Chapter 2

The normal hepatobiliary system

CHAPTER CONTENTS

INTRODUCTION

Ultrasound is the dominant first-line investigation for an enormous variety of abdominal symptoms because of its non-invasive and comparatively accessible nature. Its success, however, in terms of a diagnosis, depends upon numerous factors, the most important of which is the *skill of the operator*.

Because of their complexity and extent, the normal appearances and haemodynamics of the hepatobiliary system are dealt with in this chapter, together with some general upper-abdominal scanning issues. The normal appearances of the other abdominal organs are included in subsequent relevant chapters.

It is good practice, particularly on the patient's first attendance, to scan the whole of the upper abdomen, focusing particularly on the relevant areas, but also excluding or identifying any other significant pathology. A full abdominal survey would normally include the liver, gallbladder, biliary tree, pancreas, spleen, kidneys and retroperitoneal structures. Apart from the fact that many pathological processes can affect multiple organs, a number of significant (but clinically occult) pathological processes are discovered incidentally, for example renal carcinoma or aortic aneurysm. A thorough knowledge of anatomy is assumed at this stage, but diagrams of upper abdominal sectional anatomy are included in the appendix to this chapter for quick reference (see pp. 36–39).

It is important always to remember the operator-dependent nature of ultrasound scanning (see Chapter 1); although the dynamic nature of the scan is a huge advantage over other forms of

imaging, the operator must continuously adjust technique to obtain the maximum diagnostic information. In any abdominal ultrasound survey the operator assesses the limitations of the scan and the level of confidence with which pathology can be excluded or confirmed. The confidence limits help in determining the subsequent investigations and management of the patient.

It is important, too, to retain an open mind about the diagnosis when embarking on the scan; an operator who decides the likely diagnosis on a clinical basis may sometimes be correct but, in trying to fit the scan to match the symptoms, risks missing significant pathology.

GENERAL POINTERS ON UPPER-ABDOMINAL TECHNIQUE

Scanning technique is not something that can be learnt from a book. There is absolutely no substitute for regular practical experience under the supervision of a qualified ultrasound practitioner.

There are, however, some general approaches which help to get the best from the scanning procedure:

- Scan in a systematic way to ensure the whole of the upper abdomen has been thoroughly interrogated. The use of a worksheet, which indicates the structures to be examined, is advisable when learning.[1]
- Always scan any organ in *at least* two planes, preferably at right angles to each other. This reduces the risk of missing pathology and helps to differentiate artefact from true pathology.
- Where possible, scan in at least two patient positions. It is surprising how the available ultrasound information can be enhanced by turning your patient oblique, decubitus or erect. Inaccessible organs flop into better view and bowel moves away from the area of interest.
- Use a combination of sub- and intercostal scanning for all upper-abdominal scanning. The different angles of insonation can reveal pathology and eliminate artefact.
- Don't limit yourself to longitudinal and transverse sections. Use a variety of planes and angulations. Trace ducts and vessels along their courses. Use the transducer like a pair of eyes.
- Deep inspiration is useful in a proportion of patients, but not all. Sometimes it can make matters worse by filling the stomach with air and obscuring large areas. An intercostal approach with the patient breathing gently often has far more success.
- Positioning patients supine, particularly if elderly or very ill, can make them breathless and uncomfortable. Raise the patient's head as much as necessary; a comfortable patient is much easier to scan.
- Images are a useful record of the scan and how it has been performed, but don't make these your primary task. *Scan first*, sweeping smoothly from one aspect of the organ to the other in two planes, then take the relevant images to support your findings.
- Make the most of your equipment (see Chapter 1). Increase the confidence level of your scan by fully utilizing all the available facilities, using Doppler, tissue harmonics, changing transducers and frequencies and manipulating the machine settings and processing options.

THE LIVER

Normal appearance

The liver is a homogeneous, mid-grey organ on ultrasound. It has the same, or slightly increased echogenicity when compared to the cortex of the right kidney. Its outline is smooth, the inferior margin coming to a point anteriorly (Fig. 2.1). The liver is surrounded by a thin, hyperechoic capsule, which is difficult to see on ultrasound unless outlined by fluid (Fig. 2.2).

The smooth parenchyma is interrupted by vessels (see below) and ligaments (Figs 2.3–2.15) and the liver itself provides an excellent acoustic window on to the various organs and great vessels situated in the upper abdomen.

The ligaments are hyperechoic, linear structures; the falciform ligament, which separates the anatomical left and right lobes is situated at the

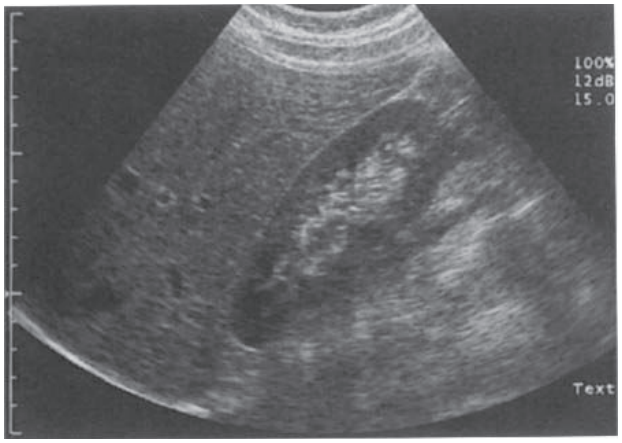


Figure 2.1 Longitudinal section (LS) through the right lobe of the liver. The renal cortex is slightly less echogenic than the liver parenchyma.

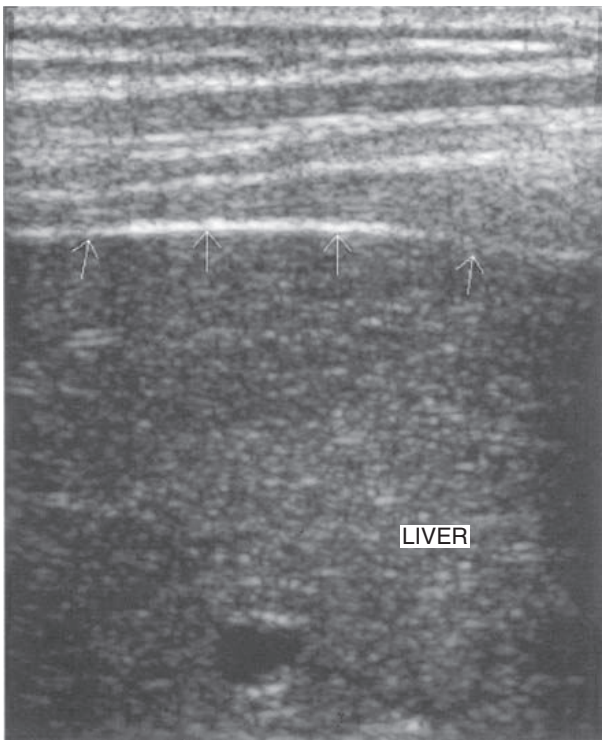


Figure 2.2 The capsule of the liver (arrows) is demonstrated with a high-frequency (7.5 MHz) probe.

superior margin of the liver and is best demonstrated when surrounded by ascitic fluid. It surrounds the left main portal vein and is known as the ligamentum teres as it descends towards the infero-anterior aspect of the liver (Figs 2.9 and 2.15). The ligamentum venosum separates the caudate lobe from the rest of the liver (Fig. 2.6).

The size of the liver is difficult to quantify, as there is such a large variation in shape between normal subjects and direct measurements are notoriously inaccurate. Size is therefore usually assessed subjectively. Look particularly at the inferior margin of the right lobe which should come to a point anterior to the lower pole of the right kidney (Fig. 2.1). A relatively common variant of this is the *Reidel's lobe*, an inferior elongation of segment VI on the right. This is an extension of the right lobe over the lower pole of the kidney, with a rounded margin (Fig. 2.16), and is worth remembering as a possible cause of a palpable right upper quadrant 'mass'.

To distinguish mild enlargement from a Reidel's lobe, look at the left lobe. If this also looks bulky, with a rounded inferior edge, the liver is enlarged. A Reidel's lobe is usually accompanied by a smaller, less accessible left lobe.

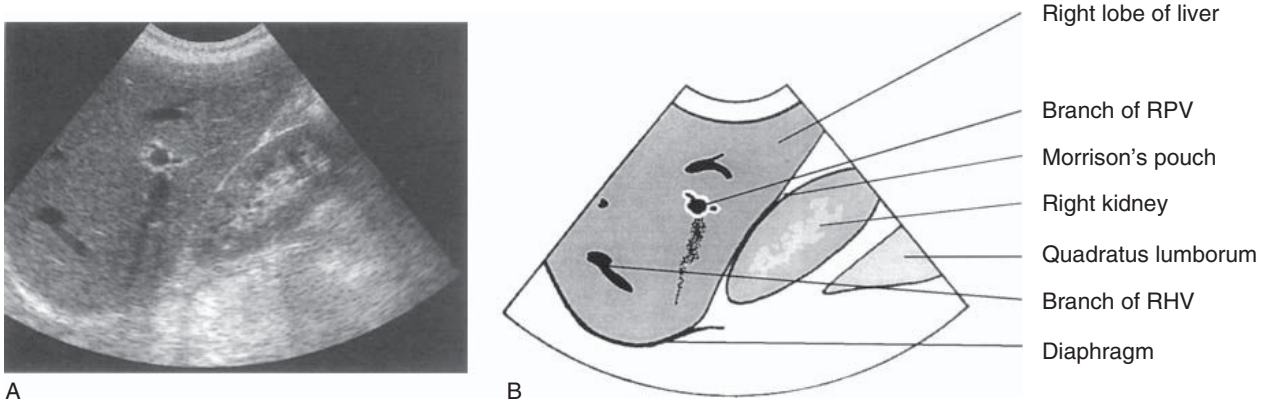


Figure 2.3 LS through the right lobe of the liver and right kidney. RPV = right portal vein; RHV = right hepatic vein.

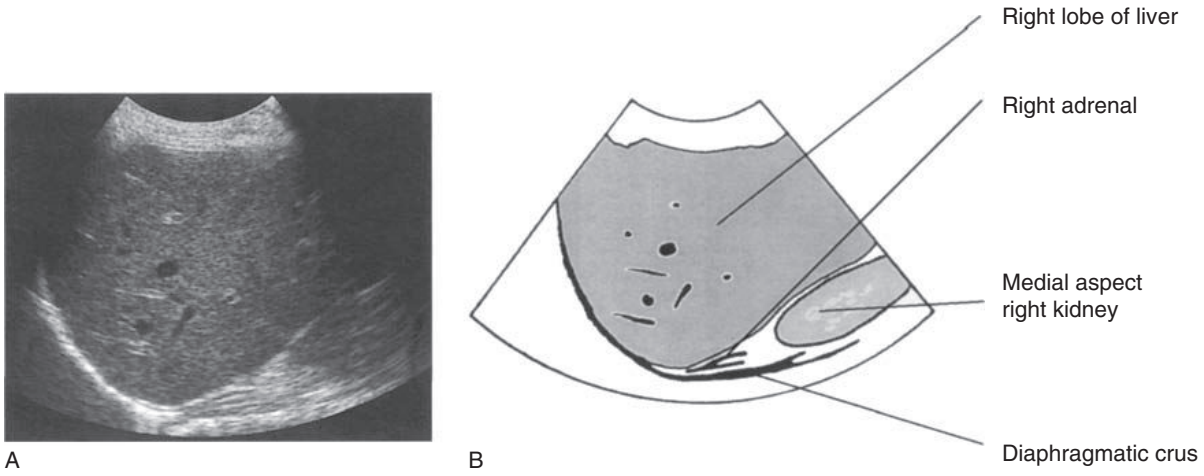


Figure 2.4 LS, right lobe, just medial to the right kidney.

