Abdominal Ultrasound
Chapter 2

THE LIVER

Niko Mayr

The Liver

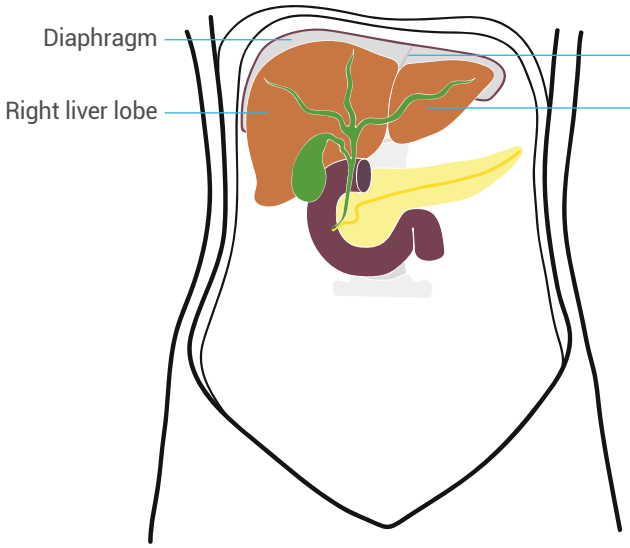
MASTERING ULTRASOUND ANATOMY

The liver is located in the right hypochondriac region, situated just below the diaphragm, to the right of the stomach. It overlies the gallbladder and is enveloped by the serosal lining of the visceral peritoneum.

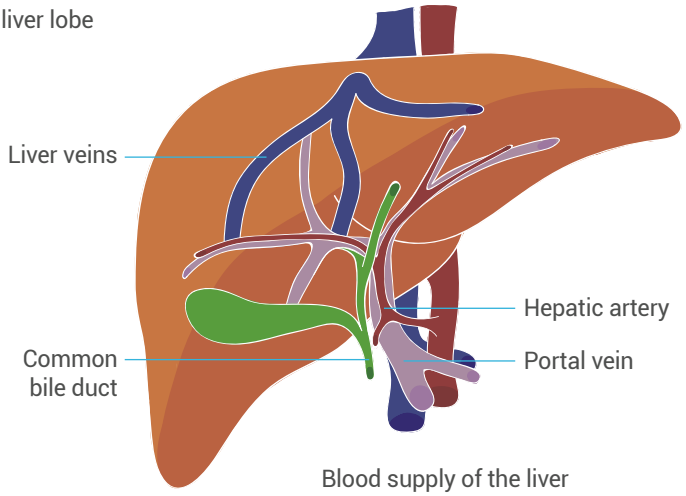
The liver is attached to the ventral body wall by the falciform ligament, which, at its free end, becomes the round ligament of the liver, dividing the liver into left and right lobes.

The liver is an excretory organ. Upon the consumption of food, it excretes gall fluid into the duodenum.

The hepatoduodenal ligament is a peritoneal duplicature that carries the vessels associated with the liver—the portal vein, the common bile duct, and the liver artery—as well as lymphatic vessels and interspersed lymph nodes.



Retroperitoneum

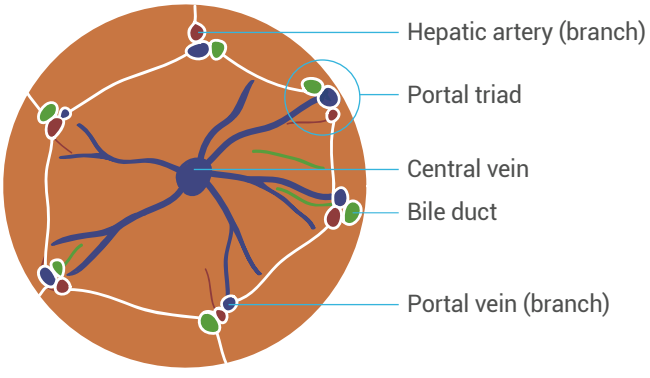


Blood supply of the liver

The liver receives a dual blood supply from the hepatic artery and the portal vein.

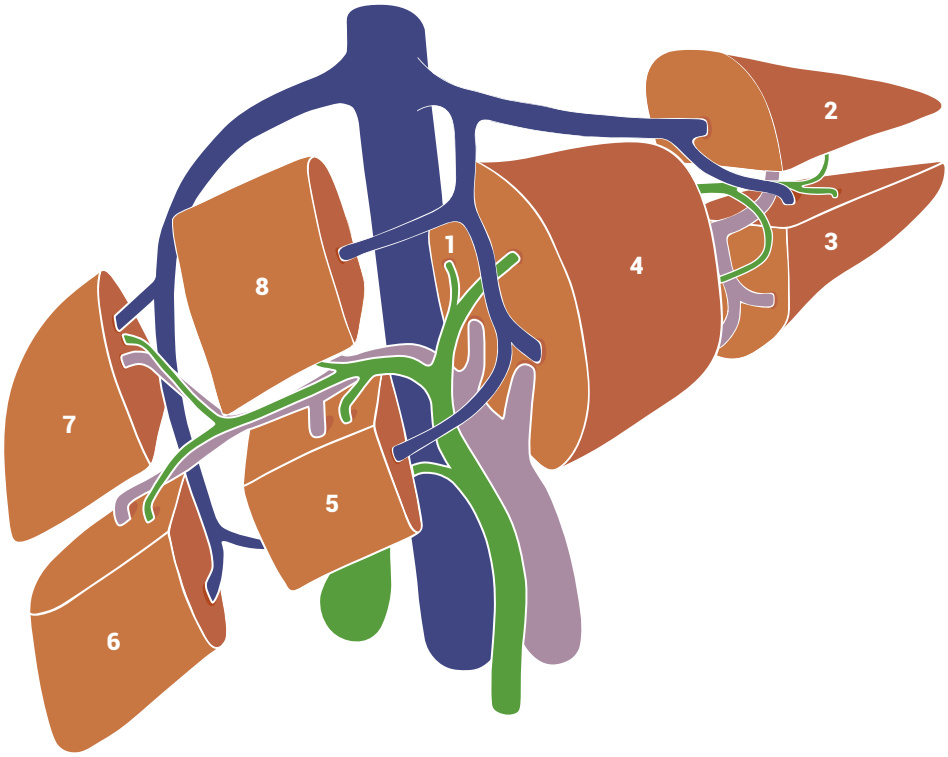
The underlying basic functional structure of the liver is the liver lobule, which is organized into a hexagonal field.

Branches of the portal vein and hepatic artery, along with a bile duct—the portal triad or triad of Glisson—can be found in the peripheral corners of the hexagonal field, while the center of each field contains a branch of the hepatic vein.



Liver lobule

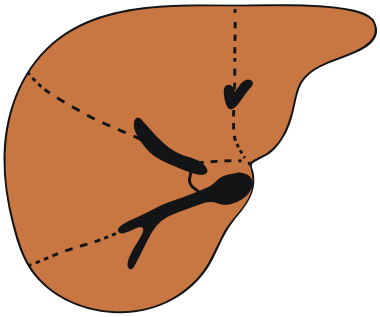
Liver segments (by Couinaud)



The Couinaud classification of liver anatomy divides the liver into eight functionally independent segments. Each segment has its own vascular inflow, outflow, and biliary drainage.

