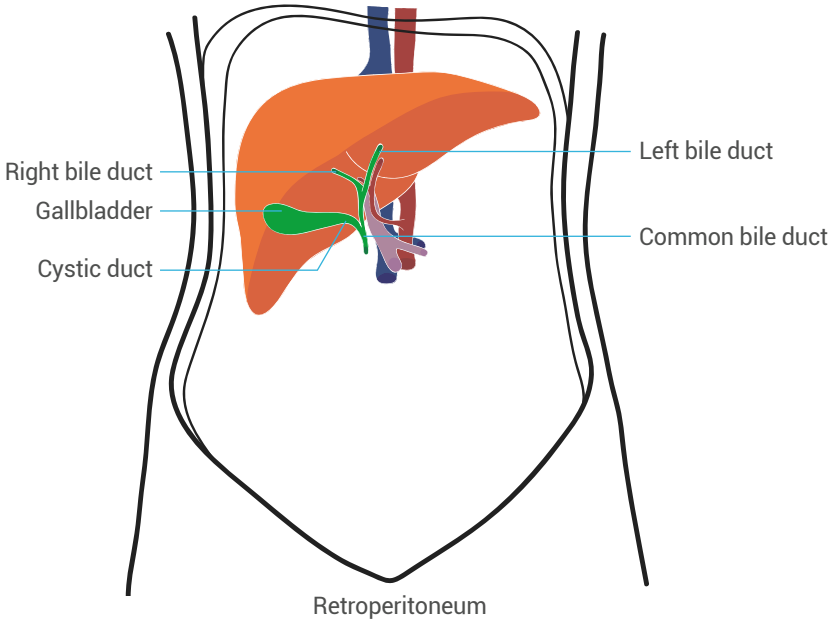
Abdominal Ultrasound
Chapter 3

THE BILIARY SYSTEM

Niko Mayr

The Biliary System

MASTERING ULTRASOUND ANATOMY

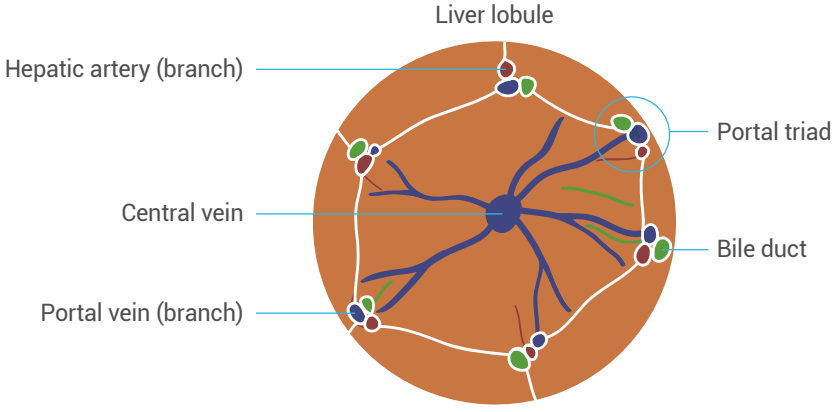


Bile fluid is produced by the gallbladder, gathers in the bile ducts, and is transported to the liver hilum, where it flows down through the common bile duct into the duodenum.

The basic underlying architecture of the liver is the liver lobule, which is organized as a hexagon.

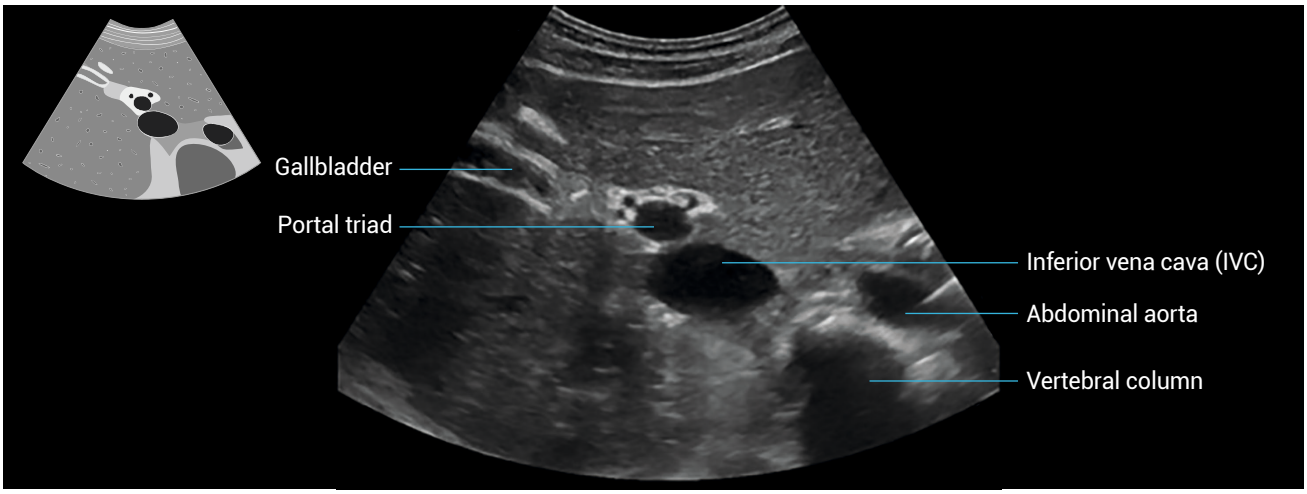
The portal triad, or triad of glisson, contains a branch of the portal vein, a hepatic artery branch, and a bile duct. Portal triads can be found at every corner of the periphery of the liver lobule, while the center of the lobule contains a branch of the hepatic vein.

Blood flows into the liver through the hepatic artery and the portal vein where it enters the capillary space between hepatocytes. Blood exits the organ via the right, middle, and left hepatic veins, which gather to form a star shape (the hepatic venous star), when entering the inferior vena cava on the dorsocranial surface of the liver.



Mickey Mouse sign

When viewed in cross section on ultrasound, the portal triad—portal vein, hepatic artery branch, and bile duct—can be clearly seen due to the echogenic connective tissue sheath surrounding it. In this orientation, the triad resembles a head (portal vein) with mouse ears (hepatic artery and bile duct) and so is called the Mickey Mouse sign. (Color Doppler can be used to identify which of the ears is the hepatic artery.)



