4 Liver

Organ Boundaries

LEARNING GOALS

- Locate the liver.
- Clearly delineate the liver from its surroundings.
- Survey the total liver volume in multiple planes.
- Recognize portions of the liver that are difficult to scan.

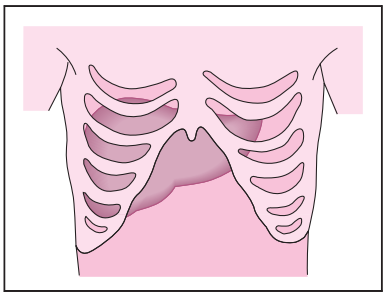


*Fig. 4.**1*** ***Approaches for scanning the liver.***

The liver is the dominant organ of the right upper abdomen. It is protected by ribs and is covered mainly by the right costal arch. These simple anatomical facts are widely known, but they have special significance and implications for ultrasound scanning.

1. The liver is so large that cannot be scanned adequately from one approach. A complete examination of the liver requires scanning from multiple angles and directions.
2. The liver cannot be scanned by the shortest route, but only from beneath the costal arch or between the ribs (Fig. 4.**1**). This means that while performing serial scans, you will view many sections of the liver more than once but are apt to miss blind spots if you are not fully familiar with the extent of the organ. Figure 4.**2** illustrates this problem with an analogy.

Locating the liver

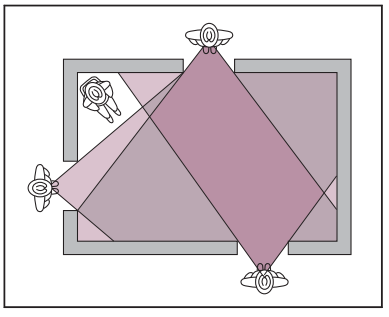


*Fig. 4.**2*** ***Difficulties of liver scanning.*** In this analogy, an observer is looking into a room through three windows. Moving from window to window, he views the center of the room several times and sees corners a total of five times. Even so, he is unable to see the man sitting in one corner of the room.

Barriers to scanning

- Ribs
- A high diaphragm

Optimizing the scanning conditions

To make the liver more accessible, have the patient raise the right arm above the head to draw the rib cage upward. Place the patient in the supine position and have him or her take a deep breath and hold it to expand the abdomen. One disadvantage of holding the breath is that it is followed by a period of hyperventilation, especially in older patients.

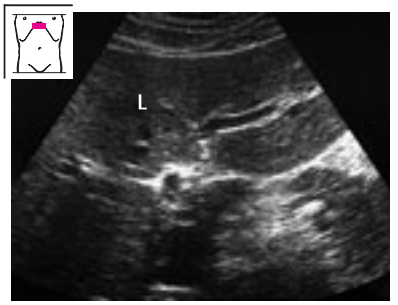


*Fig. 4.**3*** ***The liver (L) in upper abdominal transverse section.***

Organ identification

Start with the transducer placed transversely against the right costal arch, at the level where you would palpate the inferior border of the liver. Mentally picture the liver lying beneath the ribs, and angle the scan upward. Now ask the patient to take a deep breath, expanding the abdomen, and the liver will appear on the screen as a region of homogeneous echo texture. Figure 4.**3** illustrates the view of the liver that is acceptable for organ identification.

Imaging the liver in its entirety

Because the liver is so large, it is best to proceed in steps when learning how to scan the entire organ.

1 Learn the outlines of the liver:
   - the inferior border,
   - the superior border,
   - the left border.
2 Survey the liver volume:
   - in longitudinal sections,
   - in subcostal transverse and oblique sections,
   - in intercostal sections.

Outlines of the liver

Defining the inferior border of the liver

TIPS

To define the inferior border of the liver in longitudinal sections, press the caudal end of the transducer a little more firmly into the abdominal wall than the cranial end.

By varying the pressure on the transducer, you can keep the inferior border of the liver at the right edge of the image.

If there is intervening gas in the right colic flexure, have the patient take a deep breath to expand the abdomen.

The liver tapers inferiorly to a more or less sharp-angled border. This inferior border is easy to demonstrate with ultrasound. Place the transducer longitudinally on the upper abdomen, slightly to the right of the midline. Press the caudal end of the transducer a bit more deeply into the abdominal wall than the cranial end, so that the scan is directed slightly upward. This should bring the sharp inferior hepatic border into view (Fig. 4.**4a**).

