When using the systematic approach described in previous articles, the sonographic tour of the abdomen begins in the cranial abdomen, evaluating the liver and gallbladder. This article reviews the normal ultrasound appearance of the liver and gallbladder, steps for obtaining appropriate views, and some common abnormalities seen with ultrasonography of these organs. In Part 2, causes of generalized hepatic changes and the ultrasound appearance of biliary abnormalities will be reviewed.

NORMAL ULTRASOUND APPEARANCE
Complete evaluation of the liver requires extensive examination of all aspects of the liver and may also necessitate both standard transabdominal and intercostal (between the ribs within the intercostal space) approaches. Evaluation consists of longitudinal (sagittal and parasagittal) and transverse images of all aspects of the liver (right side, midline, and left side of the liver).

Initial Liver Evaluation
1. Clip the hair and apply acoustic gel at a level just caudal to the xiphoid process.
2. With the patient in dorsal or lateral recumbency, place the probe just caudal to the xiphoid process.
3. Begin the examination with the transducer in a long-axis plane and angle it cranially to view the midsection of the liver.
**Liver Lobes**
The liver is composed of 4 lobes, 4 sublobes, and 2 processes (Figure 1, page 73):
- Right lobe, including the lateral and medial sublobes
- Quadrate lobe
- Left lobe, including the medial and lateral sublobes, which makes up 1/3 to 1/2 of the liver
- Caudate lobe, including the caudate and papillary processes.

The hepatic lobes cannot be distinguished with ultrasonography. However, when significant abdominal effusion is present, the divisions between the hepatic lobes become more apparent. In dogs, the liver’s left lobe (medial sublobe), quadrate lobe, and right lobe (medial sublobe) encircle the gallbladder. The caudate lobe extends dorsally and caudally, ending with the renal fossa, which contains the cranial pole of the right kidney.

**Liver Vasculature**
The liver parenchyma has a coarse echotexture, and portal vessels are the dominant vascular structure noted throughout the liver (Figure 2). The hepatic and portal veins form specific divisions to each of the liver lobes. The porta hepatis is the central portion of the liver to the right of midline where the portal vein, hepatic artery, and bile duct (see Gallbladder Evaluation, page 76) enter and exit the liver.
- The portal vein is the easiest structure of these 3 to identify.
- The hepatic artery is smaller and easier to identify using color flow imaging.
• The bile duct is not seen in dogs, but may be visible in cats (up to 3 mm in diameter) in the porta hepatis region.

The portal veins are the dominant vessels in the hepatic parenchyma. They have an outer hyperechoic wall due to fibrofatty connective tissue surrounding the wall and within the wall itself. The intrahepatic portal veins are a continuation of the portal vein proper as it enters the porta hepatis:
  • As the main portal vein enters the liver, the right divisional branch diverges from the vein
  • The portal vein continues cranially, with the central divisional branch diverging
  • The portal vein then continues as the left divisional branch into the left lobe of the liver.

The hepatic veins drain dorsally and to the right into the caudal vena cava (Figure 3). They can be seen as hypoechoic tubular structures that do not have hyperechoic walls; the vessels taper toward the periphery of the liver and enlarge centrally within the liver. The hepatic veins enter into the caudal vena cava in the dorsal right liver along the ventral and lateral wall of the caudal vena cava.

Further Liver Evaluation
1. With the transducer in the subxiphoid position, angle it to the left to evaluate the left lobe in the long-axis plane, with the diaphragm–lung interface (a bright hyperechoic line) noted along the cranial border of the liver (Figure 2). The fundic portion of the stomach is just caudal (Figure 4) to the left lobe of the liver.
2. Angle the transducer back to midline and then toward the right side of the patient to image the gallbladder (Figure 5).
3. Angle the transducer back to midline, and rotate it 90 degrees, with the notch pointing toward the patient's right side. Then angle the probe ventrally and dorsally to see the entire extent of the liver. Dividing the liver into thirds ensures evaluation of all 3 sections: right side, midline, and left side (Figure 6). Laterally and caudally, the liver extends to the level of the spleen on the left; dorsally, the liver extends to the level of the right kidney on the right (Figure 7).

Fat within the falciform ligament is seen in

![Image of liver with transducer]
the near field, particularly in cats. Often the fat is isoechoic to the liver, and it can be difficult to delineate between the hepatic parenchyma and the falciform ligament (Figure 8).

A “window” that is often used to evaluate dogs and cats with suspected portosystemic shunts is a transverse imaging plane between the dorsal right 11th and 12th intercostal spaces. This window allows visualization of the relationship between the porta hepatis and the aorta, caudal vena cava, and portal vein (Figure 9).

**Gallbladder Evaluation**

The gallbladder is located to the right of midline. The volume of bile noted within the gallbladder is variable. Fasting and anorexia result in gallbladder distension. In cats, the gallbladder can be bilobed (Figure 10).

Parts of the gallbladder that are not normally visualized are the:
- Gallbladder wall (< 1 mm) (Figure 11)
- Intrahepatic bile ducts
- In dogs, the cystic and bile ducts are not visible; however, feline cystic and bile ducts can be visualized sometimes, and can measure up to 3 mm in diameter each (Figure 12).

**ULTRASOUND ABNORMALITIES**

Hepatic abnormalities can be categorized as focal, multifocal, or generalized. Focal and multifocal abnormalities (Table 1, page 78) are further described by:
- Size: Nodule versus mass (> 3 cm)
Echogenicity: Anechoic, hypoechoic, hyperechoic, and/or heteroechoic.

