4 Introduction to Abdominal Ultrasound: Normal Patterns

“General ultrasound” has become assimilated into abdominal ultrasound over the years. Although this is a modest part of critical ultrasound, we will begin with this classical field and provide the young physician with a better understanding of the abdominal examination. This chapter includes only notions useful for managing critical situations.

As opposed to lung ultrasound (which is a simple field since there is only one organ) the abdomen is a more complicated field, because 20 organs are concentrated here. Scanning through the abdomen requires some experience and a nice recollection of in anatomy. The recognition of one organ allows another organ to be better located, and vice versa. A suggestion of sequential analysis is suggested in Table 3.2 page 22.

The following figures were obtained using a 5-MHz microconvex probe and a sectorial 3.0-MHz probe.

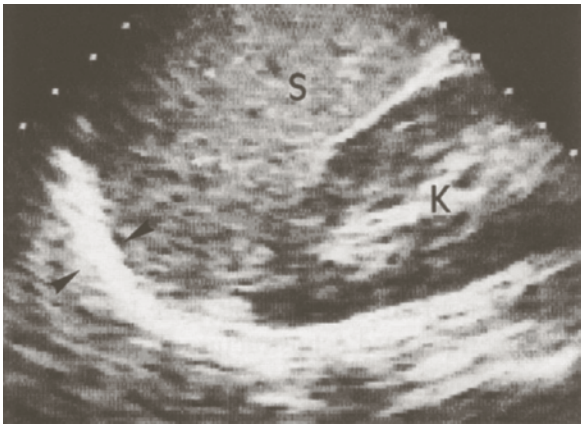

Fig. 4.1 Spleen and left kidney in a longitudinal scan. Note the left hemidiaphragm (*arrows*) just over the spleen (*S*). The kidney (*K*) is located in the splenic concavity. As in Fig. 4.8, the interface between spleen and kidney is fully distinct from the cupola. Note that the structures located above the cupola cannot be interpreted; they can be ghost mirror echoes as well as alveolar consolidation. This route is not adequate for lung or pleural ultrasound

Diaphragm

The diaphragm is a vital muscle that separates the abdomen from the thorax. Its analysis can appear complex due to the shape and the relation between aerated organs (lung/colon). There are two ways to approach its analysis.

1. It was traditionally studied with abdominal probes during abdominal examinations through the liver or the spleen when the probe head was inclined toward the patient head. The hemidiaphragm and the joined pleural layers form a large stripe, hyperechoic, curvilinear, concave downward, covering the dome of the liver or spleen, normally descending on inspiration (Fig. 4.1).
2. Using a microconvex probe, the direct intercostal approach gives another vision of the diaphragm that is of clinical interest. It will be detailed in Chaps. 14–19.

Peritoneum

The peritoneal cavity is normally virtual, but the peritoneal line is precisely located with the dynamic of gut sliding (Fig. 4.2).

D. A. Lichtenstein, *Whole Body Ultrasonography in the Critically Ill*,
DOI: 10.1007/978-3-642-05328-3_4, © Springer-Verlag Berlin Heidelberg 2010

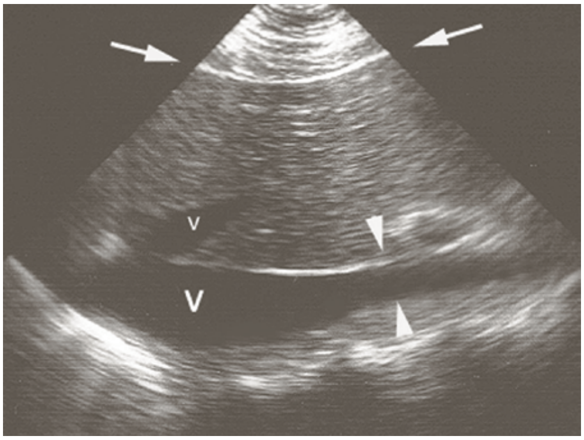

Fig. 4.2 Inferior vena cava (*V*), longitudinal view. Note the bulge (at the *V*), frequently seen. We do not measure the venous caliper of the inferior vena cava at this level but lower down (*arrowhead*). Note also the median hepatic vein (*v*), not to be confused with the inferior vena cava. The *arrows* indicate the peritoneal line

Lumbar Rachis

This is an important landmark, recognized on transversal scan as a large (4-cm) medial curved image stopping the ultrasounds, with the two main large vessels just anterior (Fig. 4.3).

