Ultrasound of the Right Lateral Intercostal Space

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Ultrasound is a widely used, safe, noninvasive diagnostic tool in veterinary medicine. Over time, ultrasound equipment has become more sophisticated, yet more affordable, for many practitioners. However, the quality of an ultrasonographic examination depends on the skill and experience of the individual performing the study. Many sonographers perform an entire abdominal examination from a ventral approach, confining the scan to a subcostal window. Although a subcostal approach may be adequate for some dogs, it may be inadequate for evaluation of the structures of the right cranial abdomen in others. These structures include the right side of the liver, porta hepatitis (caudal vena cava, portal vein, and common bile duct), right limb and body of the pancreas, duodenum, right kidney, right adrenal gland, and hepatic lymph nodes. These structures are especially difficult to evaluate via a ventral approach in dogs that are large, deep-chested, have microhepatica, have a large amount of gastrointestinal gas, or have a large volume of peritoneal effusion. For the instances described here, a right lateral intercostal approach is indicated. The technique of the right lateral intercostal approach, normal ultrasonographic anatomy, and clinical indications of this approach are described.

TECHNIQUE AND NORMAL ANATOMY

Very little patient preparation is required for the right lateral intercostal approach. This technique may be easily performed during a standard examination. As with any abdominal ultrasound study, the hair should be adequately clipped. The hair should be clipped dorsally to the level of the epaxial muscles, caudally to the pelvis, and

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cranially to the region of the diaphragm, which corresponds to approximately the eighth or ninth intercostal space (Fig. 1A, B). The animal may be positioned in dorsal or left lateral recumbency. A transducer with a small footprint, or contact surface, should be used to avoid shadowing artifacts from the ribs (see Fig. 1B). To find the appropriate window, the transducer should first be placed parallel to the ribs from the ninth through twelfth intercostal spaces to achieve an image in the transverse plane. If reverberation artifact is seen due to aerated lung, the transducer should be angled caudally or moved one intercostal space caudally. Long axis images in the dorsal plane can be acquired by turning the transducer 90°, with the left side of the image representing the cranial direction.

Examination of the liver in dogs is more difficult than in people because of its more cranial and upright position under the rib cage. Gastrointestinal gas creates difficulty when scanning from a ventral approach. In most cats and small dogs, the liver can be scanned from behind the ribs. In large and/or deep-chested dogs, this window may be inadequate for examination of the liver. In these cases, the transducer should be placed in the last three to four intercostal spaces for complete evaluation. However, if the liver is decreased in size, the sonographer may still encounter aerated lung when using this approach.

The right lateral intercostal scan plane is indicated for examination of the porta hepatis. Structures evaluated at the region of the porta hepatis include the aorta, caudal vena cava, portal vein, and common bile duct. There is a narrow acoustic window for examination of these structures through the liver, between the aerated lung and gastrointestinal gas in the right cranial abdomen. To find the porta hepatis, the transducer is placed in a transverse position (dorsal is to the left of the image) at the tenth through twelfth intercostal spaces, approximately 5 to 10 cm ventral to the spine. The appropriate window is seen when there is no artifact from air in the lung or gas in the gastrointestinal tract, and the aorta, caudal vena cava, and portal vein are seen. If aerated lung is encountered, the transducer is angled caudally or moved caudally one intercostal space. If the right kidney is seen, the transducer is angled cranially or moved cranially one intercostal space. If gas from the gastrointestinal tract is seen, the transducer is moved dorsally and angled ventromedially. The vessels of the porta hepatis are easily distinguished because of their anatomy and spectral Doppler characteristics.

Fig. 1. (A) A dog that has been inadequately clipped for a right intercostal approach. Notice the clipped area is confined caudal to the rib cage. (B) This dog is adequately prepared for a right intercostal approach. The clipped area extends cranially beyond the costal arch. Note the small size of the transducer’s footprint.
The aorta is the most dorsal structure in the region of the porta hepatis and is found on the midline. This vessel demonstrates pulsatility and seems to pass over the diaphragm. The diaphragmatic line is seen ventral to the aorta, because the aorta does not go through it but passes dorsal to it (Figs. 2A–C and 3). The caudal vena cava is ventral and slightly to the right of the aorta. The caudal vena cava is surrounded by the caudate and right lateral liver lobes as it passes through the liver (see Fig. 2A–C). Deep abdominal compression may allow narrowing of this vessel. This is not possible with the aorta. The caudal vena cava demonstrates mild to moderate pulsatility with increased flow during diastole.

