DUPLEX ANATOMY OF THE ABDOMEN

Knowledge of visceral and vascular anatomy is vital to any abdominal ultrasound examination. The anatomy is similar in most patients and the location and course of the major abdominal arteries and veins can serve as a roadmap with consistent vascular landmarks. Even so, the importance of recognizing the well-described normal variations of this vascular roadmap cannot be overstated. This highway of vessels defines the vascular supply of the major abdominal organs and also delineates visceral boundaries and specific anatomic regions. Any deviation from normal requires close scrutiny to determine if a change is a normal variation or one that is caused by some pathologic process. If disease changes the usual appearance of a structure, knowledge of normal anatomy will assist the examiner in determining the site and possible cause of the abnormality. Diagnostic accuracy is best achieved when visceral and vascular anatomy are correlated.

The following information is intended as a general overview of abdominal anatomy. As you read through this discussion, you should practice locating the organs and vessels using the indicated anatomic landmarks. But before we can start our journey through the abdomen, we have to be certain to choose the right ultrasound equipment and appropriate preparation and positioning of the patient for an abdominal sonographic examination.

CHOOSING THE RIGHT EQUIPMENT

Abdominal duplex examinations require high resolution ultrasound instruments and low-frequency pulsed Doppler transducers in the range of 2 MHz to 5 MHz. Sector, curved and phased array transducers are all satisfactory for visceral vascular examinations. A curved array transducer, optimized for the appropriate imaging depth and Doppler carrier frequency, facilitates imaging through inter and sub-costal windows. Phased array transducers provide excellent tissue characterization in patients with normal body habitus. The addition of color flow imaging facilitates identification of vessels, confirmation of aberrant vascular anatomy and recognition of disordered flow patterns. Power Doppler imaging excels in delineation of off-axis and low velocity blood flow and for defining the interface between the lumen and the vessel wall. Real-time compound and or harmonic imaging should be routinely used to improve image resolution and to decrease artifacts.

PATIENT PREPARATION AND POSITIONING

There are two major limitations to the sonographic examination of the abdomen: bowel gas and patient obesity. Air in the bowel causes scattering of the ultrasound beam resulting in an inability to appropriately image structures deep to the air. This is a particular challenge in the abdomen where bowel gas is often abundant. To decrease the amount of air in the bowel, the patient is instructed to fast for eight to ten hours prior to the ultrasound examination. Medications are to be taken with sips of water only. Patients are also asked to refrain from cigarette smoking and gum chewing as both result in significant amounts of swallowed air. Gas-reducing agents are occasionally used in some patients, with physician approval, but generally are not required in the fasted patient. To minimize the amount of abdominal gas and to optimize the chances of patient compliance, abdominal examinations are performed in the morning. Diabetic patients are permitted to have clear tea and dry toast, as necessary, to prevent hypoglycemia and their studies are prioritized to early morning. Examinations of postoperative patients may be particularly challenging due to diminished intestinal motility and gas-filled bowel.

Multiple patient positions will be used throughout the examination to optimize acoustic windows. The abdominal examination is most often initiated in the upper and central abdomen with the patient lying supine. The patient's head should be slightly elevated on a low pillow. The examination table is tilted into the reverse Trendelenburg position (feet 15-20 degrees below heart level) to create better acoustic windows by allowing the viscera to descend into the abdomen. Lateral decubitus, coronal and coronal oblique positions may be used to optimize access to the abdominal organs and vessels. Keep in mind that you can quite often create better windows by moving organs out of the way by having the patient stretch their legs out straight to pull the hip downward or by placing their arm over their ear, rather than across their chest, when they are lying in the lateral decubitus position. On occasion, it may be helpful to have the patient sit up and raise their arms over their head to elevate the rib cage for access to the proximal mesenteric arteries.

It is difficult to predict from the patient's body habitus whether imaging will be adequate. However, the more obese the patient, the greater the likelihood of poor imaging. The location of body fat (subcutaneous, intraperitoneal and/or retroperitoneal) and the particular sonographic characteristics of the fat are factors that affect the quality of the sonographic image.

Now let's begin our sonographic journey through the abdomen by following the vascular roadmap!

MAJOR ABDOMINAL VESSELS

The Abdominal Aorta

Sections of the abdominal aorta can be imaged in almost every patient, and in many patients, the entire length of the aorta can be visualized. The aorta is located to the left of the spine and tapers gradually as it courses to its bifurcation (near the level of the umbilicus) where it divides into the right and left common iliac arteries (FIGURE 1). The length of the abdominal aorta approximates 13 centimeters in an average middle-aged male. The anteroposterior (AP) diameter of the proximal segment normally measures up to 27 millimeters and tapers to approximately 13 millimeters at the bifurcation [1, 2, 3]. In older patients, the aorta is often tortuous and ectatic, occasionally even lying to the right of the spine. The aorta should be imaged in both the longitudinal (sagittal) and transverse planes, with images from the proximal, mid, and distal portions and any aneurysmal or anatomically aberrant segments retained and presented for interpretation. True transverse, or anterior to posterior, measurements (outer wall- to-outer wall) greater than 3 cm are generally considered aneurysmal. Attention must be given to any lack of normal tapering that might also indicate disease.

Figure 1. Computed tomographic angiogram of the abdominal aorta and iliac arteries.

The image of the proximal abdominal aorta is occasionally obscured by stomach and/or bowel gas but can often be seen well through the acoustic window afforded by the left lobe of the liver. A near- coronal view is often helpful for evaluating the length of the aorta. The patient is placed in the left lateral decubitus position (that is, left side down) with the right shoulder and body rolled a few degrees posteriorly toward the examination table. While scanning head to foot in a longitudinal direction using this coronal plane, the inferior vena cava (IVC) and the aorta can be viewed side-by-side. The IVC will be toward the top of the image since the ultrasound beam entering the right side of the patient encounters the IVC first; the aorta is seen deeper in the image (FIGURE 2). In addition to displaying the aortic bifurcation well, this view is useful for visualizing the proximal renal arteries (especially the right renal artery) particularly in patients with juxta-renal abdominal aortic aneurysms.

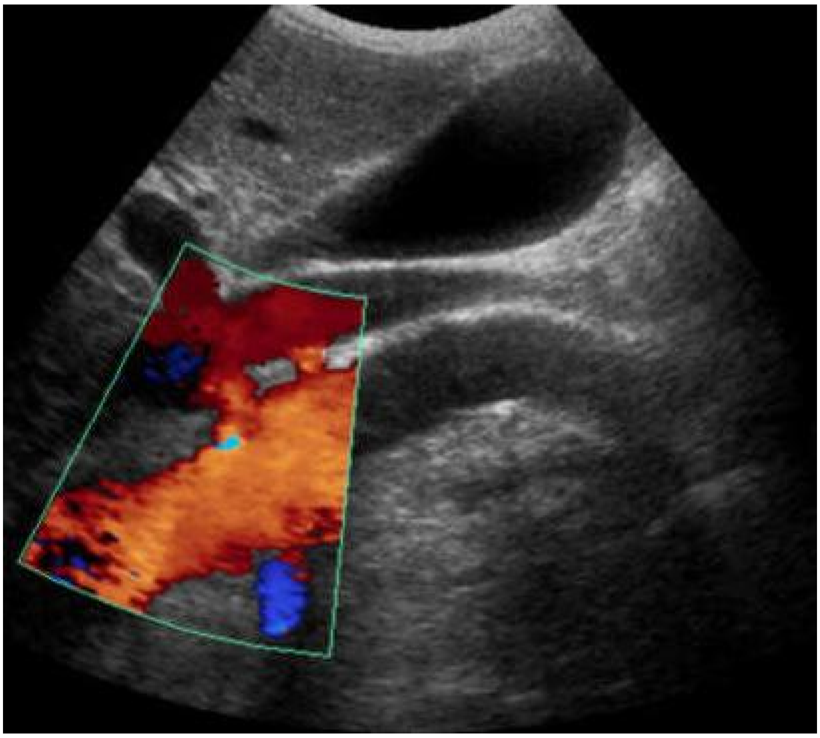

Figure 2. Longitudinal color flow image of the IVC and abdominal aorta.
Note duplicated right renal arteries.