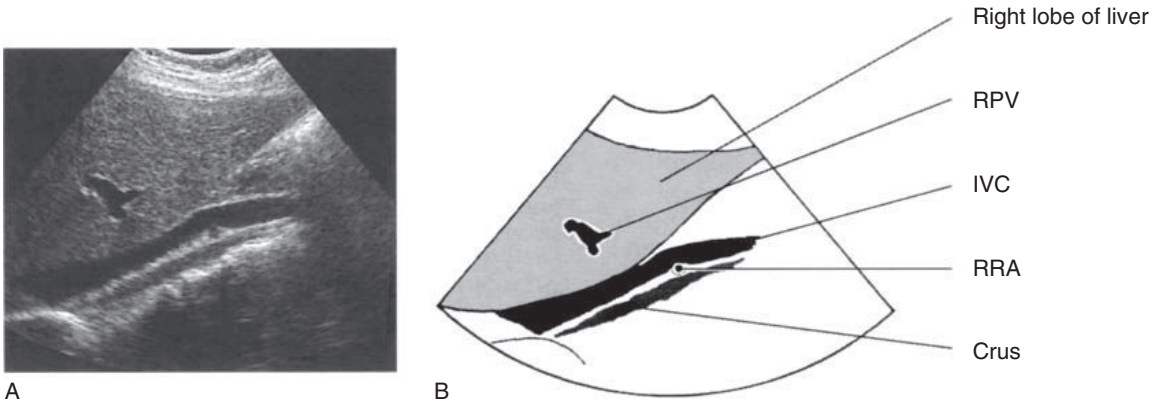


Figure 2.5 LS, right lobe, angled medially towards the inferior vena cava (IVC). RRA = right renal artery.

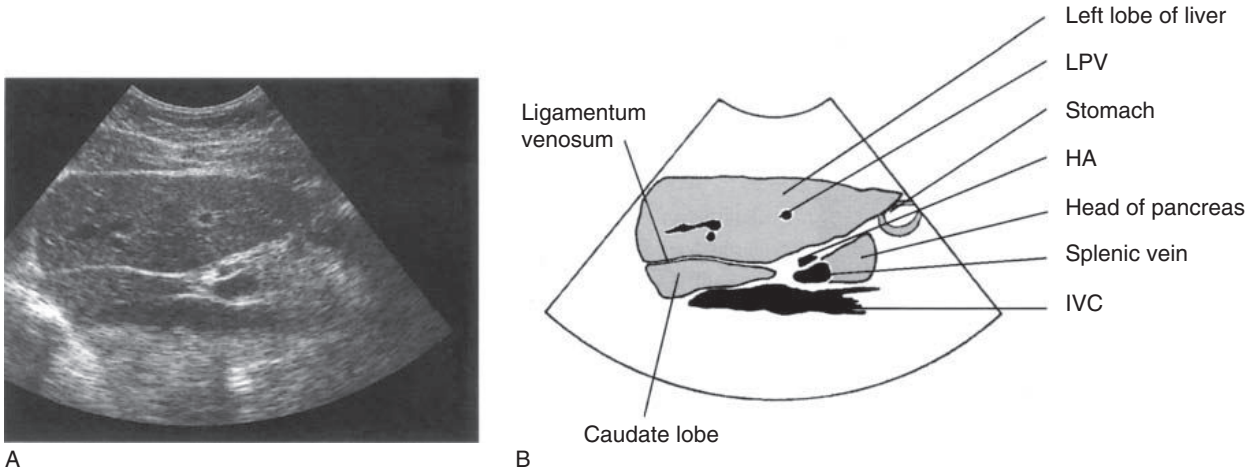
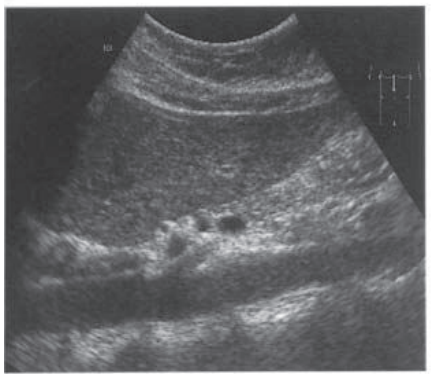


Figure 2.6 LS, midline, through the left lobe, angled right towards the IVC. LPV = left portal vein; HA = hepatic artery.



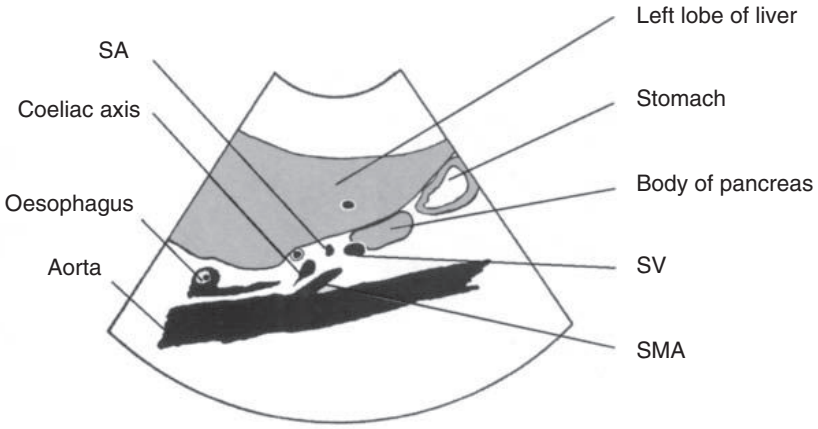


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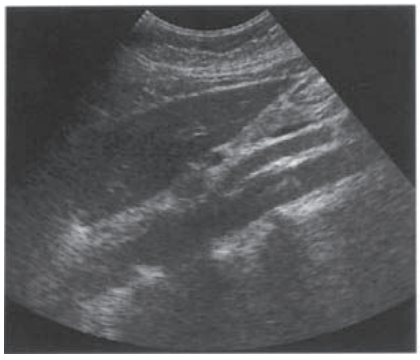
Figure 2.7 LS through the midline. SV = splenic vein; SA = splenic artery; SMA = superior mesenteric artery.



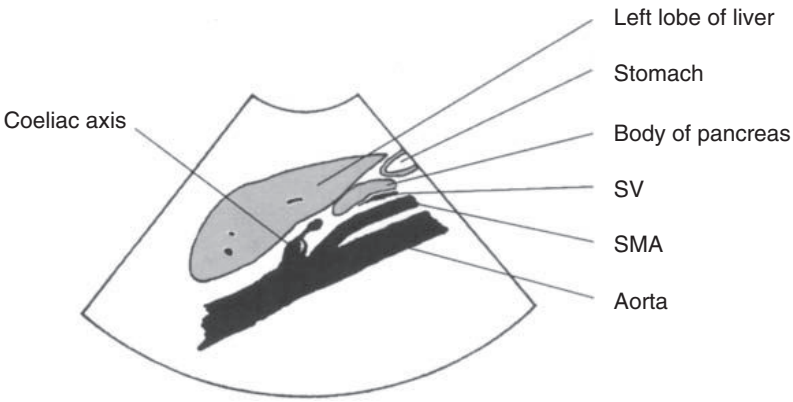


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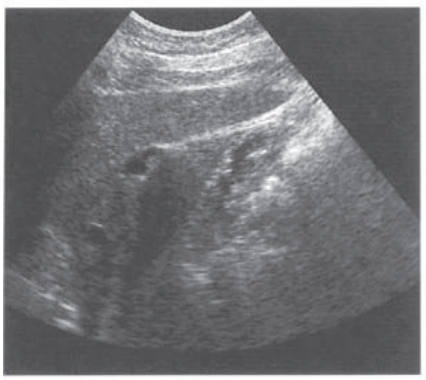
Figure 2.8 LS just to the left of midline.



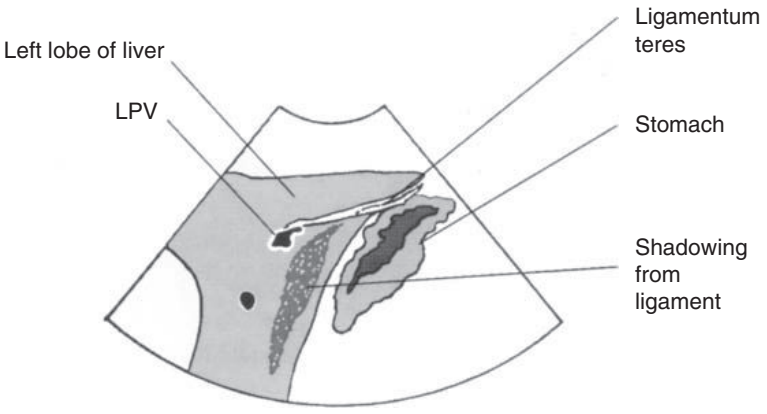


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Figure 2.9 LS, left lobe of liver.

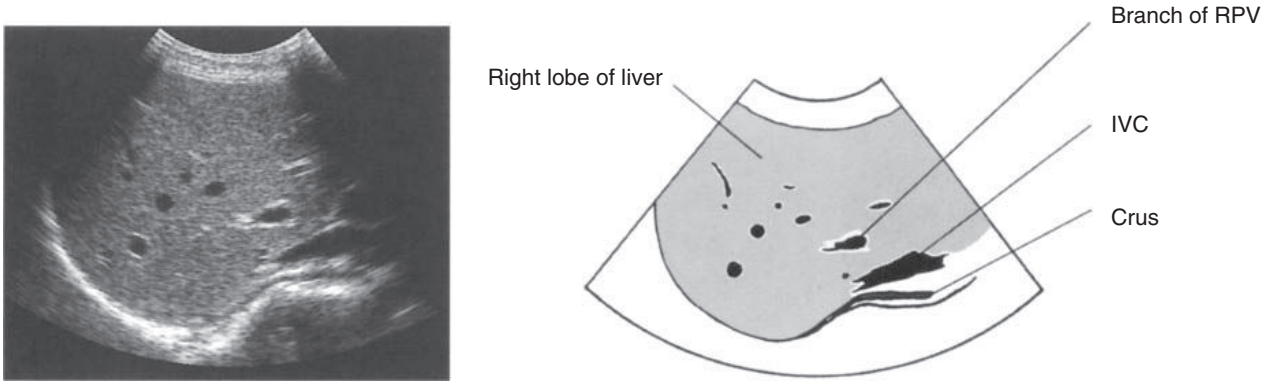

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Figure 2.10 Transverse section (TS) through the liver, above the confluence of the hepatic veins.

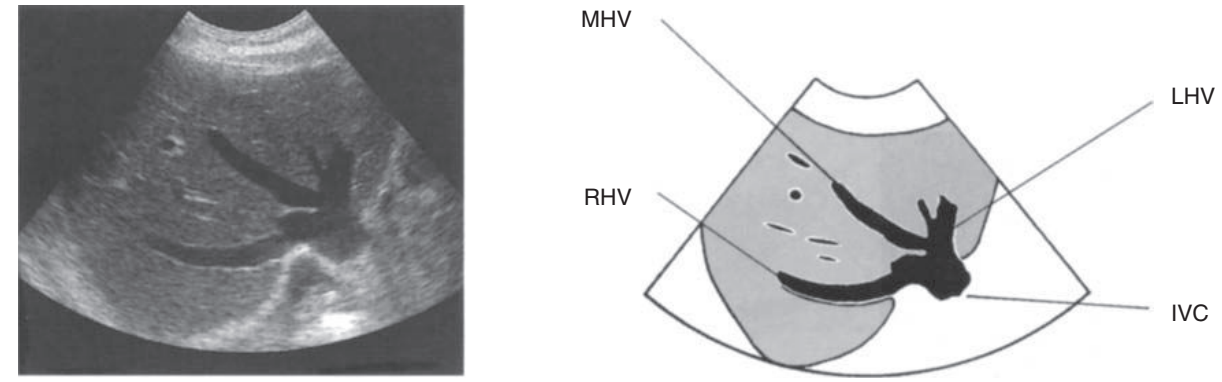

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Figure 2.11 TS at the confluence of the hepatic veins (HV).