The portal vein is ventral and slightly to the left of the caudal vena cava. The cross-sectional areas of the three vessels is roughly equal (see Figs. 2A–C and 3). The walls of the portal vein are echogenic due to the presence of fat and fibrous tissue. Portal vein blood flow is uniform and nonpulsatile. On pulsed-wave Doppler, the portal vein demonstrates a wide range of velocities across the lumen (spectral broadening). The mean velocity of portal blood flow is 15 cm/s (12–17 cm/s), with minimal fluctuation over time. In normal dogs, the cross-sectional area of the portal vein is slightly greater on expiration than on inspiration. Factors that influence normal portal flow include eating (increase), exercise (decrease), and upright posture (decrease).

The common bile duct is ventral and slightly to the right of the portal vein (Fig. 4). The common bile duct leaves the liver and enters the duodenum at the major duodenal papilla. The normal common bile duct in dogs measures approximately 1 to 3 mm on ultrasound. The cystic duct, hepatic ducts, and peripheral intrahepatic bile ducts are not seen in normal animals. It is difficult to demarcate the end of the cystic duct and the beginning of the common bile duct. However, this demarcation is not necessary in normal dogs.

The hepatic veins are also easily evaluated from the right intercostal approach. Two hepatic veins enter the caudal vena cava from the right, and one enters from the left. Unlike the portal veins, the walls of the hepatic veins are not echogenic. In a study of 16 normal dogs of various conformations, the best positions for locating and evaluating the caudate and right lateral hepatic veins were from the right ninth through eleventh intercostal spaces half way along the ribs and cranial to the right kidney, with the dogs in left lateral recumbency. The quadrate and right medial hepatic veins were also evaluated from the right. In some dogs in the study, all of the hepatic veins could be seen with the transducer at the costochondral junction at the right seventh or eighth intercostal spaces and angled dorsocranially.

Evaluation of the hepatic veins with two-dimensional imaging and spectral Doppler may be useful in the examination of dogs with heart disease, liver disease, or fluid overload. Doppler interrogation of the hepatic veins may be performed from the right ninth through eleventh intercostal spaces (Fig. 5A, B). The right medial and quadrate hepatic veins are easily identified due to their relationship with the gall bladder. Doppler interrogation is most accurate with the vessels imaged in long axis, as close to parallel with the Doppler signal as possible. The movement of blood across the hepatic veins depends on the pressure gradient between the venous pressure in the abdomen and the pressure in the right atrium. On pulsed-wave Doppler, the hepatic veins demonstrate a periodic signal, corresponding to right atrial pressure (Fig. 6). The pressure changes in the thorax and abdomen that occur with respiration influence the Doppler waveform. There is increased velocity in the forward direction with inspiration. Doppler interrogation of the hepatic veins may be useful in the evaluation of cardiac disease, hepatic disease, and in dogs with volume overload.
The common hepatic artery is a small structure that is often not seen in normal dogs. It may sometimes be located using a right lateral intercostal approach. The common hepatic artery is a major branch of the celiac artery. It may be found by using a right intercostal approach to locate the first large branch of the celiac artery that courses
to the porta hepatis (Fig. 7). The celiac artery is easily identified because of its close association with the cranial mesenteric artery. The common hepatic artery was interrogated with pulsed-wave Doppler in 10 normal adult beagles, 20 normal puppies, and 7 dogs with hepatic disease. In the normal adult beagles, mean peak systolic velocity was 1.5 m/s (1.1–2.3 m/s), with a resistive index of 0.68 (0.62–0.74). In the normal puppies, the mean peak systolic velocity was lower at 1.0 m/s (0.8–1.3 m/s) with a lower resistive index of 0.59 (0.46–0.65). There were no differences in values obtained after fasting and postprandially. Two dogs with congenital arteriportal fistulae demonstrated higher peak systolic velocity and lower mean resistive index than normal puppies. There were no differences in the normal adult beagles and the five adult dogs with acquired hepatopancreatic disease. Intrahepatic arteries are not seen in normal animals.