Now slide the transducer to the left, keeping it in a longitudinal plane while following the line of the costal arch as closely as possible. Also, make sure that the inferior border of the liver stays at the right edge of the image. You can do this by varying the pressure on the transducer as needed.

As the transducer moves farther to the left, the cross section of the liver diminishes in size. Its roughly triangular outline becomes progressively smaller and finally disappears. The image is now dominated by a chaotic pattern of highly contrasting light and dark areas with no discernible shape, caused by the gas and liquid contents of the stomach.

Now return to the starting point and scan past it toward the right side. As you track across the abdomen, you will recognize the aorta and then the vena cava. As you scan past the vena cava, the gallbladder can be identified as a "black" structure in the fasted patient. With luck, the right kidney may also be seen. As the transducer moves farther to the right, the angle of the inferior hepatic border becomes increasingly blunted (Fig. 4.**4b, c**).

Visualization often becomes poor at this point, especially in obese patients and when there is interposed gas in the right colic flexure. It can be helpful to have the patient breathe in deeply and inflate the abdomen.

The series of images in Fig. 4.**4** were selected to illustrate good scanning conditions. You should keep this in mind if you do not achieve the desired result right away. Figure 4.**5** shows the appearance of a liver that is difficult to scan. This scan corresponds to the section in Fig. 4.**4b**.

Fig. 4.**4** ***Demonstrating the inferior border of the liver***

a Scan of the left hepatic lobe, with the transducer placed approximately in the midline. Note the sharp angle of the inferior border (↑).

b The transducer was moved toward the right side, approximately to the midclavicular line. The inferior border appears less sharp (↑).

c The transducer was moved farther to the right. Now the inferior border cannot be clearly defined. The angle is relatively blunt (↑).

Fig. 4.**5** ***The inferior border of this liver (↑) is difficult to scan.***

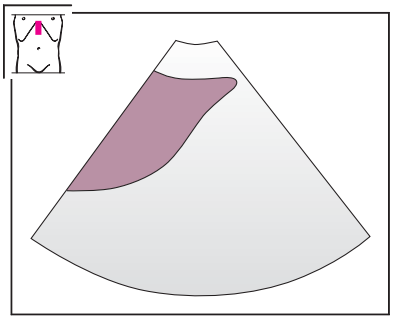
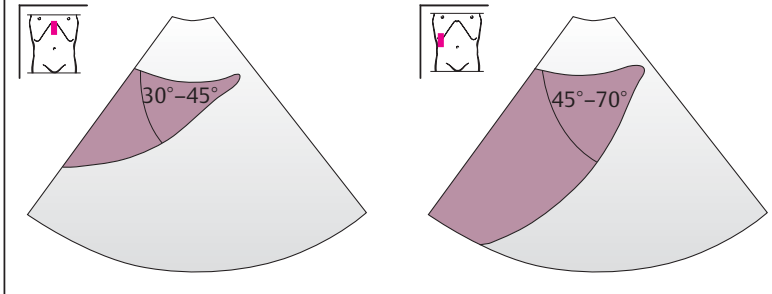


Fig. 4.**6** ***Shape of the inferior border.*** Note that the posterior surface of the liver is concave below (toward the inferior border) and convex above.

After you have scanned across the inferior border of the liver once for orientation, make a second pass while giving attention to details. You have already seen that the inferior border has an approximately triangular shape in the ultrasound image. The anterior surface of the liver, which lies against the abdominal wall, is flat and smooth. The posterior surface is slightly concave in its lower portion and becomes slightly convex superiorly (Fig. 4.**6**). The angle between the anterior and posterior surfaces is 30–45° on the left side and 45–70° on the right side (Fig. 4.**7**). The posterior surface has several concavities that interrupt its triangular shape: the porta hepatis and the impressions from the gallbladder and right kidney.

Fig. 4.**7** ***Angle of the inferior border***



a Left side of the liver.

b Right side of the liver.