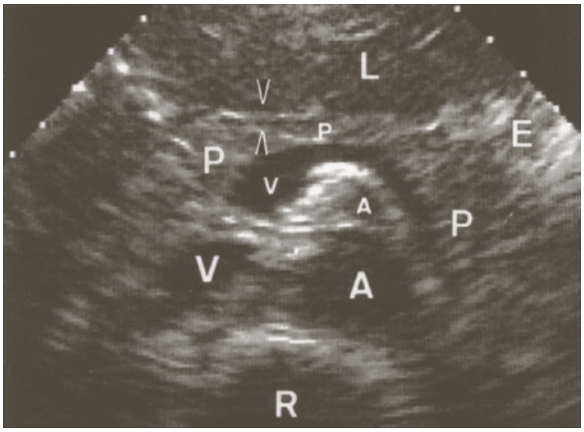

Fig. 4.3 Pancreas, transverse scan. Identifiable from rear to front are: the rachis (*R*), then the aorta (*A*) and inferior vena cava (*V*), then the left renal vein, and then the superior mesenteric artery (*a*). Just anterior to it, the splenic vein (*v*) has a comma shape. The splenic vein constitutes the posterior border of the pancreas, which is now located. Its head (*P*) is in contact with the inferior vena cava. The isthmus and body (*p*) are in continuity with the head. Anterior to the pancreas, the virtual omental sac (*arrows*), the stomach (*E*) and the left lobe of the liver (*L*) are outlined. These structures are rarely all present in a single view

Large Vessels

The abdominal aorta descends anteriorly at the left of the rachis. Its caliper is regular. The celiac axis and the superior mesenteric artery arise from its anterior aspect (Fig. 4.4).

The inferior vena cava rises anterior to the rachis at the right of the aorta, passes posterior to the liver (Fig. 4.2) and ends at the right auricle (Fig. 4.5). It receives the renal veins and the three hepatic veins, just before opening into the right auricle. The walls are rarely parallel, and wide movements are often observed. In thin patients, the vein can be compressed.

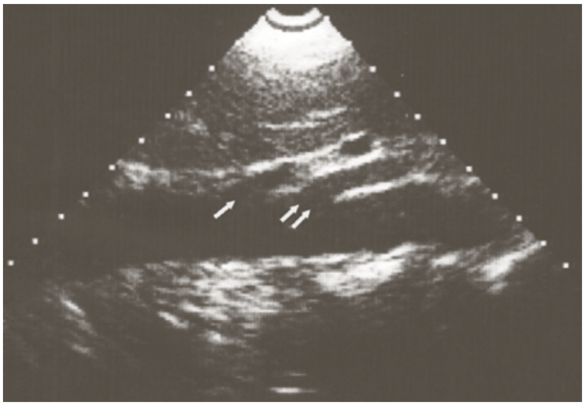

Fig. 4.4 Abdominal aorta. Longitudinal view, with the origin of the celiac axis (*arrow*) and the superior mesenteric artery (*arrows*)

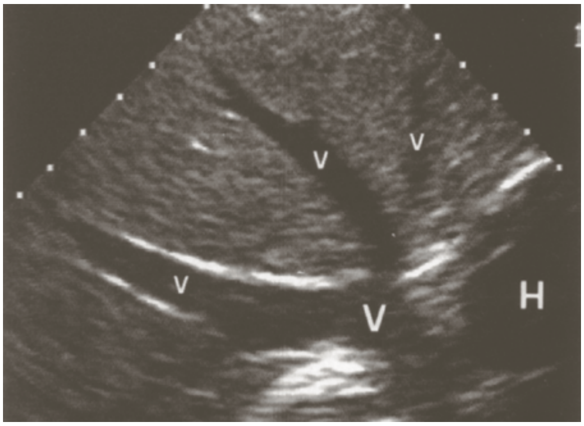

Fig. 4.5 Liver and the three hepatic veins. Oblique scan through the axis of the three hepatic veins (*v*), which meet in the inferior vena cava (*V*), a little before it opens into the right auricle (*H*). Although reputed as having no visible wall, they can, like the right vein here, be separated from the liver by a thin echoic stripe

With all these features, the aorta and inferior vena cava cannot be confused.

