Basic Abdominal Sonography
Procedural Overview

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In this article, a procedural overview of basic abdominal sonography in the average patient is provided. Patient preparation (*i.e.*, fasting) for specific examinations is discussed. Transducer selection on the basis of the body habitus of the patient, as well as the examination to be performed, is reviewed. Use of patient history and communication in decisions regarding the anatomy to be evaluated is discussed. A detailed technical review of scanning techniques to image the liver, gallbladder, pancreas, spleen, and kidneys is also provided.

Key words: abdominal anatomy, gallbladder, kidneys, liver, pancreas, patient preparation, scanning techniques, spleen, transducer.

Basic gray scale sonographic evaluation of abdominal anatomy in the average patient is outlined in this article. Patient preparation relative to clinical questions, transducer selection, anatomy to be evaluated, and scanning techniques are reviewed.

Patient Preparation

Patient preparation for abdominal ultrasound is fairly standardized in all laboratories to a 6- to 8-hour minimum fast before the examination.[1] This preparation precedes any examination or combination of examinations evaluating the liver, gallbladder, bile ducts, pancreas, and abdominal aorta. Examinations evaluating only the kidneys and/or spleen do not require a fasting preparation, which serves to help minimize gastrointestinal air, prevent a change in the hepatic vasculature or biliary tree, and eliminate normal physiologic gallbladder contraction.[1,2] Any air in the path of the ultrasound beam is a limiting factor; the beam cannot penetrate the air and is thereby rendered useless in that setting.[3–5] Gallbladder contraction, engorgement of hepatic vasculature, and changes in the biliary tree due to eating can be false-positive indicators of pathologic conditions such as cholecystitis, portal hypertension, and biliary obstruction.

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Transducer Selection

Transducer selection for abdominal ultrasound should take into consideration the body habitus of the patient being evaluated, as well as the examination to be performed. An increase in the frequency of a transducer equates to an increase in resolution or increased sensitivity to smaller structures.[3–5] Any gain in resolution, however, results in a loss in depth of penetration, as the higher frequencies are absorbed or attenuated by the tissues more rapidly, resulting in a loss of signal received.[1,4,5] A decrease in the transducer frequency gives up some sensitivity but gains a greater depth of penetration.[3–5] For the average patient, a 3.5-MHz transducer of a sector or curved array design is a typical choice to start the examination. Linear transducers, by design, are better for superficial imaging, whereas sector and curved array designs are better for imaging deeper, larger structures.[3–5] A larger or more difficult patient may require a 2.5-MHz transducer, and a smaller patient may require a 5-MHz, or even a 7-MHz, transducer in pediatric cases. More than one transducer may be used. For example, a 3.5-MHz for the liver, and, if the gallbladder is more superficially located, a 5-MHz, possibly even a linear, transducer, may provide more detailed images for this area.

Anatomy to Be Evaluated

The anatomy to be evaluated depends largely on the clinical question to be answered and laboratory preferences. Specific protocols for abdominal imaging have been developed by both the American Institute of Ultrasound in Medicine and the American College of Radiology. A detailed patient history informing the investigators of previous or existing medical problems, relevant surgeries, abnormal laboratory values, and previous imaging studies is a necessity, along with patient communication. "What concerns bring you here/to your referring physician?" or the even more basic "Where/how/when does it hurt?" can bring out more specific questions or target areas rather than settling for "rule out abdominal pain" on the requisition.

Scanning Techniques

LIVER

One method of evaluating the abdomen begins with scanning the liver by placing the transducer in the midline epigastric region in a longitudinal plane. Start with the lateral segment of the left lobe and sweep to the medial segment and caudate lobe, paying close attention to any change in the normal homogeneous appearance of the liver parenchyma to evaluate for signs of pathology such as irregular borders, masses, fluid collections, or dilated bile ducts along the portal veins.[1] Landmarks to look for and document are the gastroesophageal junction, proximal abdominal aorta, celiac axis, and superior mesenteric artery posterior to the lateral segment of the left lobe (Figure 1).[1,3,6] The abdominal aorta is included in the scanning protocol; continue inferiorly in a longitudinal plane, taking anterior to posterior measurements of the aorta (outer wall to outer wall) at the proximal, mid, and distal segments down to the level of the aortic bifurcation, approximately at the level of the umbilicus, and repeat in a transverse plane, including transverse measurements of the same areas. One may need to apply transducer compression as a technique to push bowel gas out of the scan window, because the mid and distal segments are completely covered by bowel.[3] Continuing with the left lobe anatomy and landmarks, scan and document the ligamentum teres/umbilical vein remnant, which is the division between the lateral and medial segments of the left lobe, the ligamentum venosum between the posterior left lobe and the caudate lobe, the inferior vena cava posterior to the left medial and caudate lobes, and the left hepatic and portal veins.[1,3,6] To distinguish between portal and hepatic vein, note that the hepatic veins are located more superiorly and have poorly defined borders, becoming larger as they empty into the inferior vena cava, whereas portal veins branch

FIG. 1 Longitudinal image of the left lobe of the liver. Aorta posterior to the liver demonstrating the origins of the celiac axis and superior mesenteric artery.