In the past, the normal pancreas was difficult, if not impossible, to evaluate with ultrasound. With improvements in equipment, the normal pancreas is not the elusive structure it once was. However, proper technique is required to image this organ. Complete evaluation is often impossible from a subcostal approach. The right limb and body may be examined with a right lateral intercostal approach. This approach is especially helpful in deep-chested dogs and dogs with pain in the right cranial abdomen. The pancreas consists of a left lobe, body, and right lobe. If seen, the left lobe is typically imaged from a subcostal approach, whereas the body and right limb often require a right intercostal approach (Fig. 8A–E). Several structures serve as landmarks for the pancreas. The pancreatic body unites the right and left lobes and can be found caudal to the pylorus, ventral to the portal vein, and craniomedial to the right kidney and caudate process of the liver. The right lobe lies in the mesoduodenum, dorsal or dorsomedial to the descending duodenum, ventral to the right kidney, and ventrolateral to the portal vein. To make sure that the entire right lobe has been imaged, the descending duodenum should be followed caudally to its caudal flexure. The normal pancreas is isoechoic or slightly hyperechoic to the liver.

The only visible veins in the pancreas are those that drain the right lobe. The cranial and caudal parts of the pancreaticoduodenal vein lie in the right lobe and run parallel to the descending duodenum. The descending duodenum is identified by its straight course and prominent walls. The cranial pancreaticoduodenal vein becomes the gastroduodenal vein, which drains into the portal vein near the porta hepatis. The caudal pancreaticoduodenal vein meets with the cranial mesenteric vein. The right kidney is often more difficult than the left to evaluate from a ventral or subcostal approach because of its dorsocranial position in the renal fossa of the caudate lobe of the liver and because it is dorsal to the duodenum and proximal portion of the
colon. This is especially true in deep-chested dogs. In these animals, the right kidney should be examined with the transducer placed at the right tenth through twelfth intercostal spaces. With the right lateral intercostal approach, the right kidney may be located by moving caudally from the porta hepatis.1

The echogenicity of the kidneys relative to the other abdominal organs is evaluated in every thorough abdominal ultrasound examination. Because of its position in the right cranial abdomen, the echogenicity of the right kidney is easily compared to that of the caudate lobe of the liver.1,19 In normal dogs, the renal cortex is hypoechoic or isoechoic to the liver. The renal cortex is sharply marginated against and is more echogenic than the medulla because of the presence of glomeruli, tubules, and other structures.1,18,20 The renal diverticula and interlobar vessels are seen as hyperechoic,

Fig. 3. Transverse image of the cranial abdomen of a dog obtained with computed tomography (CT). Vascular structures are enhanced due to the administration of intravenous iodinated contrast. Note the aorta (Ao) dorsal to the diaphragm. The caudal vena cava (CVC) is ventral and to the right of the aorta. The portal vein (PV) is ventral to the caudal vena cava. RK, right kidney; D, dorsal; R, right; V, ventral; L, left.

Fig. 4. Transverse ultrasonographic image of the porta hepatis of a dog with severe hepatic disease and biliary obstruction. The common bile duct (CBD) is prominent and lies ventral to the portal vein (PV). D, dorsal; R, right; V, ventral; L, left; CVC, caudal vena cava.
linear structures in the medulla. Assuming that the surrounding organs are normal, changes in renal echogenicity may indicate renal disease.