Liver

The liver can be studied by longitudinal and transversal scans. Its anatomy is complex to describe, with a right lobe occupying the right hypochondrium, and a smaller left lobe extending to the epigastrium. Radiologists use precise reference scans. Analysis of the hepatic segmentation is of no use to the intensivist. *We advise the beginner in critical ultrasound not to invest too much energy on the liver, biliary tract or portal system, as far as other critical domains (lung, veins, simple heart) are not mastered.*

Several vessels cross the liver. Using more or less transverse scans, and from top to bottom, one recognizes:

- The three hepatic veins, which converge toward the inferior vena cava (Fig. 4.5).
- The branching of the portal vein (Fig. 4.6).
- The portal vein, which has reached the inferior aspect of the liver, in an oblique ascending right route (Fig. 4.7).

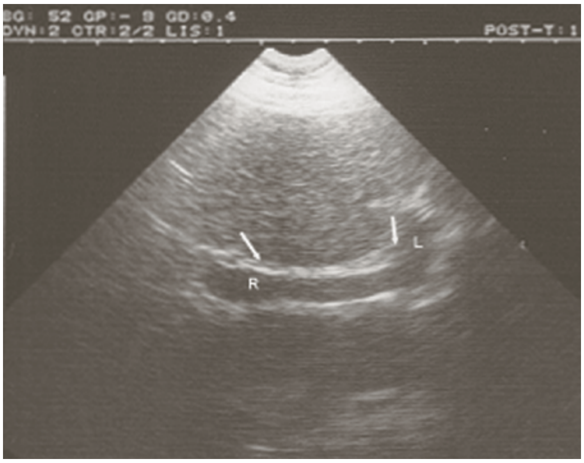

Fig. 4.6 Portal branching. Subtransverse scan (slightly oblique to the top and left). This scan shows the right branch (*R*) pointing to the right, and the left branch (*L*), also slightly pointing to the right. The walls of the veins are thick and hyperechoic, a sign which, among others, distinguishes portal from hepatic veins. Intrahepatic bile ducts are anterior to the portal branching and are normally hardly visible (*arrows*). This is one of the rare figures in this book with moderate clinical relevance in the acute patient

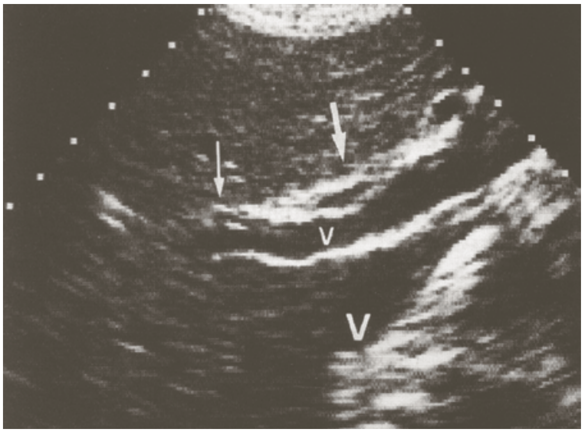

Fig. 4.7 Portal vein, long axis. The common bile duct (*thick arrow*) and the hepatic artery (*thin arrow*) run anterior to the portal vein. The inferior vena cava (*V*) passes posterior to it

- The biliary intrahepatic ducts should be looked for just anterior and parallel to the branching of the portal vein (Fig. 4.6).
- The common bile duct passes anterior to the portal vein. Its normal caliper is less than 4 mm (7 mm for some) (Fig. 4.7).
- The portal vein comes from the union of the splenic vein, horizontal, coming from the spleen (Fig. 4.3), and the superior mesenteric vein, visible anterior to the aorta (see Fig. 6.17 page 50).