The Celiac and Superior Mesenteric Arteries

The celiac artery (a.k.a., trunk, axis) is the first major branch arising from the abdominal aorta (FIGURE 3), originating anteriorly at about the level of the first lumbar vertebra [3, 4]. The celiac has three major branches that can be visualized with ultrasound –the splenic, the common hepatic, and the left gastric arteries. The celiac artery supplies blood to the liver, pancreas, spleen, stomach, and small bowel. If you rotate the transducer 90 degrees to image the aorta in a transverse plane at this level, you will obtain a longitudinal view of the celiac trunk arising from the anterior aortic wall. If you follow the celiac trunk to its bifurcation, you will note that the trunk divides into two branches which appear as seagull wings or, if you view the trunk and branches together, you will note that they resemble the letter “T” (FIGURE 4). The left branch, the splenic artery, is directed toward the hilum of the spleen. The right branch, the common hepatic artery (CHA), courses toward the liver. At the point where the first major branch of the CHA (the gastroduodenal artery) descends to supply the pancreas, the CHA becomes the proper hepatic artery (FIGURE 5). The proper hepatic artery eventually branches into the right, middle, and left hepatic arteries within the liver [2]. The third, and smallest, branch of the celiac artery, the left gastric artery, is not seen on transverse images. In optimal longitudinal images of the aorta and celiac trunk, the left gastric artery can be seen coursing cephalad for a short distance. It supplies blood to the anterior and posterior portions of the stomach and esophagus. Other abdominal structures, such as the gastroesophageal junction, also can be seen in this same longitudinal view of the proximal aorta. You will encounter the next major branch of the abdominal aorta, the superior mesenteric artery (SMA), approximately one to two centimeters caudal to the origin of the celiac artery [3, 4] (refer to FIGURE 3). Normally, it lies to the left of the superior mesenteric vein, and posterior to the splenic vein and the pancreas (a portion of the pancreas drapes over the SMA) (Refer to FIGURE 15C). If you image the SMA from a transverse aortic view, the vessel will appear disk-like lying immediately inferior to the celiac artery and superior to the left renal vein as it crosses over the anterior aortic wall (FIGURE 6). The superior mesenteric artery supplies much of the blood flow to the small intestines, cecum, ascending colon, a portion of the transverse colon and also sends branches to the pancreas and duodenum. Rarely, the celiac artery and SMA share a common origin; however, there is often the appearance of a common trunk when in fact the two orifices of the celiac and SMA are very near each other, but separate. The SMA has a collar of fairly bright echoes around it. The echogenicity, which is especially appreciated on transverse images, is attributed to peritoneal fat that surrounds the artery and separates it from the pancreas. Just beyond its origin, the SMA proceeds anteriorly for a short distance and then curves until it courses parallel to the aorta as it continues distally, giving rise to multiple branches along its course (Refer to FIGURE 3. The length of the artery that can be visualized depends on patient body habitus and the amount of overlying bowel gas.

Figure 3. Longitudinal gray scale image of the abdominal aorta demonstrating the origin of the celiac artery and, 1-2 cm distally, the superior mesenteric artery coursing parallel to the aortic wall.

Figure 4.Longitudinal gray scale image of the celiac artery and its branches, the common hepatic artery and the splenic artery.

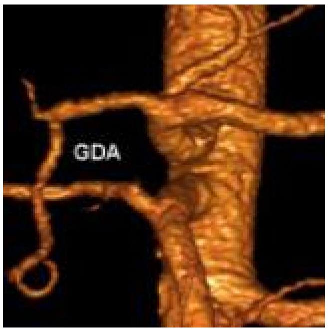

Figure 5. Computed tomographic angiogram of the celiac artery bifurcation. The gastroduodenal artery (GDA) can be seen arising from the common hepatic artery and descending caudally.

Figure 6. Transverse color flow image of the abdominal aorta. The superior mesenteric artery (SMA) appears disk-like superior to the left renal vein and anterior wall of the aorta.

The renal arteries are the next major exits on the aortic highway but we're going to skip over those for just a bit and finish our tour of the mesenteric arteries. You will find the small inferior mesenteric artery (IMA) by scanning further distally along the abdominal aorta. The IMA usually originates at the level of the fourth lumbar vertebra [5] which is about two finger widths above the umbilicus or 4 centimeters above the bifurcation. It is commonly surrounded by small bowel and mesenteric fat. The IMA supplies the descending and rectosigmoid colon. While it can be seen for a short distance beyond its origin (from a longitudinal image of the distal aorta), it is best viewed from a transverse image plane arising anterolaterally from the left aortic wall (FIGURE 7).

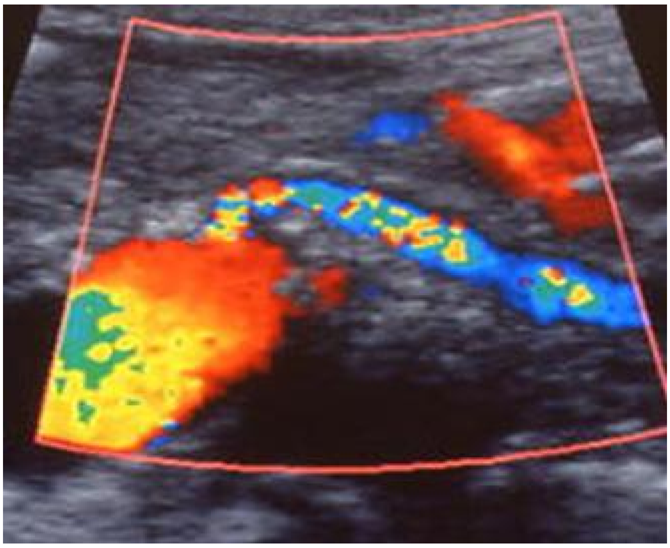

Figure 7. Transverse color flow image of the distal abdominal aorta. The inferior mesenteric artery (IMA) can be seen arising from the left anterolateral wall of the aorta.

The Renal Arteries

Now, let’s scan back up the aorta to the level of the SMA to locate the renal arteries which arise from the proximal aorta just caudal to the SMA (FIGURE 8). The right renal artery usually originates anterolaterally from the aortic wall and then courses posterior to the Inferior vena cava (IVC). The left renal artery most often arises from the lateral or posterolateral aortic wall and then takes a gradual path, coursing posterior to the left renal vein, to enter the hilum of the kidney. While the majority of patients will have a single renal artery on each side, up to 30% of the population has multiple renal arteries [6] (FIGURE 9). The most common anatomic variants are duplicated main renal arteries, accessory renal arteries, and polar renal arteries [7, 8]. Duplicated renal arteries originate from the aorta and enter the renal hilum. Accessory renal arteries also enter the renal hilum but they may originate from the aorta or the iliac arteries. Like accessory renal arteries, polar renal arteries may arise from the aorta or the iliac arteries but, in contrast, they course to the surface of a pole of the kidney and occur more often on the left side than the right for reasons that are not well understood. The proximal renal arteries can most often be identified from a transverse aortic image or from a coronal view of the aorta (described earlier), particularly when using color flow imaging. From a transverse view, they are found posterior to the renal veins (refer to FIGURE 8). The right renal artery can also be identified on longitudinal scans of the inferior vena cava as a disk-like structure coursing behind the IVC (FIGURE 10). Dependent on patient body habitus and the extent of bowel gas, the length of the arteries from aorta to renal hilum may be imaged (FIGURE 11). In the majority of patients, however, the best views of the distal-to-mid segments of the renal artery are obtained from a transverse image of the kidney where the distal artery can be seen coursing into the renal hilum lying in proximity to the renal vein (FIGURE 12).