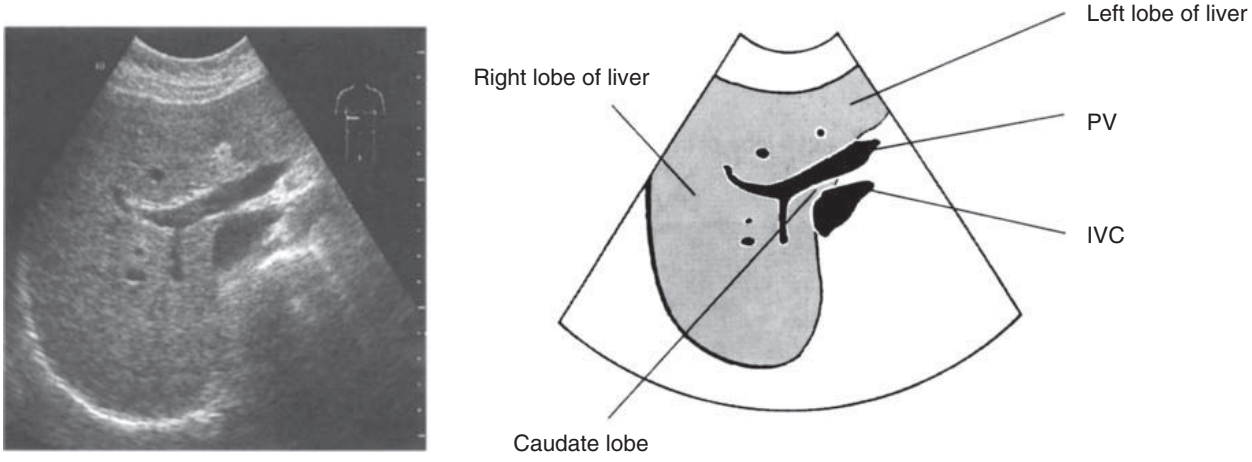

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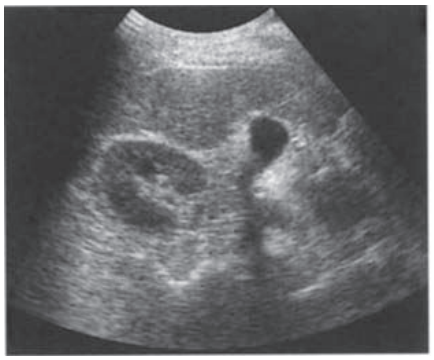
Figure 2.12 TS at the porta hepatis. PV = portal vein.



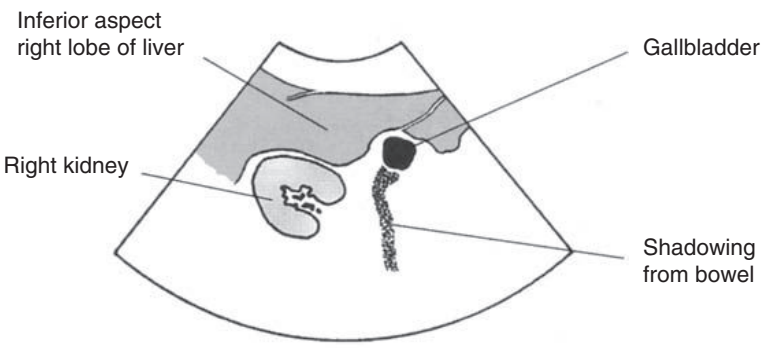


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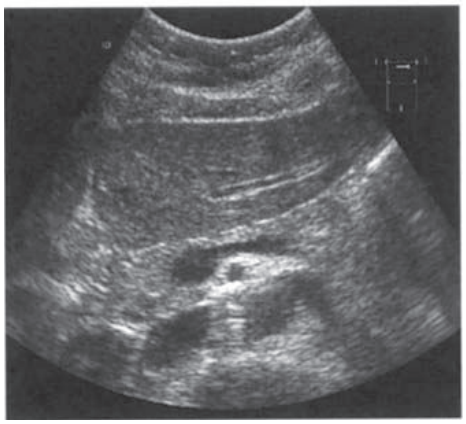
Figure 2.13 TS through the right kidney.



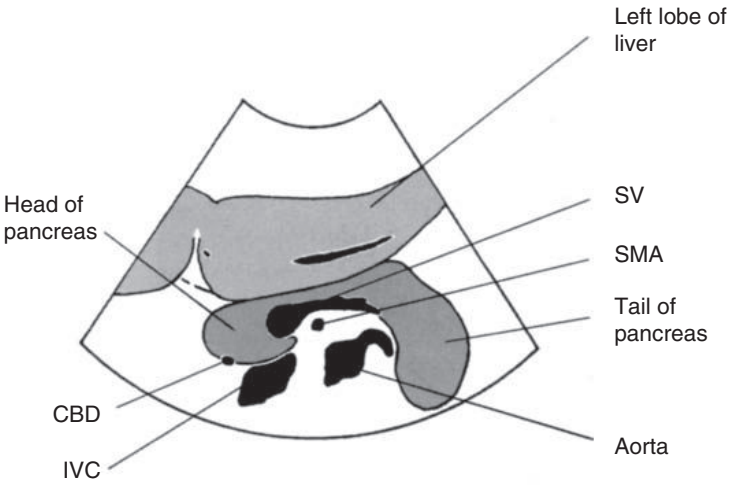


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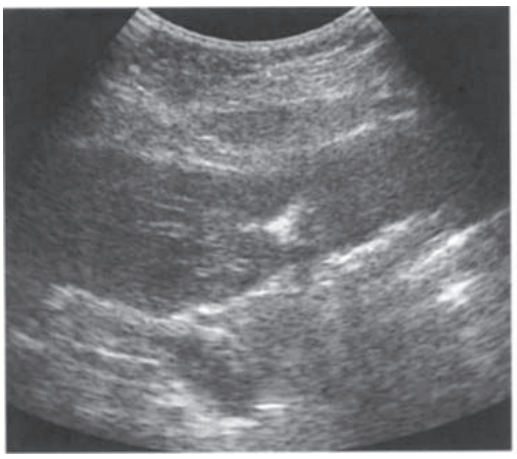
Figure 2.14 TS at the epigastrium. CBD = common bile duct.



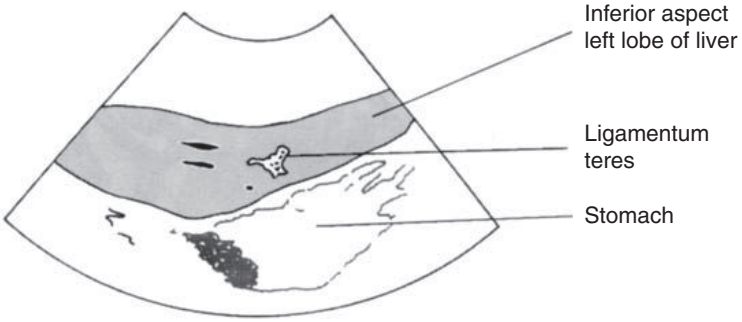


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Figure 2.15 TS at the inferior edge of the left lobe.

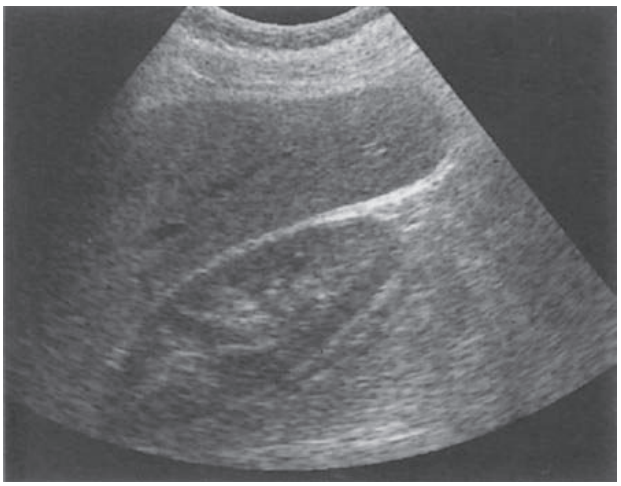


Figure 2.16 LS through the right lobe, demonstrating a Reidel's lobe extending below the right kidney. (Compare with the normal liver in Figure 2.1.)

The segments of the liver

It is often sufficient to talk about the 'right' or 'left' lobes of the liver for the purposes of many diagnoses. However, when a focal lesion is identified, especially if it may be malignant, it is useful to locate it precisely in terms of the surgical segments. This allows subsequent correlation with other imaging, such as computerized tomography (CT) or magnetic resonance imaging (MRI), and is invaluable in planning surgical procedures.

The segmental anatomy system, proposed by Couinaud in 1954,[2] divides the liver into eight segments, numbered in a clockwise direction. They are divided by the portal and hepatic veins and the system is used by surgeons today when planning surgical procedures (Fig. 2.17). This system is also used when localizing lesions with CT and MRI.

Identifying the different segments on ultrasound requires the operator to form a mental three-dimensional image of the liver. The dynamic nature of ultrasound, together with the variation in planes of scan, makes this more difficult to do than for CT or MRI. However, segmental localization of hepatic lesions by an experienced operator can be as accurate with ultrasound as with MRI.[3] Systematic scanning through the liver, in transverse section, identifies the main landmarks of the hepatic veins (Fig. 2.11) separating segments VII, VIII, IV and II in the superior part of the liver. As the transducer is moved inferiorly, the portal vein appears, and below this segments V and VI are located.

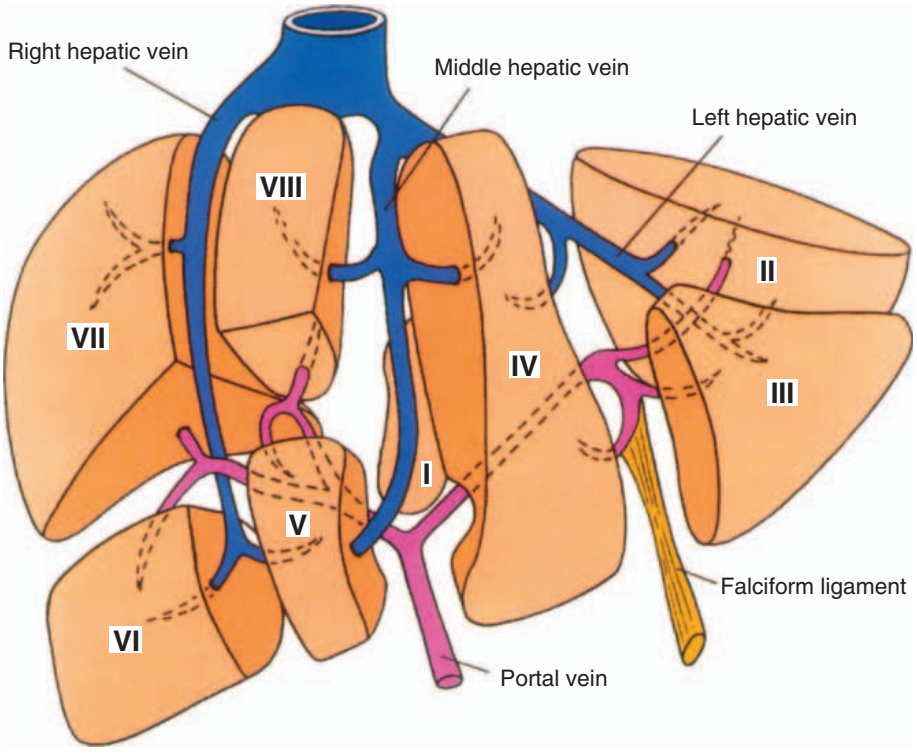


Figure 2.17 The surgical segments of the liver (after Couinaud[2]).

Hepatic vasculature

The *portal veins* radiate from the porta hepatis, where the main portal vein (MPV) enters the liver (Fig. 2.18). They are encased by the hyperechoic, fibrous walls of the portal tracts, which make them stand out from the rest of the parenchyma. Also contained in the portal tracts are a branch of the hepatic artery and a biliary duct radical. These latter vessels are too small to detect by ultrasound in the peripheral parts of the liver, but can readily be demonstrated in the larger, proximal branches (Fig. 2.19).

At the porta, the *hepatic artery* generally crosses the anterior aspect of the portal vein, with the common duct anterior to this (Fig. 2.20). In a common variation the artery lies anterior to the duct. Peripherally, the relationship between the vessels in the portal tracts is variable, (Fig. 2.21).

The three main *hepatic veins*, left, middle and right, can be traced into the inferior vena cava (IVC) at the superior margin of the liver (Fig. 2.11). Their course runs, therefore, approximately perpendicular to the portal vessels, so a section of liver with a longitudinal image of a hepatic vein is likely to contain a transverse section through a portal vein, and vice versa.

Unlike the portal tracts, the hepatic veins do not have a fibrous sheath and their walls are therefore less reflective. Maximum reflectivity of the vessel walls occurs with the beam perpendicular (Fig. 2.22).

