DIAGNOSTIC IMAGING: LIVER DISEASE

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ABBY CAINE reviews both established and newer, more advanced radiography and ultrasound imaging techniques, in the first of a two-part article

IMAGING is the key to progressing a case with symptoms and blood changes consistent with liver disease.

The first part of this article aims to review well-established radiography and ultrasound techniques in the investigation of liver disease. The forthcoming second part will introduce advanced imaging techniques, including vascular ultrasound, contrastenhanced ultrasound, computed tomography (CT), scintigraphy and magnetic resonance imaging (MRI), which are beginning to be used to investigate the liver in a non-invasive fashion.

Anatomy

In both cats and dogs, there are six liver lobes: right medial and lateral, left medial and lateral, and quadrate and caudate lobes.

These lobes are not usually identified individually with radiography and ultrasound, but their location can be inferred by examining the vascular supply on CT, since the portal vein branches to each lobe can be followed.

With ultrasound, it can be helpful to know the gallbladder lies on the right ventral aspect of the liver, and is located between the right medial and quadrate lobes. The cystic bile duct (which becomes the common bile duct once the last hepatic duct has joined) can be followed in many cats, and

some dogs, to the major papilla with ultrasound: in normal dogs it is less than 3mm[1], and in normal cats it is up to 4mm in diameter[2]. In cats, the bile duct may be quite tortuous at the gall bladder neck.

The major papilla is identified as a homogenous, echogenic round structure in the wall of the duodenum. It can be quite prominent in normal dogs, and more so in cats. It is worth noting the common bile duct passes adjacent to the pancreas, so pancreatic disease can compress and even obstruct the duct. In cats, the pancreatic duct joins the distal common bile duct to have a single opening; in dogs, the pancreatic duct and the common bile duct have separate openings at the major papilla.

The liver is drained by the hepatic lymph nodes, which lie along the portal vein at the porta hepatis. They are multiple in both dogs and cats, and are rarely seen in normal adult patients. Sometimes, the drainage route may pass through the gastric or splenic lymph nodes before drainage to the hepatic nodes, so in cases of suspected neoplasia, all these lymph nodes should be examined with ultrasound (or another modality) to look for metastasis.

Radiography

Radiography remains the mainstay of abdominal pathology assessment in dogs and cats. No radiographic changes alone are pathognomic for one liver pathology against another, but radiography is unique in offering a quick and cheap overview of the abdomen. Thorax radiographs should be considered if neoplasia or systemic disease is suspected. Radiography will be of less value in patients with ascites and, in these cases, other techniques (such as ultrasound) may yield more information.

Liver size can be inferred from several adjacent structures. It lies between the diaphragm and the stomach on a lateral radiograph, so changes in hepatic size will alter stomach position.

The “gastric axis” is an imaginary line drawn (Figure 1) between the centre of the fundus dorsally, and the ventral and caudal part of the stomach (the pylorus or the body, depending on patient conformation). The axis will vary with conformation, so barrel-chested dogs have a gastric axis parallel with the last ribs, and deep-chested dogs have a gastric axis perpendicular to the spine. Anticlockwise rotation indicates hepatomegaly (Figure 2); clockwise indicates microhepatica (Figure 3).

The liver’s shape should also be assessed to provide supporting evidence for pathological size changes, since breed differences alone make quite a marked variation in size. Usually, only the tip of the liver extends beyond the costal arch, and it should have a sharp, pointed caudal margin. If the liver is enlarged, it often extends beyond the costal arch, and may become rounded and mass-like. If there are liver masses, we may see changes affecting other organs, such as the fundic gas outline being indented by a left lobar liver mass (Figure 4), or the right kidney being pushed caudally by a right dorsal liver mass.

Another type of pathology frequently seen is hepatomegaly in hyperadrenocorticism. In this case, the liver is enlarged, but laxity of the supporting ligaments leads to the liver “slipping down” along the floor of the abdomen, making the caudal margin extend well beyond the costal arch, and appear “slipper shaped”. Since this all occurs ventrally, there can be a normal gastric axis despite marked change in liver volume, so gastric axis should be interpreted in light of breed and change in liver shape (Figure 5). The causes of hepatomegaly and microhepatica are described in Table 1.

The liver should be of uniform soft tissue opacity. Its margins are determined by the adjacent falciform fat pad (this can be large in obese animals, particularly cats, leading to the liver appearing to “float” from the ventral abdominal wall), the mesenteric fat and gastric gas caudally, and the lungfields cranially. The diaphragm should never be identified as a separate structure from the liver; if it is separated, this usually indicates a pneumoperitoneum.

Increases in liver opacity indicate mineralisation: this may be in the hepatic parenchyma (a rare occurrence that can occur in neoplasia, such as extraskeletal osteosarcoma; chronic inflammation, such as abscess, granuloma, parasitic cysts; and even mineralisation of benign regenerative nodules, so that mineralisation does not indicate prognosis); or in the biliary tree, which may be choleliths, gall bladder wall mineralisation, or even be seen incidentally in some small-breed dogs.

Occasionally, lucencies are seen in the liver, indicating the presence of gas: this may be in the biliary tree indicating reflux, or emphysematous cystitis (particularly seen with patients with diabetes mellitus), in the hepatic parenchyma (very occasionally seen with hepatic abscesses or necrosis, such as in lobar torsion or entrapment), or as a very sinister finding seen in the portal veins (may be seen in gastric dilatation and volvulus syndrome, necrotising gastroenteritis or air embolisation).