Figure 8. Transverse gray scale image of the proximal aorta demonstrating the origins of the right and left renal arteries. Note the Left renal vein crossing over the aorta and the SMA (transverse image) just superior to the vein.

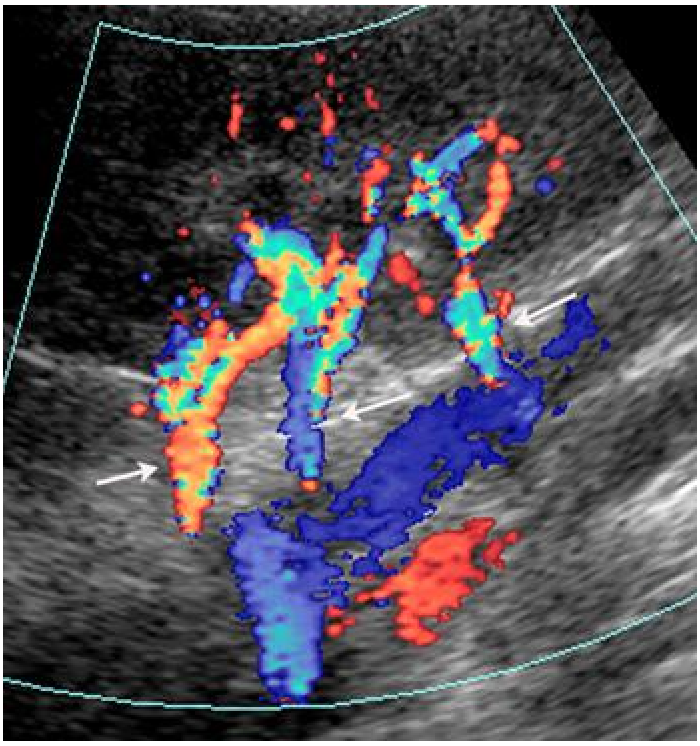

Figure 9. Longitudinal color flow image demonstrating multiple renal arteries arising from the aorta and entering the hilum of the kidney.

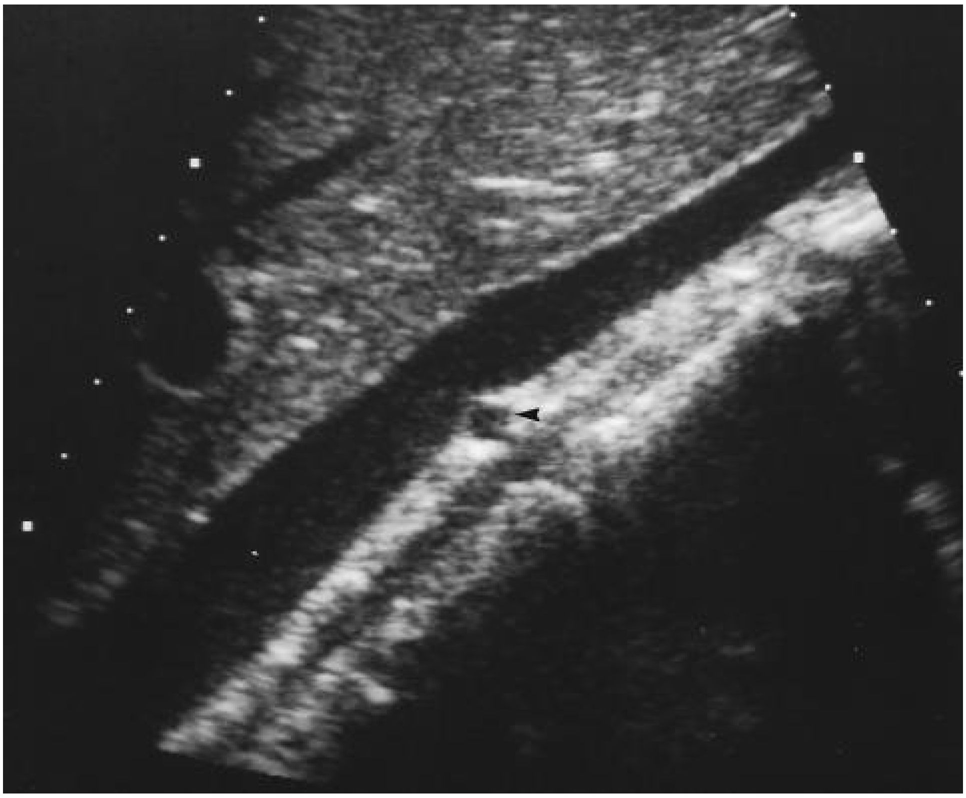

Figure 10. Longitudinal gray scale image of the inferior vena cava (IVC). Note the cross-sectional image of the right renal artery coursing behind the IVC.

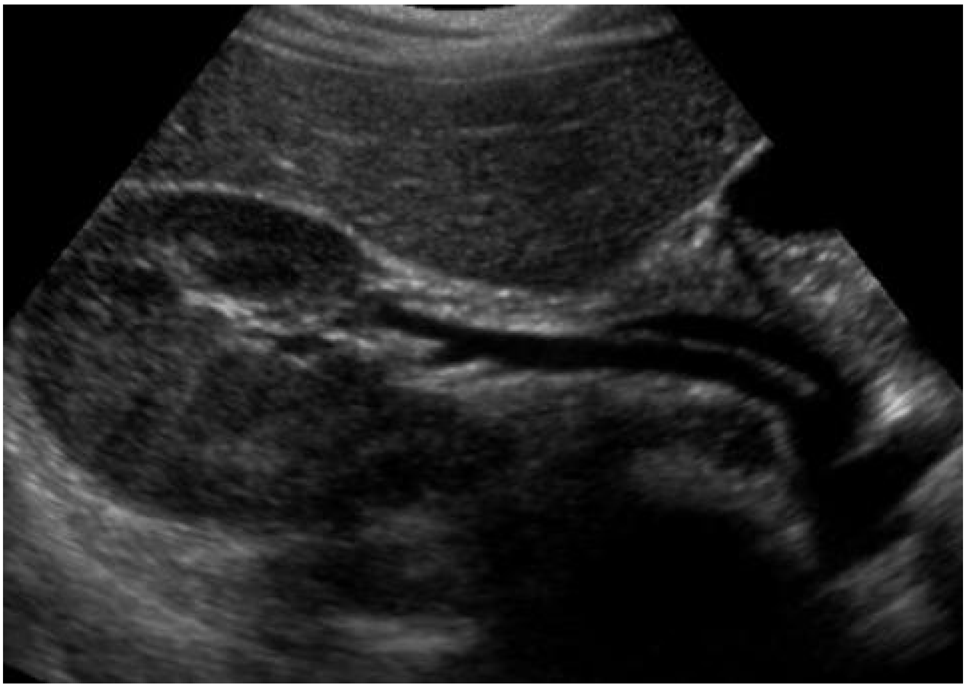

Figure 11. From a transverse image of the kidney, the length of the renal artery can be viewed from the renal hilum to its origin from the aorta.