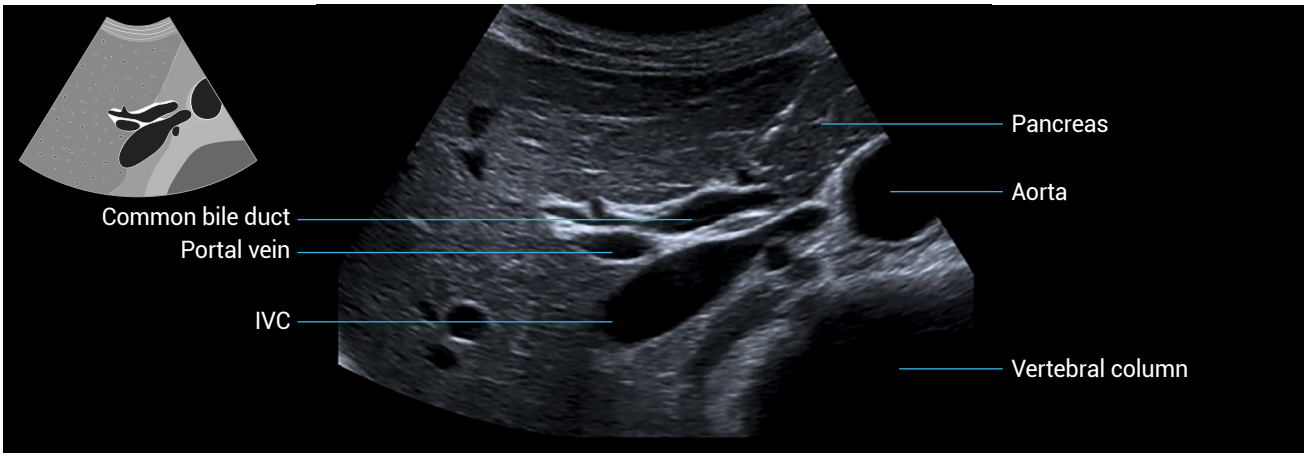
NOTE

Under normal conditions, the Mickey Mouse sign can only be seen in the central liver (central intrahepatic) and in extrahepatic regions where the bile ducts are of sufficient diameter. Elsewhere the bile ducts are too small in caliber to be seen by ultrasound.

Common bile duct

The common bile duct can be viewed in an ultrasound window that is aligned with the shoulder umbilical line (an imaginary line formed by connecting the right shoulder with the belly button)

In this view, the common bile duct (CBD) appears in long section running within the hepatoduodenal ligament extending from the liver hilum. The common bile duct normally has a diameter up to 6 mm.



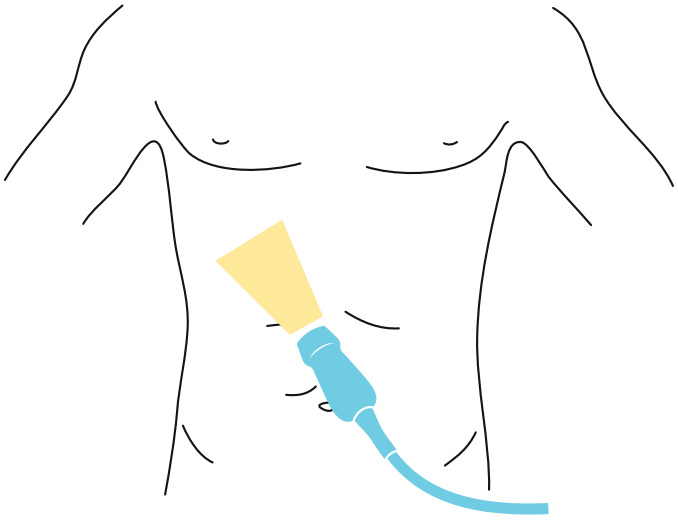
The Biliary System

RECOGNIZING THE LANDMARKS

Jumping stag sign

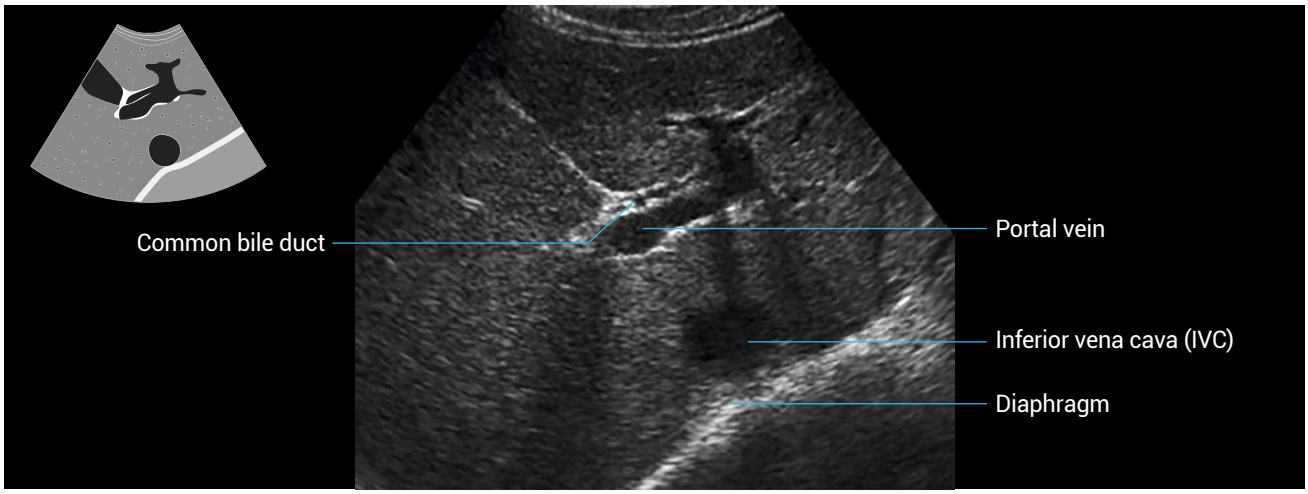
The easiest way to locate the gallbladder is to look for the jumping stag sign. In longitudinal section, this sign shows the portal vein branching in the center of the liver hilus.

The ultrasound probe is held at 30° to the cross section of the body.



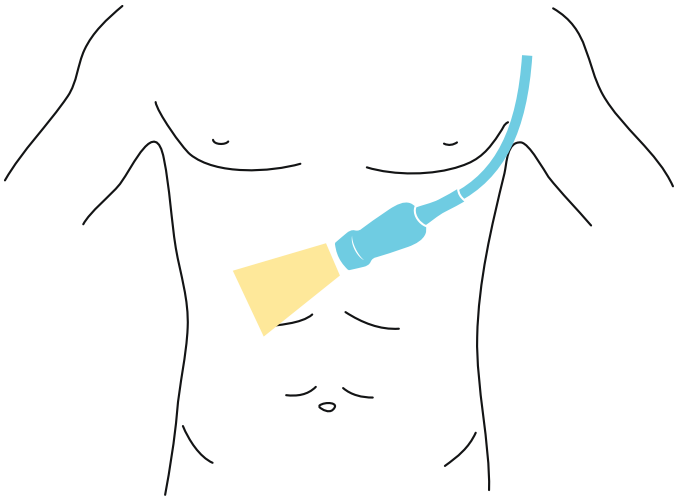
Here you can see the portal vein branching—the right hepatic duct and the left hepatic duct join to form the common bile duct, riding on the back of the jumping stag.