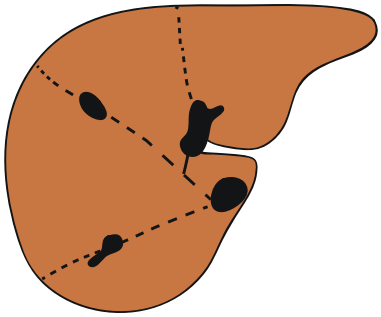
Transverse anatomy of the liver

There are three transverse levels that assist in distinguishing the liver segments in ultrasound, even though this is sometimes not easy:



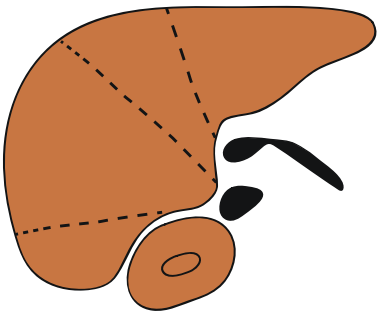
Cranial level

- Hepatic venous star / hepatic vein confluency or junction
- Segments 7 / 8 / 4 / 2



Middle level

- Left portal vein
- Segments 7–6 / 8–5 / 1 / 4 / 2–3



Lower level

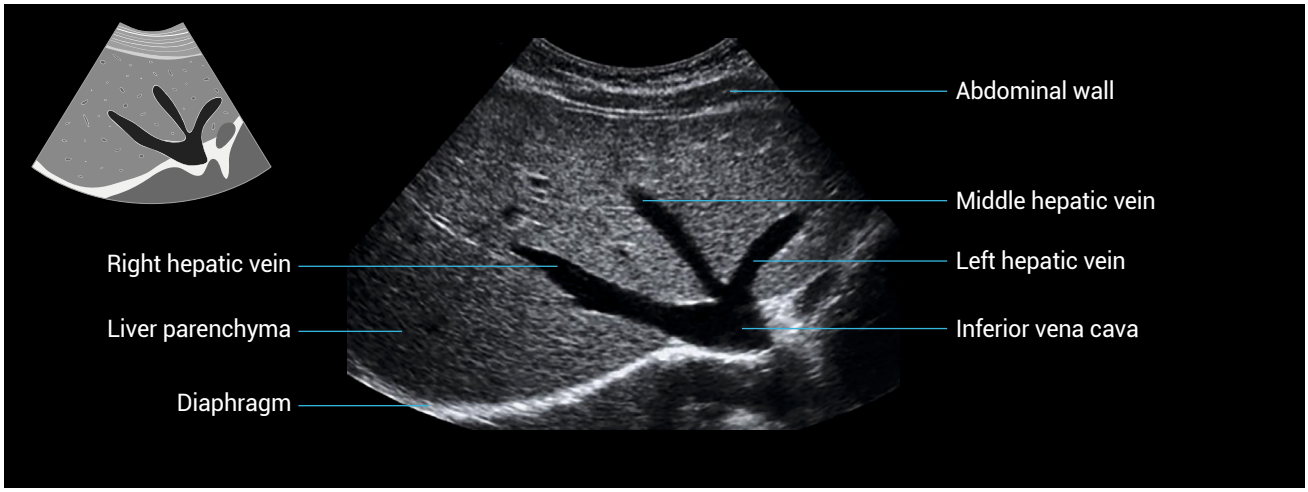
- Splenic vein
- Segments 6 / 5 / 4 / 3

The Liver

RECOGNIZING THE LANDMARKS

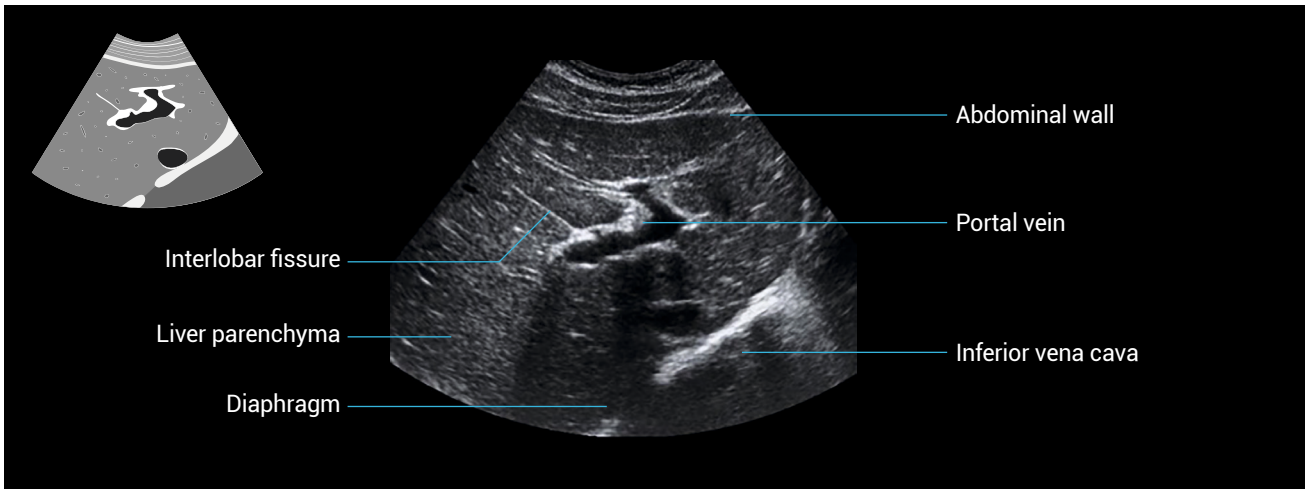
Hepatic venous star

The hepatic venous star can be seen in the most cranial of the three transverse segments. It is formed by the convergence of the left, middle, and right hepatic veins as they drain the liver blood into the inferior vena cava.



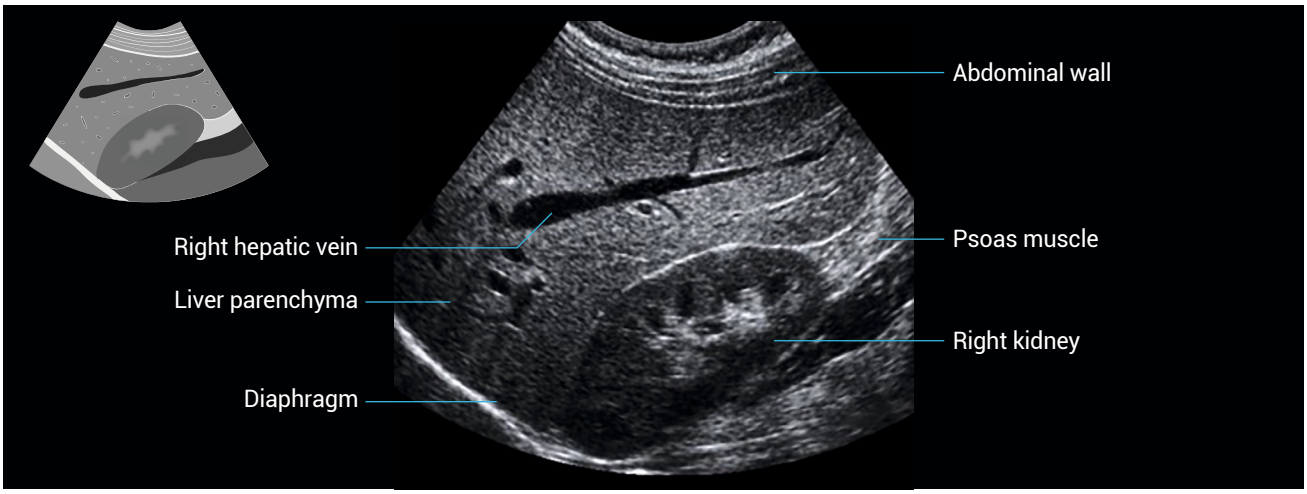
Jumping stag sign

At the second transverse level of the left portal vein, it divides into right and left portal vein branches. The echogenic connective tissue surrounding the the branching veins—called the *jumping stag sign*—is the landmark for locating intrahepatic biliary ducts and the hepatic arteries. The interlobar fissure should be followed caudally when looking for the gallbladder.