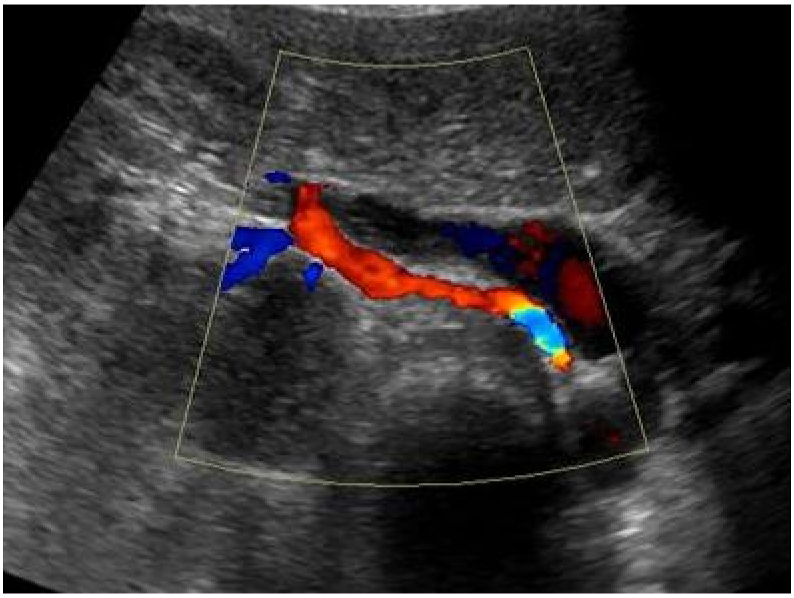

Figure 12. Longitudinal color flow image of the right renal artery and right renal vein at the level of the renal hilum. Note the renal artery coursing posterior to the IVC.

The Inferior Vena Cava

The large abdominal and pelvic veins can be visualized quite well in most patients. The inferior vena cava (IVC) is the largest of the highways that return blood flow from the extremities to the heart and is located to the right of the spine. It has a variable diameter depending on the stage of respiration during which it is visualized; it can be quite prominent and still normal. With the patient in a left lateral decubitus position, and using a near coronal view, large segments of the IVC can be seen well in most patients (Refer to FIGURE 10). It is important to keep in mind that venous filling is optimized when the patient is lying on an examination table placed in reverse Trendelenburg and that extrinsic compression of the abdominal and pelvic veins may occur secondary to masses, fluid collections, or during late stages of pregnancy.

The Iliac Veins

In the lower abdomen and pelvis, the IVC receives blood flow from the lower extremities. It is possible to visualize the larger of these veins (especially the common iliac veins) as they converge to form the IVC (FIGURE 13). Generally, a lateral decubitus position works well for visualizing the iliac veins. It is often helpful to begin scanning over the common femoral vein at the level of the inguinal crease and moving the transducer superiorly following the long axis of the vein from the common femoral through the external and common iliac veins to the inferior vena cava. You will note that the external iliac vein dives deep and then curves upward as you enter the common iliac.

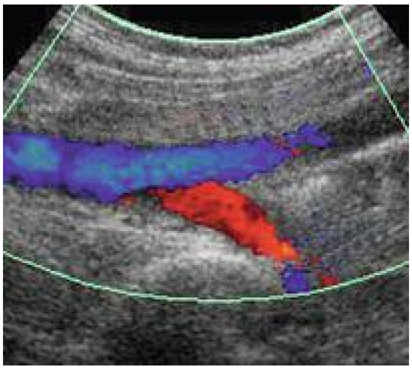

Figure 13. Longitudinal color flow image of the confluence of the right and left common iliac veins to form

the inferior vena cava.

The Renal Veins

In the upper abdomen, the renal veins provide drainage from the kidneys. The right renal vein courses directly to the IVC. The longer left renal vein, which will serve as a valuable landmark on our journey, passes between the SMA and the anterior aortic wall as it courses toward the IVC (Refer to FIGURE 6). If you don't see it at this location, look beneath the aorta. It may be retroaortic or it may even encircle the aorta (a.k.a. bifid) as a normal variant in some patients (FIGURE 14). The renal veins should be evaluated for possible thrombus, especially in suspicious clinical settings including, but not limited to, nephrotic syndrome, membranous glomerulonephritis, IVC or ovarian vein thrombus, hypercoagulable states, and renal cell carcinoma.[9] Oblique views may be useful in such evaluations, as well as the routine transverse and longitudinal views. Identification of acute renal vein thrombosis may be technically challenging because the most common findings of kidney enlargement and changes in parenchymal echogenicity are nonspecific and spectral Doppler signals may be difficult to obtain. The diagnosis is dependent on visualization of thrombus within the renal vein.

Figure 14. Transverse gray scale image of the abdominal aorta demonstrating a retroaortic left renal vein, a normal variant.

The Superior Mesenteric, Splenic and Inferior Mesenteric Veins

The superior mesenteric vein (SMV) can be seen coursing parallel to the IVC providing drainage from the small bowel, cecum, and colon. It serves as a valuable sonographic landmark for locating the head of the pancreas, a portion of which wraps around its proximal segment (FIGURE 15 A, B, C). The SMV joins the splenic vein which exits the hilum of the spleen and courses across the left abdomen. As you follow the often tortuous course of the splenic vein from the patient's left toward the right side, you will encounter a bulbous area located posterior to the head of the pancreas (FIGURE 16). This is the site of the convergence of the splenic vein, the superior mesenteric vein, and the inferior mesenteric vein (IMV). This area may be referred to as the portal confluence or the portal splenic confluence (PSC). The portal vein provides the majority of blood flow to the liver. Yes, that's correct…the portal vein doesn't drain the liver, it is responsible for supplying at least 70% - 80% of the liver's vascular needs! The inferior mesenteric vein, which is variable in size, is much more difficult to visualize than the SMV. It can occasionally be seen as it courses to the left of the SMV and empties into the splenic vein.

Figure 15. (A) Longitudinal gray scale image of the superior mesenteric vein (SMV) coursing parallel to the IVC (deeper in the image).

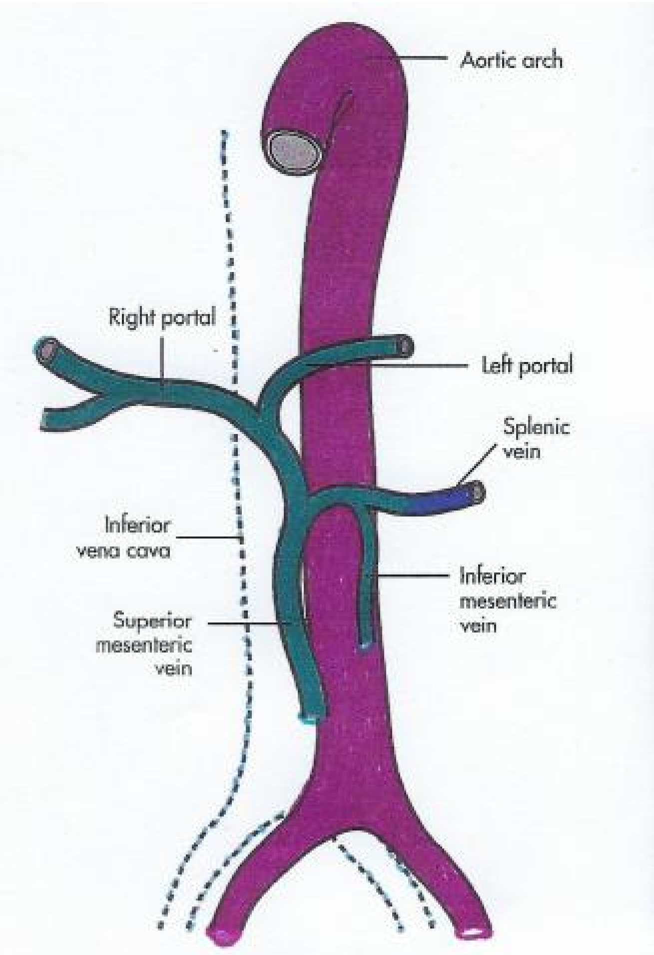

Figure 15. (B) Illustration demonstrating the confluence of the SMV and splenic vein to form the main portal vein. Modified from Gill KA, Abdominal Ultrasound.