The tail of the jumping stag is the interlobar fissure, which separates segment 4 from segments 5, and 8. If you follow that interlobar fissure caudally you will find the gallbladder.

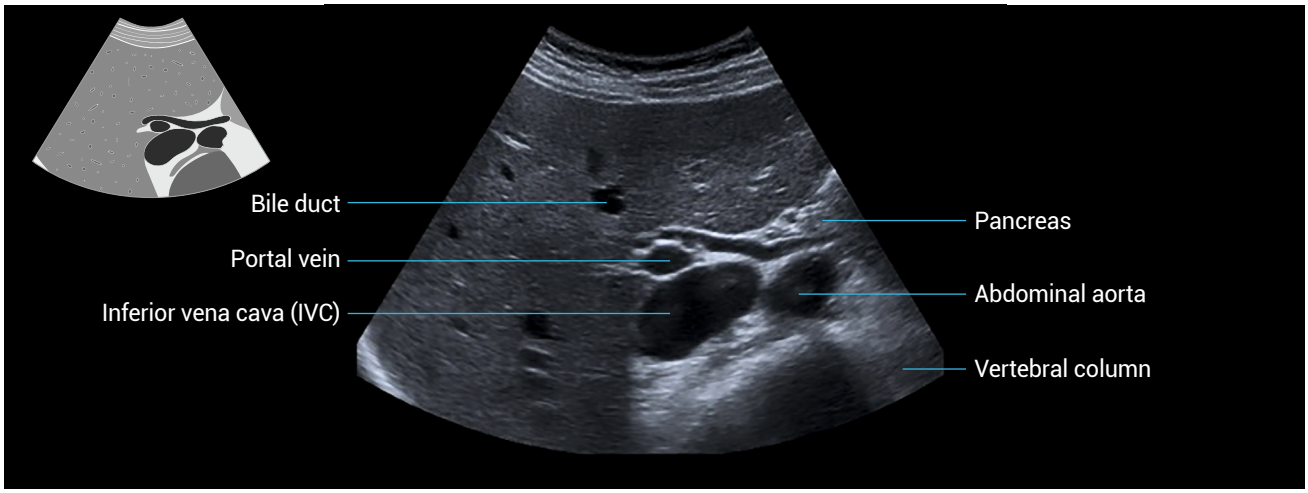


Shoulder umbilical line

The shoulder umbilical line is the long section over an imaginary line formed between the umbilicus and the right shoulder.



It is similar to a long section over the hepatoduodenal ligament, in which we find the bile duct riding atop the portal vein.



The Biliary System

HOW DO I DO IT?

Examination algorithm

The first steps are the same as those for imaging the liver.

Suggested algorithm for the ultrasound of the biliary system

1. Right liver lobe transverse section
2. Left liver lobe transverse section
3. Right liver lobe long section
4. Left liver lobe long section
5. Shoulder umbilical line
6. Landmarks: jumping stag sign, shoulder umbilical line, hepatoduodenal ligament

Important:
Always follow the same sequence!

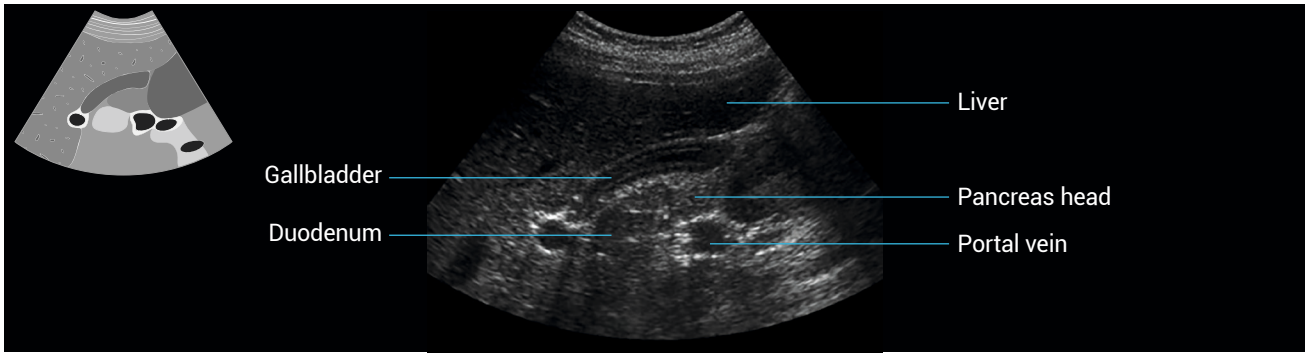
The Biliary System

RECOGNIZING VARIANTS

Contracted

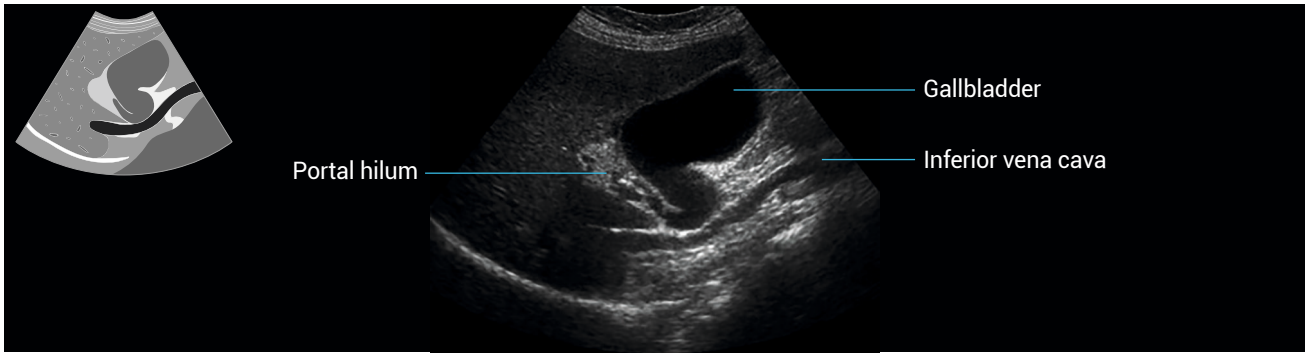
When the patient has recently eaten, the gallbladder contracts to excrete the stored bile into the extrahepatic biliary tract.

In it's contracted form, the gallbladder has a three layered wall that appears thicker than normal. This is a normal finding and does not indicate pathology.