Contrast radiography of the liver is rare, and limited mainly to demonstration of portosystemic shunts (PSS) by injection of iodinated contrast media downstream of the portal system (often at surgery, by catheterising one of the mesenteric veins), and taking a radiograph at end injection so there is a contrast bolus in the portal vein and (if present) filling any shunting vessels, since the shunting vessels fill preferentially as they are taking blood flow to the lower pressure systemic venous circulation.

Although this technique can demonstrate PSS, it is more invasive than many other techniques described below, and is now often used only during surgery to help guide the surgeon and confirm if surgical intervention has been successful.

Ultrasound

• Technique

A large volume of liver can be examined using sagittal and transverse probe orientations

immediately caudal to the xiphisternum. In addition, the probe can be slid dorsally along the ribcage to the left and the right, so more dorsal areas of liver can be examined.

Since the liver extends more dorsally on the right, it is also useful to use a right dorsal intercostal approach to examine this portion of the liver. The depth should be set so the curved reflective interface of the diaphragm is seen in the far field (to ensure that deep liver lesions are not missed), and the time gain compensation adjusted so the liver has a uniform echogenicity at all depths. In obese animals, the large ventral falciform fat pad can be very attenuating of the ultrasound beam, so the probe should be set to the lowest (most penetrating) frequency in these patients.

• Hepatic diffuse disease

Ultrasound alone is not accurate in distinguishing different types of generalised liver disease[3], but many diffuse parenchymal diseases will consistently result in diffuse hyperechogenicity or hypoechogenicity, so the differential list can be prioritised. Diffuse changes to liver echotexture can be difficult to recognise, and comparison of echogenicity to the spleen and kidney (providing these are normal) can be the most helpful technique.

The echogenicity can be compared to the right kidney, where it sits against the renal fossa of the liver in the right dorsal approach, and can be compared to splenic echogenicity in the left ventral area. The spleen should always be hyperechoic to the liver (Figure 6), and the renal cortex should be a similar echogenicity to the liver (Figure 7) – the actual echogenicity will vary between patients and transducer settings, so it may be slightly hyper or hypo to the liver. It is important to compare echogenicity using the same gain factors, so, ideally, make the comparison on the same image at the same depth. Diffuse liver changes are often accompanied by changes in liver size (usually enlargement, which can be subjectively assessed – objective ultrasound measures of liver volume are described, but can vary between operators). Also, many diffuse changes lead to rounding of the liver lobe margin, instead of its usual crisp wedge-shaped margin (Figure 8). If there is a change in shape and size, it gives supporting evidence for a diffuse hepatic change in echogenicity.

Some of the most severe diffuse liver changes are mixed hyper and hypoechoic, likely reflecting the severe chronic changes leading to fibrosis, with patches of more regenerative normal liver in between (Figure 9). The differentials for diffuse echogenicity change are in Table 2.

If a diffuse change is identified, a definitive diagnosis is often only reached by liver biopsy. A fine needle aspiration (FNA) sample of diffuse change is only rarely diagnostic – for example, in lymphoma or hepatic lipidosis in cats – since the pathologists often require the cell architecture to be included to make a diagnosis.

• Hepatic focal disease

To make a definitive diagnosis of the cause of a focal liver abnormality, a FNA or liver biopsy will

be needed – an FNA is often attempted first, but will often have a lower diagnostic yield.

Other features can help predict the outcome of hepatic cytology: neoplasia has been associated with a hepatic mass, ascites and abnormalities in the hepatic lymph nodes and spleen[4]. Nodules and masses may be hypo, iso or hyperechoic to the surrounding liver parenchyma, and a thorough examination of the liver should make these easy to identify with ultrasound (Figure 10).

Unfortunately, ultrasound is good at identifying lesions, but does not distinguish lesion type very well: nodular hyperplasia, neoplasia (primary and metastatic) and abscesses can all be hyperechoic, hypoechoic or of mixed echogenicity in relation to the surrounding liver parenchyma. Mineralisation, fat and gas are likely to be hyperechoic, while haematomas and necrosis are likely to be hypoechoic.

One type of lesion frequently mentioned is the target lesion[5], which has the appearance of a ring around a central region, like an archery target (Figure 11). These lesions have been associated with malignancy, and in this study there was a positive predictive value of 74 per cent for malignancy if a target lesion was identified. However, tissue samples are still required, since these lesions are also seen with nodular hyperplasia and other benign liver pathologies.

Anechoic masses will frequently be identified, and are associated with hepatic cysts (in cats, these have been associated with polycystic kidney disease), and with biliary cystadenoma (more rarely cystadenocarcinoma) – a type of neoplasia seen particularly in older cats, where single or multiple, often septated, cystic lesions are identified.

Rarely, other neoplasias and haematomas will have a cystic component. A true cyst can be distinguished from a hypoechoic nodule due to its distal acoustic enhancement, since the ultrasound beam is less attenuated as it passes through the fluid of the cyst than the surrounding tissue.

• Interventional procedures

Liver biopsy is carried out either with ultrasound guidance (using a dedicated biopsy needle), or with laparoscopic or surgical techniques.

In all cases, general anaesthesia is required, and the patient should be assessed prior to anaesthesia. In particular, the ability to clot should be investigated, since many chronic liver diseases lead to vitamin K deficiency and clotting disorders.

With any technique, haemorrhage is the greatest risk post liver biopsy, with damage to adjacent organs (in particular, the stomach and gall bladder with ultrasound-guided biopsies), and infection being less frequent complications.

Part two will continue the discussion of methods to image the liver, including ultrasound techniques for the biliary tract and vascular malformations, and advanced techniques such as contrast ultrasound, CT, MRI and scintigraphy.

References

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