Morison's pouch

Morison's pouch is a peritoneal duplicature located between the right liver lobe and in the right epigastrium. Morison's pouch forms the lowest point in the intraperitoneal cavity and therefore it is common to find intraperitoneal fluid collecting here.



The Liver

HOW DO I DO IT?

Examination algorithm

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. Landmarks: Hepatic venous star, jumping stag sign, Morison‘s pouch

Important:
Always follow the same sequence!

The Liver

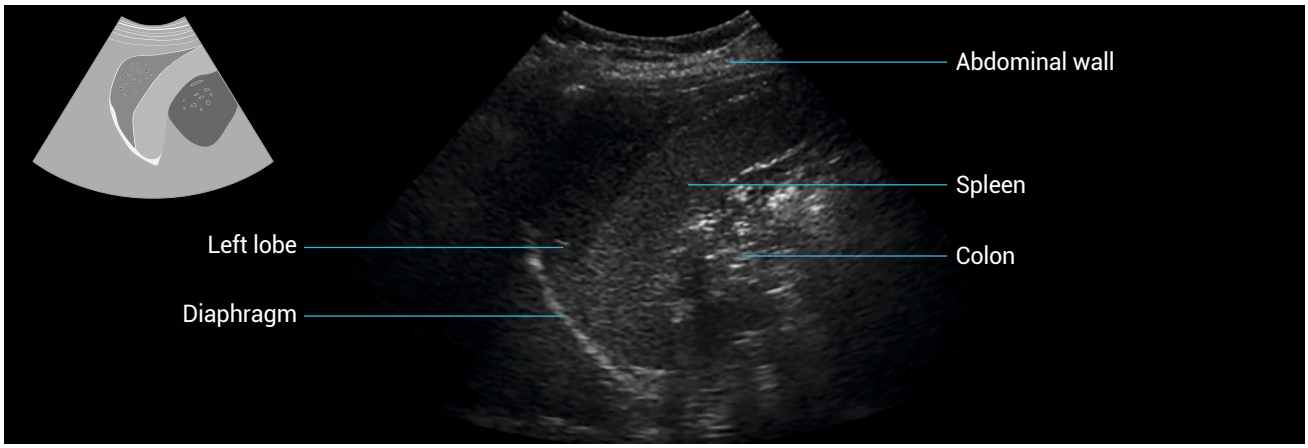
IDENTIFYING VARIANTS AND CHANGES IN ECHOGENICITY

Kissing phenomenon

When you see the two organs (liver and spleen) *kissing* it is called the kissing phenomenon.

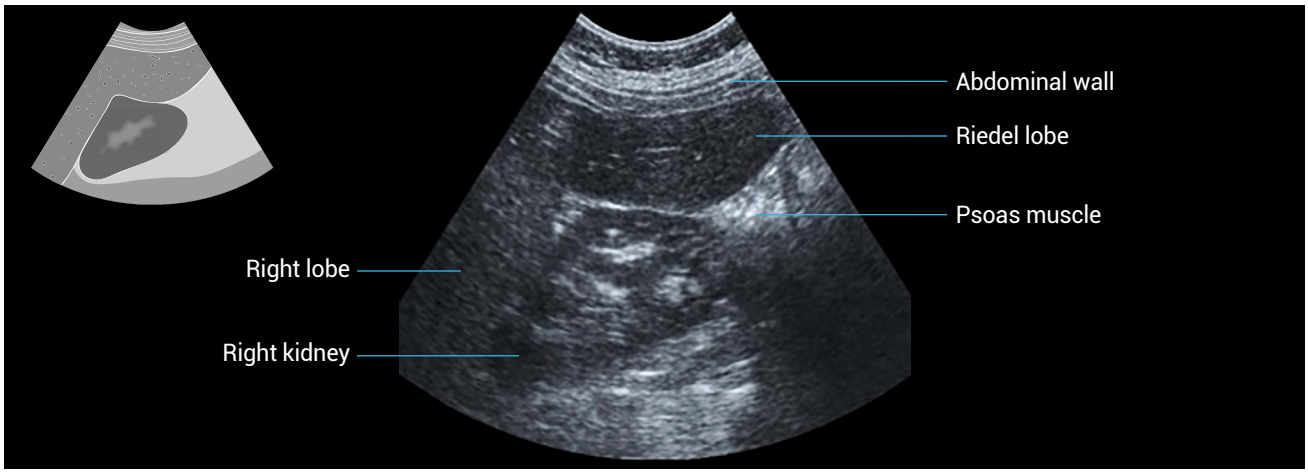
The kissing phenomenon represents a normal variant—found mostly in tall and slender women, where the left liver lobe reaches over to the left epigastrium and can be seen between the diaphragm and the spleen (or occasionally between the spleen and kidney).

This phenomenon is also sometimes called the beaver tail liver or sliver of liver.



Riedel liver lobe

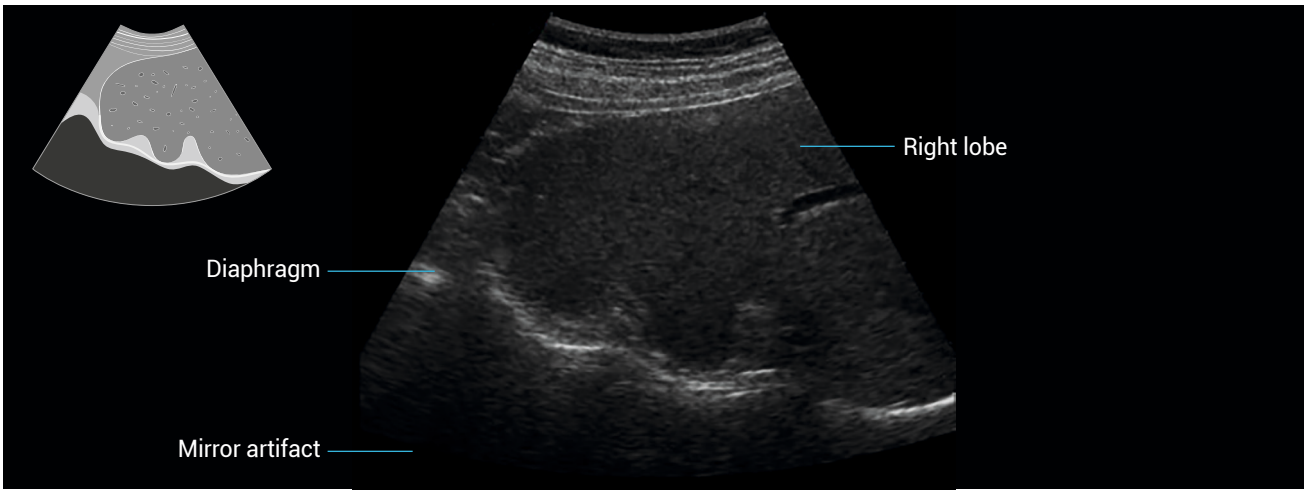
The Riedel liver lobe (sometimes inappropriately called the *third liver lobe*), is a normal variant in which there is a *bridge-like* thinning in the right liver lobe (the segment ventral to the right kidney), which causes the liver segment to form a tongue-like mass more caudally. The Riedel lobe can be so long that it reaches toward the upper pelvic aperture. It is important to recognize this as a normal variant because it can be misidentified as a liver mass and therefore lead to unnecessary surgery!