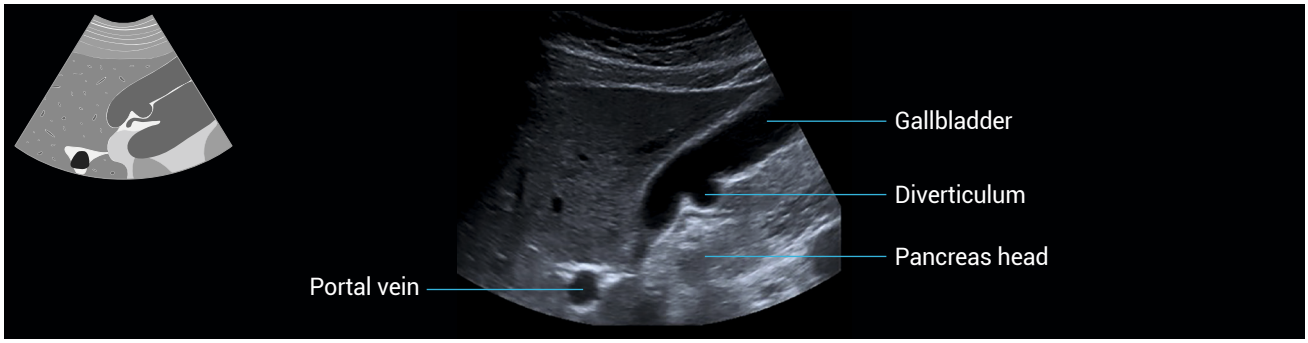
Phrygian cap (folded gallbladder)

The Phrygian cap formation is the most common congenital anatomic variant of the gallbladder. It denotes folding of the fundus back upon the gallbladder body and is asymptomatic with no pathological significance. This variant gets it's name because the gallbladder resembles a Phrygian cap, a head garment worn by inhabitants of Phrygia (modern Turkey) from 1200–700 BC.



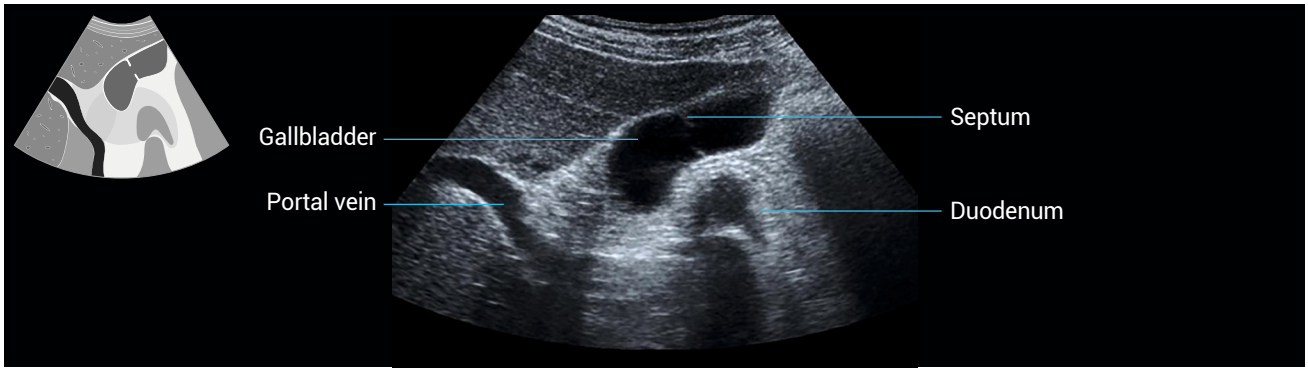
Diverticulum

Gallbladder diverticula can occur in any part of the gallbladder, but are most frequently seen in the fundus region. They can sometimes be filled with echogenous material (sludge or stones)—making them difficult to identify.



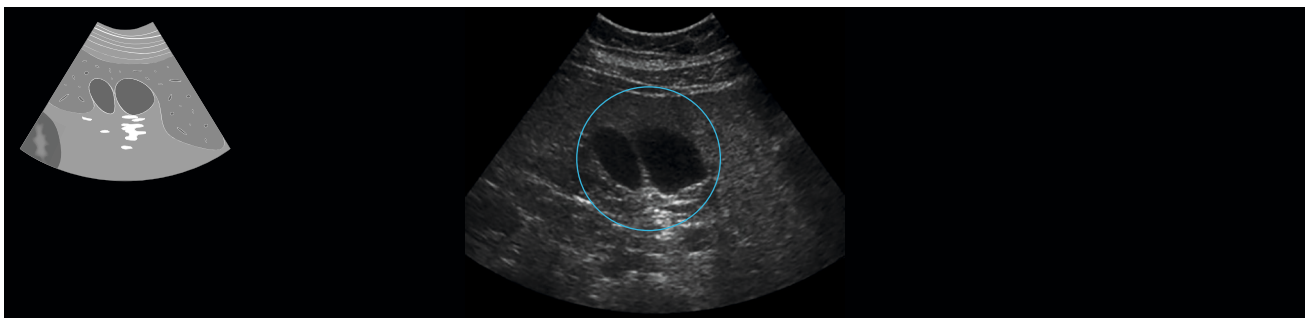
Septum

It is only possible to diagnose true septa of the gallbladder if the form of the septum remains consistent when the ultrasound is performed with the patient in a variety of positions—right lateral, left lateral, and standing. If the wall configuration does not change, a true septum is present.



Duplication

A real duplication is present when two cystic ducts, or at least a common cystic duct, can be observed draining from both gallbladders into the common bile duct. Otherwise, the perceived duplication is likely a typical liver cyst that is neighboring the normal gallbladder.

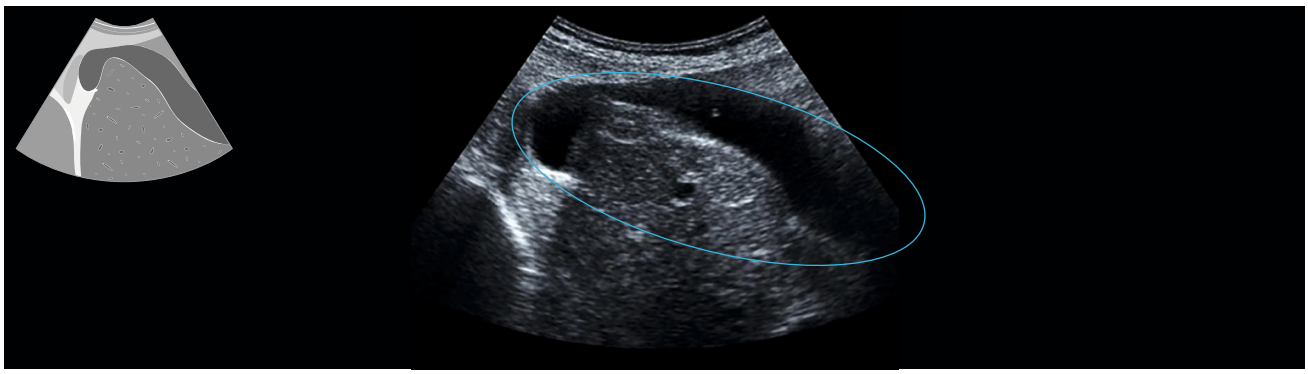


Transverse location

In this picture you see an ectopic gallbladder with transverse location, to the right lateral side beneath the diaphragm.