FIG. 2 Longitudinal image through the right lobe of the liver, demonstrating homogeneous echo texture. Note the hepatic vasculature and diaphragm.

FIG. 3 Transverse image through the right lobe of the liver demonstrating the confluence of the hepatic veins and inferior vena cava.

away from the porta hepatis in the right lobe and have echogenic collagenous walls.[3] To finish the longitudinal images of the liver, change to an intercostal or right lateral approach to evaluate the right lobe, seen in Figure 2. In some patients, usually pediatric, the right lobe can be evaluated from the midline approach, but this is more the exception than the rule. Here again, a sweep from medial to lateral segments should be performed. The middle hepatic vein divides the right from the left lobe superiorly, and inferiorly the main lobar fissure is another landmark seen as an echogenic line running from the right portal vein to the gallbladder.[1,3] Continuing to the inferior margin, the main portal vein, proper hepatic artery, and common bile duct are located at the porta hepatis. Lateral to that are the common hepatic duct (common duct), right undivided, right posterior, and right anterior branches of the portal vein, and at the lateral margin is the right hepatic vein.[1,3,6] Return to the midline approach in a transverse scan plane and sweep from the diaphragm through the inferior margin of the left and caudate lobes, doing the same for the right lobe from the intercostal or right lateral approach (Figure 3). Because most of the liver is inside the rib cage, imaging can sometimes present a challenge in getting around the ribs. A left lateral decubitus position, deep inspiration, or even full expiration while distending the belly may move the liver into a more approachable position.[3]

GALLBLADDER AND PANCREAS

The gallbladder lies positioned against the inferior liver edge, posteriorly within the gallbladder fossa, which is located in the inferior portion of the main lobar fissure.[1,3,6] Longitudinal (Figure 4A) and transverse (Figure 4B) images can be obtained either from an intercostal or subcostal window to look for stones, polyps, sludge, folds, wall thickening, air, or pericholecystic fluid. Deep inspiration will often move the gallbladder out from under the costal margin. The gallbladder is frequently anterior enough to be well seen with a higher-frequency transducer, allowing for improved resolution.[4,5] Left lateral decubitus images should also be obtained, regardless of the findings on the supine images. When the gallbladder falls into a different position, this can potentially reveal findings not visible in a supine view.[3] Measurement of the common hepatic duct is standard in evaluating the biliary tree. The measurement should be obtained in a longitudinal plane, where the duct crosses over the right portal vein and hepatic artery to join with the cystic duct and exit the liver (Figure 5, A and B).[1] Normal values for the measurement of the common hepatic duct vary from laboratory to laboratory, but a good rule of thumb is 1 mm per decade of age—for example, 3 mm for a 30-year-old patient.[3] The duct can measure larger in a postcholecystectomy patient.[3] The extrahepatic portion is now called the common bile duct and can be found anterior to the main portal vein coursing toward the inferior margin of the pancreatic head, where it will form a common trunk with the pancreatic duct at the ampulla of Vater in the duodenum.[1] The pancreas lies transverse midline (Figure 6), with the head resting directly anterior to the inferior vena cava, the body directly anterior to the splenic vein/portal vein confluence. Deeper,