Although small, examination of the adrenal glands is essential for a complete abdominal ultrasound exam. The right adrenal gland is typically more difficult to evaluate than the left, because it is in a more cranial position, creating the need for intercostal imaging in many dogs. This gland is also difficult to evaluate due to the presence of gas in
the pylorus and duodenum, which tends to be more of a problem on the right than on the left. The intercostal approach to the right adrenal gland is especially helpful in large dogs. The celiac and cranial mesenteric arteries, cranial pole of the right kidney, and the caudal vena cava serve as landmarks for locating the right adrenal gland. The cranial pole of the right kidney is located at the eleventh or twelfth intercostal space and the transducer angled medially. If the caudal vena cava is encountered, the transducer is then angled slightly laterally. The right adrenal gland is located at the level of or just cranial to the celiac and cranial mesenteric arteries, between the cranial pole of the right kidney and caudal vena cava (Fig. 9A–C). In long axis from this window, the right adrenal gland is oval or comma shaped.

Fig. 6. Duplex-Doppler interrogation of a hepatic vein (HV). Note the normal periodic signal generated within the hepatic vein. The irregular signal above the baseline is an artifact caused by respiratory motion. CVC, caudal vena cava; PV, portal vein.

Fig. 7. Right intercostal transverse image at the porta hepatis in a dog. The small hepatic artery (HA) is seen to the left of the caudal vena cava (CVC). D, dorsal; R, right; V, ventral; L, left; PV, portal vein.
Although typically not seen in a normal dog, multiple lymph nodes may be examined via a right intercostal approach. Normal lymph nodes are usually isoechogenic to surrounding tissues. Blood vessels or other organs are used as landmarks for locating lymph nodes on ultrasound. The hepatic lymph nodes lie on both sides of the portal vein, approximately 1 to 2 cm caudal to the porta hepatis (Fig. 10). The right nodes vary in number from one to five, are adjacent to the body of the pancreas, and are smaller than those on the left. The left is larger at 1 to 6 cm in length and is found in the lesser omentum dorsal to the common bile duct. The hepatic lymph nodes drain the stomach, duodenum, pancreas, and liver. The gastric lymph nodes are inconsistently found in the lesser omentum near the pylorus and right gastric artery and drain the stomach, esophagus, diaphragm, liver, mediastinum, and peritoneum. The pancreaticoduodenal lymph nodes are also inconsistent and may be found in the mesoduodenum and greater omentum. They drain the duodenum, pylorus, and right limb of the pancreas. The lymph nodes described here are part of the celiac lymphocenter of the visceral abdominal lymph nodes.

**CLINICAL INDICATIONS**

The right lateral intercostal ultrasound scan plane is indicated in some dogs for evaluation of diseases involving the right lateral, right medial, and caudate lobes of the liver, especially in large and deep-chested dogs and in cases of microhepatica or large volumes of peritoneal effusion. In large or deep-chested dogs, mass or nodular lesions of the right aspect of the liver may be missed if only a subcostal approach is used (Fig. 11). If mass lesions are detected in other abdominal organs, it is important to thoroughly examine the liver. The liver is commonly the first organ where metastasis is seen, because many abdominal organs are drained by the portal vein.

When the liver is small, there may be a very small window of visible hepatic tissue between the aerated lung and gas in the stomach. Conditions that may cause microhepatica include cirrhosis, congenital portosystemic shunts, or other chronic diseases of the liver.

The “classic” combination of ultrasonographic findings in hepatic cirrhosis includes a small, irregularly margined, hyperechoic liver with nodules and peritoneal effusion. However, in a study of 55 dogs and two cats with a histopathologic diagnosis of hepatic cirrhosis, this classic appearance was seen only in 5% of the cases. Four dogs (7%) had a normal study. The most common finding in this study was peritoneal effusion in 62%, followed by irregular liver margination in 53%, and hepatic nodules in 51%. More livers were normal in size (55%) and echogenicity (51%) than were small (34%) and hyperechoic (38%). The “classic” form of cirrhosis may be detected only late in the disease process. However, the right lateral intercostal view is still indicated due to the presence of effusion.

Cirrhosis is the most common cause of portal hypertension in dogs. In a study of 10 normal dogs and 10 dogs with surgically induced hepatic cirrhosis, the portal vein was interrogated with pulsed-wave Doppler. The transducer was placed at the right eleventh or twelfth intercostal space for these examinations. Mean portal flow and mean portal flow velocity were decreased in dogs with cirrhosis. The portal vein diameter was unchanged.