In longitudinal scans, the liver is visible, from right to left, anterior to the right kidney (Fig. 4.8), the gallbladder (Fig. 4.9), the inferior vena cava (Fig. 4.2), and the aorta (Fig. 4.4).

Gallbladder

The gallbladder is located at the inferior aspect of the right liver, with a piriform shape (Fig. 4.9). It should be sought first in the right hypochondrium, but can be found in unusual places such as the epigastrium or even the right lower quadrant. It is often visible only via the intercostal approach. In order to avoid gross confusions (with renal cysts, normal duodenum, enlarged inferior vena cava, aortic aneurysm, etc.), one should locate the gallbladder by first locating the right branch of the portal vein, from which arises a hyperechoic line (called the “fossa vesicae felleae”), which leads to the gallbladder.

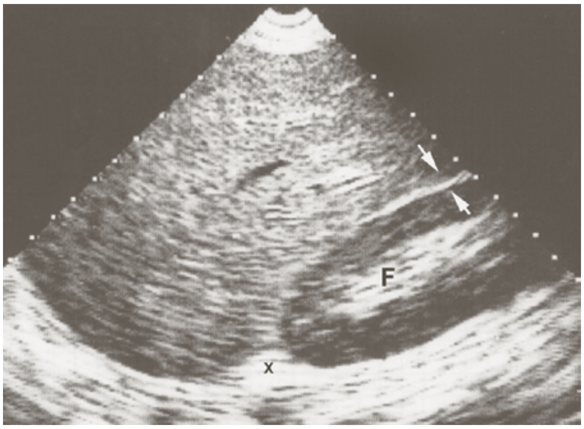

Fig. 4.8 Liver and right kidney. Longitudinal scan. The kidney has a normal size in its long axis, regular boundaries, a mildly echoic peripheral area, an echoic internal area (*F*). The interface (*arrows*) between liver and kidney (Morrison's space) should not be confused with the diaphragm. The technique of lung ultrasound, described in pages 117–127, makes this mistake impossible. Note for the expert level: the adrenal area (*X*)

Kidneys

The right kidney is located behind and below the right liver. From the surface area to the core, a gray, then white, then black pattern can be described. The gray, echoic peripheral pattern corresponds to the parenchyma. The pyramids (or medulla) are slightly less echoic than the cortex, with little clinical relevance to our knowledge. The white, hyperechoic central pattern corresponds to the central zone, an area rich in fat and interfaces. The dark zone, at the core, is inconstant and corresponds to the renal pelvis, which is normally barely or not visible (Fig. 4.8).

Just under the spleen (Fig. 4.1), the left kidney is less easy to access than the right.

Over each kidney, the adrenal is normally not identified within the fat (Fig. 4.8).

Below, the psoas muscle is recognized, with a striated pattern. It descends, vertically, from the rachis to the ala ilii.

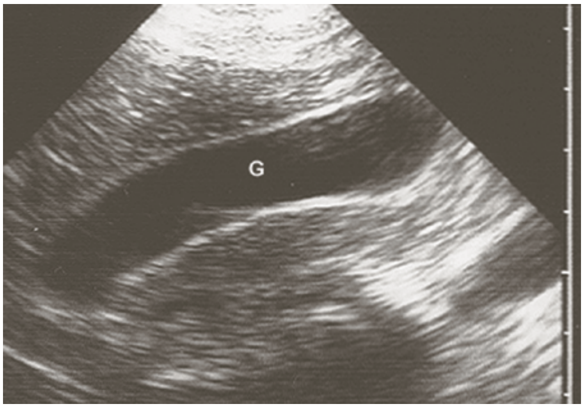

Fig. 4.9 The gallbladder (*G*). It is usually located at the inferior aspect of the liver, and a familiar piriform shape. It is seen here in the long axis, has thin walls, anechoic contents and usual dimensions

Normal dimensions in a normal fasting subject are approximately 50 mm in the long axis and 25–30 mm in the short axis. The content is anechoic. The wall is at best measured by a transverse scan of the gallbladder. The proximal wall should be preferentially measured. Tangency artifacts should be avoided by making a transversal rather than an oblique scan. A normal gallbladder wall is less than 3 mm thick.