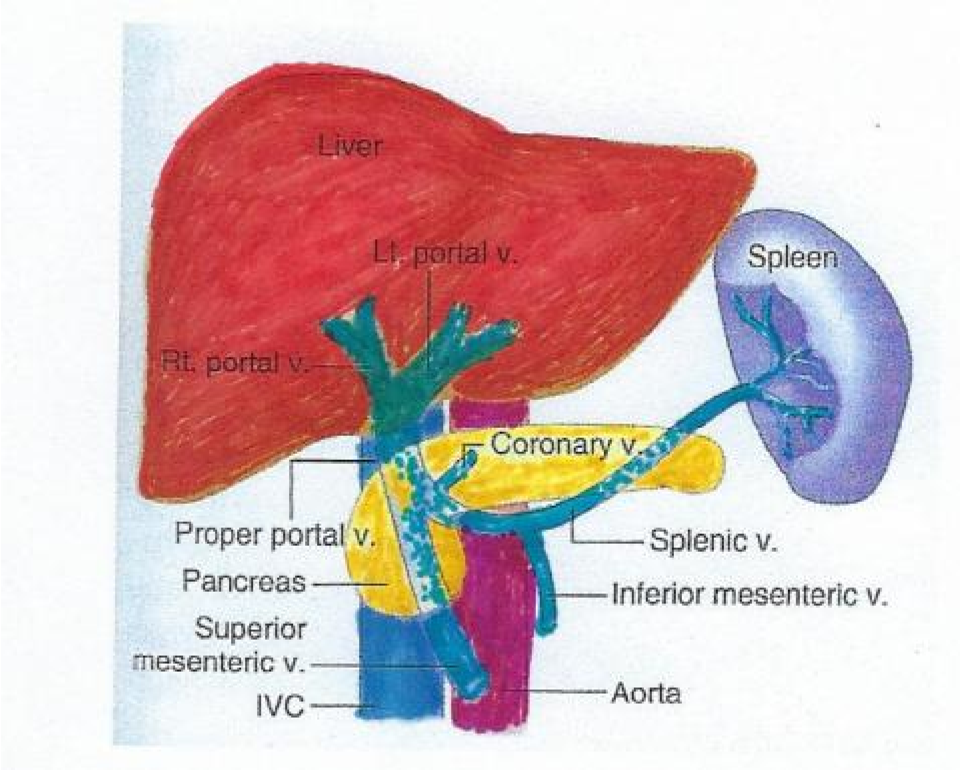

Figure 15. (C) Illustration demonstrating the anatomic relationship of the SMV, IMV, splenic vein, and the pancreas. Modified from Pellerito JS and Polak JF, Introduction to Vascular Ultrasonography.

VASCULAR ANATOMIC LANDMARKS

Central and Upper Abdomen

Knowing the location of the central and upper abdominal vessels is a vital key to understanding any abdominal sonogram. The transverse plane images are the most helpful in this regard. The superior mesenteric artery is a major landmark. As you will recall from the initial part of our journey, the SMA is located from eleven to three o'clock in relation to the transverse image of the aorta (ref to FIGURE 6). The general area of the pancreas is anterior to the SMA. The splenic vein and the SMA (coursing posterior to the splenic vein) form the dorsal boundary of the pancreas on the ultrasound image. The splenic artery is usually just cephalad to the pancreas, and occasionally, tortuous loops of the splenic artery may be seen entering in and out of the image of the pancreas. These arterial loops should not be confused with a prominent or dilated main pancreatic duct; when in doubt, confirm their identity with spectral Doppler. The splenic vein should be evaluated in every patient by following it to the right until the portal confluence (PSC) is seen. The portal vein should then be scanned throughout its length including its entry into the liver through the porta hepatis (FIGURE 17).

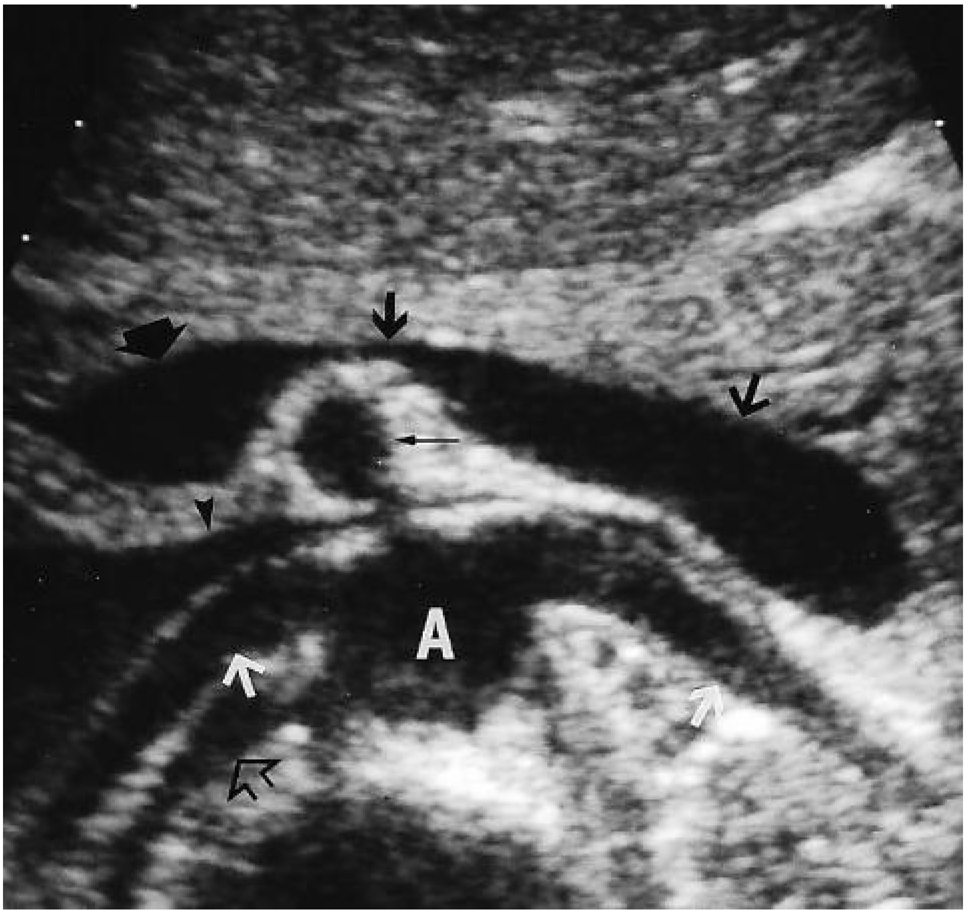

Figure 16. Longitudinal gray scale image of a prominent superior mesenteric vein. Note the bulbous area posterior to the pancreas where it joins with the splenic vein to form the portal confluence.

