IMAGING ESSENTIALS

Small Animal Abdominal Ultrasonography: The Spleen

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Welcome to our series of articles on small animal abdominal ultrasonography. The initial articles provided an overview of basic ultrasonography principles and a discussion about how to perform a sonographic tour of the abdomen. The rest of the series discusses ultrasound evaluation of specific abdominal organs/systems.

Read the other small animal abdominal ultrasonography articles published in *Today's Veterinary Practice* at **tvpjournal.com**.

Anatomically, the spleen is divided into 3 parts (**Figure 1**):

- Dorsal extremity (left craniodorsal)
- Body (mid-abdominal)
- Ventral extremity (right mid-abdomen and slightly caudoventral)

In cats, however, these 3 parts are not commonly specified because the spleen is smaller, superficial, and located in the left cranial abdomen.

Along the visceral surface border of the spleen, the hilum is surrounded by fat, where splenic vessels can be found. The splenic portal veins can be seen originating from the splenic hilum and can be traced between the stomach and colon to a common confluence that then enters into the portal vein. The splenic arteries are not distinguishable without color Doppler.

Landmarks that help identify the location of the spleen include the stomach, descending colon, and left kidney:

- The stomach is located cranial and medial to the spleen.
- The left colic flexure and transverse colon are located dorsal (far field), medial and caudal to the body of the spleen (**Figure 1**).
- The left kidney is located dorsal, medial (far field) and caudal to the spleen.

NORMAL ULTRASONOGRAPHIC FEATURES

The spleen is an elongated, solid organ. Its size is highly variable in dogs but more fixed and much smaller in cats. German shepherds and greyhounds have a larger spleen than other canine breeds.[1]

FIGURE 1. Long-axis sagittal images of a normal spleen. The dorsal extremity can be seen in the far field (**between arrows in A**). The body can be seen along the left lateral side adjacent to the stomach (**B**). The ventral extremity can be seen in the far field (**arrow in C**).

In cats, the spleen is neither thick nor long, measuring less than 1 cm in thickness and 4 to 6 cm in length (**Figure 2**).[1] The feline spleen is located in the near field. When the transducer is positioned in long axis relative to the cat (craniocaudal), the spleen will be a short-axis triangular shape similar to that seen on ventrodorsal abdominal radiographs.

The canine spleen is found along the left cranial and ventral abdominal wall that parallels the greater curvature of the stomach within the greater omentum. Because the spleen is only attached by the gastrosplenic ligament of the greater omentum, its position in dogs can be variable.

The feline spleen is located in the left cranial and lateral abdomen, caudal and lateral to the stomach. The left lobe of the pancreas in cats is deep and medial to the spleen; it is larger than the canine left pancreatic lobe. The left lobe of the pancreas in cats is more readily seen on both ultrasonography and abdominal radiography when compared with dogs (**Figure 3**).

FIGURE 2. Long-axis (relative to the patient) sagittal image of a normal spleen in a cat.

In dogs, the splenic parenchyma is slightly hyperechoic relative to the adjacent liver and mesenteric fat; in cats, it is isoechoic to hypoechoic to the surrounding fat. The spleen has an outer hyperechoic capsule. It is normally homogeneous in echotexture, but when using a high-frequency linear array transducer, the

FIGURE 3. Ventrodorsal radiograph of a normal abdomen in a cat. Note the clear demarcation between the spleen (**white arrowheads**) and the left lobe of the pancreas (**black arrowheads**).

spleen can have a coarser architecture and more heterogeneous appearance (**Figure 4**).

Changes in the size, shape, echogenicity, and echotexture of the spleen may be a normal response and may be sonographically indistinguishable from a significant pathologic process. A normal scan does not equate with the absence of disease.

PREPARATION AND SCANNING TECHNIQUE

Examination of the spleen is part of a comprehensive routine ultrasound examination of the entire abdomen. Before beginning the examination, clip the patient's hair and apply ultrasonic gel to the skin.

Starting at the craniodorsal extremity of the spleen along the cranial border, use a distance motion to slide the transducer along the abdominal wall from the left cranial abdomen to the left caudal abdomen until the entire cranial border of the spleen has been evaluated (see **Transducer Motions**).

In deep-chested animals, an intercostal left-sided approach through the 11th and 12th intercostal spaces may be needed to image the dorsal extremity of the spleen. In dogs without hepatomegaly or gastric distension, the dorsal extremity of the spleen is usually located deep to the 11th to 13th ribs, cranial to the left kidney, and often folds medially onto itself. For cats, sweep the left cranial abdomen in a right to left distance motion, just caudal to the stomach.