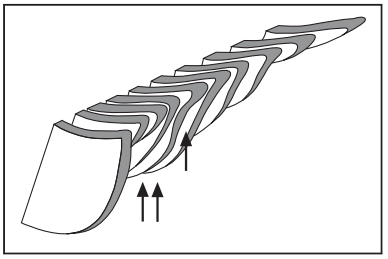


*Fig. 4.**8*** ***Longitudinal serial scans of the inferior border.*** The posterior surface of the liver bears impressions from the gallbladder (↑) and right kidney (↑↑).

Figure 4.**8** illustrates a series of longitudinal sections of the inferior hepatic border obtained by scanning across the liver from left to right. Notice the changes in the liver outline caused by the gallbladder and kidney.

Abnormalities and variants of the inferior border

Fatty liver. Besides increased echogenicity (see p. 53 ff.), fatty infiltration of the liver leads to rounding and broadening of the inferior border (Figs. 4.**9**, 4.**10**).

Cirrhosis of the liver. The normal liver presents a smooth inferior surface contour. With cirrhosis, regenerative nodules in the liver produce a lobulated contour (Fig. 4.**11**).

*Fig. 4.**9*** ***Fatty liver.*** The angle between the anterior and posterior surfaces of the liver is broadened (↑).

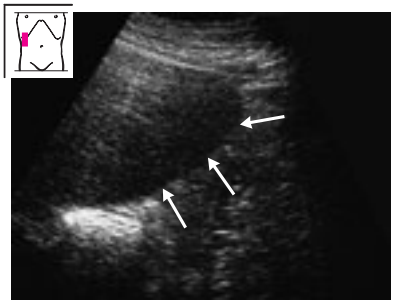


*Fig. 4.**10*** ***Fatty liver.*** Note the rounding of the inferior border (↑↑↑).

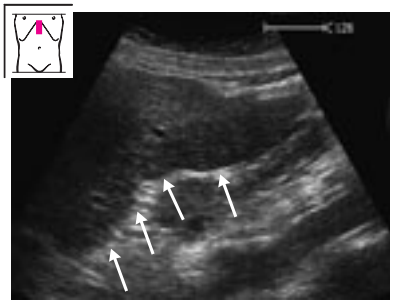


*Fig. 4.**11*** ***Alcoholic cirrhosis of the liver.*** The inferior surface of the liver has a nodular appearance (↑↑↑).

Riedel's lobe. Riedel's lobe is a tongue-like inferior projection of the right lobe that extends well past the lower pole of the kidney (Fig. 4.**12**).

*Fig. 4.**12*** ***Riedel's lobe.*** A tongue-like projection of the right lobe (↑) extends down past the inferior pole of the kidney. Mp = psoas muscle, K = kidney.

Defining the superior border of the liver

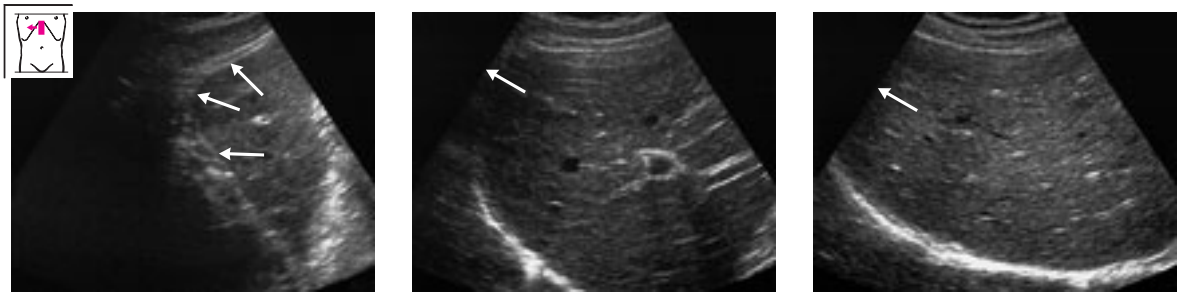
TIP

Press firmly with the transducer along the right costal arch so that you can scan beneath the ribs at a relatively flat angle.

The superior border of the liver is flat on the left side and convex on the right side. The scanning technique is similar to that for the inferior border. Place the transducer longitudinally to the right of the midline just below the costal arch. Angle upward until the superior border of the liver appears on the left side of the screen. Notice the bright echo return from the diaphragm. The pulsating heart can be seen cranially (left side of the image).