Congenital portosystemic shunts are abnormal vascular connections between the portal venous system and the systemic venous system. Most congenital, single extrahepatic portosystemic shunts connect a major tributary of the portal vein and the caudal vena cava, cranial to the phrenicoabdominal veins. In dogs, the shunt vessel usually arises from the main portal vein, splenic vein, or left gastric vein.
Fig. 8. (A) Transverse image of the right lobe of the pancreas (open arrow) obtained via a right lateral intercostal approach in a dog. The duodenum (solid white arrow) is ventral to the pancreas. D, dorsal; R, right; V, ventral; L, left. (B) Long axis right intercostal view of the right lobe of the pancreas in a dog with lymphoma. The pancreas is ventrolateral to the portal vein (PV). An enlarged hepatic lymph node (LN) is present medial to the pancreas. Cr, cranial; R, right; Cd, caudal; L, left. (C) Cross section of a canine cadaver at the level of T13-L1. Note the relative locations of the duodenum and right lobe of the pancreas. (Adapted from Feeney DA, Fletcher TF, Hardy RM. Atlas of correlative imaging anatomy of the normal dog: ultrasound and computed tomography. Philadelphia: WB Saunders; 1991. p. 248; with permission.) (D) Cross section of a canine cadaver at the level of the third lumbar vertebra. Note the location of the right lobe of the pancreas and its association with the descending duodenum and right kidney. (Adapted from Feeney DA, Fletcher TF, Hardy RM. Atlas of correlative imaging anatomy of the normal dog: ultrasound and computed tomography. Philadelphia: WB Saunders; 1991. p. 254; with permission.) (E) Same image as that in Fig. 9D, magnified to demonstrate the positions of the right lobe of the pancreas (arrow), descending duodenum (D), and right kidney (RK). (Adapted from Feeney DA, Fletcher TF, Hardy RM. Atlas of correlative imaging anatomy of the normal dog: ultrasound and computed tomography. Philadelphia: WB Saunders; 1991. p. 254; with permission.)
anomalous vessels may present a diagnostic challenge. The right lateral intercostal approach is indicated in any suspected congenital portosystemic shunt.\textsuperscript{9,28} In a study of 82 dogs with clinical and/or clinicopathologic signs consistent with portosystemic shunt, the condition was confirmed in 38 via mesenteric portography. Ultrasound was 95% sensitive, 98% specific, and 94% accurate for congenital portosystemic shunts.\textsuperscript{9}

Two-dimensional ultrasonographic findings with portosystemic shunts may include microhepatica, decreased visibility of the intrahepatic portal veins, and an abnormal blood vessel draining into the caudal vena cava (Fig. 12).\textsuperscript{9} It is recommended to
look for the shunt vessel where it enters the caudal vena cava rather than looking for all of the tributaries of the portal vein (Fig. 13).\textsuperscript{16}

Portoazygos shunts, in which the shunt vessel communicates with the azygos vein rather than the caudal vena cava, are a less common type of congenital, single, extra-hepatic portosystemic shunt. Using the right lateral intercostal window, the shunt
vessel is seen coursing cranial to the diaphragm. It runs parallel to and near the caudal vena cava but does not enter it.\textsuperscript{16} The azygos vein is parallel and to the right of the aorta and is rarely seen in normal dogs.\textsuperscript{12}

The right lateral intercostal approach is also useful in the evaluation of congenital intrahepatic portosystemic shunts. These anomalous vessels are classified by the division of the liver they affect. Left-divisional intrahepatic shunts are consistent with patent ductus venosus and have a consistent morphology. With this type of shunt, the abnormal vessel courses through the left division and connects the portal vein and caudal vena cava via the left hepatic vein. From a right lateral intercostal approach in a retrospective study of 13 dogs and four cats with a left-divisional shunt, an intrahepatic portal vessel was found to bend to the left and away from the transducer. In the same study, 13 dogs had a central-divisional shunt, which was easy to see from

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**Fig. 10.** Right lateral transverse ultrasound image at the porta hepatis in a dog with lymphoma. An enlarged, hypoechoic hepatic lymph node (arrow) is seen to the left of the portal vein (PV). D, dorsal; L, left; R, right; V, ventral.