Even though ectopic gallbladders can sometimes make identifying these structures difficult, there are two anatomical features that can aid in the diagnosis.

In all ectopic variants, the gallbladder neck is located in the interlobar fissure and the gallbladder is always connected to the cystic duct. Looking for these features can assist in identifying ectopic gallbladders.



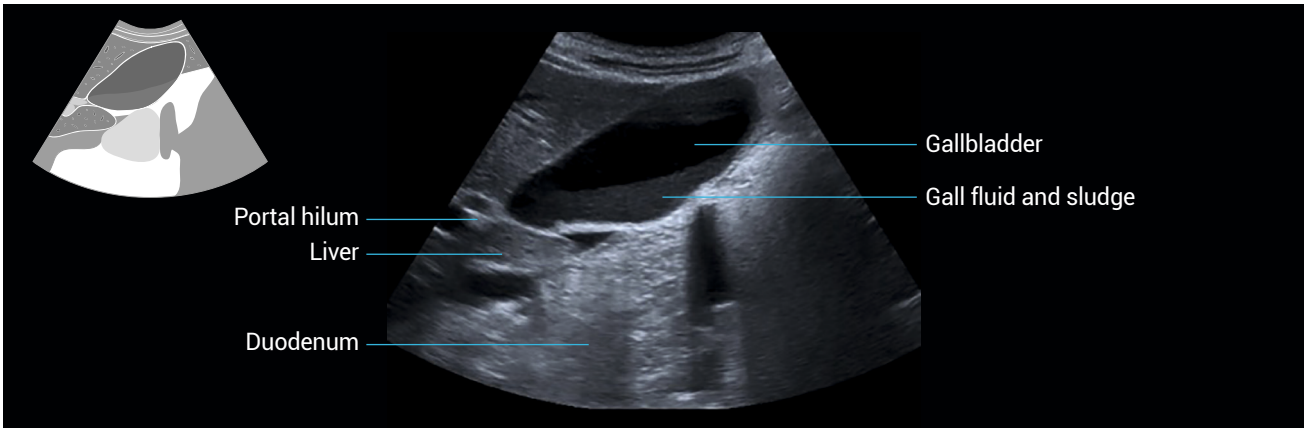
The Biliary System

DETECTING LUMEN ALTERATIONS

Sludge

Gallbladder sludge presents as a low echogenic fluid level on the posterior wall of the gallbladder. It moves slowly with changes in the patient's position.

Small amounts of gallbladder sludge may mimic gallstones (so-called tumefactive sludge), but sludge does not cause shadowing unless it is associated with gallstones. Large amounts of tumefactive sludge may also mimic a mass.

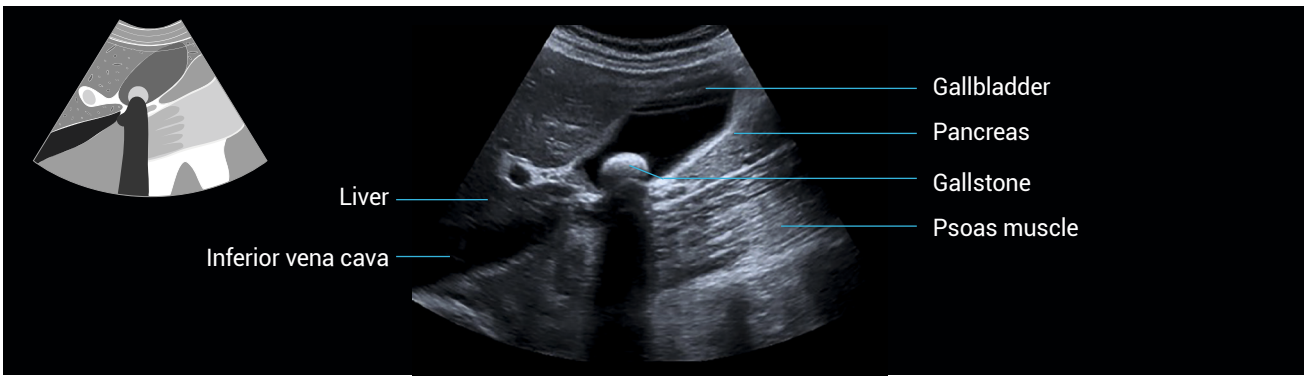


Gallstones

Ultrasound is considered the gold standard for detecting gallstones.

Gallstones will present with the following characteristics

- High echogenic structure within the gallbladder lumen, normally showing a prominent posterior acoustic shadowing.
- Gravity-dependent movement is often seen with a change in patient position (the rolling stone sign).
- Color Doppler may demonstrate a twinkle artifact and is particularly useful for identification of small stones.

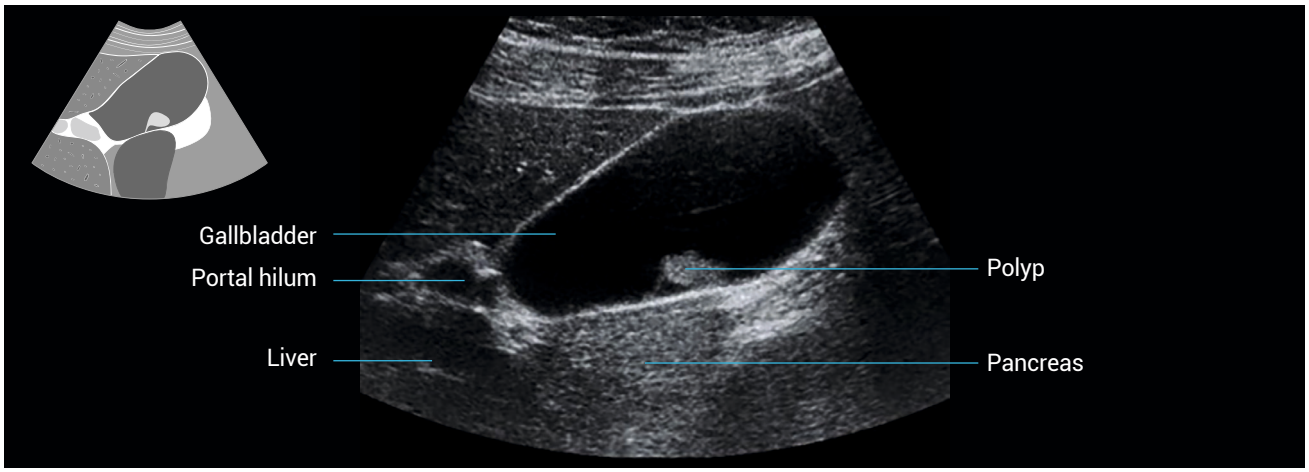


Polyps

Gallbladder polyps are elevated lesions on the mucosal surface of the gallbladder. They are relatively frequent findings, seen in 7% of the population. Over 90% are benign (malignant polyps are possible).

Cholesterol polyps are most frequently identified (especially in patients between 40 and 50 years of age) and are nearly three times more common in women.