Now scan toward the left in parallel longitudinal sections, following the line of the costal arch, until you reach the end of the liver. Then return to the right and continue the scan along the right costal arch (Fig. 4.**13**). You will need to apply firmer transducer pressure in this region in order to scan beneath the ribs at a relatively flat angle.

*Fig. 4.**13*** ***Demonstrating the superior border of the liver***



a Superior border of the left lobe (↑↑↑). The transducer was placed approximately in the midline.

b The transducer was moved to the right. Notice that the liver does not transcend the left edge of the image, indicating a complete section (↑).

c The transducer was moved farther to the right. Now the anterior superior portion of the liver is not included in the image (↑). Compare this scan with Fig. 4.**15**.

KEY POINT

Anterior and superior portions of the liver near the diaphragm are often poorly visualized in longitudinal scans.

Repeat the longitudinal pass along the superior border of the liver, this time noticing the shape of the hepatic cross section. The superior border of the liver is flat on the left side. The heart rests upon the diaphragm in this area. The superior surface of the liver forms a right angle with its anterior surface (Fig. 4.**14**). The farther the transducer is moved toward the right, the more convex the surface becomes. At this point you will have to press harder on the transducer and scan beneath the ribs at a relatively steep angle to view the part of the diaphragm that borders the liver. Even so, it is often not possible to define the full cross section of the liver on the left side of the screen, and a portion of the liver will appear cut off (Fig. 4.**15**).

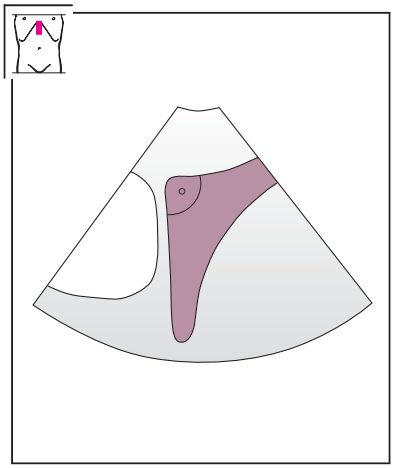


*Fig. 4.**14*** ***Superior border of the left lobe.*** Notice the right angle formed by the anterior and diaphragmatic surfaces of the liver.

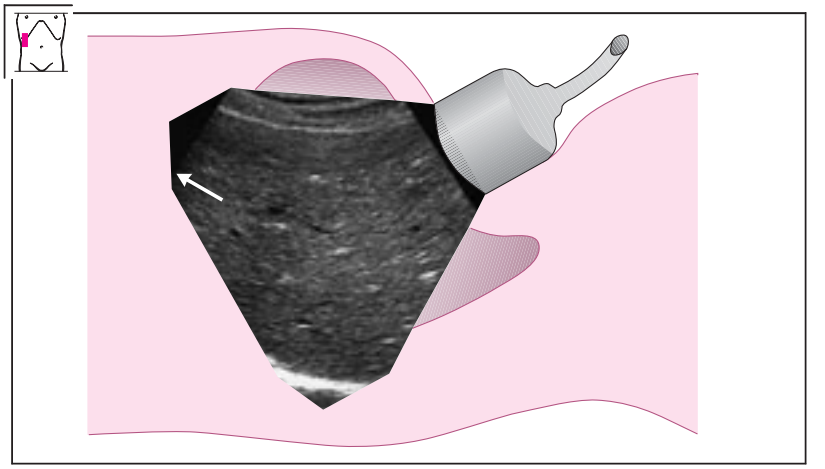


*Fig. 4.**15*** ***Superior border of the right lobe.*** Notice that the anterior border cannot be adequately defined.

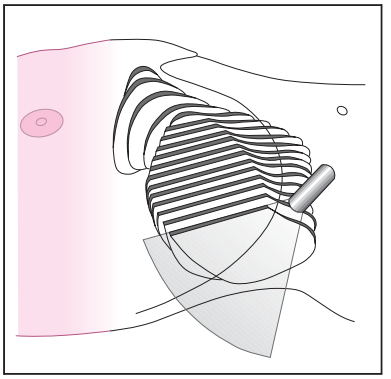


*Fig. 4.**16*** ***Scanning across the superior border of the liver.*** Notice that the anterior portions of the right lobe are not visualized.

