ABDOMINAL ULTRASONOGRAPHY: PRACTICE MAKES PERFECT SENSE

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NATALIE WEBSTER discusses scanning techniques and encourages practitioners to add to their skills by having a go.

PERFORMING abdominal ultrasonography can be a daunting prospect, especially on large, panting dogs.

The ultrasound learning curve is steep. However, picking up the probe and having a go is one of the best ways to increase your skills. Practising on your own pets is a useful way to become familiar with manipulating the ultrasound probe and imaging normal structures.

Preparation

Depending on the patient’s temperament, abdominal ultrasound may be performed conscious, sedated or under general anaesthetic. The examination may be performed with the patient in lateral or dorsal recumbency (in this article, lateral recumbency is described with the patient beginning in left lateral and then placed into right lateral recumbency to complete the examination). The patient should be restrained and the ventral abdominal hair clipped. Acoustic gel is applied to the skin to provide an acoustic coupling of the transducer to the patient. If possible, the patient should be fasted so that gastric gas and food content does not interfere with imaging of the liver.

Ultrasound machine
The higher the frequency of a transducer, the better the image resolution. However, the lower the frequency of the transducer, the better the tissue penetration. Therefore, it is important to select the highest frequency transducer available (to maximise resolution) that adequately penetrates to the depth of the liver in the particular patient. In large dogs 5MHz may be necessary; in most medium to small dogs and cats 7-10MHz allows an optimal image (Figure 1a). The depth should be adjusted to include the entire organ that is being examined and care should be taken to adjust the depth throughout the examination to ensure the organ occupies most of the screen.

If the machine allows the selection of multiple focal points, these should be set to optimise the image. Placing focal points deeper in the image allows better resolution of deeper structures, whereas placing the focal points higher on the image will optimise superficial structures (Figure 1b).

Gain settings should be adjusted to create a uniform level of brightness throughout the image. Gain is the amount of amplification applied to the returning ultrasound echoes. The time-gain compensation controls should be adjusted prior to changing the overall gain. In general, reducing the near-field gain and increasing the far-field gain will optimise the image (Figure 1c). Power is basically the volume or intensity of the ultrasound beam entering the patient. Power should be kept as low as possible to reduce distortion of the image.

**Scanning technique**

It is important to have a systematic, thorough method of examining the abdomen. This will prevent organs and structures from being missed from the examination. Many sonographers scan in the order of: liver; spleen; stomach; duodenum; pancreas; kidneys; adrenal glands; bladder; prostate/uterus and ovaries; and sublumbar lymph nodes, followed by a sweep of the remaining intestinal tract and additional abdominal lymph nodes.

Image orientation should follow a standard protocol: sagittal and dorsal scan planes of the abdomen are orientated so that the cranial part of the patient is on the left side of the screen. This is achieved by directing the orientation mark on the transducer cranially. Transverse scan planes are orientated so that the right side of the body is placed on the left of the screen by pointing the orientation mark on the transducer towards the patient’s right. Typically, during abdominal ultrasonography, the indicator on the screen corresponding to the transducer orientation mark is present on the left side of the screen (Figure 1b).

**Liver**

The liver is in the deepest portion of the cranial abdomen and imaging it usually requires the most depth of field and gain. Larger patients may require the use of a lower-frequency transducer to image the liver compared to the remaining abdominal structures. The liver is best imaged by placing the transducer on the ventral midline, directly caudal to the sternum’s xiphoid process.
The liver is first imaged in a sagittal plane using the gall bladder as a point of reference. The probe should be fanned to the left and the right, and tilted cranially and caudally to ensure the entire liver is imaged. It is important to ultrasound up to the very edges of the liver lobes to ensure nothing has been missed. Additionally, imaging the liver from the right intercostal position is recommended as lesions in the right side of the liver may only be visible from this position.