Gallbladder polyps are often incidental findings during upper abdominal imaging, performed in response to upper abdominal discomfort reported by the patient. In most instances, the polyps are thought to be asymptomatic.

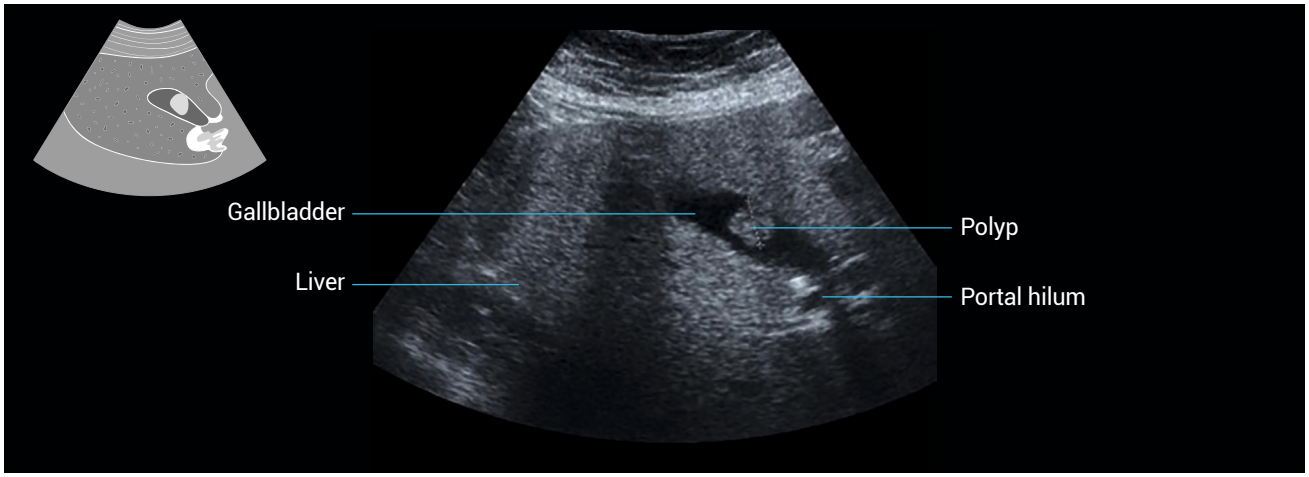


Adenoma

Adenomas are more rare than polyps and are typically sessile tumors of the gallbladder wall.

However, they tend to be larger, solitary, and show a broad connection to the gallbladder wall with internal vascularity and intermediate echogenicity.

Since adenomas follow the adenoma-carcinoma sequence, surgical treatment or regular follow ups should be performed.



The Biliary System

DIAGNOSING CHOLECYSTITIS

Acute cholecystitis

Cholecystitis refers to any form of inflammation involving the gallbladder and has many forms.

The majority (90–95%) of acute cholecystitis cases are due to gallstones (i.e., acute calculous cholecystitis) with the remainder being acute acalculous cholecystitis.

It is the primary complication of cholecystolithiasis and the most common cause of acute pain in the right upper quadrant (RUQ).

The development of acute calculous cholecystitis follows a sequence of events:

1. Gallstone obstruction of the gallbladder neck or cystic duct.

2. Inflammation from chemical injury of the mucosa by bile salts.

3. Reactive production of mucus, leading to increased intraluminal pressure and distention.

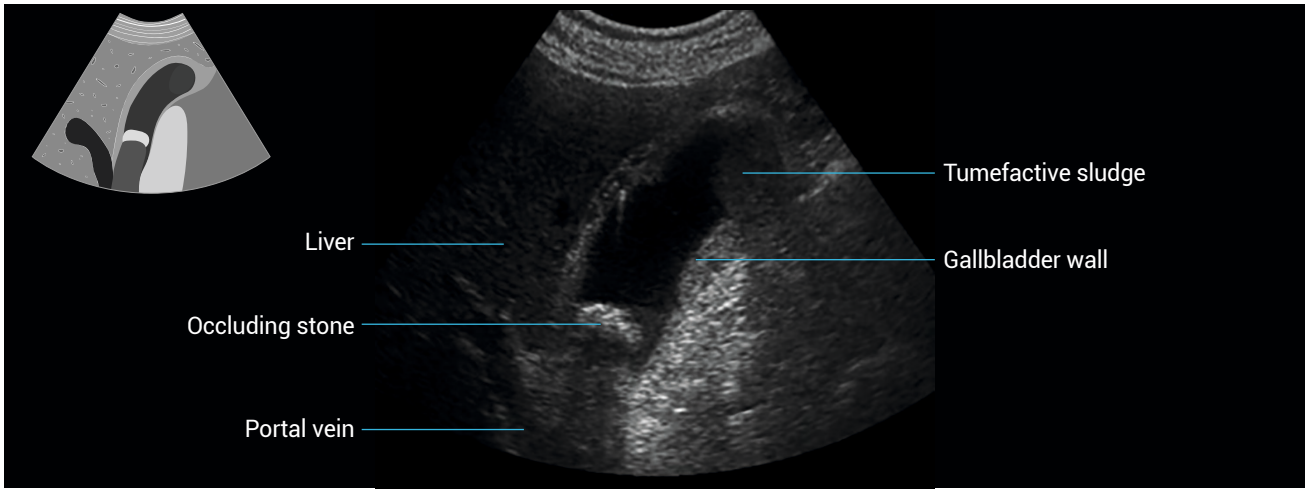
4. Increased luminal distention that restricts blood flow to the gallbladder wall (gallbladder hydrops).

5. Increased wall thickness due to edema and inflammatory changes.

6. Secondary bacterial infection in ~ 66% of patients.

The most sensitive ultrasound finding in acute cholecystitis is the presence of cholelithiasis in combination with the Murphy sign. Both gallbladder wall thickening (> 3 mm) and pericholecystic fluid are secondary findings. Other less specific findings include gallbladder distension and sludge.

Every effort should be made to visualize the occluding stone in the gallbladder neck or cystic duct.