Try to picture mentally which portion of the liver is not seen. Recall that in a longitudinal scan, the left side of the screen is cranial and the right side is caudal. But as the transducer is angled cephalad, the angle of the scan becomes more horizontal and this rule becomes less valid. With a flat scanning angle, anterior portions of the liver are displayed on the left side of the screen. For our purposes, this means that the hidden, "truncated" portion of the liver cross section is anterior and superior. This blind spot is shown schematically in Fig. 4.**16**.

Defining the left border of the liver

The left border of the liver was already seen in the longitudinal sections of the superior and inferior borders. Now you will also scan down the left border in transverse sections. Place the transducer in a transverse or slightly oblique position along the costal arch, a little to the left of the midline. Scan up toward the liver beneath the costal arch, angling the probe upward until you see the pulsating heart. Scan at a very steep angle so that the left border of the liver is just visible on the screen. Now scan down the left border by angling the transducer. Notice how the shape of the liver section changes as the scan moves downward, changing from trapezoidal above (Fig. 4.**17a**) to triangular below (Fig. 4.**17b, c**).

14 The Sono Consultant

The tables in this chapter serve as a "sono consultant"—a systematic framework for helping the examiner to evaluate specific ultrasound findings and make a differential diagnosis.

The chapter consists of two parts, which represent the situations that beginners will most often encounter in ultrasound examinations:

Part I: The examiner sees an abnormality at ultrasound and wants to analyze it in a systematic way.

Part II: The examiner is consulted for the ultrasound evaluation of a specific clinical situation.

Part I, Ultrasound Findings, provides a comprehensive, step-by-step approach for systematically analyzing an abnormality that is noted during an ultrasound examination.

Part II, Clinical Presentation, offers guidelines for interpreting findings and extracting the maximum amount of information that ultrasonography can supply in a given clinical situation.

Both parts deal with the most common sonographic findings and clinical situations that arise in diagnostic ultrasonography. Of course, the exact sequence of steps for interpreting ultrasound findings will vary considerably from one examiner to the next. The goal of this chapter is to provide the beginner with a logical, structured routine that will train and reinforce a complete, systematic ultrasound examination.

I Ultrasound Findings

1. Aorta: Widening

Finding	Interpretation
Verify, measure in two dimensions	
< 25 mm	Normal
25–30 mm	Ectasia
> 30 mm	Aneurysm
> 50 mm	High risk of rupture
Full-length visualization of the aorta	
Longitudinal shape ▪ Straight ▪ Curved	 Kinked?
Wall ▪ Circumscribed plaques, diffuse thickening	 Aortic sclerosis?
Lumen ▪ Echo-free ▪ Echogenic ▪ Floating membrane	 Thrombus? Dissecting aneurysm
Location ▪ Start and end of the dilatation ▪ Relationship to vessels – Suprarenal – Infrarenal?	
Aortic branches ▪ Vessel origins ▪ Iliac vessels	

2. Vena cava: Dilatation

Finding	Interpretation
Verify, measure	
< 20 mm in late inspiration and end expiration	Normal
> 20 mm	Suspicious for abnormal dilatation Stasis?
Pulsation, respiration, lumen	
Double-beat pattern synchronous with the pulse ■ Present	Physiologic dilation? Young, thin patient?
■ Not present	Stasis?
Luminal change with respirations ■ Present	Physiologic dilation?
■ Not present	Stasis?
Lumen ■ Echo-free	Stasis?
■ Echogenic	Thrombus?
Other signs of congestive failure	
Visualization of all vena cava tributaries ■ Hepatic veins ■ Renal veins ■ Iliac vessels	
Liver ■ Echo pattern ■ Borders ■ Size	
Ascites?	

II Clinical Presentation

1. Splenomegaly

Finding	Interpretation
Verify, measure	
< 11.5 cm	No splenomegaly
> 12.5 cm	Splenomegaly?
Echo pattern	
Homogeneous	Portal hypertension? Hemolytic anemia? Heart failure? Epstein–Barr virus? Storage disease?
Inhomogeneous	Lymphoma? Hematologic disease?
Look for signs of portal hypertension	
Splenic hilar vessels dilated, splenic vein dilated, portal vein dilated, signs of hepatic cirrhosis, ascites on right side	Portal hypertension?
Look for signs of hematologic disease	
Enlarged lymph nodes	Lymphoma? Hematologic disease?