Transducer Motions

Wielding the transducer is an integral part of any ultrasound examination. When performing an abdominal ultrasound exam, there are 3 primary types of transducer movements:

- **Distance motion:** The transducer is slid along the abdomen in a cranial-caudal, lateral, or dorsal-ventral direction.
- **Nondistance, angular motion:** The transducer is held in place while the angle is changed.
- **Nondistance, rotational motion:** The transducer is held in place but is rotated very slightly (usually millimeters).

1. Evaluate the cranial border of the spleen (transducer in sagittal plane and spleen is in transverse plane) by moving in a left to right direction along the cranial border of the spleen. Once on the right side of the abdomen, move the transducer caudal and then in a distance motion back across the abdomen (right to left) in the middle of the spleen, ensuring some overlap between the cranial pass and the current middle pass.
2. Once back to the dorsal extremity of the spleen, move the transducer caudally along the caudal border.
3. Move the transducer in a distance motion from left to right all the way through the caudoventral extremity.
4. From there the continuation can be variable, and the tip of the ventral extremity may be

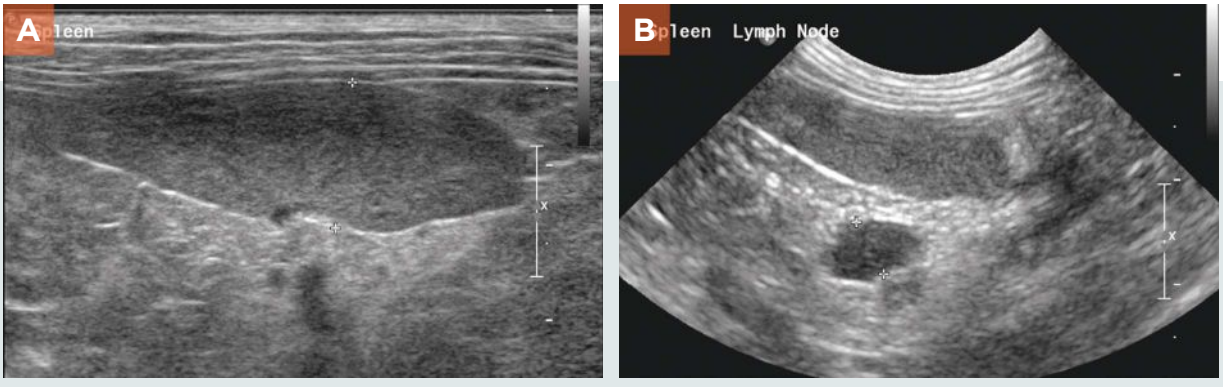

FIGURE 4. Long-axis sagittal images of the spleen in a cat with an enlarged splenic lymph node. Note the coarse echotexture when a linear array transducer is used (**A**) compared with a microconvex transducer (**B**).

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found anywhere from alongside the left wall of the urinary bladder to curving ventrally toward the right ventral mid-abdominal wall. In cats, the entire spleen is usually visible just deep to the left cranial abdominal wall. Evaluate any abnormalities in both long- and short-axis views.

Differential Diagnosis of Splenic Conditions

- Focal or multifocal disease (nodules and/or masses)
  - Hematoma: from trauma, lymphoid hyperplasia, vascular tumor[2,3]
  - Nodular (lymphoid) hyperplasia[4]
  - Extramedullary hematopoiesis
  - Primary neoplasia: Lymphoma, histiocytic sarcoma, hemangiosarcoma, hemangioma, fibroma, fibrosarcoma, extraskeletal osteosarcoma, myxosarcoma, myelolipoma, lipoma, liposarcoma, leiomyoma, leiomyosarcoma[5-8]
  - Metastatic tumor[9]
  - Granuloma
  - Abscess[10,11]
- Increase in size without parenchymal alterations
  - Anesthetic agents (tranquilizers)[12]
  - Nodular (lymphoid) hyperplasia[4]
  - Extramedullary hematopoiesis
  - Autoimmune hemolytic anemias
  - Chronic anemias
  - Hematopoietic neoplasia: Mast cell tumor, lymphoma, histiocytic sarcoma[6-8]
- Diffuse nodular disease or inhomogeneous alterations in parenchyma
  - Hemangioma, hemangiosarcoma
  - Round cell neoplasia: Mast cell tumor, lymphoma, histiocytic sarcoma[6-8]
  - Granulomatous disease
  - Histoplasmosis
  - Nodular (lymphoid) hyperplasia[4]
  - Amyloidosis
- Normal splenic ultrasound without parenchymal alterations
  - Round cell neoplasia
  - Lymphoid hyperplasia
  - Splenitis
  - Extramedullary hematopoiesis