The anatomy of the hepatic venous confluence varies. In most cases the single, main right hepatic vein (RHV) flows directly into the IVC, and the middle and left have a common trunk. In 15–35% of patients the left hepatic vein (LHV) and middle hepatic vein (MHV) are separate. This usually has no significance to the operator. However, it may be a significant factor in planning and performing hepatic surgery, especially tumour resection, as the surgeon attempts to retain as much viable hepatic tissue as possible with intact venous outflow (Fig. 2.23).[4]

Haemodynamics of the liver

Pulsed and colour Doppler to investigate the hepatic vasculature are now established aids to diagnosis in the upper abdomen. Doppler should always be used in conjunction with the real-time image and in the context of the patient's presenting symptoms. Used in isolation it can be highly misleading. Familiarity with the normal Doppler

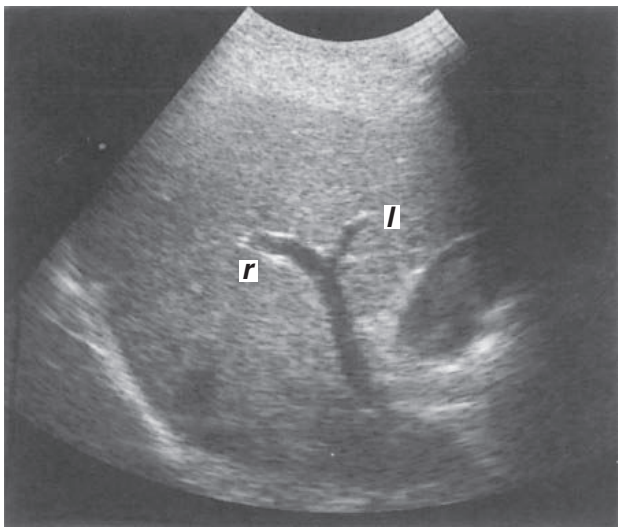


Figure 2.18 The right and left branches of the portal vein.

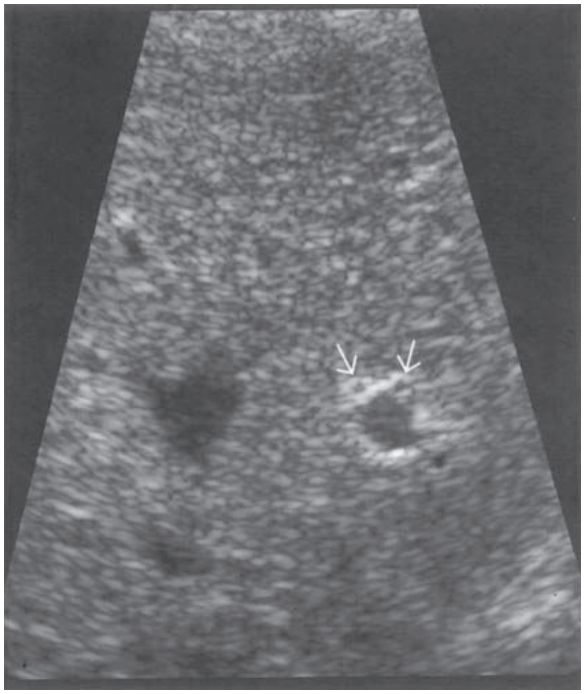
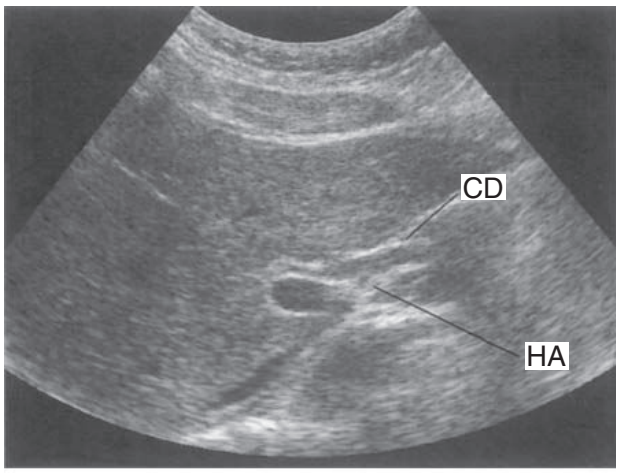


Figure 2.19 The portal vein radical is associated with a branch of the hepatic artery and a biliary duct (arrows) within the hyperechoic fibrous sheath.



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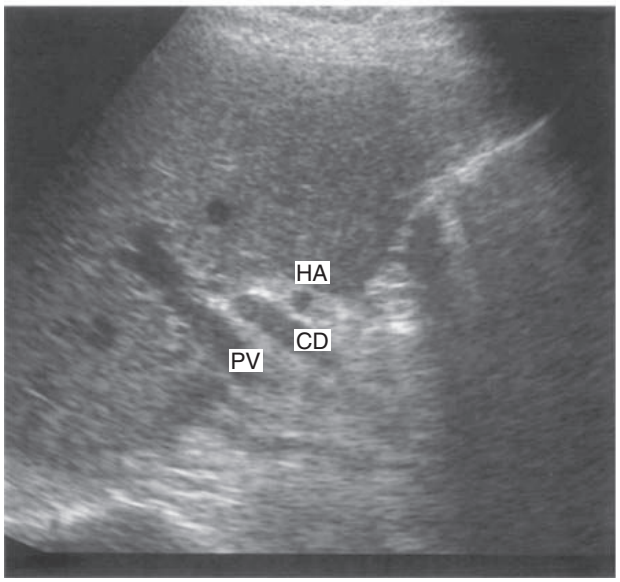

B

Figure 2.20 (A) The porta hepatis. (B) A variant with the hepatic artery anterior to the duct. CD = common duct.

spectra is an integral part of the upper-abdominal ultrasound scan.

Doppler of the portal venous and hepatic vascular systems gives information on the patency, velocity and direction of flow. The appearance of the various spectral waveforms relates to the downstream resistance of the vascular bed (see Chapter 1).

The portal venous system

Colour Doppler is used to identify blood flow in the splenic and portal veins (Figs 2.24 and 2.25). The direction of flow is normally hepatopetal, that is towards the liver. The main, right and left portal branches can best be imaged by using a right oblique approach through the ribs, so that the course of the vessel is roughly towards the transducer, maintaining a low (< 60°) angle with the beam for the best Doppler signal.

The normal portal vein diameter is highly variable but does not usually exceed 16 mm in a resting state on quiet respiration.[5] The diameter increases with deep inspiration and also in response to food and to posture changes. An increased diameter may also be associated with portal hypertension in chronic liver disease (see Chapter 4). An absence of postprandial increase in diameter is also a sign of portal hypertension.

The normal portal vein (PV) waveform is monophasic (Fig. 2.26) with gentle undulations which are due to respiratory modulation and cardiac activity. This characteristic is a sign of the normal, flexible nature of the liver and may be lost in some fibrotic diseases.

The mean PV velocity is normally between 12 and 20 cm per second[6] but the normal range is wide. (A low velocity is associated with portal hypertension. High velocities are unusual, but can be due to anastomotic stenoses in transplant patients.)

The hepatic veins

The hepatic veins drain the liver into the IVC, which leads into the right atrium. Two factors shape the hepatic venous spectrum: the flexible nature of the normal liver, which can easily expand to accommodate blood flow, and the close proximity of the right atrium, which causes a brief 'kick' of blood back into the liver during atrial systole (Fig. 2.27). This causes the spectrum to be triphasic. The veins can be seen on colour Doppler to be predominantly blue with a brief red flash during atrial contraction. Various factors cause alterations to this waveform: heart conditions, liver diseases and extrahepatic conditions which compress the liver, such as ascites. Abnormalities of the hepatic vein waveform are therefore highly unspecific and should be taken in context with the clinical picture.

As you might expect, the pulsatile nature of the spectrum decreases towards the periphery of the liver, remote from the IVC.

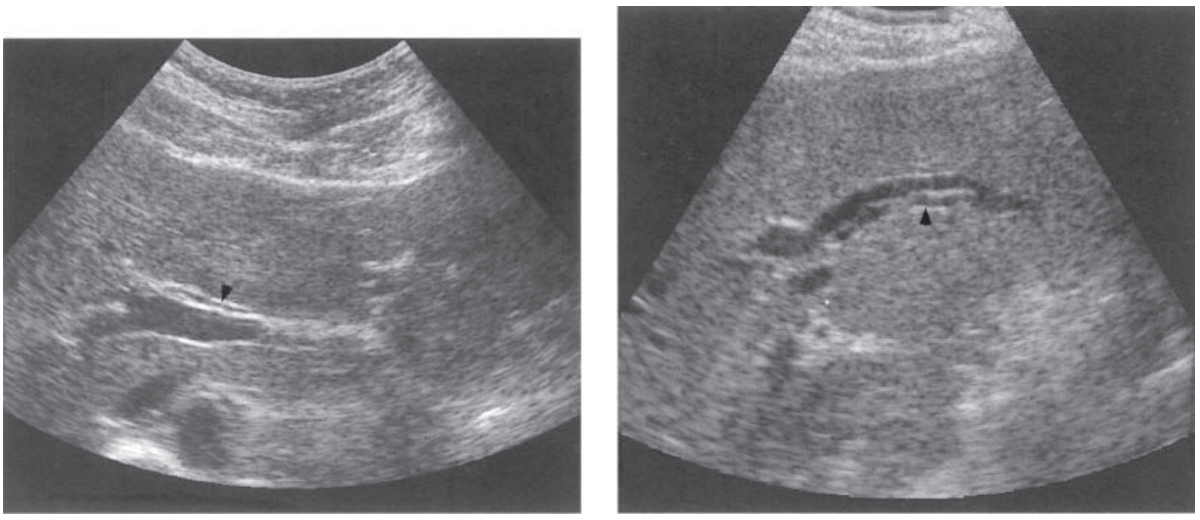

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Figure 2.21 The relationship of the biliary duct to the portal vein varies as the vessels become more peripheral. In (A) the duct lies anterior to the LPV; in (B) the duct is posterior to the LPV.

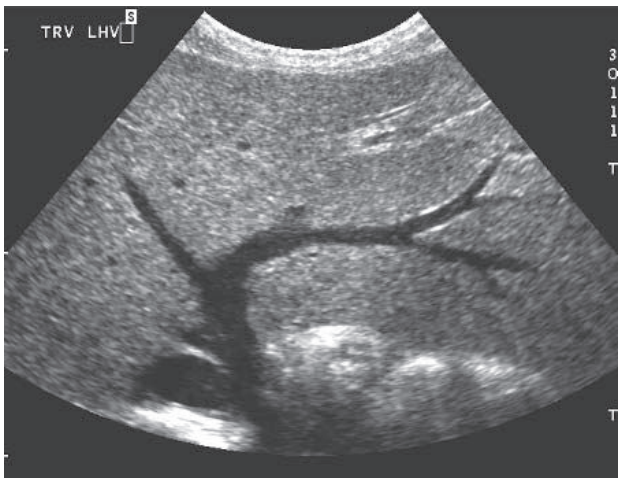


Figure 2.22 The left hepatic vein. Vessel walls are not as reflective as portal veins; however, maximum reflectivity is produced when the beam is perpendicular to the walls, as at the periphery of this vessel.

The hepatic artery

The main hepatic artery arises from the coeliac axis and carries oxygenated blood to the liver from the aorta. Its origin makes it a pulsatile vessel and the relatively low resistance of the hepatic vascular bed means that there is continuous forward flow throughout the cardiac cycle (Fig. 2.28). In a normal subject the hepatic artery may be elusive on colour Doppler due to its small diameter and tortuous course. Use the MPV as a marker, scanning from the right intercostal space to maintain a low angle with the vessel. The hepatic artery is just anterior to this and of a higher velocity (that is, it has a paler colour of red on the colour map (Fig. 2.24)).

THE GALLBLADDER

The normal gallbladder is best visualized after fasting, to distend it. It should have a hyperechoic, thin wall and contain anechoic bile (Fig. 2.29). Measure the wall thickness in a longitudinal section of the gallbladder, with the calipers perpendicular to the wall itself. (A transverse section may not be perpendicular to the wall, and can overestimate the thickness.)

After fasting for around six hours, it should be distended with bile into an elongated pear-shaped sac. The size is too variable to allow direct measurements to be of any use, but a tense, rounded shape can indicate pathological, rather than physiological dilatation.