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**Fig. 11.** Transverse intercostal image of the porta hepatis in a dog with an indistinctly marginated, hyperechoic nodule (dashed outline) in the right aspect of the liver. The nodule was not visible from a subcostal approach. CVC, caudal vena cava; D, dorsal; L, left; PV, portal vein; R, right; V, ventral.
the right lateral intercostal view. In those dogs, there was marked aneurysmal dilation of the portal vein. Right-divisional shunts were seen in two dogs and one cat and demonstrated a large, tortuous vessel that coursed far to the right of the midline. Right-divisional and central-divisional shunts had variable morphology, making them difficult to classify on ultrasound.28

Several large breeds are predisposed to intrahepatic shunts. Irish wolfhounds are predisposed to left-divisional intrahepatic shunts (patent ductus venosus), whereas

![Fig. 12. Right intercostal view of the porta hepatis in a puppy with a single, extrahepatic, portocaval shunt. The shunt vessel is tortuous and is seen entering the caudal vena cava (CVC). D, dorsal; DUOD, duodenum; HA, hepatic artery; L, left; R, right; V, ventral.](image1)

![Fig. 13. Dorsal plane intercostal image of the liver of a puppy with a portoazygos shunt (solid arrow). The abnormal vessel does not enter the caudal vena cava (CVC) but courses cranial to the diaphragm (open arrow) and is seen adjacent to the aorta (Ao). D, dorsal; HA, hepatic artery; L, left; R, right; V, ventral.](image2)
Old English sheepdogs are predisposed to central-divisional shunts. Australian cattle dogs are predisposed to right-sided and central-divisional shunts. Retrievers are predisposed to multiple types of intrahepatic shunt morphologies.\textsuperscript{28} Intrahepatic shunts are typically large and easy to find (Fig. 14). However, it is important to evaluate their morphology as thoroughly as possible. The type of intrahepatic shunt is an important determinant of whether or not surgical correction is feasible.\textsuperscript{28} A left-divisional intrahepatic shunt is consistent with a patent ductus venosus and can be treated by attenuating the left hepatic vein or the shunt vessel where it enters the left hepatic vein. Right-divisional and central-divisional shunts are more difficult to approach surgically.\textsuperscript{28}

The use of color and spectral Doppler may increase the sensitivity of ultrasound for the detection of portosystemic shunts.\textsuperscript{9,16} Color Doppler may demonstrate turbulent blood flow at the site of entrance of the shunt vessel and may confirm the presence of the abnormal vessel.\textsuperscript{9} The normal portal vein has intestinal capillaries at one end and hepatic sinusoids at the other, keeping it unexposed to the pressure variability seen in the arteries and systemic veins.\textsuperscript{16} The normal caudal vena cava demonstrates variable pressure and flow because of changing right atrial and pleural pressures throughout the cardiac and respiratory cycles.\textsuperscript{9} In dogs with congenital portosystemic shunts, the portal vein is exposed to the same pressure changes as the caudal vena cava, so portal flow may be more variable. Its diameter may change with the cardiac and respiratory cycles like the caudal vena cava. Because these shunts have low resistance to flow, portal flow velocity may also be increased.\textsuperscript{9,16} In a prospective study of 38 dogs with confirmed congenital portosystemic shunt, 70\% had increased and/or variable portal flow velocity.\textsuperscript{9}

In the authors’ experience, the common hepatic artery is enlarged and easily seen in some dogs with portosystemic shunts (see Figs. 12 and 13). The liver is a highly perfused organ, receiving 25\% of cardiac output. Approximately one-third of its blood supply comes from the hepatic artery. Approximately two-thirds comes from the portal vein. Flow from the hepatic artery and portal vein adjust to keep total hepatic flow constant. If one source of flow is decreased, the other increases and vice versa.\textsuperscript{14} Increased flow from the hepatic artery may protect the liver in dogs with portosystemic shunts.\textsuperscript{14,27}