DIFFERENTIAL DIAGNOSIS OF SPLENIC DISEASES

Diseases of the spleen fall into 1 of 4 categories (see **Differential Diagnosis of Splenic Conditions**):

- Focal or multifocal disease
- Increased spleen size with no parenchymal alterations
- Diffuse nodular disease or inhomogeneous parenchymal changes
- Normal splenic ultrasound without parenchymal alterations

Focal or Multifocal Splenic Diseases

Nodular (Lymphoid) Hyperplasia and Extramedullary Hematopoiesis

The ultrasound appearance of nodular hyperplasia varies from hypoechoic to isoechoic nodules (**Figure 5**) that are usually sharply marginated and typically have no other parenchymal abnormalities. In addition, areas of hyperplasia can appear as an isoechoic mass because of changes in splenic echotexture or shape or increased echogenicity.[4]

Extramedullary hematopoiesis can look similar to nodular hyperplasia, so cytology is required to differentiate between the two. Typically these lesions do not break the normal margins or extend beyond the normal splenic capsule; however, they can create a large mass effect as previously reported.[4]

Myelolipoma

Myelolipomas are benign, irregularly shaped or rounded, hyperechoic foci of varying sizes. They can be found at the splenic hilum along the visceral border at the exit of the splenic portal vessels or, less commonly, within the splenic parenchyma (**Figure 6**).[13] Myelolipomas cannot be distinguished from other poorly shadowing hyperechoic foci in the spleen. These lesions are more common in geriatric dogs but are occasionally seen in geriatric cats.[14]

Dystrophic Mineralization

Focal areas of dystrophic mineralization can be identified as hyperechoic speckles and thin lines throughout the splenic parenchyma. The lesions

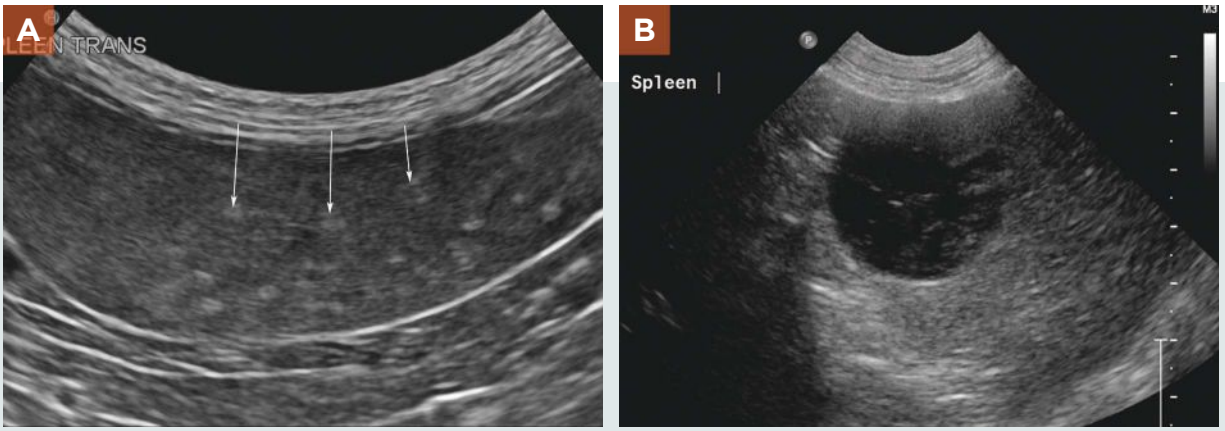

FIGURE 5. Long-axis sagittal images showing the varied appearance of nodular (lymphoid) hyperplasia in a mixed-breed dog (**A**) and an American pit bull terrier (**B**). Note the small, ill-defined, hyperechoic foci throughout the splenic parenchyma (**arrows**) in **A** and the large, well-defined, hypoechoic mass in **B**.

are consistent with vascular arterial changes and dystrophic mineralization secondary to chronic endocrinopathies such as hypothyroidism, diabetes mellitus, and hyperadrenocorticism.[1]