Figure 17. Color flow image of the portal vein and the common hepatic artery within the porta hepatis. Note the bifurcation of the main portal vein into the right and left portal veins.

Just a short distance caudal to this central abdominal region, you can see the left renal vein course under the SMA and over the anterior aortic wall. From this image, you can determine the approximate level of the renal hila. Only two major structures normally pass between the SMA and the aorta – the left renal vein and the duodenum.

These two transverse planes, a) the level of the pancreas, SMA, SMV, and splenic vein and b) the aorta, SMA, left renal vein and renal arteries should be evaluated carefully in every patient.

There are several common anatomic variations in this region which call for very careful examination of the superior mesenteric artery and the hepatic artery. The most common aberrancy is the so-called replaced right hepatic artery, which originates from the SMA and then courses posterior, instead of anterior, to the portal vein (FIGURE 18 A, B). This variant is found in up to 17% of the population [10]. Also of note, the common hepatic artery can arise from the SMA (2% to 3% of cases) or from the aorta (1% to 2% of cases) rather than the celiac trunk. A very uncommon finding (less than 1% of the population) is a shared origin of the celiac artery and the SMA from the aorta [3,4]. This common trunk is termed a celiacomesenteric artery.

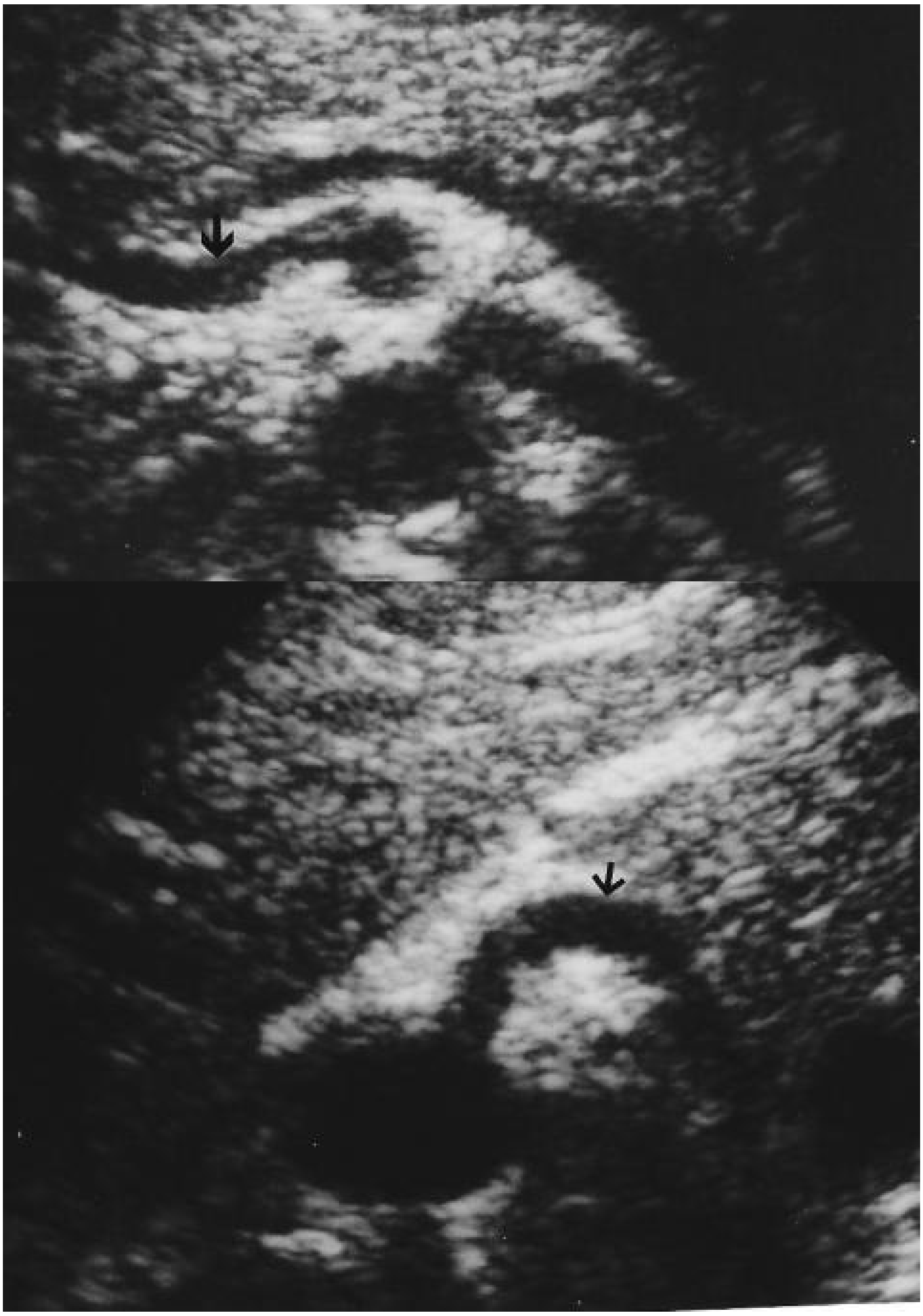

Figure 18. Transverse gray scale images demonstrating an aberrant hepatic artery. (A) The common hepatic artery originates from the SMA and courses toward the liver on the patient’s right side. (B) Slightly more cephalad, there is only a splenic artery branching from the celiac artery. No common hepatic artery is seen at this level.

The Liver Anatomy

There are many different descriptions of liver anatomy in the literature depending on the approach of the anatomist. Historically, liver anatomy was described by its gross anatomic appearance. More recent classifications utilize a functional approach, basing anatomic description on vascular supply. The

explanation which follows is a simplified approach, one which will help you identify basic liver anatomy based on its major arterial and venous circulation. Once mastered, the more complex divisions can then be pursued if desired.
There are two general, and very helpful, rules to keep in mind: 1) hepatic veins are boundary formers; that is, they describe the boundaries of the hepatic lobes and segments, and 2) portal veins are not boundary formers (with one exception); rather, they are located within the lobes and segments.

THE PORTAL VEINS

The liver has three functional lobes: the right hepatic lobe, the left hepatic lobe, and the caudate lobe. The portal vein (formed from the splenic and superior mesenteric veins) courses from its origin in an oblique upward path toward the patient's right shoulder. The main portal vein enters the liver through the porta hepatis (Refer to FIGURE 17). It is accompanied by the common bile duct, which courses anteriorly and to the right, and the common hepatic artery which takes an anterior and medial path (FIGURE 19). The three vessels travel throughout the liver bound together by an echogenic membrane, termed Glisson's capsule. Together, these three vessels are known as the portal triad. Longitudinal images of the vessels within the porta hepatis are usually definitive and should demonstrate what appears as "rungs of a ladder". If only two parallel channels are seen without the artery between them, spectral Doppler and color flow imaging are mandatory to determine which structure is portal vein, hepatic artery or bile duct. You should also notice that the triad has a "Mickey Mouse" appearance on transverse gray scale images, the two "ears" representing the lateral bile duct and more medial hepatic artery.

Figure 19. Longitudinal gray scale image of the extrahepatic portal triad. The common bile duct is anterior, and the main portal vein is posterior. The common hepatic artery is seen in the transverse image plane lying between them.