Diaphragmatic muscular bundles

Diaphragmatic muscular bundles (slips) connect the central tendon of the diaphragm to the inner aspect of the lower thoracic cage.

These bundles cause hepatic invaginations, which can be visualized with ultrasound (US) or computed tomography (CT).



High echogenicity—steatosis of the liver

Compared to the abdominal organs (such as the liver and kidneys), fat has a higher echogenicity and appears more white on ultrasound. Liver steatosis is a condition in which an increased amount of fat is stored in the liver cells causing the echogenicity of the liver to increase.

The kidney cortex normally has the same echogenicity as the liver. However, unlike the liver, kidney cells do not take up and store fat. Therefore, when performing an ultrasound of a long section of the kidney, the liver will appear more white than the kidney, if liver steatosis is present.

Liver steatosis can be quantified by examining the long section of the right liver lobe, showing the Morison's pouch, and documenting the difference in echogenicity between the liver and kidney cortex.

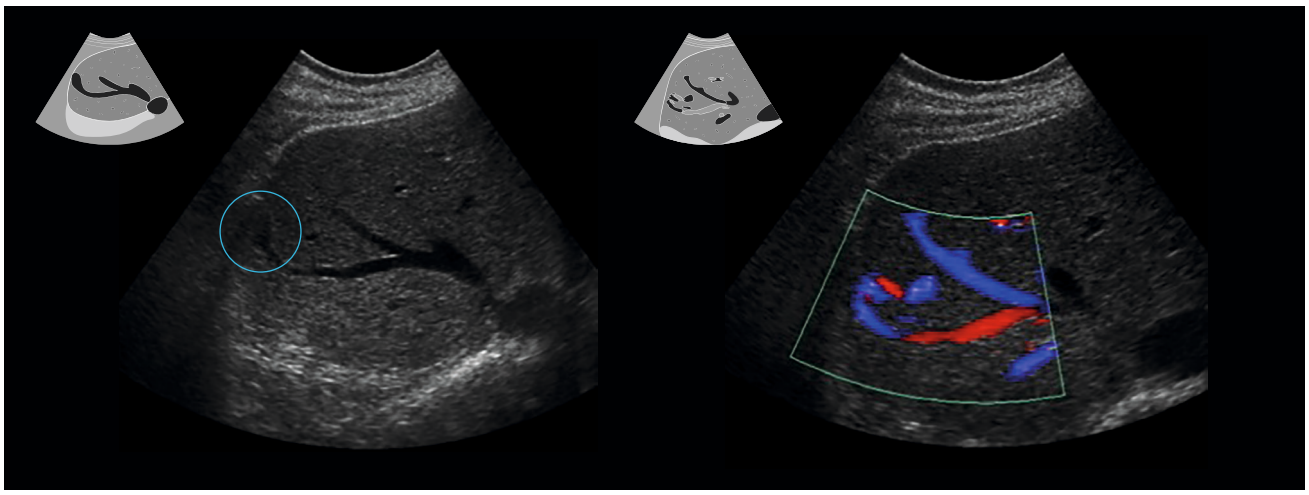
The Liver

DIAGNOSING VASCULAR LIVER DISEASES

Portosystemic shunts

The most common vascular anomaly in the liver is the portosystemic shunt, an abnormal connection between a branch of the portal vein and a liver vein.

This shunt enables the portal blood to flow into the systemic liver veins without undergoing clearance through hepatocytes.



Congestive hepatopathy

Dilated liver veins can often be seen when performing ultrasound on a patient with congestive hepatopathy.

As hepatic vein outflow decreases, the hydrostatic pressure in the liver veins grows and the veins dilate. If this clinical state remains for days or weeks, the liver parenchyma becomes more echogenic, since the microvascularization of the hepatocytes is compromised, and liver function decreases.

The end product of congestive hepatopathy is cirrhosis.

Portal vein thrombosis

Portal vein thrombosis may be observed in a variety of clinical contexts, and when acute, it can be a life-threatening condition.

It is a major cause of non-cirrhotic presinusoidal portal hypertension. Portal vein thrombosis may be either benign or malignant (i.e., tumor thrombus).

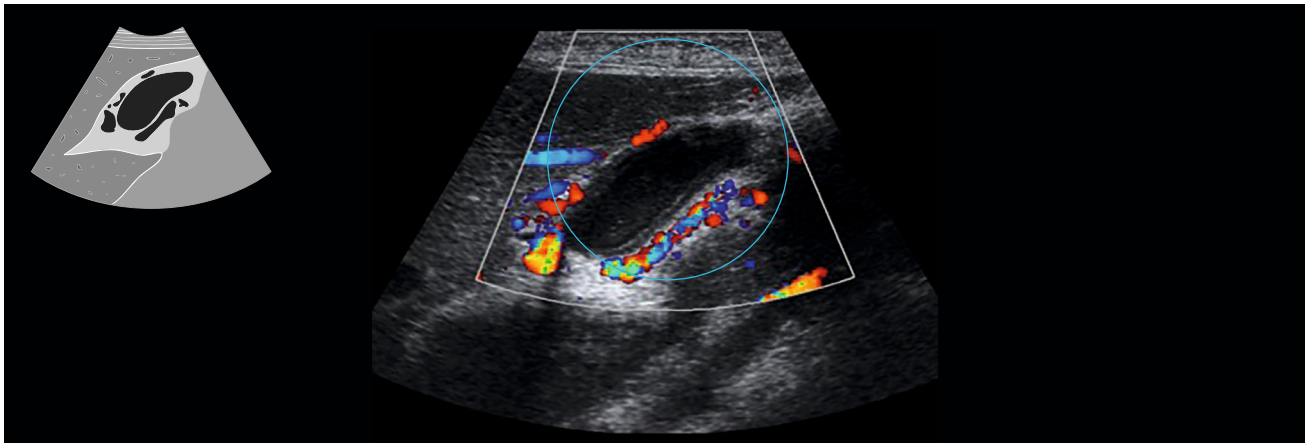
Portal vein thrombosis underlies the Virchow triad:

1. Reduced flow / portal hypertension (most commonly seen in cirrhosis and carcinoma)

2. Hypercoagulable state

3. Endothelial disturbance (most common in acute pancreatitis, ascending cholangitis, or chronic inflammatory diseases like chronic appendicitis, Crohn's disease, and colitis ulcerosa)