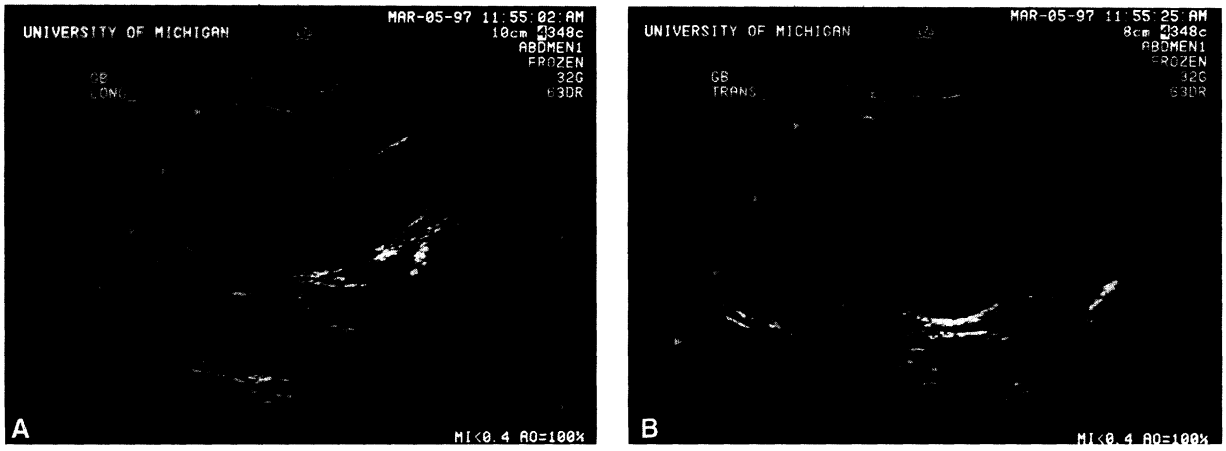

FIG. 4 **A**, Longitudinal image through the gallbladder and right portal vein. Note the main lobar fissure, seen as an echogenic line running from the portal vein to the gallbladder. **B**, Transverse scan through the gallbladder.

one sees the superior mesenteric artery and aorta in their transverse axis, finally ending with the tail between the spleen and upper pole of the left kidney.[1,3,6] The pancreatic duct, also seen running in a transverse plane from tail to head, should measure approximately 2 mm or less.[3] The gastric antrum and a portion of the duodenum lie anterior to the area encompassing the pancreas and extrahepatic bile duct, making it difficult to image in most cases. The antrum and duodenum are typically gas filled, even after fasting, creating an acoustic shadow that obscures all or most of the target anatomy.[3–5] Changing the patient's position, deep inspiration, or ingestion of water can sometimes be helpful in this situation.[3]

SPLEEN

The spleen is in the left upper quadrant under the left hemidiaphragm, bordered medially by the left lobe of the liver and the stomach, and inferiorly by the pancreatic tail and left kidney.[1,3] Place the patient in a right lateral decubitus position and scan in a transverse oblique plane between the ribs, evaluating splenic size and texture.

KIDNEYS

The kidneys lie posteriorly on the lower portion of the quadratus lumborum muscle, roughly between the 12th thoracic and 3rd lumbar vertebral bodies, usually with the left kidney 1–2 cm higher than the right.[1,3,6] They are bordered medially by the psoas muscle and laterally by the transverse abdominus muscle.[1,3,6] To evaluate renal length and parenchymal integrity and to check for masses, calculi, and calyceal, pelvic, or ureteral dilatation in the right kidney, scan from an anterolateral or coronal position with the patient supine (Figure 7). Use the liver as a window as much as possible. If

FIG. 5 **A**, Longitudinal image demonstrating the common hepatic duct anterior to the right portal vein. **B**, The same scan plane, demonstrating the appropriate measurement of the common hepatic duct.

FIG. 6 Transverse scan plane demonstrating the pancreas in its longitudinal axis. Directly posterior to the pancreatic head is the inferior vena cava, and posterior to the body lie the splenic vein, superior mesenteric artery, and the aorta, respectively.

bowel gas obscures the lower pole, roll the patient into a left lateral decubitus position or have the patient take a deep breath.[3] Typically, the same scan window and technique can be used for the transverse images (Figure 8). The left kidney is often more difficult to image because the spleen does not afford an adequate acoustic window, and bowel occupies most of the left upper quadrant.[1,3,6] Scanning coronally or more posteriorly, rolling the

FIG. 7 Longitudinal image of the right lobe of the liver and the right kidney. This would be an ideal image for obtaining a renal length measurement, as well as demonstrating the cortical and collecting system integrity.

FIG. 8 Transverse image through the right renal hilum, also visualizing a portion of the inferior right lobe of the liver and the gallbladder anterior to the inferior vena cava.

patient into a right lateral decubitus position, and deep, suspended inspiration are often the only techniques available to get around the bowel gas.[3] Depending on the protocol set up by the laboratory, one may also need to include longitudinal and transverse images of the urinary bladder to complete the renal study. The adrenal glands are not seen in the average adult patient, but knowing their approximate location is important, because it may be necessary when differentiating upper pole renal from adrenal pathology.[3] The right adrenal gland lies between the upper pole of the right kidney, the posterior surface of the liver, and the inferior vena cava.[1,3,6] The left adrenal gland rests on the upper pole of the left kidney, bordered anteromedially by the spleen.[1,3,6]

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