![Fig. 14. Right intercostal view of a puppy with an intrahepatic portosystemic shunt. A large tortuous shunt vessel is seen coming from the portal vein (PV). Its termination at the caudal vena cava (CVC) is not visible in this image. Cd, caudal; Cr, cranial; L, left; R, right.](image-url)
Congenital hepatic arterioportal fistulas may cause portosystemic shunting. This condition may be difficult to diagnose, because it demonstrates features of both congenital and acquired portosystemic shunts on ultrasound. These conditions may all form a complex pattern of dilated vessels in the liver. However, arterioportal fistulas demonstrate reversed, pulsatile portal flow and signs of portal hypertension, such as peritoneal effusion and hepatofugal blood flow.

Portal vein thrombosis is an uncommon complication of portosystemic shunt ligation in dogs. However, ante mortem diagnosis of spontaneously occurring portal vein thrombosis is rare. Conditions appropriate for the development of thromboemboli include a hypercoagulable state, vascular stasis, and vascular endothelial damage. Reported causes of spontaneous portal vein thrombosis in dogs include ehrlichiosis, pancreatitis, autoimmune disease, renal amyloidosis, sepsis, peritonitis, and retrograde growth of hepatic tumors. In many cases, the cause is never determined. Neoplasia can cause portal vein thrombosis by direct invasion into the vessel lumen (tumor thrombus) or by distorting the vessel wall and causing a blood clot.

Portal vein thromboses are best seen using a right lateral intercostal view. Ultrasoundographic findings associated with portal vein thrombosis include echogenic material in the venous lumen, peritoneal effusion due to portal hypertension, and dilation of the portal vein. If the thrombus is causing complete vessel obstruction, no flow around it will be seen on color Doppler. If the thrombus is not obstructive, there may still be flow around it on color Doppler.

A right intercostal window is often useful for evaluation of disease of the biliary tract, as it is commonly difficult to evaluate from a ventral approach. Extrahepatic biliary obstruction may be caused by neoplasia of the liver, gall bladder, bile ducts, pancreas, gastrointestinal tract, and lymph nodes; cholelithiasis; abscesses; granuloma; or fibrosis due to trauma or inflammation. Ultrasound is a useful tool for the detection of extrahepatic biliary obstruction. With obstruction of the common bile duct, the common bile duct becomes enlarged by 24 to 48 hours. The gall bladder reaches its maximum size by 48 hours. Intrahepatic bile duct distention is seen by 5 to 7 days. Compared with hepatic veins and intrahepatic portal veins, the intrahepatic bile ducts are more tortuous with irregular borders and do not demonstrate flow on color Doppler. It is not possible to determine the duration of obstruction based on

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**Fig. 15.** (A) Long-axis ultrasonographic image obtained via a right intercostal approach in a dog with an adrenal tumor and tumor thrombus (arrow) in the portal vein. Note the irregularly shaped, echogenic material in the vessel lumen. Cd, caudal; Cr, cranial; L, left; R, right. (B) Right intercostal image of the liver of a dog with a thrombus in the portal vein (PV). The normally anechoic lumen of the portal vein is nearly completely obscured by the echogenic thrombus. CVC, caudal vena cava; D, dorsal; L, left; R, right; V, ventral.
the size of the ducts. The biliary system may remain dilated even after the obstruction has been relieved.

Pancreatic disease, especially pancreatitis, is a common disease in small animals. Ultrasound is an important diagnostic tool for detection of pancreatitis, determining the severity of the disease, identifying involvement of the duodenum, and discovering the presence of other disease complications. Ultrasound is sensitive, safe, noninvasive, and allows the sonographer to differentiate diffuse pancreatic enlargement versus discrete mass lesions. In many animals with pancreatitis, it may be difficult to image the entire organ from a subcostal approach. Reasons for incomplete subcostal evaluation include interference due to gas in the gastrointestinal tract and pain associated with the disease. An intercostal approach may also be less painful, as the sonographer cannot apply much pressure to the region. This approach allows the examiner to avoid bowel gas.