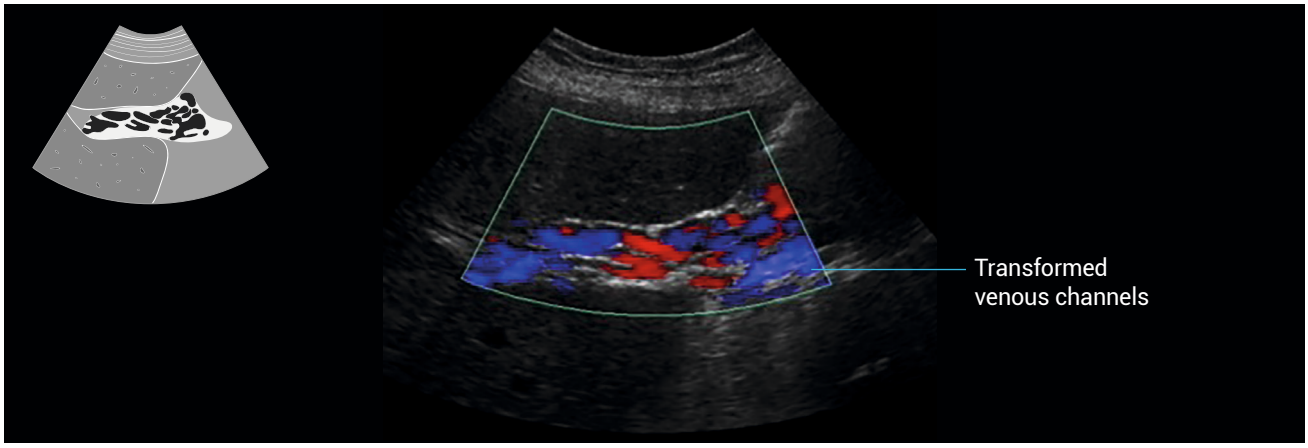
The normal b-mode picture of the thrombus can be echo-free—similar to the echo-free lumen of a vessel. Color Doppler imaging can be used to help locate the missing perfusion within the thrombotic area.



Cavernous transformation of the portal vein

Cavernous transformation of the portal vein is a sequela of portal vein thrombosis. It represents the replacement of the normal single channel portal vein with numerous tortuous venous channels. Following thrombosis, the portal vein may or may not recanalize.

Recanalization is more frequently seen in patients without cirrhosis or liver disease leading to inherently increased resistance to portal flow. In patients whose portal vein does not recanalize, or only partially recanalizes, collateral veins (thought to be paracholedochal veins) dilate and become serpiginous.This process can take as little as a week or as long as a year.



The Liver

DIFFERENTIATING BENIGN FOCAL LESIONS

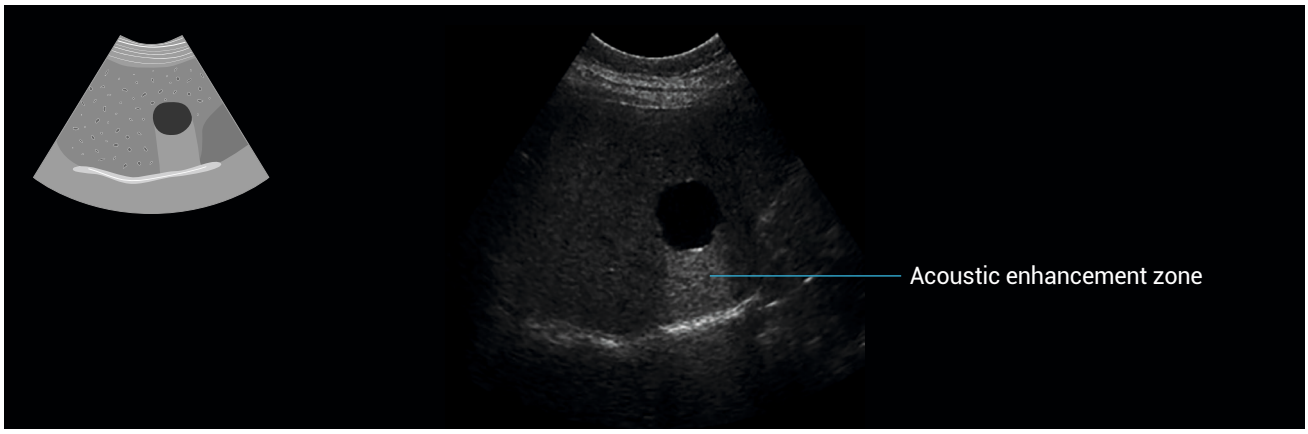
Simple hepatic (liver) cysts

Simple hepatic cysts are one of the most common liver lesions, occurring in approximately 2–7% of the population. There may be a slight female predilection.

Hepatic cysts are typically discovered incidentally and are almost always asymptomatic.

Simple hepatic cysts may be isolated or multiple and may vary from a few millimeters to several centimeters in diameter.

Simple hepatic cysts are benign developmental lesions that do not communicate with the biliary tree.

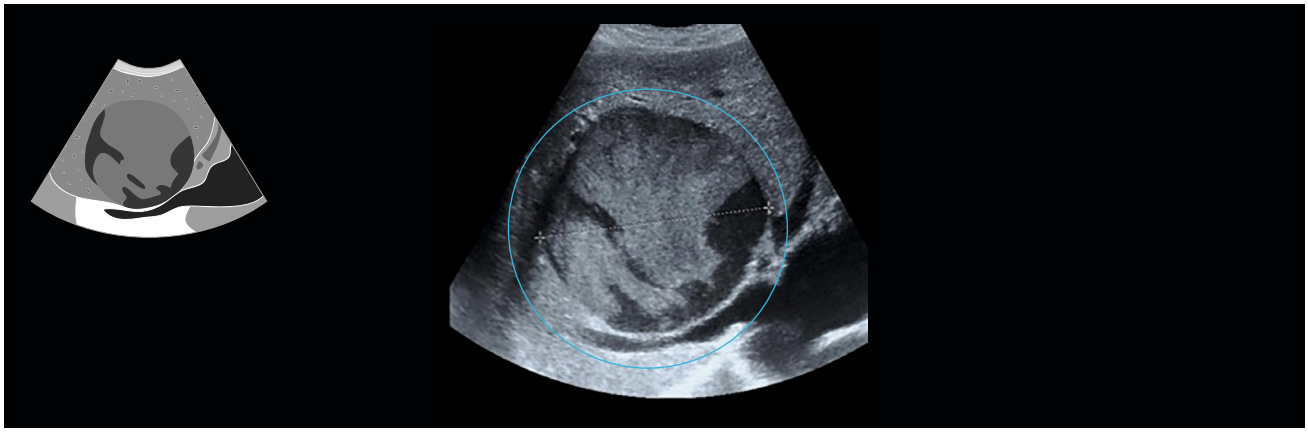


Findings

- Round or ovoid anechoic lesion (may be lobulated)
- Well-marginated with a thin or imperceptible wall and a clearly defined back wall
- May show posterior acoustic enhancement, if large enough
- A few septa may be present, but no wall thickening occurs
- A small amount of layering debris is possible
- No internal vascularity on color Doppler