Because the size, shape and position of the gallbladder are infinitely variable, so are the techniques required to scan it. There are, however, a number of useful pointers to maximize visualization of the gallbladder:

- Use the highest frequency possible: 5.0 MHz or higher is especially useful for anterior gallbladders.
- Use a high line density to pick up tiny stones or polyps (reduce the sector angle and the frame rate if possible). Make sure the focal

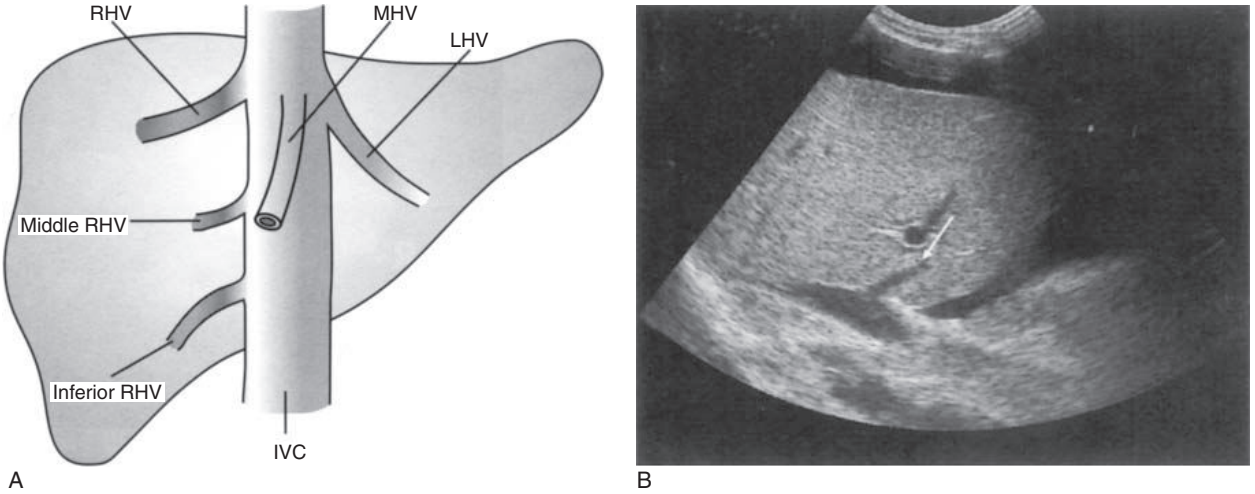


Figure 2.23 (A) Configuration of the hepatic venous system. (B) Inferior middle hepatic vein (arrow) arising from the IVC.

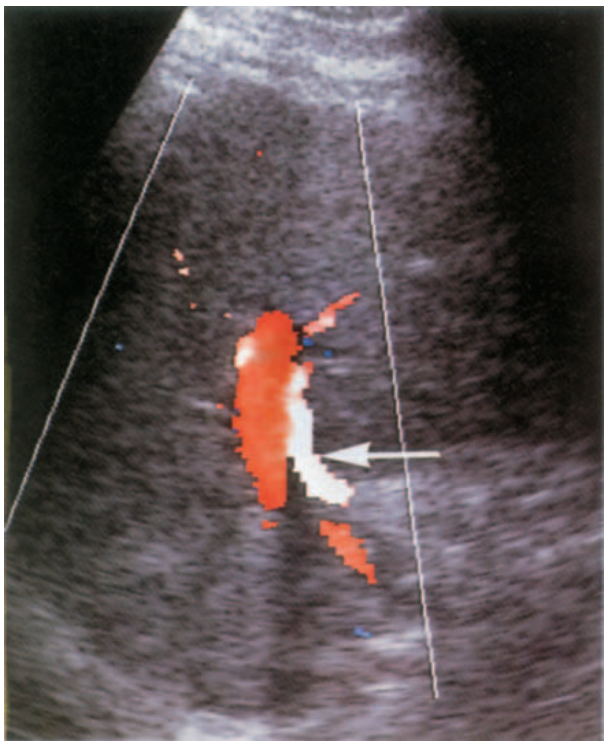


Figure 2.24 Main portal vein at the porta hepatis demonstrating hepatopetal flow. The higher velocity hepatic artery lies adjacent to the Main portal vein (arrow).

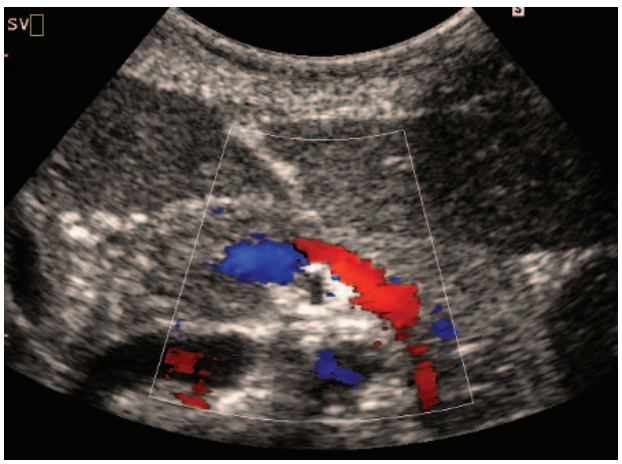


Figure 2.25 TS through the epigastrium, demonstrating the normal splenic vein with flow towards the liver. Note the change from red to blue as the vessel curves away from the transducer.

zone is set over the back wall of the gallbladder to maximize the chances of identifying small stones (see Chapters 1 and 3).

- Alter the time gain compensation (TGC) to eliminate or minimize anterior artefacts and reverberation echoes inside the gallbladder, particularly in the near field.
- Use tissue harmonic imaging to reduce artifact within the gallbladder and sharpen the image of the wall (particularly in a large abdomen).
- Always scan the gallbladder in at least two planes (find the gallbladder's long axis, incorporating the neck and fundus; sweep from side to side, then transversely from neck to fundus) and two patient positions. You will almost certainly miss pathology if you do not.

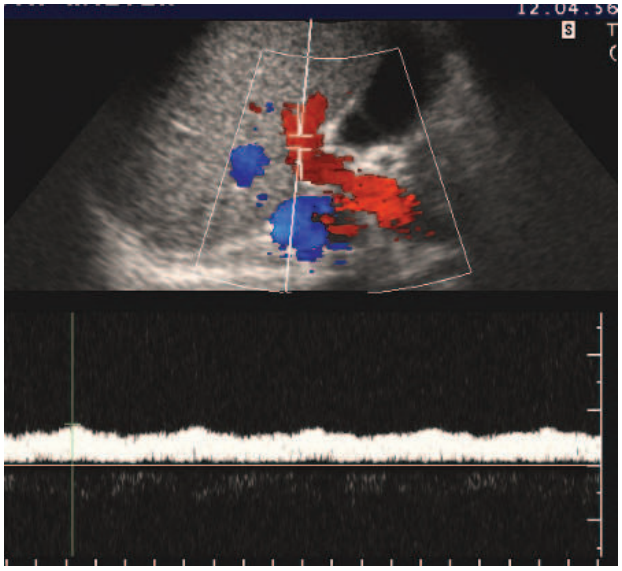


Figure 2.26 Normal portal vein waveform. Respiratory modulations are evident.

- The gallbladder may be 'folded' (the so-called Phrygian cap). To interrogate its contents fully, unfold it by turning the patient decubitus (right side raised), almost prone or erect (Fig. 2.30).
- Bowel gas over the fundus can also be moved by various patient positions.

Normal variants of the gallbladder

The mesenteric attachment of the gallbladder to the inferior surface of the liver is variable in length. This gives rise to large variations in position; at one end of the spectrum the gallbladder, attached only at the neck, may be fairly remote from the liver, even lying in the pelvis; at the other the gallbladder fossa deeply invaginates the liver and the gallbladder appears to lie 'intrahepatically' enclosed on all sides by liver tissue.

The presence of a true septum in the gallbladder is rare. A folded gallbladder frequently gives the impression of a septum but this can be distinguished by positioning the patient to unfold the gallbladder.

Occasionally a gallbladder septum completely divides the lumen into two parts. True gallbladder duplication is a rare entity (Fig. 2.31) and it is important not to mistake this for a gallbladder with a pericholecystic collection in a symptomatic patient. Occasionally the gallbladder is absent altogether.

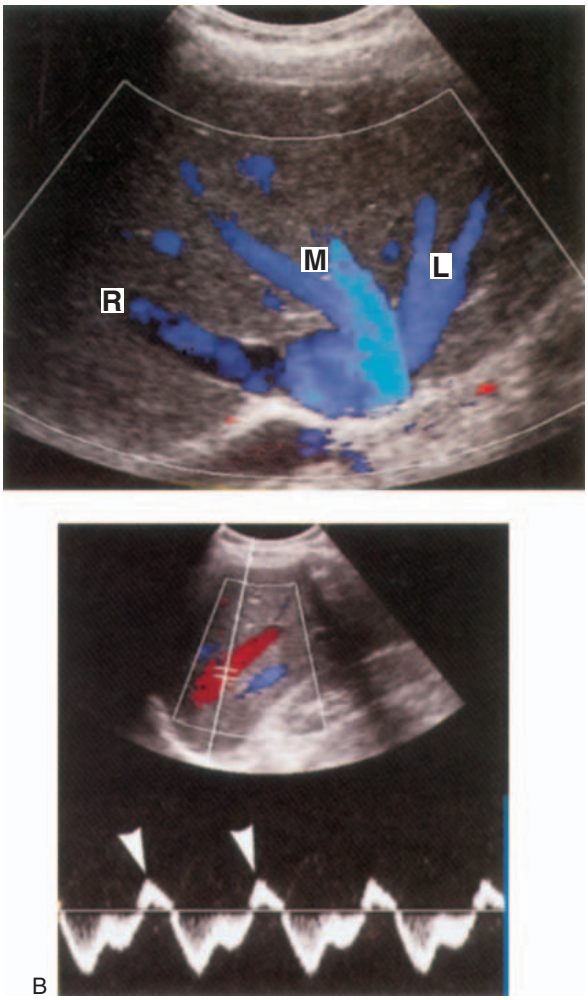


Figure 2.27 (A) The confluence of the right, middle and left hepatic veins with the IVC. (B) Normal hepatic venous waveform. The reverse flow in the vein (arrows) is due to atrial systole. Note that the image has also been frozen during atrial systole, as the hepatic vein appears red.

Pitfalls in scanning the gallbladder

If the gallbladder cannot be found

- Check for previous surgery; a cholecystectomy scar is usually obvious, but evidence of laparoscopic surgery may be difficult to see in the darkened scanning room.
- Check the patient has fasted.

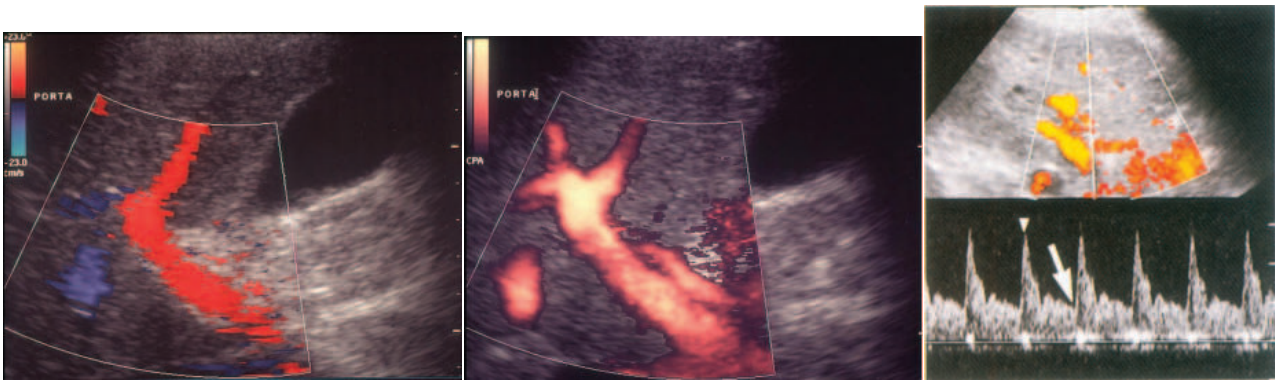


Figure 2.28 (A) The hepatic artery may be difficult to locate with colour Doppler in some subjects. (B) The same patient using power Doppler; visualization is improved. (C) The normal hepatic artery waveform demonstrates a relatively high-velocity systolic peak (arrowhead) with good forward end-diastolic flow (arrow).

- Look for an ectopic gallbladder, for example positioned low in the pelvis.
- Check that a near-field artefact has not obscured an anterior gallbladder, a particular problem in very thin patients.
- Ensure the scanner frequency and settings are optimized, find the porta hepatis and scan just below it in transverse section. This is the area of the gallbladder fossa and you should see at least the anterior gallbladder wall if the gallbladder is present (Fig. 2.32).
- A contracted, stone-filled gallbladder, producing heavy shadowing, can be difficult to identify due to the lack of any contrasting fluid in the lumen.

Duodenum mimicking gallbladder pathology

- The close proximity of the duodenum to the posterior gallbladder wall often causes it to invaginate the gallbladder. Maximize your machine settings to visualize the posterior gallbladder wall separate from the duodenum and turn the patient to cause the duodenal contents to move.
- Other segments of fluid-containing gastrointestinal tract can also cause confusion (Fig. 2.33).