Focal Infarction

Splenic infarction occurs secondary to embolism or thrombosis within the splenic artery (**Figure 7**). In dogs, it has been described with bacterial endocarditis, hypercoagulable conditions secondary to liver disease, renal disease (amyloidosis in shar-peis), hyperadrenocorticism, neoplasia, and thrombosis associated with cardiovascular disease.[15-17]

Initially, splenic infarctions result in focal hypoechogenicity with lack of blood supply as seen on color Doppler evaluation. Then, as the area undergoes revascularization and fibrosis, they ultimately shrink and the splenic shape becomes distorted. Infarctions can be poorly marginated, hypoechoic, or complex, acutely indistinguishable from other focal splenic lesions.[15-18]

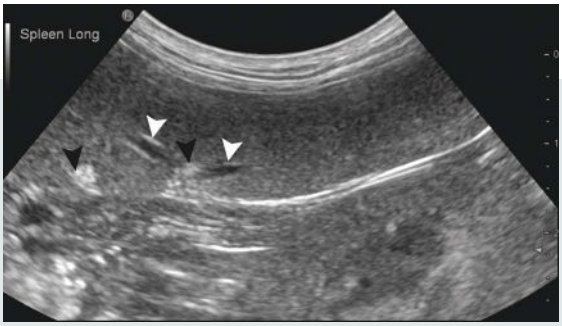

FIGURE 6. Long-axis sagittal image of the spleen in an otterhound showing myelolipomas in the splenic hilum. There are two irregularly shaped, hyperechoic foci (**black arrowheads**) without distal acoustic shadowing. These structures are located at the splenic hilum, surrounding the splenic portal veins (**white arrowheads**) and along the visceral margin of the spleen.

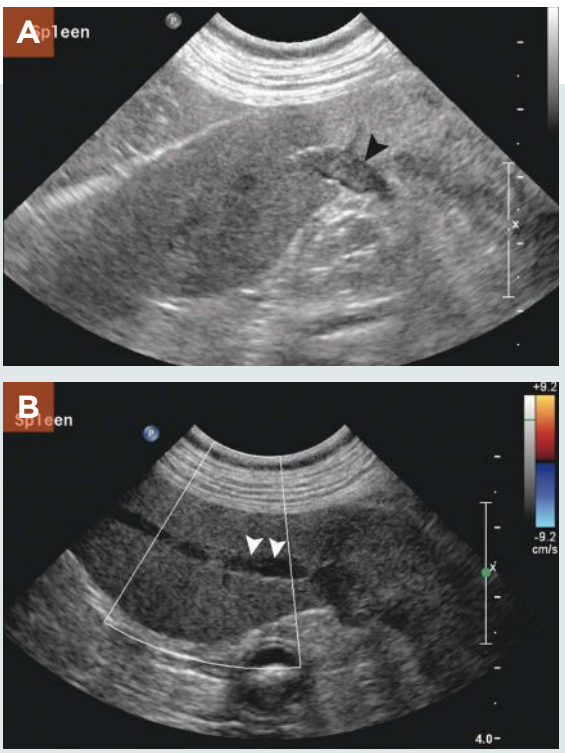

FIGURE 7. Long-axis sagittal images of an enlarged infarcted spleen in a collie. The splenic artery is abnormally distended with echogenic material within its lumen (**arrowhead in A**). No splenic arterial blood flow is detected within the spleen using color Doppler (**arrowheads in B**).

Circular, hypoechoic or anechoic, irregularly delineated masses have also been described in dogs and humans.[15,18]

After 4 to 7 days, blood clots can become hyperechoic with collateral vessels surrounding them. Diagnostic differentials for this lesion include nodular hyperplasia, abscess, hematoma undergoing clot organization or lysis, and neoplasia.

Abscess

Splenic abscesses are uncommon. They can be focal or multifocal, and their appearance varies from poorly marginated, hypoechoic lesions to complex lesions with variable cystic components and echogenic debris.[10,11,19] Distal acoustic enhancement is variable and depends on the viscosity of the fluid. If hyperechoic foci with or without comet-tail artifacts are present within the lesion, gas-forming microorganisms should be suspected (**Figure 8**).

Hematoma

Hematomas can be caused by abdominal trauma, clotting disorders, or splenic neoplasia (hemangiosarcoma or lymphoma). They may happen within the parenchyma, subcapsular region, and/or adjacent to the spleen. Splenic margination may be altered if the lesion is large or close to the surface.