Atypical hepatic (liver) cysts

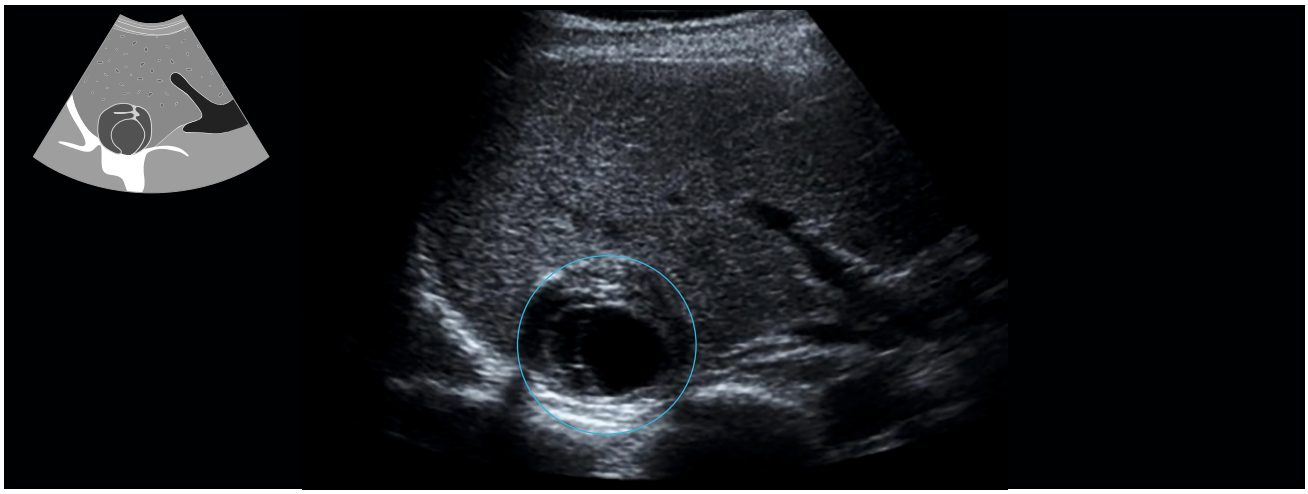
With atypical hepatic cysts, the findings diverge on one or more criteria. Always keep differential diagnoses such as necrotic metastases, hepatic hydatid cysts, hepatic bilioma, or hepatic absesses, in mind.



Hepatic hydatid cysts

Hepatic hydatid cysts are a parasitic zoonosis caused by the Echinococcus tape worm. The infection typically leads to the formation of spherical, fibrous rimmed cysts, with little if any surrounding host reaction.

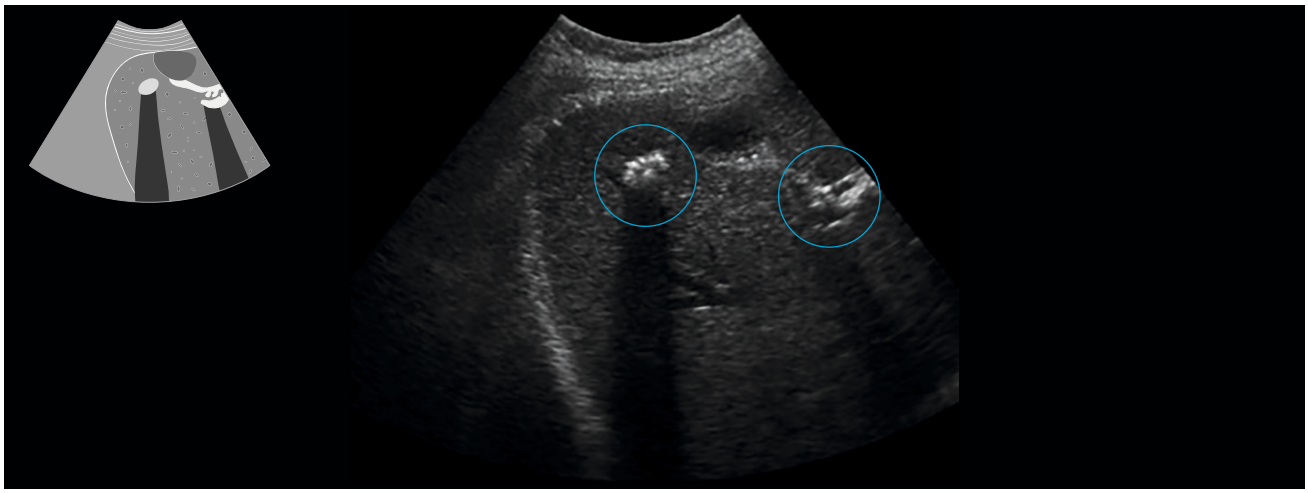
Classically, a large parent cyst forms, within which numerous peripheral daughter cysts are present. Satellite daughter cysts (outside the parent cyst) are also frequently observed (~16% of cases).



Focal liver calcification

Focal liver calcifications are diagnosed based on their typical appearance—a dome reflex and a typical tail shadow—which indicates that no echo is returning from behind the calcification.

Focal calcifications, especially when they are small, are typically benign lesions, but can sometimes be a target sign of hepatic tumors such as hepatocellular adenoma or carcinoma. In addition, colonic metastases tend to calcify when treated.