Stones that don't shadow

- Ensure they are stones and not polyps by standing the patient erect and watching them move with gravity. (Beware—polyps on long stalks also move around.)
- The stones may be smaller than the beam width, making the shadow difficult to display. Make sure the focal zone is set at the back of the gallbladder.
- Increase the line density, if possible, by reducing the field of view.
- Scan with the highest possible frequency to ensure the narrowest beam width.
- Reduce the TGC and/or power to make sure you have not saturated the echoes distal to the gallbladder (see Chapter 3).

Beware the folded gallbladder

- You may miss pathology if the gallbladder is folded and the fundus lies underneath bowel. Always try to unfold it by positioning the patient (Fig. 2.30).
- A fold in the gallbladder may mimic a septum. Septa are comparatively rare and have been over-reported in the past due to the presence of folding.

Pathology or artefact?

Sometimes the gallbladder may contain some echoes of doubtful significance, or be insufficiently distended to evaluate accurately. A rescan, after a meal followed by further fasting, can be useful.

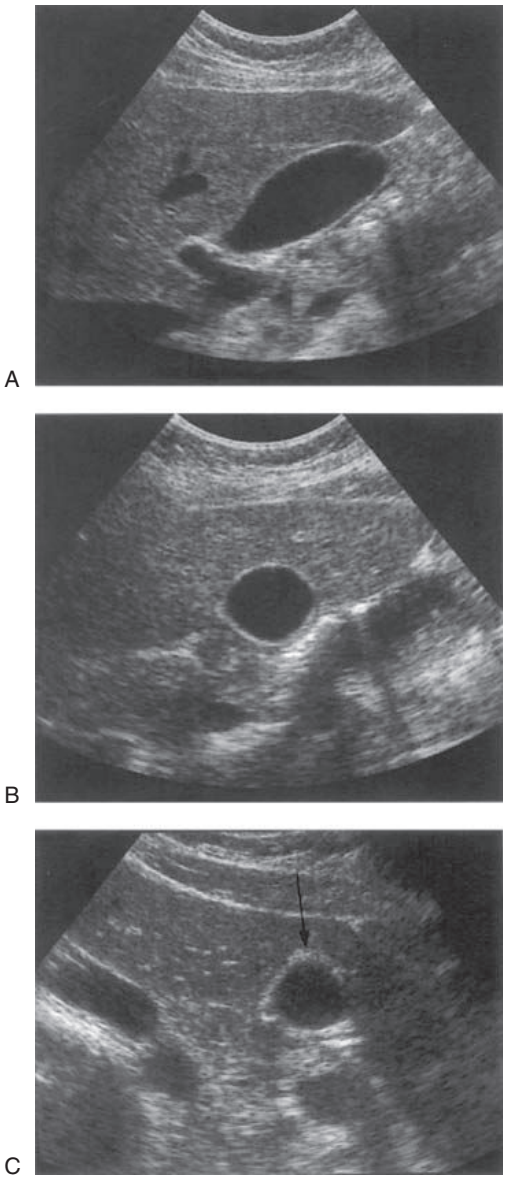


Figure 2.29 The gallbladder: (A) LS, (B) TS. (C) False appearance of wall thickening is produced (arrow) when the angle of scan is not perpendicular to the gallbladder wall in TS.

This can flush out sludge, redistending the gallbladder with clear bile. It may also help to clarify any confusing appearances of adjacent bowel loops.

BILE DUCTS

The common duct can be easily demonstrated in its intrahepatic portion just anterior and slightly to the right of the portal vein. A cross-section of the main hepatic artery can usually be seen passing between

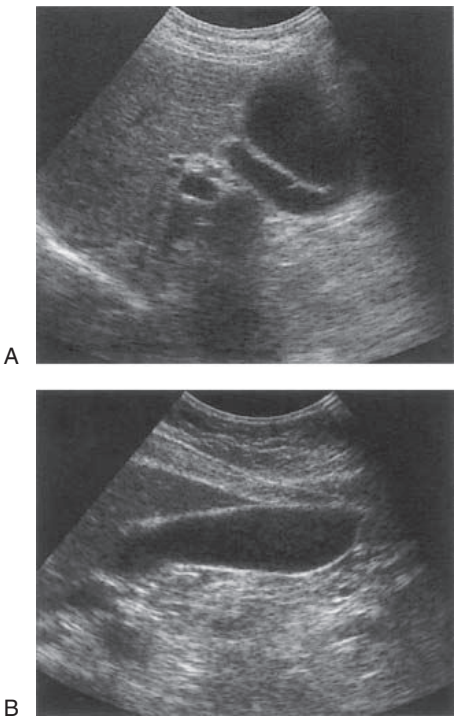


Figure 2.30 (A) A folded gallbladder is difficult to examine with the patient supine. (B) Turning the patient decubitus, right side raised, unfolds the gallbladder, enabling the lumen to be satisfactorily examined.

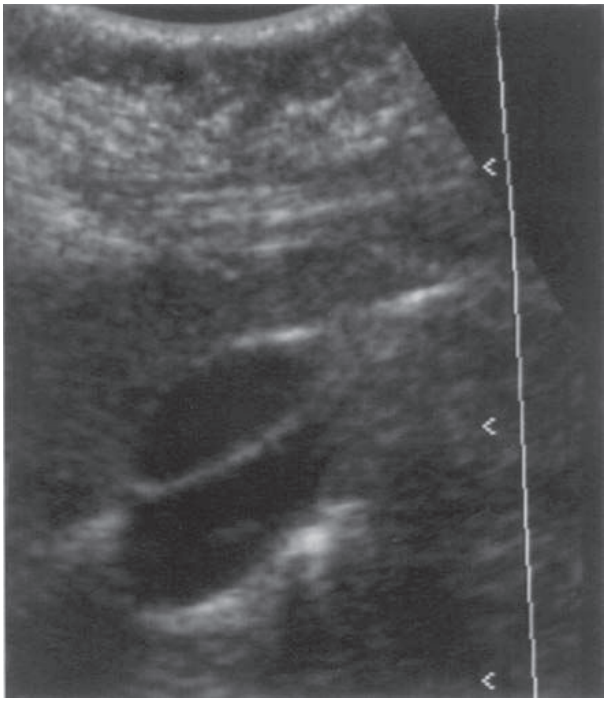


Figure 2.31 Double gallbladder—an incidental finding in a young woman.

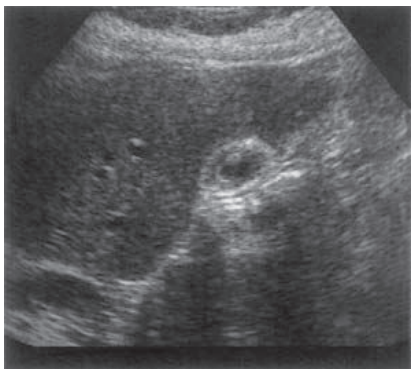
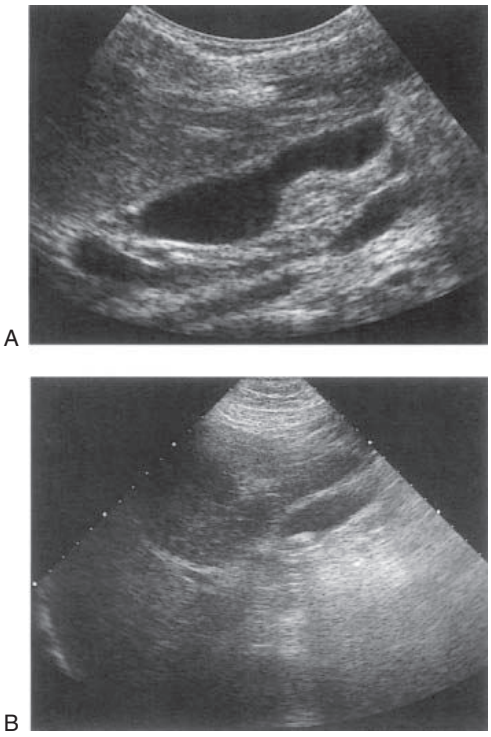


Figure 2.32 A contracted, thick-walled gallbladder located in the gallbladder fossa on TS.



A

B

Figure 2.33 (A) The duodenum frequently invaginates the posterior wall of the gallbladder and may mimic pathology if the machine settings are not correctly manipulated. (B) Fluid-filled stomach near the gallbladder fossa mimics a gallbladder containing a stone. The real gallbladder was normal.

the vein and the duct (Figs 2.20A and 2.34), although a small proportion of hepatic arteries lie anterior to the duct (Fig. 2.20B). At this point it is usually referred to as the common duct, although it may, in fact, represent the right hepatic duct[7] rather than

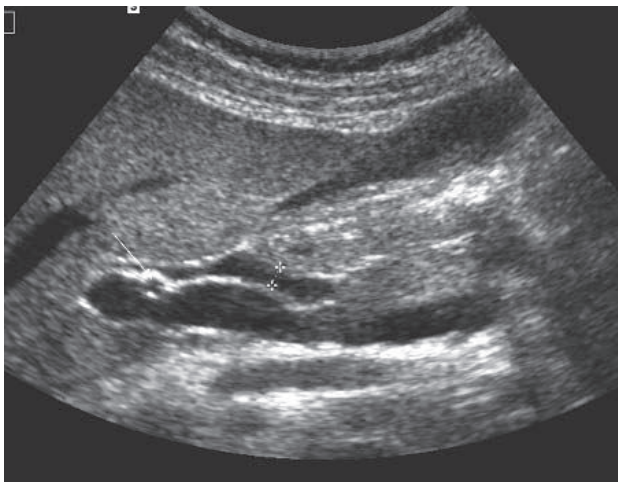


Figure 2.34 CBD at the porta hepatis. The lower end is frequently obscured by shadowing from the duodenum. The duct should be measured at its widest portion.

the common *bile* duct, because we can't tell at what point it is joined by the cystic duct.

The extrahepatic portion of the duct is less easy to see as it is often obscured by overlying duodenal gas. Good visualization of the duct usually requires perseverance on the part of the operator. It is insufficient just to visualize the intrahepatic portion of the duct, as early obstruction may be present with a normal-calibre intrahepatic duct and dilatation of the distal end. (Fig. 2.35).

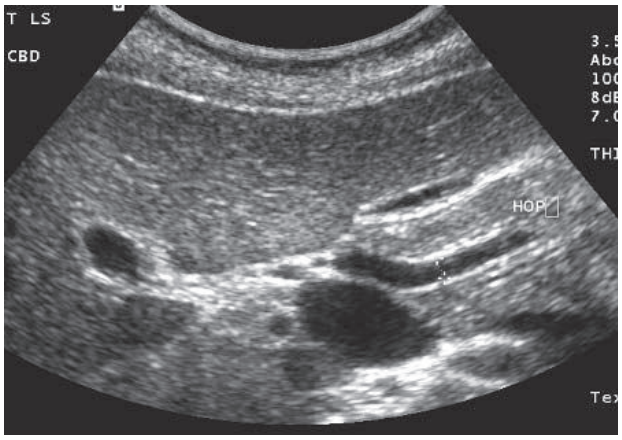


Figure 2.35 Visualization of the lower end of the duct often requires the operator to persevere with technique and patient positioning. The normal duct (calipers) is seen in the head of the pancreas.

Bile duct measurements

The internal diameter of the common duct is usually taken as 6 mm or less. It is age-dependent, however, and can be 8 or 9 mm in an elderly person, due to degeneration of the elastic fibre in the duct wall. Ensure this is not early obstruction by thoroughly examining the distal common bile duct or rescanning after a short time interval. The diameter can vary quite considerably, not only between subjects, but along an individual duct. The greatest measurement should be recorded, in longitudinal section. Never measure the duct in a transverse section (for example at the head of pancreas); it is invariably an oblique plane through the duct, which will overestimate the diameter. Intrahepatically, the duct diameter decreases. The right and left hepatic ducts are just visible, but more peripheral branches are usually too small to see.

Patients with a cholecystectomy who have had previous duct dilatation frequently also have a persistently dilated, but non-obstructed, duct (Fig. 2.36). Be suspicious of a diameter of 10 mm or more as this is associated with obstruction due to formation of stones in the duct.

Techniques

The main, right and left hepatic ducts tend to lie anterior to the portal vein branches; however as the biliary tree spreads out, the position of the duct relative to the portal branches is highly variable. Don't assume that a channel anterior to the PV branch is always a biliary duct—if in doubt, use colour Doppler to distinguish the bile duct from the portal vein or hepatic artery.

The proximal bile duct is best seen either with the patient supine, using an intercostal approach from the right, or turning the patient oblique, right side raised. This projects the duct over the portal vein, which is used as an anatomic marker.