Bladder

If empty, it cannot be detected. If half-full, it shows a medial fluid image over the pubic area, with a square section in the transverse scan (Fig. 4.10) and piriform in the longitudinal scan. When full, the bladder

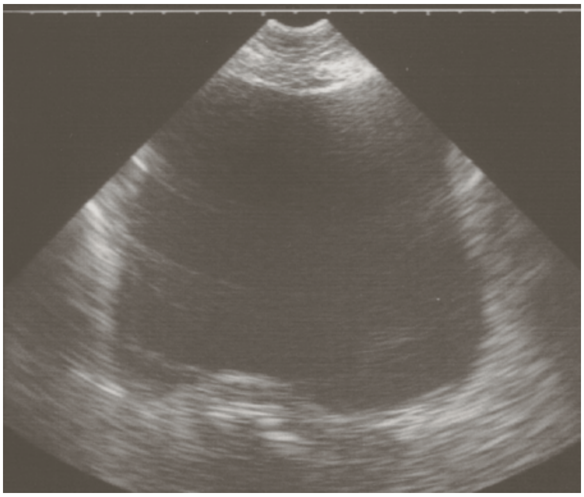

Fig. 4.10 Normal bladder. Transverse scan over the pubis. Its roughly square shape (in fact slightly concave) indicates moderate repletion

becomes enlarged and round. An usual laterolateral caliper of a full bladder in a normal adult is roughly 7–10 cm, with probably large variations.

Pancreas and Celiac Area

We strongly advise the intensivist not to invest too much energy in this field, as long as critical domains (lung, veins, simple heart) are not mastered. The pancreas, with the plexus celiacus area, is one of the most intricate to master. The surrounding vessels make it possible to recognize it, with, from rear to front, in a transverse scan, the following ten structures (Fig. 4.3):

1. The rachis, large (4–5 cm) echoic arc concave backward.
2. The inferior vena cava to the right, the abdominal aorta to the left.
3. The left renal vein, oriented horizontally between the aorta and the superior mesenteric artery.
4. The superior mesenteric artery in cross-section. It is easily located since it is surrounded by hyperechoic fat.
5. The splenic vein, horizontal and comma-shaped with a large end to the right, where it receives the superior mesenteric vein. Both give rise to the portal vein.
6. The pancreatic gland is then recognized anterior to the splenic vein. The head is anterior to the inferior vena cava. The isthmus and the body are parallel to the splenic vein.
7. The main pancreatic duct can be observed within the gland, horizontal.
8. The virtual omental sac anterior to the pancreas.
9. The horizontal portion of the stomach even farther anterior.
10. The left liver.

Maximal dimensions of a normal pancreas are 35 mm at the head, 25 mm at the isthmus and 30 mm at the body [1]. The celiac axis is located in a superior plane, and gives the splenic artery to the left and a hepatic artery to the right, which converges toward the portal vein and is applied anterior to it. All these details are rarely of interest to the critical care physician.

Spleen

In a supine patient, the probe should virtually sink into the bed since the spleen is more posterior than lateral. The technique is the one for the left PLAPS point, described on page 121, just aiming lower.

Located under the left hemidiaphragm, the spleen has a familiar convex/concave shape and is homogeneous (Fig. 4.1).

Normal Ultrasound Anatomy in a Patient in Intensive Care

To the previous descriptions, one must add the gastric tube (see Fig. 6.8 page 46), urinary probe (see Fig. 9.12 page 72), central venous catheters (see Fig. 12.5 page 92) and tracheal tube (see Fig. 24.11 page 251).

Reference

1. Weill FS (1985) Pathologie pancréatique. In: Weill FS (ed) L'ultrasonographie en pathologie digestive. Vigot, Paris, pp 345–375