Within the liver, the main portal vein divides into two major branches, the right and left portal veins (FIGURE 20). This branching is easily seen in most patients. The right portal vein supplies (and is thus within) the right hepatic lobe; the left portal vein supplies the left lobe. Using this anatomic approach, the right and left lobes of the liver each have two basic segments. The right lobe has an anterior and a posterior segment. These are supplied by anterior and posterior segmental branches of the right portal vein. The left lobe of the liver has a lateral and a medial segment which are supplied by the lateral and medial branches of the left portal vein. The medial segment generally corresponds with what has previously been called the quadrate lobe. On transverse images of the liver, the left lobe segmental branches are almost always seen; they appear as small parallel track-like lines that lie perpendicular to the fissure between the two left lobe segments. The right lobe branches are frequently seen as they arborize from the right main portal vein. Spectral Doppler and color flow imaging can be helpful in differentiating some of these portal branches from bile ducts.

Figure 20. Longitudinal gray scale image of the main portal vein and its two major branches, the right and left portal veins. Note the thrombus within the veins.

The course of the left portal vein needs a little more explanation. Beyond its origin from the main portal vein, it begins in a transverse plane (the “pars transversa”) and then turns anteriorly in the plane of the fissure between the lateral and medial segments of the left lobe (FIGURE 21). The latter portion is called the ascending or “umbilical” portion of the left portal vein; it is that part of the portal system that received blood from the umbilical vein in the fetus. Why is this ascending portion so important? One reason is that the ascending left portal vein is an exception to the other portal vein branches since it is a boundary former – between the lateral and medial segments. Another reason is that a major collateral vein (the recanalized paraumbilical vein) found in many patients with portal hypertension exits from this vein [11]. On transverse images of the left lobe, this collateral appears as a round “target” lesion, with the hypoechoic recanalized vein being central, surrounded by an echogenic rim of fat. Other serpiginous collateral vessels can be seen in the region of the main portal vein; these can be confusing unless the normal anatomy is understood and delineated. The vascular response to hepatic disease is discussed in the article “Sonographic Evaluation of the Hepato-Portal System: Mastering the Maze”.

Figure 21. Gray scale image of the left portal vein and its ascending (umbilical) segment. The umbilical segment may serve as an important collateral in patients with portal hypertension.

The Hepatic Veins

The hepatic venous drainage consists primarily of three major hepatic veins –the right, middle, and left–which empty into the IVC (FIGURE 22). There are other smaller veins, but these three are the most important to identify on the ultrasound image. The left and middle hepatic veins often drain into the IVC through a common trunk; the right hepatic vein drains independently. Quite often all three veins can be visualized in a transverse plane by placing the transducer under the xiphoid process and angling cephalad. When only two of the three veins are imaged, sonographers refer to it as the "Playboy Bunny sign". The veins are seen high in the liver from this view, coursing cephalad to the plane of the main portal vein and its two branches. If a hepatic vein draining the posterior segment of the right lobe is seen at the same level as the major portal vein branches, this most likely represents the most common hepatic variant, the inferior right hepatic vein. This occurs in approximately 10% of patients [12]. The right hepatic vein forms the boundary between the anterior and posterior segments of the right lobe; the left hepatic vein forms the boundary between the lateral and medial segments. The middle hepatic vein divides the liver into functional right and left lobes.

It should be noted that the left hepatic vein and the ascending ("umbilical") portion of the left portal vein describe the same boundary between lateral and medial segments of the left lobe, only at slightly different levels. The left hepatic vein is more cephalad and the portal vein more caudal.

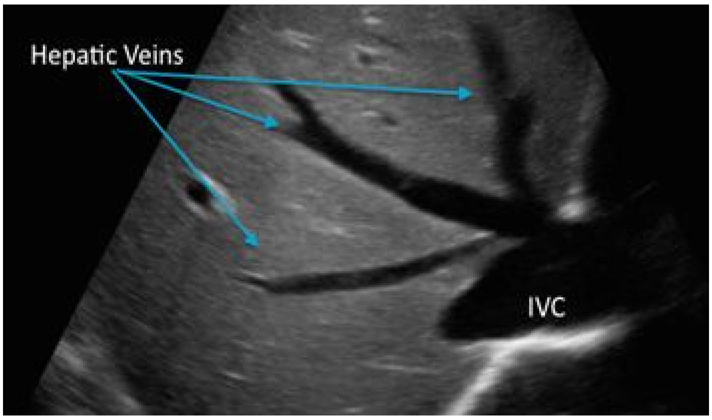

Figure 22. Longitudinal image of the three major hepatic veins – the right, middle, and left-demonstrating their confluence with the IVC.

The Caudate Circulation

In normal patients, the caudate lobe is the smallest of the three hepatic lobes. It has two processes: the papillary process (which is more anterior and medial) and the caudate process. The papillary process has been confused with lymphadenopathy in some patients. Care must be taken to trace its connection to the caudate lobe if there is any question about a papillary structure in this region. The caudate lobe receives its blood supply from both the right and left portal veins; its venous drainage is into the IVC or a hepatic vein [13]. Occasionally, these small veins in the caudate lobe can be seen sonographically. Because of this dual blood supply, the caudate lobe may be the last area involved with such hepatic disorders as cirrhosis.

Other Structures

While the gallbladder does not have an easily visualized vascular supply, it is so readily seen in many patients that you should always note whether there are gallstones (FIGURE 23), masses, wall thickening, etc. These issues can then be pursued for more detailed examination if indicated. The gallbladder lies in the plane which divides the right and left hepatic lobes; this is the same plane as the middle hepatic vein although it is more caudal. There is an incomplete fissure in this area called the interlobar or chief fissure of the liver. This fissure can be seen to extend to the right portal vein on longitudinal views, and can be a means of locating the gallbladder when it is small and contracted and difficult to see. To accomplish this task, locate the right portal vein on a longitudinal image, trace the interlobar fissure caudally and it will lead you to the gallbladder!

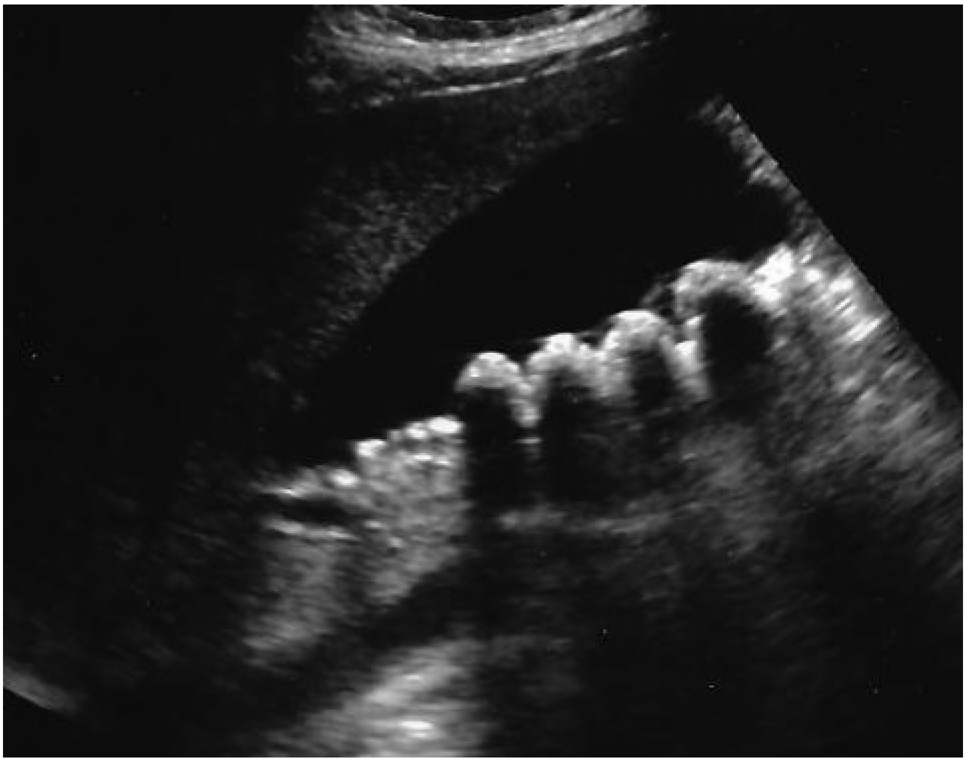
Figure 23. Multiple gallstones, which are seen as bright angular echoes within the gallbladder, casting acoustic shadows.