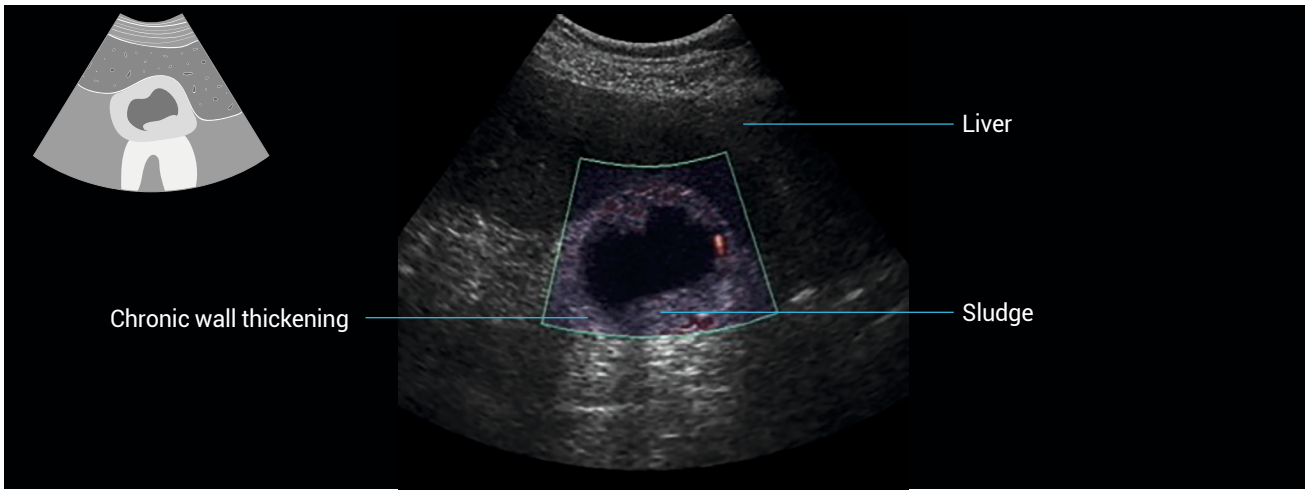


Chronic cholecystitis

Chronic cholecystitis refers to a prolonged inflammatory condition that affects the gallbladder.

It is almost always present in the setting of cholelithiasis (95%), caused by intermittent obstruction of the cystic duct or infundibulum, or biliary dysmotility.

Patients with chronic cholecystitis may have a history of recurrent acute cholecystitis or biliary colic, although some may be asymptomatic.

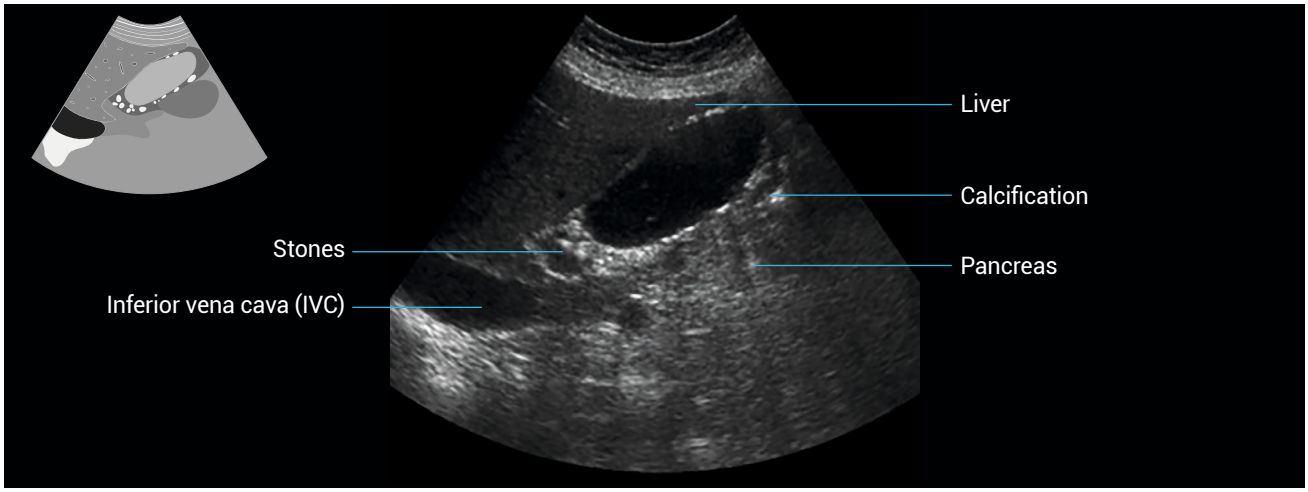


Porcelain gallbladder

Porcelain gallbladder refers to extensive calcium encrustation of the gallbladder wall. Patients are usually asymptomatic, and porcelain gallbladder is most often seen on plain abdominal radiographs, ultrasound images, or CT images.

On ultrasound, the gallbladder demonstrates dense shadowing, which can be mistaken for gas in the gallbladder wall (emphysematous cholecystitis) or gallstones in the lumen.

Based on early studies, which revealed a high association between porcelain gallbladder and gallbladder adenocarcinoma, cholecystectomy is routinely performed when a porcelain gallbladder is identified.



The Biliary System

DIAGNOSING CHOLEDOCHOLITHIASIS

Choledocholithiasis

Choledocholithiasis denotes the presence of gallstones within the bile ducts (common hepatic duct / common bile duct). Stones within the bile duct are often asymptomatic and may be found incidentally; however, they are more frequently accompanied by symptoms such as

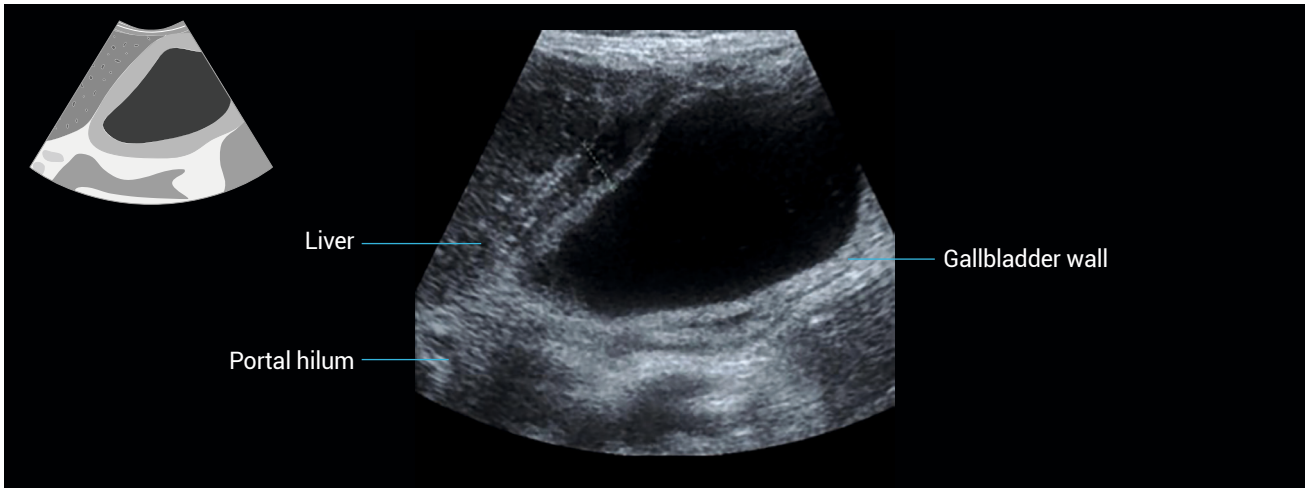
- Biliary colic
- Ascending cholangitis
- Obstructive jaundice
- Acute pancreatitis

Stones within the bile duct may either form in situ or pass from the gallbladder.