Consistent landmarks for the right pancreatic lobe in dogs with pancreatitis include the right kidney and descending duodenum. The vascular landmarks used in normal dogs may not be visible in cases of pancreatitis because of surrounding inflammation and bowel gas. With pancreatitis, the pancreas becomes hypoechoic, and the surrounding mesentery becomes hyperechoic (Fig. 17A, B). In some dogs, there may be ill-defined masses that correspond to areas of pancreatic swelling, inflammation, and hemorrhage. There may be free abdominal fluid. The duodenum may be dilated, fluid-filled, atonic, and demonstrate wall thickening. The descending duodenum may also be displaced ventrally and/or laterally. In some dogs with pancreatitis, the right lobe of the pancreas may shift lateral to the duodenum rather than maintaining its normal position medial to the duodenum. Pancreatitis may lead to biliary obstruction and fibrosis with resulting dilation of the common bile duct. Other pancreatic diseases such as neoplasia, cysts, or abscess may be evaluated via the right lateral intercostal approach.

The right lateral intercostal approach may also be useful for evaluation of disease of the right kidney, especially in large and deep-chested dogs and in dogs with gas in the gastrointestinal tract. This window also allows comparison of the relative echogenicities of the liver and right kidney. In normal dogs, the renal cortex is hyperechoic or isoechoic to the liver. The renal cortex may be hyperechoic relative to the liver in...
conditions such as nephrotoxicosis or nephrocalcinosis (Fig. 18). The right intercostal approach may be especially helpful in cases of chronic renal disease in which the kidneys are small or in focal renal disease, such as masses, infarcts, or cysts.

Ultrasound is commonly used to examine the adrenal glands. The right is generally more difficult to evaluate than the left due to its more cranial position and its proximity to the pylorus and duodenum. The right intercostal window is helpful in the detection of diffuse adrenal gland enlargement, such as with pituitary-dependent hyperadrenocorticism, adrenal mass lesions, and invasion or compression of the caudal vena cava by an adrenal lesion (Fig. 19A–C).

The normal lymph nodes of the right cranial abdomen, such as the hepatic, pancreaticoduodenal, and gastric lymph nodes, are usually not seen in normal animals, because they are small and isoechoic to surrounding tissues. When abnormal,
due to neoplasia or inflammation, these lymph nodes may be enlarged and/or hypoechoic, making them easier to detect.  

Cytologic or histopathologic examination of lesions is essential for the diagnosis of many diseases. Ultrasound is a fast, safe, and relatively inexpensive way to locate lesions and obtain samples for microscopic evaluation. Ultrasound is used to view needle placement during fine-needle aspiration or when obtaining a core biopsy, thereby increasing the chance of obtaining a diagnostic sample while avoiding surrounding blood vessels. In a study of 98 dogs and 16 cats, tissue core samples obtained with an 18-gauge biopsy needle were diagnostic in 92% of hepatic biopsies and 100% of renal biopsies. Lesions of the right aspect of the liver or right kidney may be most easily accessed using the right lateral intercostal approach. Contraindications for biopsy include increased bleeding time, decreased platelet count, and increased prothrombin time and partial thromboplastin time. The abdomen should be examined for the presence of hemorrhage following the biopsy procedure and the patient monitored for any signs of bleeding.
SUMMARY

When performing an abdominal ultrasound, a ventral or subcostal approach may be inadequate for a thorough examination. A right lateral intercostal window may be necessary for complete evaluation of the right cranial abdomen. Structures evaluated with this intercostal approach include the right aspect of the liver, porta hepatis, pancreas, proximal duodenum, right kidney, right adrenal gland, and several lymph nodes. Dogs for which this window may be most useful include large and deep-chested dogs, dogs with large volumes of peritoneal effusion or gas in the gastrointestinal tract, and cases of microhepatica and abdominal pain. The right intercostal approach is simple and requires little patient preparation.

REFERENCES