Scanning the distal duct usually requires more effort. Right oblique or decubitus positions are useful. Gentle pressure to ease the duodenal gas away from the duct can also be successful. Sometimes, filling the stomach with water (which also helps to display the pancreas) and allowing it to trickle through the duodenum does the trick. Try also identifying the duct in the pancreatic head (Fig. 2.37) and then tracing it retrogradely towards the liver. Asking the patient to take deep breaths is occasionally successful, but may make matters worse by filling the stomach with air. It is definitely worth persevering with your technique, particularly in jaundiced patients.

SOME COMMON REFERRAL PATTERNS FOR HEPATOBILIARY ULTRASOUND

There is an almost infinite number of reasons for performing abdominal ultrasound. Some of the more common referrals are discussed below.

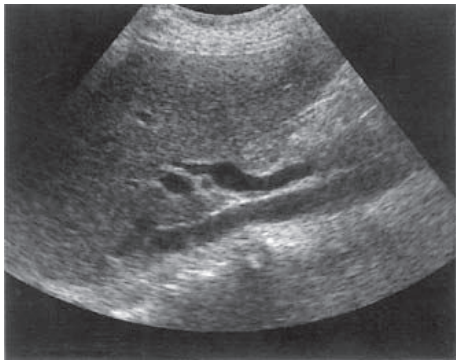


Figure 2.36 A persistently, mildly dilated duct postcholecystectomy (8.5 mm).

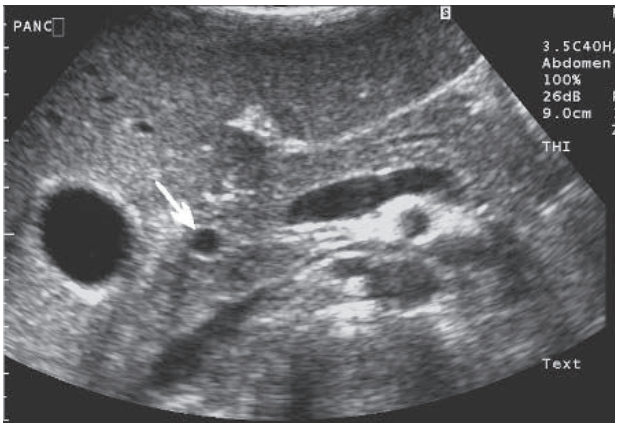


Figure 2.37 The common bile duct (arrow) seen on the head of pancreas on transverse section.

Jaundice

This symptom is a frequent cause of referral for abdominal ultrasound. It is therefore essential for the sonographer to have a basic understanding of the various mechanisms in order to maximize the diagnostic information from the ultrasound scan. The causes and ultrasound appearances of jaundice are dealt with more fully in Chapters 3 and 4; a brief overview is included here.

Jaundice, or *hyperbilirubinaemia*, is an elevated level of bilirubin in the blood. It is recognized by a characteristic yellow coloration of the skin and sclera of the eye, often accompanied by itching if prolonged.

Bilirubin is derived from the haem portion of haemoglobin. Red blood cells are broken down in the liver into haem and globin, releasing their bilirubin, which is non-soluble. This is termed *unconjugated bilirubin*. This is then taken up by the liver cells and converted to a water-soluble form, *conjugated bilirubin*, which is excreted via the biliary ducts into the duodenum to aid fat digestion.

By knowing which of these two types of bilirubin is present in the jaundiced patient, the clinician can narrow down the diagnostic possibilities. Ultrasound then further refines the diagnosis (Fig. 2.38).

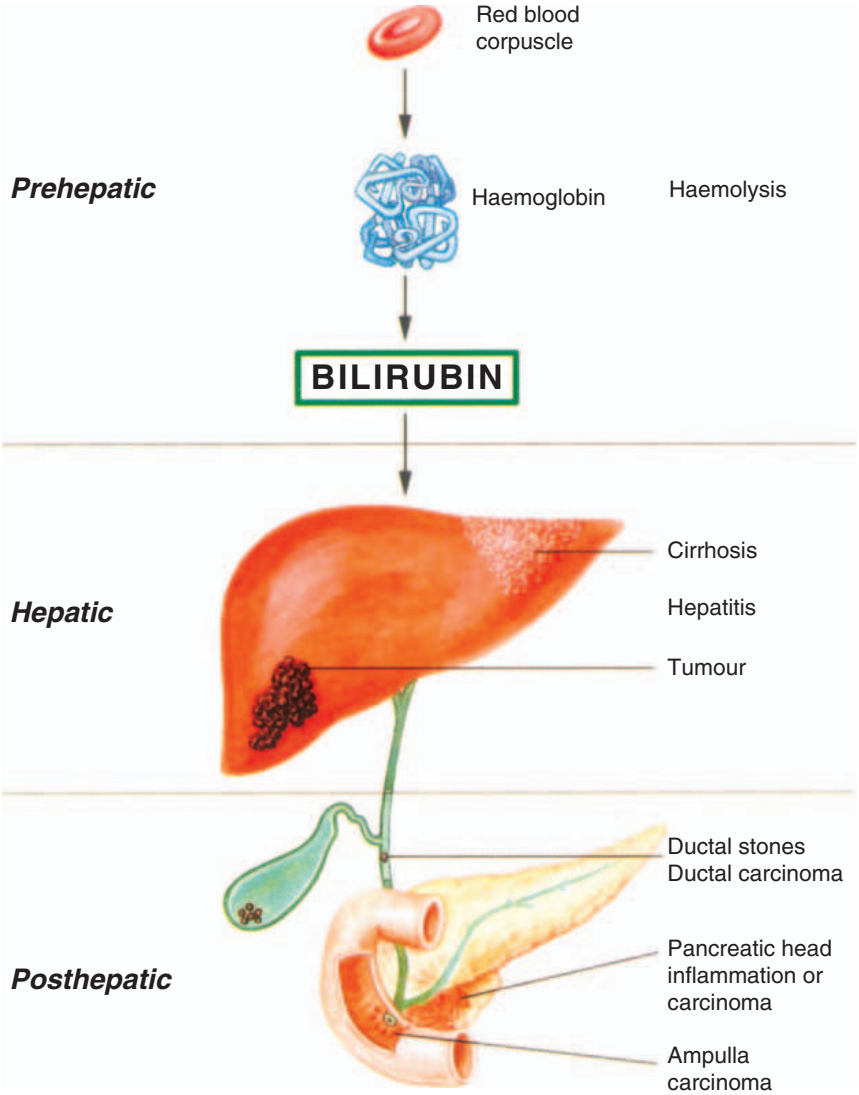


Figure 2.38 Some common causes of jaundice.

Jaundice can fall into one of two categories:

- *obstructive* (sometimes called posthepatic) in which the bile is prevented from draining out of the liver because of obstruction to the biliary duct(s)
- *non-obstructive* (prehepatic or hepatic) in which the elevated bilirubin level is due to haemolysis (the breakdown of the red blood cells) or a disturbance in the mechanism of the liver for uptake and storage of bilirubin, such as in inflammatory or metabolic liver diseases.

Naturally, the treatment of jaundice depends on its cause (Table 2.1). Ultrasound readily distinguishes obstructive jaundice, which demonstrates some degree of biliary duct dilatation, from non-obstructive, which does not.

Abnormal liver function tests

Altered or deranged liver function tests (LFTs) are another frequent cause of referral for abdominal ultrasound.

Biochemistry from a simple blood test is often a primary pointer to pathology and is invariably one of the first tests performed as it is quick and easily accessible. Most of these markers are highly unspecific, being associated with many types of diffuse and focal liver pathology. The most frequently encountered LFTs are listed in Table 2.2.

Other common reasons for referral

In some cases, the presenting symptoms may be organ-specific or even pathognomonic, simplifying the task of ultrasound diagnosis. Often, however,

Table 2.2 Common serum liver function tests

Test	Association with increased level
Bilirubin	Obstructive or non-obstructive jaundice. (Differentiation can be made between conjugated and unconjugated bilirubin)
Alkaline phosphatase (ALP) *(liver enzyme)*	Non-obstructive jaundice Metastases Other focal hepatic lesions
Alpha fetoprotein	Hepatocellular carcinoma (HCC)
Prothrombin time	Malignancy Diffuse liver disease (often with portal hypertension)
Gamma glutamyl transferase	Obstructive jaundice Alcoholic liver disease
Alanine amino-transferase (ALT)	Obstructive or non-obstructive jaundice
Aspartate amino-transferase (AST) *(liver enzymes)*	Hepatitis Viral infections Other organ failure (e.g. cardiac)
Protein (serum albumin)	Lack of protein is associated with numerous liver diseases. Low levels are associated with ascites, often due to portal hypertension

Table 2.1 Common causes of jaundice

Non-obstructive	Obstructive
Unconjugated hyperbilirubinaemia	*Conjugated hyperbilirubinaemia*
—haemolysis	—stones in the biliary duct
—haematoma	—carcinoma of the duct, head of pancreas or ampulla
—Gilbert's disease	—acute pancreatitis
	—other masses which compress the common bile duct (e.g. lymph node mass)
	—biliary atresia
Mixed hyperbilirubinaemia	
—hepatitis	
—alcoholic liver disease	
—cirrhosis of all types	
—multiple liver metastases	
—drug-induced liver disease	

(See Chapters 3 and 4 for further information.)

the symptoms are vague and non-specific, requiring the sonographer to perform a comprehensive and knowledgeable search. The non-invasive nature of ultrasound makes it ideal for the first-line investigation.

Upper abdominal pain

- Upper abdominal pain, the origin of which could be linked to any of the organs, is one of the most frequent causes of referral. The sonographer can narrow the possibilities down by taking a careful history (see Box 2.1).
- Is the pain focal? This may direct the sonographer to the relevant organ, for example a thick-walled gallbladder full of stones may be tender on gentle transducer pressure, pointing to acute or chronic cholecystitis, depending on the severity of the pain.
- Bear in mind that gallstones are a common incidental finding which may be a red herring. Always consider multiple pathologies.
- Is the pain related to any event which may give a clue? Fat intolerance might suggest a biliary cause, pain on micturition a urinary tract cause, for example.
- Is it accompanied by other symptoms such as a high temperature? This may be associated with an infective process such as an abscess.
- Could it be bowel-related? Generalized abdominal pain could be due to inflammatory or obstructive bowel conditions and knowledge of the patient's bowel habits is helpful.
- Has the patient had any previous surgery which could be significant?

Box 2.1

Always:
- take a verbal history from the patient—don't just rely on the request card
- obtain the results of any previous investigations, including previous radiology
- consider the possibility of multiple pathologies

Palpable right upper quadrant mass

A palpable right upper quadrant mass could be due to a renal, hepatobiliary, bowel-related or other cause. The sonographer should gently palpate to get an idea of the size and position of the mass and whether or not it is tender. Specifically targeting the relevant area may yield useful and unexpected results, for example a Reidel's lobe, colonic carcinoma or impacted faeces, which will help to guide the nature of further investigations.

APPENDIX: UPPER-ABDOMINAL ANATOMY

Diagrams of sectional upper-abdominal anatomy are reproduced here for quick reference. See Box 2.2 for the abbreviations used here.

Box 2.2 Abbreviations

AO	Aorta
CBD	Common bile duct
GB	Gallbladder
GDA	Gastroduodenal artery
HA	Hepatic artery
HOP	Head of pancreas
IVC	Inferior vena cava
LHV	Left hepatic vein
LL	Left lobe of liver
LPV	Left portal vein
LRV	Left renal vein
MHV	Middle hepatic vein
R Adr	Right adrenal gland
RHV	Right hepatic vein
RK	Right kidney
RL	Right lobe of liver
RPV	Right portal vein
RRA	Right renal artery
SA	Splenic artery
SMA	Superior mesenteric artery
SMV	Superior mesenteric vein
SPL	Spleen
ST	Stomach
SV	Splenic vein
TOP	Tail of pancreas

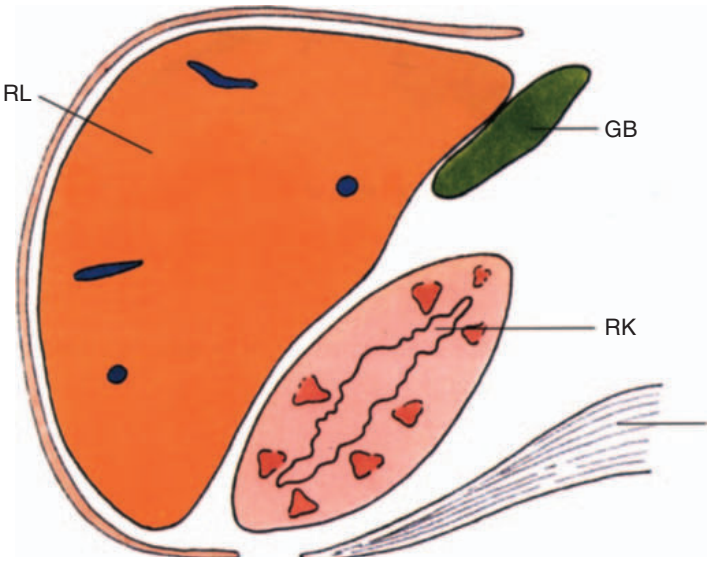


Figure 2A.1 LS through the right lobe of the liver.