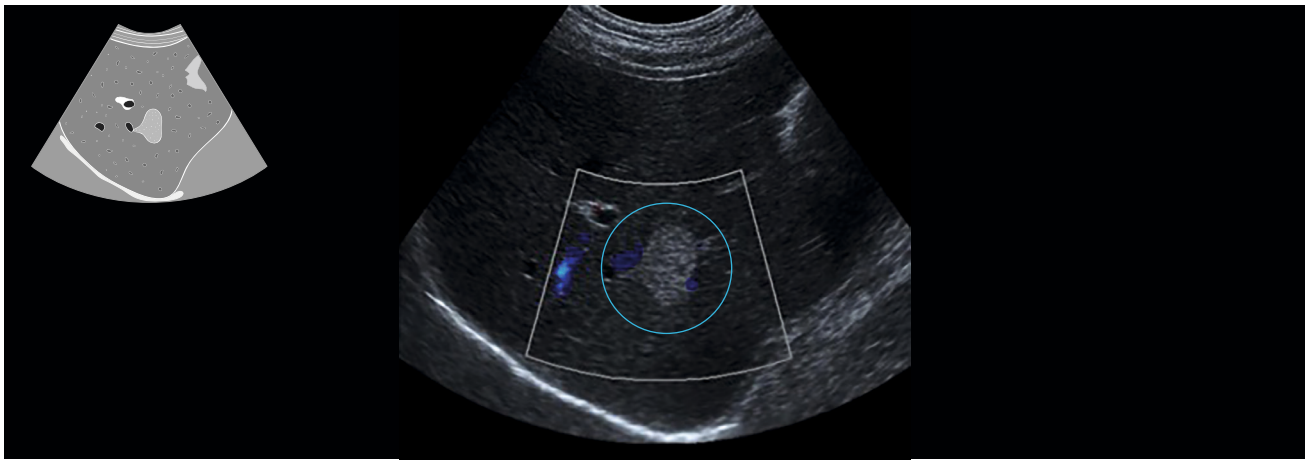


The Liver

DISTINGUISHING BENIGN HEPATIC TUMORS

Hepatic hemangiomas

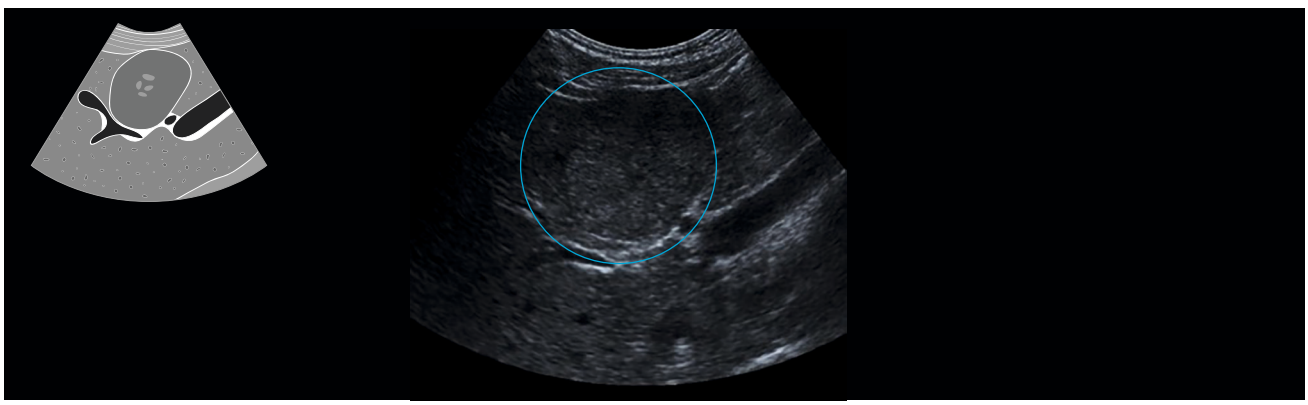
Hepatic hemangiomas, also known as hepatic venous malformations, are benign, non-neoplastic, hypervascular liver lesions. They are frequently diagnosed as an incidental finding on imaging, and most patients are asymptomatic. Hepatic hemangiomas are typically well-defined hyperechoic lesions. Only a small proportion (10%) of these are hypoechoic. Hypoechoic hepatic hemangiomas mainly result from underlying hepatic steatosis where they present as hypoechoic lesions in a hyperechoic liver.



Focal nodular hyperplasia

Focal nodular hyperplasia is a regenerative mass lesion of the liver and the second most common benign liver lesion after hemangioma. Focal nodular hyperplasias are typically asymptomatic lesions usually requiring no treatment.

Some lesions have well-defined margins and are easily seen, whereas others are isoechoic with the surrounding liver. Upon color Doppler examination, detectable lesions characteristically demonstrate a central vascular scar with the displacement of peripheral vasculature.



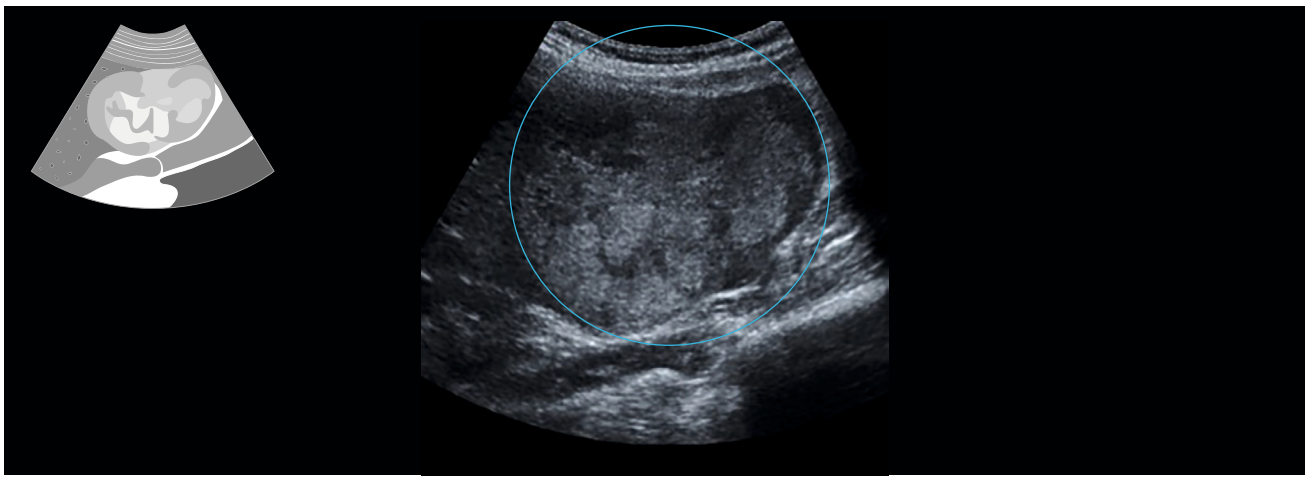
Hepatic adenoma

Hepatic adenoma is an uncommon benign liver tumor that is hormone-induced. These tumors are usually solitary and have a predilection to hemorrhage, therefore they must be differentiated from other focal liver lesions.

This is the most frequent type of hepatic tumor in young women taking oral contraceptives.

They are also found in other situations, including in young men using anabolic steroids and in patients with glycogen storage diseases.

Hepatic adenomas are often hyperechoic due to the presence of fatty tissue. On color Doppler, they may show perilesional sinusoid vessels.



The Liver

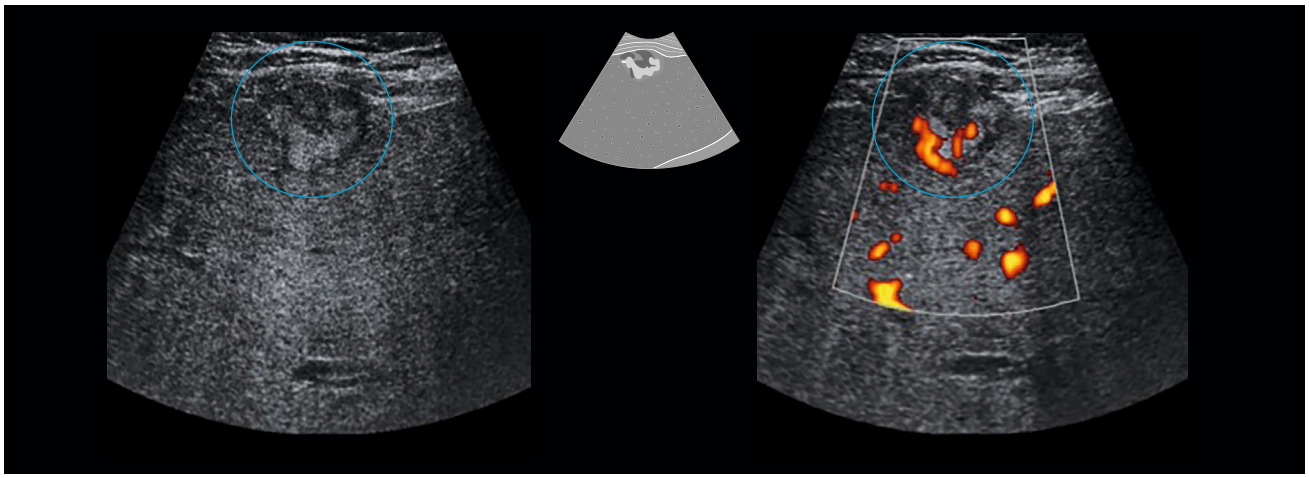
DETECTING MALIGNANT FOCAL LESIONS

Primary liver tumors—hepatocellular carcinoma

Hepatocellular carcinoma (HCC) is the most common primary malignancy of the liver. It is strongly associated with cirrhosis, due to both alcohol and viral etiologies. Hepatocellular carcinomas can have variable appearances depending on the individual lesion, size, and echogenicity of the background liver.