These lesions are hyperechoic initially in intraparenchymal hemorrhage and anechoic to hypoechoic with larger collections of unclotted blood.[20] Clotted blood within a hematoma may appear isoechoic or hyperechoic, gradually becoming hypoechoic relative to the splenic parenchyma.[21] Hematomas can also have internal septation and cavitations, and differentiation from tumors such as hemangiosarcoma is not possible.

Primary Neoplasia

Hemangiosarcomas are the most commonly diagnosed neoplasia in the canine spleen. Other splenic neoplasias include histiocytic sarcoma, malignant histiocytosis, leiomyosarcoma, fibrosarcoma, undifferentiated sarcoma, extraskeletal osteosarcoma, chondrosarcoma, liposarcoma, myxosarcoma, rhabdomyosarcoma, and fibrous histiocytoma. In cats, splenic neoplasias include mast cell tumor, lymphoma, myeloproliferative disease and, less commonly, hemangiosarcoma.

The ultrasonographic appearance of splenic neoplasia is variable and can include splenomegaly or focal mass lesions, which are commonly poorly defined, anechoic, hypoechoic, targetlike,[22] or complex, similar to those of the liver. Following are the characteristic features of some splenic neoplasias:

- *Hemangiosarcoma* is the most common mass lesion of the spleen in dogs.[23,24] Hemangiosarcomas have variable amounts of anechoic to hyperechoic areas throughout (**Figure 9**), occasionally with weak distal acoustic enhancement.[5,25] Hemoperitoneum is a common sequela to splenic hemangiosarcoma, and this tumor is the most common cause of acute nontraumatic hemoperitoneum in

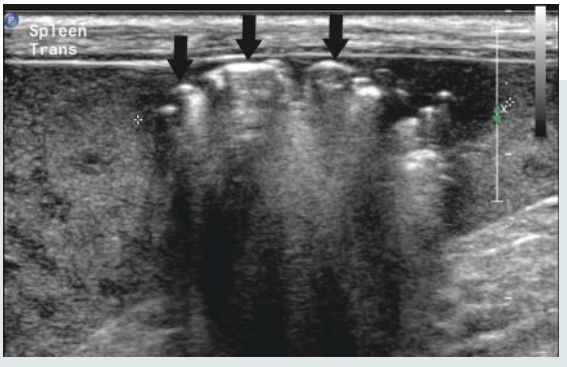

FIGURE 8. Long-axis sagittal image of the spleen in a mixed-breed dog. The parenchyma contains multiple, ill-defined hypoechoic foci throughout. There is a large abscess within the parenchyma, characterized by irregularly shaped, hyperechoic foci (**arrows**) with distal reverberation artifact consistent with gas.

FIGURE 9. Long-axis sagittal image of the spleen in a golden retriever with hemangiosarcoma. There is a large, irregularly shaped, well-demarcated, heterogeneous mass causing distortion of the splenic capsule in the far field. Note the continuation of the more normal splenic parenchyma into this mass (**arrowhead**).

dogs.[26] Hemangiosarcomas can be large and cavitated, with the cavitations typically central secondary to necrotic centers. Differentials include hematoma and nodular hyperplasia.

- *Lymphoma* typically is a diffuse disease of the spleen, but it can sometimes form focal masses that may distort the splenic contour or cavitate if the masses are large (**Figure 10**).[7,25] Hemorrhagic abdominal effusion may also be present.[7] In dogs, the abdominal lymph nodes (eg, medial iliac, hepatic, and mesenteric) are often markedly enlarged.
- *Malignant histiocytosis*, *malignant fibrous histiocytoma*, and *histiocytic sarcoma* have multiple well-defined, hypoechoic nodules that may distort the splenic margin (**Figure 11**).[27] Abdominal lymphadenopathy may be present. The spleen is the most common organ involved, followed by the liver. The pancreas, kidneys, adrenal glands, ovaries, and gastrointestinal tract may also be affected.[27]
- *Mast cell tumors* infiltrating the spleen cause splenomegaly with diffuse hypoechogenicity or one or more hypoechoic nodules (**Figure 12**).[28] Occasionally, the spleen may appear normal on ultrasound.[29] In cats, there may be splenomegaly only, a diffusely hypoechoic spleen, a mottled and irregular spleen, or a spleen containing hypoechoic or hyperechoic nodules.[25,28]
- *Metastatic carcinoma* appears as solitary, well-defined, anechoic to hypoechoic nodules in cats[25] and can appear as target lesions in dogs.[22]
- *Multiple myeloma* is a systemic disease in which multiple, small hyperechoic nodules can be seen in dogs, but the spleen may appear normal in cats.[30]