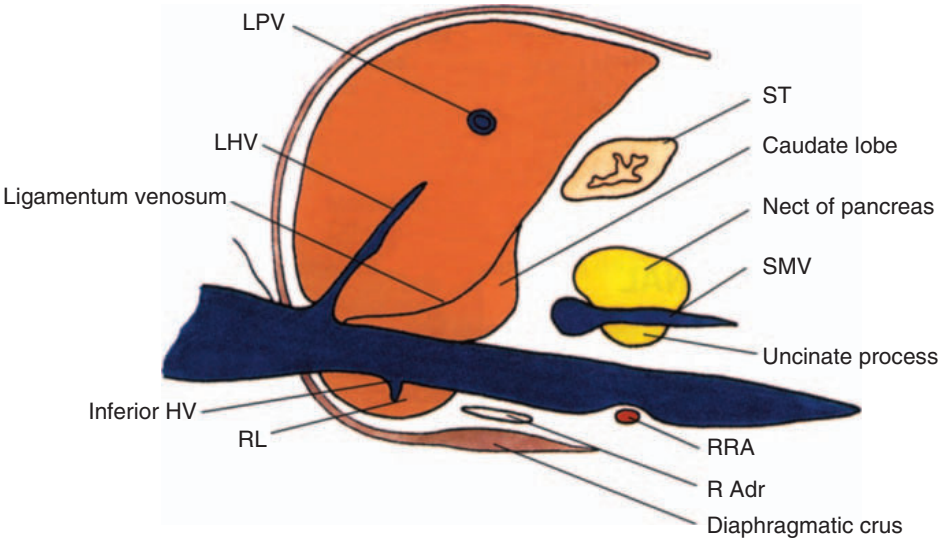


Figure 2A.2 LS through the IVC.

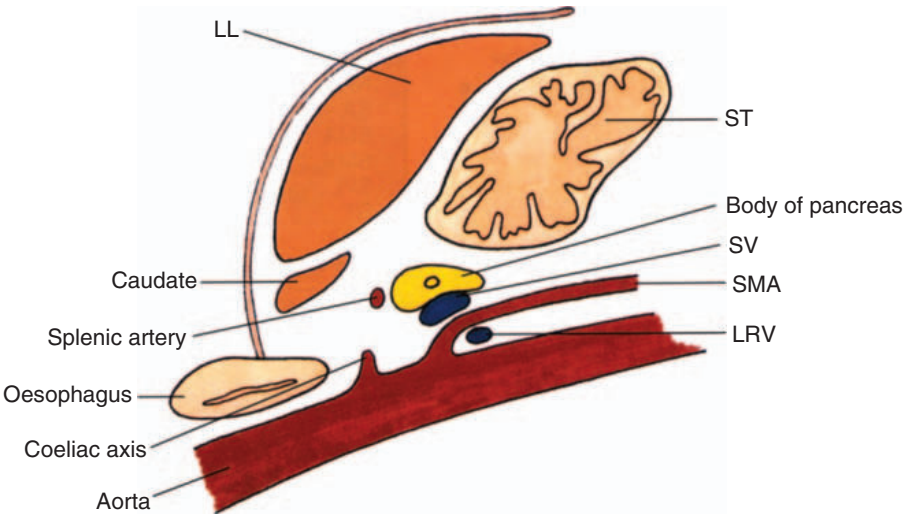


Figure 2A.3 LS through the midline, level of the aorta.

Figure 2A.4 Longitudinal oblique section through the CBD.

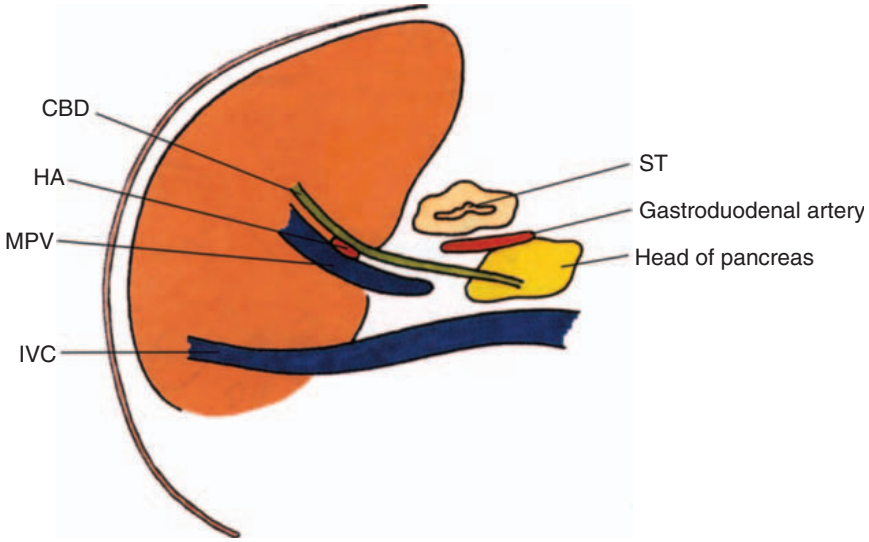
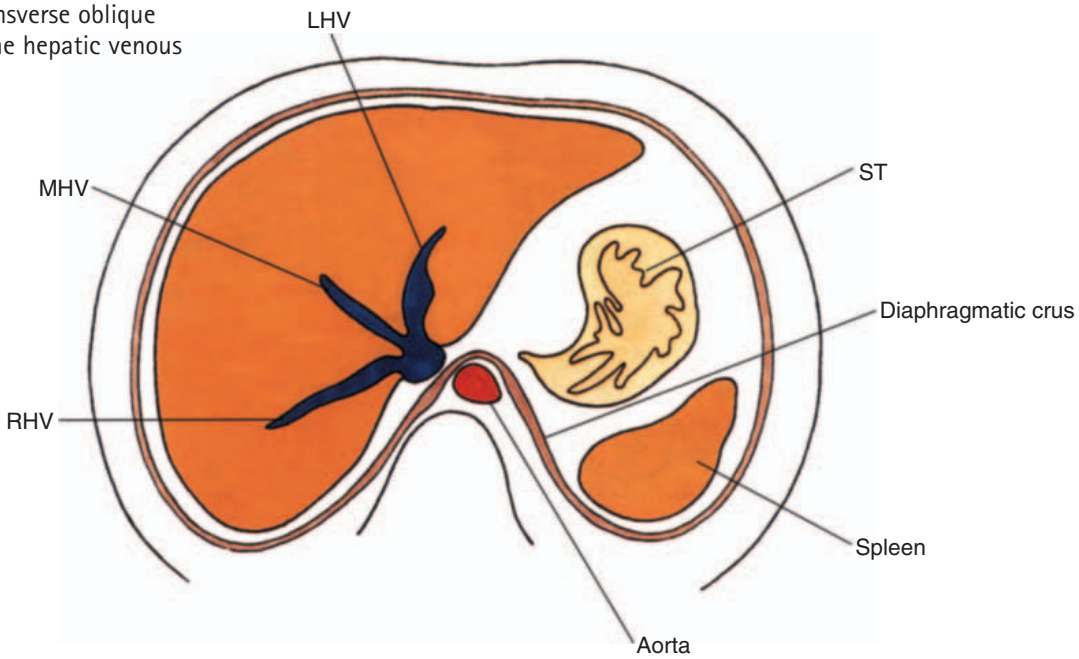


Figure 2A.5 Transverse oblique section through the hepatic venous confluence.



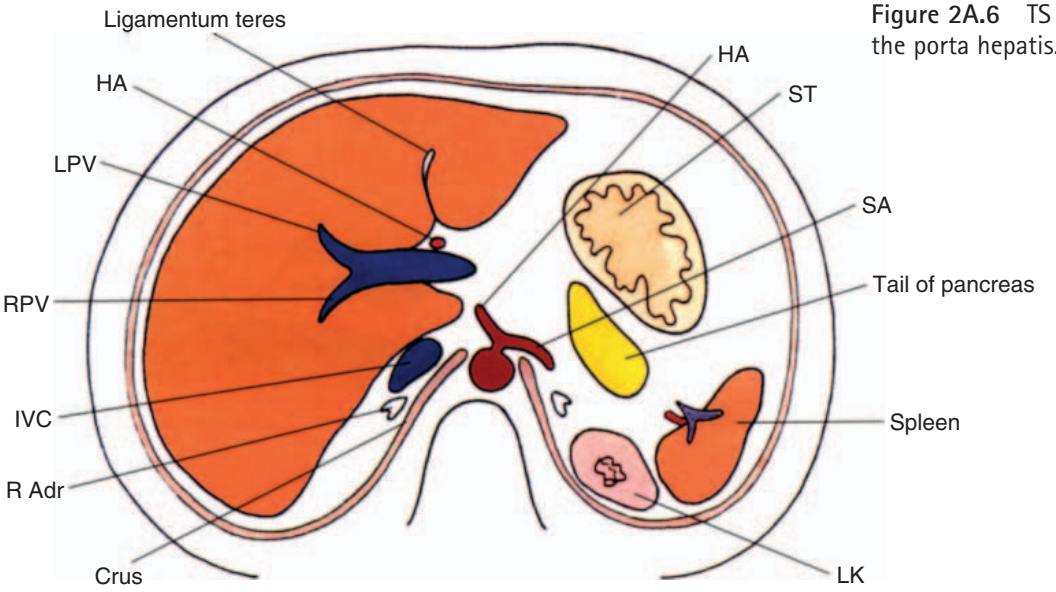


Figure 2A.6 TS through the level of the porta hepatis.

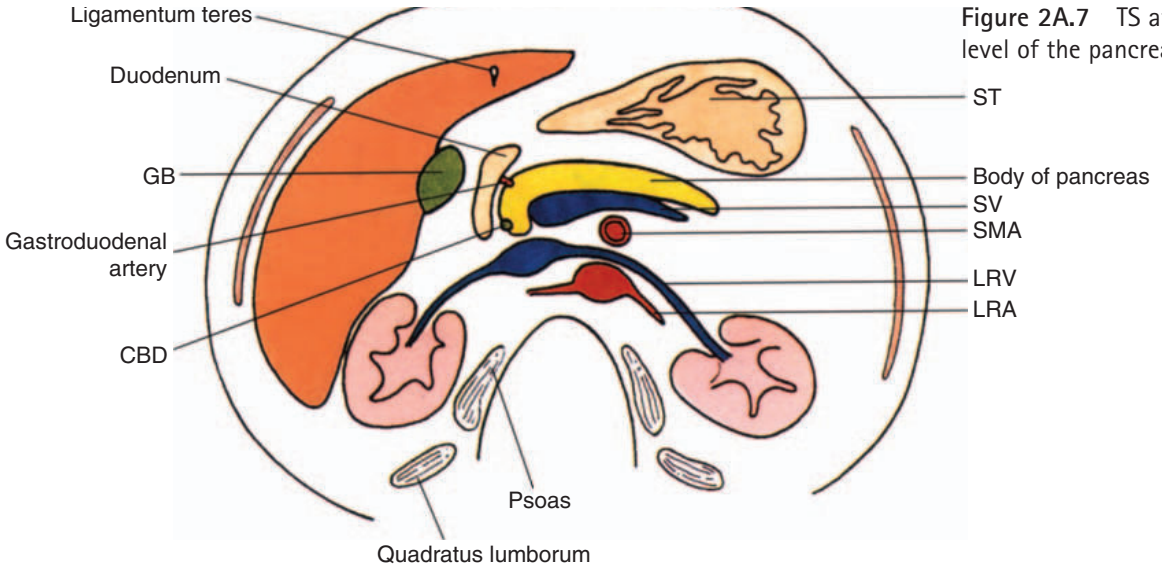


Figure 2A.7 TS at the level of the pancreas.

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