Generalized abnormalities will be discussed in Part 2 of this article.

**Hepatic Nodules**

Focal and multifocal nodules are < 3 cm, and can be anechoic, hyperechoic, hypoechoic, and/or heteroechoic, with a target lesion appearance (Figure 13).

Target lesions are nodules with hyperechoic centers and hypoechoic rims. These lesions are often metastatic, particularly if there are multiple target lesions in several abdominal organs (liver, spleen, kidneys). Due to the overlap in ultrasound appearance between benign and malignant lesions, either cytology or histology is needed for a final diagnosis.

**Hepatic Masses**

Hepatic masses can be complex, with hyperechoic and hypoechoic features and areas of cavitation consistent with necrosis (Figure 14, page 78). These lesions can become quite large and create a cranial abdominal mass effect on abdominal radiographs. A large hepatic mass is most commonly a primary hepatic tumor, with varying grades of malignancy (from hepatoma to hepatocellular carcinoma).
Cystic Adenomas & Adenocarcinomas
In cats, cystic adenomas and adenocarcinomas are common and have a hypoechoic appearance with multifocal cystic areas (Figure 15). Other tumors that can cause single or multiple hepatic masses include lymphoma, histiocytic sarcoma, and hemangiosarcoma. Any large tumor mass in the liver can result in hemorrhage and peritoneal effusion.

Mineralization & Intraparenchymal Gas
Other causes of focal or multifocal abnormalities include areas of mineralization (hyperechoic focus with distal shadowing) or intraparenchymal gas (hyperechoic focus with distal acoustic reverberation artifact).

Dystrophic mineralization typically occurs within the parenchyma and can be seen as:
• Chronic granulomas from prior parasitic migration or fungal infection
• Dystrophic mineralization within the biliary tree, secondary to ascending inflammation and cholecystitis (Figure 16).
• Focal mineralized choleliths in the intrahepatic biliary tree.
• Intraparenchymal gas can be seen:
  • In the biliary tree and gallbladder after surgery
  • In the gallbladder wall in diabetic dogs with emphysematous cholecystitis
  • Within the biliary tree, secondary to ascending infection
  • In a liver abscess and liver lobe torsion (Figure 17).

TABLE 1. Differential Diagnostic Considerations for Focal & Multifocal Hepatic Lesions

<table>
<thead>
<tr>
<th>ANECHOIC</th>
<th>HYPOECHOIC</th>
<th>HYPERECHOIC</th>
<th>MIXED ECHOGENICITY*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyst</td>
<td>Nodular hyperplasia</td>
<td>Nodular hyperplasia</td>
<td>Nodular hyperplasia</td>
</tr>
<tr>
<td>Necrosis</td>
<td>Hematoma</td>
<td>Metastasis</td>
<td>Metastasis</td>
</tr>
<tr>
<td>Abscess</td>
<td>Lymphoma</td>
<td>Myelolipoma</td>
<td>Hematoma</td>
</tr>
<tr>
<td>Cystic tumor</td>
<td>Complex cyst</td>
<td>Granuloma</td>
<td>Abscess</td>
</tr>
<tr>
<td>Biloma</td>
<td>Metastasis</td>
<td>Primary neoplasia</td>
<td>Primary neoplasia</td>
</tr>
<tr>
<td></td>
<td>Primary neoplasia</td>
<td>Mineralization</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Necrosis</td>
<td>Gas</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Extramedullary hematopoiesis</td>
<td></td>
</tr>
</tbody>
</table>

* A target lesion is a nodule that has an outer hypoechoic rim and inner hyperechoic nodule or circle. This type of lesion, particularly in the spleen and liver, holds an 80% positive predictive value for neoplasia (metastatic disease).
Ultrasonography of the gallbladder is complicated by the:
• Small size of the organ
• Echogenic material within it that varies, depending on the species and the patient (Figure 5).

IN SUMMARY
Liver evaluation takes time, with both intercostal and intraabdominal approaches often needed. It is important to note both the structures that can, and cannot, be visualized in the liver and gallbladder (Table 2).

Suggested Reading

**TABLE 2.**
**Sonographic Visualization of Liver & Gallbladder Anatomy**

<table>
<thead>
<tr>
<th>ANATOMIC COMPONENT</th>
<th>DOG</th>
<th>CAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hepatic lobes</td>
<td>Only if effusion is present</td>
<td>Only if effusion is present</td>
</tr>
<tr>
<td>Bilobed gallbladder</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Portal vein</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Hepatic artery</td>
<td>May require color Doppler imaging</td>
<td>Requires color Doppler imaging</td>
</tr>
<tr>
<td>Aorta</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Caudal vena cava</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Falciform ligament</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Gallbladder wall</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Bile duct</td>
<td>No (sometimes)</td>
<td>Yes</td>
</tr>
<tr>
<td>Intrahepatic bile ducts</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

**FIGURE 17.** Transverse image from the cranial left abdomen of a dog. Note the large hypoechoic mass with multiple areas of speckled increased echogenicity consistent with gas. At surgery, a liver lobe torsion with necrosis was identified; anaerobic infection was found on culture.

**FIGURE 16.** Long-axis left-sided image from a dog. There is a focal area of mineralization (white arrow) with distal acoustic shadowing. Active hepatic disease was not seen at this time.