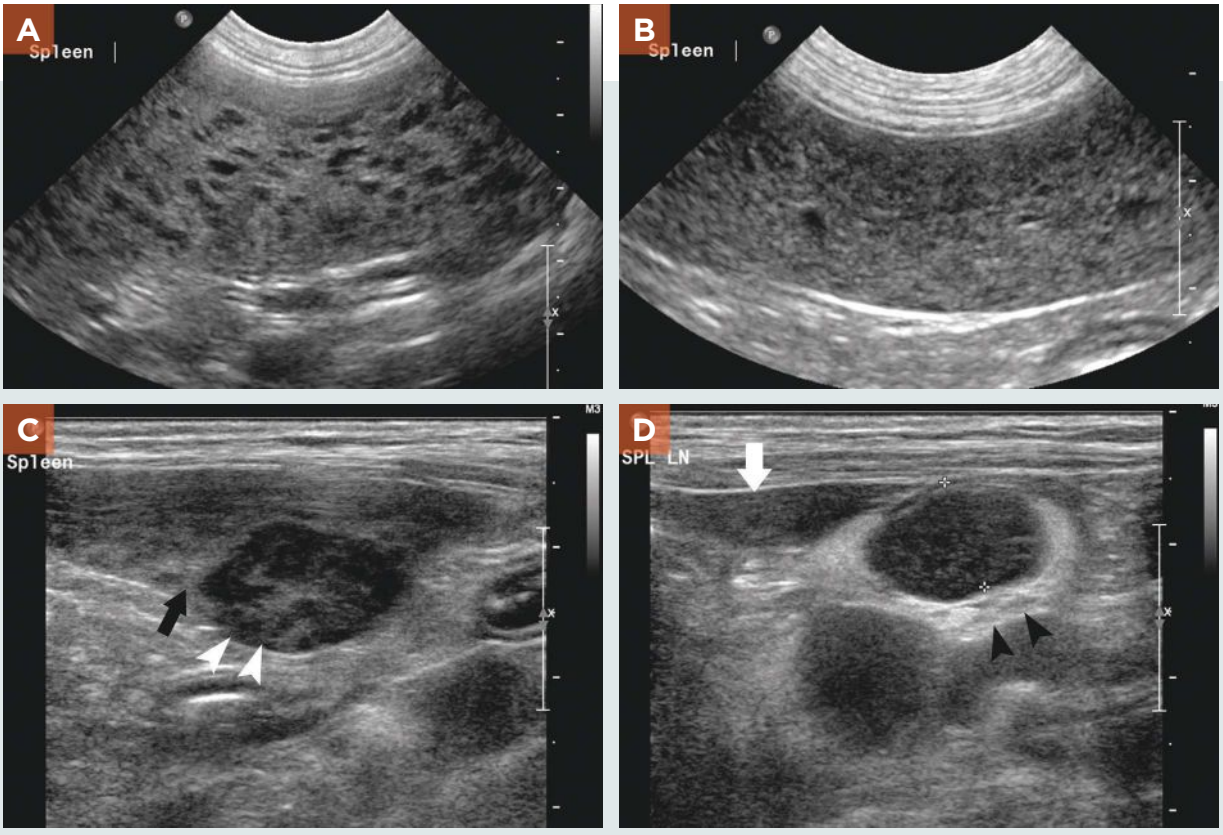

FIGURE 10. Long-axis sagittal images of the spleen in 3 dogs with lymphoma. "Leopard spots" in a German shepherd (**A**). Note the multiple to coalescing, oval-shaped, hypoechoic foci throughout the splenic parenchyma. Mottled parenchyma in a Pomeranian (**B**). Oval-shaped, well-defined, heterogeneously hypoechoic mass along the visceral border of the spleen in a shih tzu (**arrowheads in C**). Note the clear demarcation between the more normal splenic parenchyma and the mass (**arrow**). (**D**). Same dog as in C. The spleen is noted in the near field at the end of the splenic border (**white arrow**). There is a hypoechoic oval structure (+ signs denoting margins) consistent with a splenic lymph node. The lymph node is surrounded by hyperechoic mesentery (**black arrowheads**) consistent with regional inflammation or cellular infiltration.