Typically, small focal HCC appears hypoechoic compared with normal liver. Larger lesions are heterogeneous due to fibrosis, fatty change, necrosis, and calcification. A peripheral halo of hypoechogenicity may be seen.

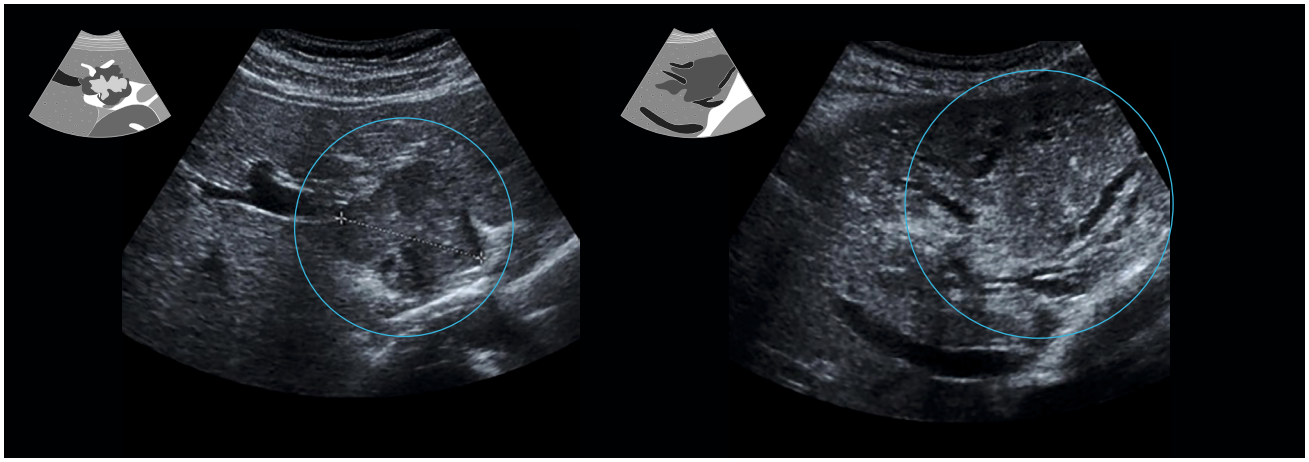
A diffuse growing HCC may be difficult to identify or distinguish in a liver presenting with cirrhosis.



Primary liver tumors—cholangiocarcinoma

Cholangiocarcinoma is a malignant tumor arising from cholangiocytes in the biliary tree. It tends to have a poor prognosis and high morbidity. It is the second most common primary hepatic tumor, with intrahepatic cholangiocarcinomas (ICCs) accounting for 10–20% of primary liver tumors.

ICCs show two growth forms: mass forming, which are mostly located peripherally, or periductal infiltrating, which are located at the hilum and grow along the biliary duct, but can also sometimes form masses.



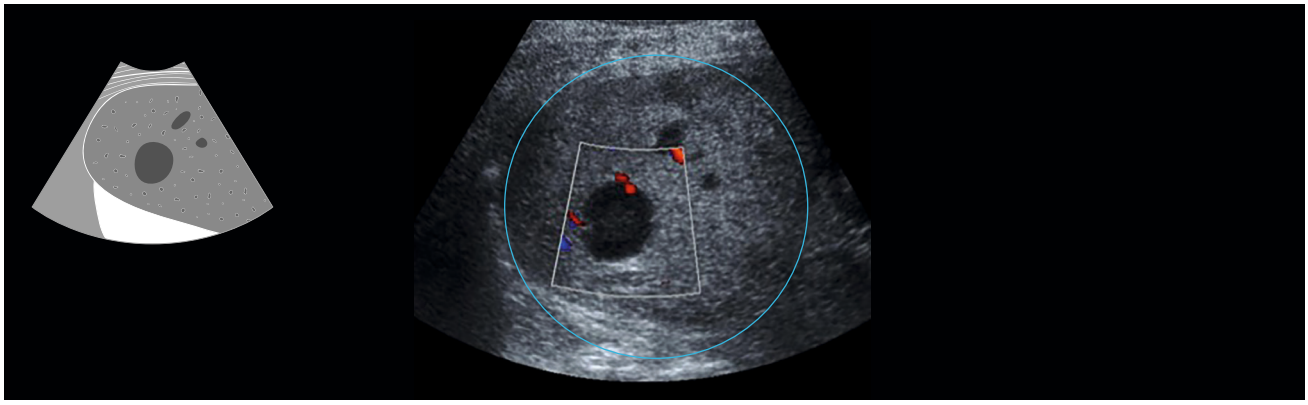
Hepatic metastases

Hepatic metastases show three different sonographical appearances

Hyperechoic

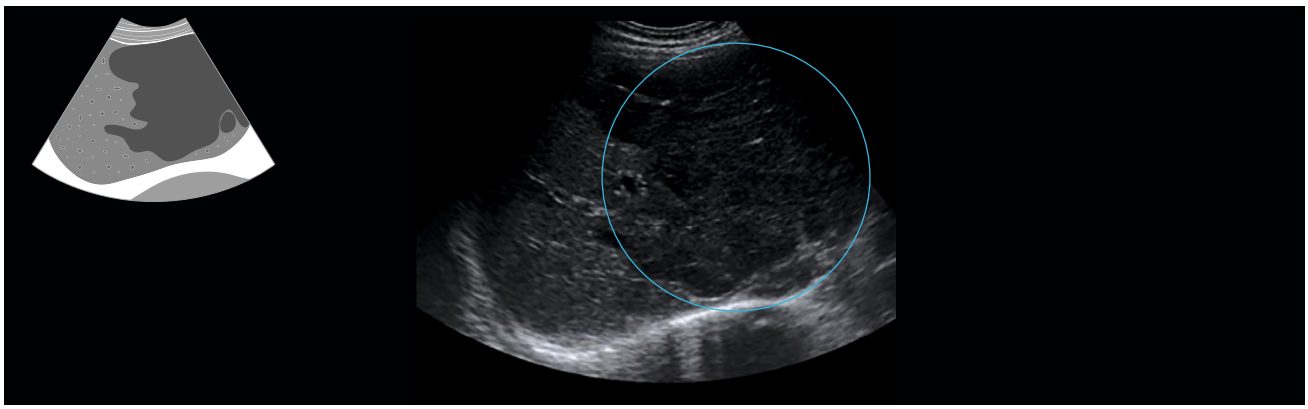
- Colorectal carcinoma
- Renal cell carcinoma
- Choriocarcinoma
- Kaposi sarcoma
- Neuroendocrine tumors

Hypoechoic—most common (~ 65%)



- Lung cancer
- Breast cancer
- Pancreatic adenocarcinoma
- Lymphoma

Poorly defined mass—infiltrative



- Melanoma
- Breast cancer
- Lung cancer