Gallbladder edema

Gallbladder edema can be a secondary phenomenenon following dilation of extrahepatic and intrahepatic bile ducts due to stone obstruction.

Ultrasound should be performed (along the shoulder-umbilical line) to find the common bile duct in longitudinal section. Pay particular attention to the very distal portion of the common bile duct as it passes though the pancreatic head (this can be best assessed transversely).



The Biliary System

DIFFERENTIATING MALIGNANT BILIARY TUMORS

Gallbladder carcinoma

Gallbladder carcinomas are usually asymptomatic until they reach an incurable stage. As such, early incidental detection is important if a patient is to be successfully treated. The majority (90%) are adenocarcinomas, and the remainder are squamous cell carcinomas.

Gallbladder carcinomas predominantly affect older people with long-standing cholecystolithiasis, and as such are most common in elderly women.

Clinical presentation depends on the direction in which the mass extends. In cases where biliary obstruction is created, jaundice is often the first presentation. If the malignancy is located in the body or fundus of the gallbladder, then extension into the liver, adjacent colon or small bowel can lead to local pain or bowel obstruction, respectively.

Other symptoms include right upper quadrant pain, weight loss, and anorexia.

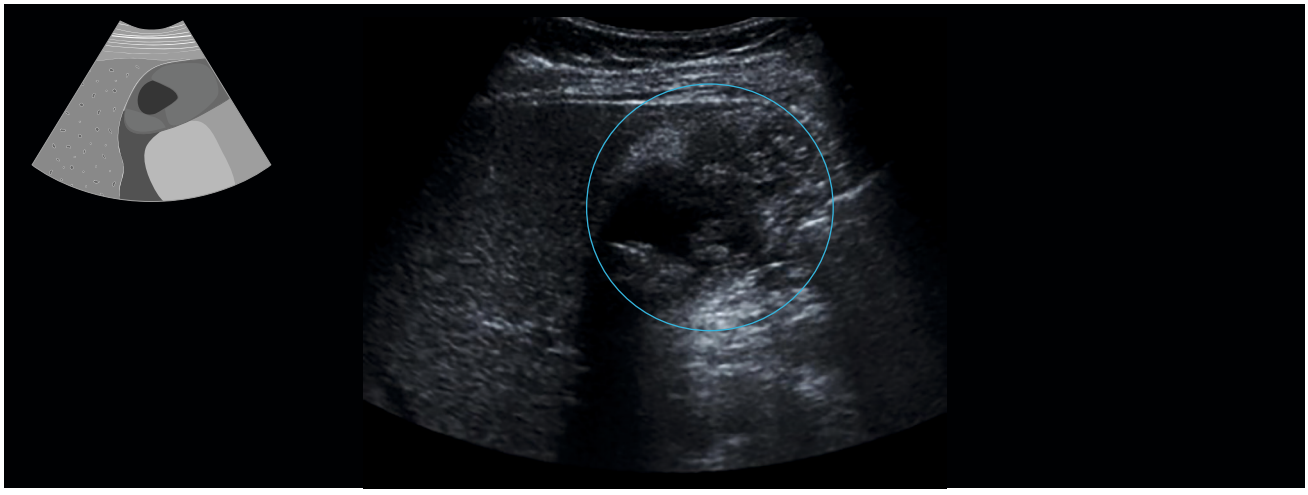
Gallbladder adenocarcinomas present in one of three morphologies

1. Intraluminal mass

2. Diffuse mural thickening

3. Mass replacing the gallbladder (presumably the end result of progression from either of the above states).
   This is the most common presentation.

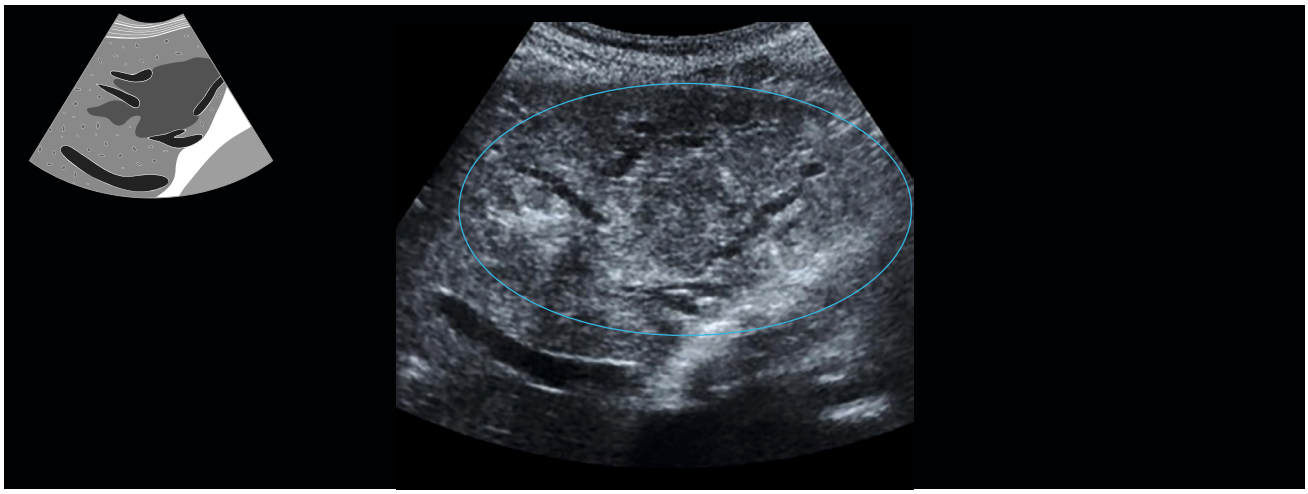
Fixed gallstones are a typical phenomenon that are due to fixation of the gallstones within the tumor tissue, immobilizing them when the patient changes position.



Intraductal cholangiocarcinomas

Intraductal tumors make up 8–18% of resected cholangiocarcinomas and a much smaller number of all cholangiocarcinomas (as most are inoperable).

They are characterized by alterations in duct caliber (usually duct ectasia) with or without a visible mass. The visible mass may be mural or polypoid in shape. The duct dilatation is thought to result from abundant mucin production. This entity is thought to be similar to the pancreatic (IPMN).



Extrahepatic / large duct cholangiocarcinomas

There is much confusion in the literature as to the definition of extrahepatic cholangiocarcinomas, and there is thus some overlap. Large duct (hilar and extrahepatic) tumors show the following distribution:

- Intrahepatic large ducts: 15%
- Hilum / proximal third of the common bile duct: 50%
- Middle third of the common bile duct: 17%
- Distal third of the common bile duct: 18%

These tumors are most commonly infiltrating, although both exophytic (mass-forming) and polypoid (intraductal) types have been identified. They have similar appearances to their intrahepatic counterparts.