Generalized Splenic Diseases

Splenic Torsion

Splenic torsions cause severe splenomegaly with a coarse, diffuse "lacy," hypoechoic to anechoic parenchymal pattern with interspersed linear echoes.[15,17,31] Torsion can also be seen as hypoechoic overall with small hyperechoic speckles (gas) throughout the parenchyma, giving it a "starry night" appearance. These appearances are caused by splenic congestion when the spleen rotates along its pedicle of the greater omentum, cutting off the venous outflow and ultimately leading to progressive active congestion and eventual infarction. As a result, the splenic veins near the hilum are also enlarged from venous outflow tract obstruction.

The mesenteric fat around the hilus is often hyperechoic and hyperattenuating. Anechoic or slightly echogenic fluid may be seen adjacent to the spleen. In chronic splenic torsion, foci of hyperechogenicity with distal acoustic enhancement may be seen; this represents gas secondary to gas-producing bacteria causing an abscess.[32] Splenic torsion is a disease of dogs (typically large breeds) and not cats.

Acute Systemic Infectious Disease (Bacterial or Fungal)

Infectious splenitis may cause splenomegaly with normal to reduced echogenicity. Infectious or inflammatory splenitis is seen as hypoechogenicity and severe splenomegaly. In severe, acute inflammation, the spleen is diffusely hypoechoic and might have a mottled, heterogeneous appearance.[14,16]

Extramedullary Hematopoiesis and Lymphoid Hyperplasia

These diffuse non-neoplastic diseases can appear as normal to reduced echogenicity in dogs and can be normal in echogenicity in cats. Hypoechoic nodules may be present.[25] Cats with extramedullary hematopoiesis, lymphoid hyperplasia, or both can have splenomegaly with normal echogenicity, hypoechoic nodules, or mottling.[25]

Diffuse Neoplastic Disease

Common diffuse splenic neoplasias include lymphoma and mast cell tumor. These neoplasias, along with malignant histiocytic, myelomatous, and leukemic infiltrations, may reduce splenic echogenicity, or the parenchyma may appear normal.[29,33] Following are the ultrasonographic characteristics of lymphoma and mast cell tumor.

- *Lymphoma* may produce a spectrum of abnormalities with diffuse lymphomatous infiltration ranging from no abnormalities to splenomegaly; multiple, variably sized hypoechoic nodules; diffuse increased or decreased echogenicity with coarse echotexture; or multiple hypoechoic nodules often referred to as a "honeycomb pattern," "moth-eaten appearance," "spotted spleen," or "leopard spots" (**Figure 10**).

FIGURE 11. Short-axis transverse image of the spleen in a Jack Russell terrier with histiocytic sarcoma. Multifocal, round, well-defined, heterogeneously hypoechoic masses can be seen throughout the splenic parenchyma, mildly distorting the splenic capsule.

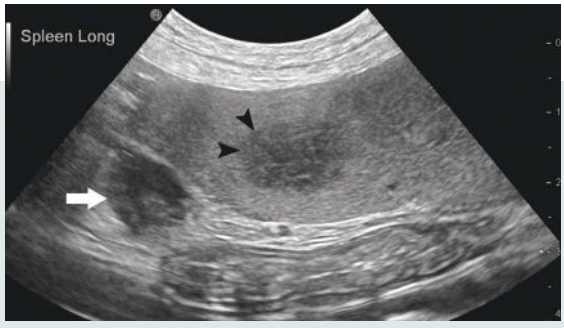

FIGURE 12. Long-axis sagittal image of the spleen in a mixed-breed dog with mast cell tumor. A large, heterogeneously hypoechoic, ill-defined mass can be seen in the splenic parenchyma (**arrowheads**). In addition, there is a round, heterogeneously hypoechoic mass within the mesentery, adjacent to the splenic parenchyma, that is presumed to be a metastatic splenic lymph node (**arrow**).

- *Mast cell tumors* may appear normal or may look similar to the patterns (multiple hypoechoic to anechoic areas) in cats with splenic lymphoma or myeloproliferative disease (**Figure 12**).[33] These diseases cannot be distinguished from each other. However, mesenteric lymphadenopathy and abdominal effusion are more likely in cats with lymphoma. Splenic mast cell tumors in cats are more likely to have an irregular contour. **TVP**

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