Next, locate the pancreas lying anterior to the SMA. The pancreas generally has a somewhat oblique position in the body, the tail being more cephalad than the head. An oblique-transverse orientation of the transducer may be necessary to visualize the splenic vein in the region of the pancreatic tail. Occasionally, a flank approach can be helpful in further delineating this vein.

In many patients, the gastroduodenal artery (GDA) can be seen along the anterior border of the head of the pancreas (Refer to FIGURE 5). The GDA serves as an important collateral in patients with mesenteric ischemia; I'll discuss this in more detail in an article on ultrasound evaluation of the mesenteric arterial system. The common bile duct is seen posteriorly. The main pancreatic duct (the duct of Wirsung) can be seen in the normal pancreas; it normally measures 2 millimeters or less. Care must be taken to not confuse it with a blood vessel –again, a good use for spectral Doppler!

Let's take a closer look at the spleen lying in the left upper quadrant of the abdomen. Because of bowel gas in the region of the splenic flexure, the best approach is usually a left posterior coronal plane. The coronal plane will usually display the splenic hilum well; this can be embellished by a 90 degrees turn of the transducer to create a transverse image originating laterally (FIGURE 24). With these two image planes, the splenic artery and vein can be demonstrated entering and exiting the splenic hilum. In the majority of patients, the kidney and its hilar vessels can be imaged quite well (FIGURE 25). The right kidney can usually be seen from either a parasagittal, oblique parasagittal, or coronal plane. A generous right hepatic lobe helps to provide a good acoustic window in many patients. It is important to keep in mind that normally the lower pole is more lateral and anterior. The entire renal contour (both upper and lower poles) should be delineated. Intercostal scanning through the liver may be required to adequately visualize the upper pole of the right kidney. The left kidney is often a bit more difficult to evaluate, requiring a coronal, or coronal oblique approach. In some patients, scanning with the posterior approach (patient in a decubitus or prone position) may be necessary.

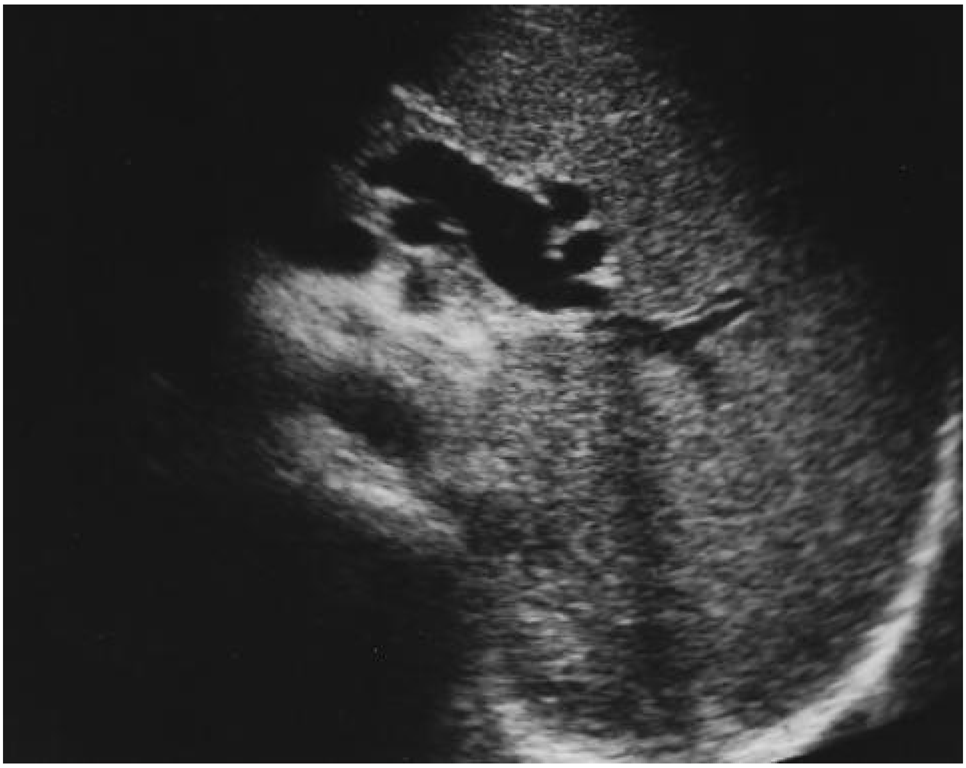

Figure 24. Transverse gray scale image of a spleen from a patient with splenomegaly. Note the marked enlargement of the organ and the splenic vein.

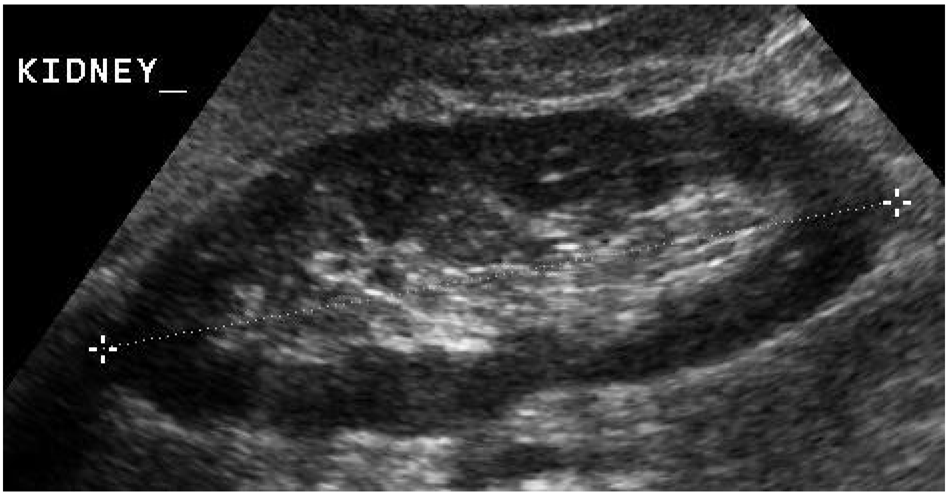

Figure 25. Longitudinal gray scale image of a normal kidney. The central echogenic sinus is primarily composed of fat, renal collecting system, small vessels and lymphatics. The cortex is less echogenic than adjacent liver.

The kidneys should be evaluated for echo texture (which is normally less than the liver), for any evidence of dilation of the collecting system, for masses, calcifications, contour defects, and the presence of any perirenal abnormality such as fluid collections or masses. When evaluating the renal arteries and veins, it is important to be aware of the renal axis and position; this may provide information regarding a horseshoe kidney, ectopic location, or presence of an adjacent extra-renal mass.

CONCLUSION

Understanding normal visceral and vascular anatomy provides one of the exciting and rewarding challenges in ultrasound examination. However, as you probably realize, this is more than of passing interest. An appropriate knowledge of abdominal structures and their major blood supply is mandatory for accurate diagnosis. The optimal sonographic examination of the abdomen requires correlation of the visual anatomic image with Doppler information. Keep in mind as you scan that such a complete sonographic evaluation provides a powerful tool for assisting patients and for helping their physicians define the best therapeutic options.

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