The liver parenchyma is echogenic, homogenous, and of medium texture (Figure 2). Anechoic round and tubular structures will be seen throughout the liver parenchyma representing portal and hepatic veins. Portal veins have walls with increased echogenicity compared with hepatic veins. The gall bladder is located to the right of midline and is seen as variably sized, round, anechoic black structure.

The liver should be examined for masses or areas of reduced or increased echogenicity. Diffuse changes in hepatic echogenicity is difficult to appreciate, especially when beginning ultrasonography. However, the liver should be approximately the same echogenicity as the renal cortex and less than that of the spleen.

• Spleen

The size and position of the spleen can vary greatly. The superficial location and potentially large size means that several sweeps are needed to image the entire spleen. It is vital that the spleen is imaged from the head to the tail and that the cranial and caudal margins are visualised.

The spleen should be imaged in cross section. This often requires rotating the probe to be at cross section to the spleen itself rather than positioning the probe with respect to external landmarks on the patient. If the spleen is large, the tail of the spleen may be present on the right side of the abdomen and should be imaged either from underneath the patient in right lateral recumbency or with the patient in left lateral recumbency.

The head of the spleen should be imaged in every abdominal ultrasound. Failure to do so may result in a splenic mass being missed. The head of the spleen is examined by gently pushing the transducer up under the left costal arch and flattening the angle of the transducer so that the beam is directed up underneath the rib cage along the spleen (Figures 3a, 3b, and 3c). The spleen should be examined closely for any nodules, masses or changes in echogenicity

• Stomach and duodenum

The sonographic appearance of the stomach is extremely variable – depending on size and content. In the near field, the stomach wall is seen as a thin, layered, curvilinear structure. Invaginations of the wall into the lumen represent rugal folds. Gas in the stomach is often present and may obscure parts of the stomach. If the stomach is empty, the rugal folds and crypts produce a striated or spoke wheel pattern, especially in cats. With the transducer at the level of the xiphoid
process, directed in a sagittal body plane, the stomach is seen directly caudal to the liver. Following
the stomach to the left allows examination of the fundus, then the transducer is slowly moved to the
right, allowing examination of the body of the stomach. Following the stomach towards the right will
allow examination of the pyloric antrum and pylorus. Note that the feline pylorus is near midline,
while in dogs the pylorus is on the right side of the abdomen.

The duodenum may be located by following the pyloric outflow tract. However, this may be difficult
in patients with a large amount of gas in the stomach or intestines. The duodenum may be imaged
with the patient in right lateral recumbency by placing the transducer beneath the patient and
pushing upwards (Figure 4a). From this position the right kidney is located in the cranial right lateral
abdomen and gentle pressure is applied. The pressure is removed slowly and, with luck, the
duodenum will slip into the field of view. This approach reduces the amount of gas within the
duodenum.

Another approach is to examine the duodenum with the patient in left lateral recumbency with the
transducer placed on the dorsal right cranial abdomen. The right kidney is located and the
transducer is fanned laterally. The duodenum has a thicker mucosa layer than the rest of the small
intestine and runs in a straight line along the right side of the abdomen from the pyloric outflow to
the caudal flexure (Figures 4c and 4d).

• Pancreas

The pancreas is a challenging organ to locate, especially in overweight dogs. The pancreas is often
poorly marginated and hypoechoic to isoechoic to the surrounding mesentery. In many cases the
pancreas is not seen using ultrasound and a close examination of the region of the pancreas is
performed.

The pancreas is a small, v-shaped organ. The left lobe lies between the greater curvature of the
stomach and the transverse colon, and the right lobe lies in the mesoduodenum, between the
medial surface of the duodenum and the lateral surface of the ascending duodenum. The body of
the pancreas connects the two lobes in the angle of the pylorus and the duodenum.

The left limb of the pancreas is best visualised by examining the area of the cranial left side of the
abdomen. The transducer is positioned to visualise the spleen, stomach and colon in cross section.
The left limb of the pancreas may be found within the area of the triangle formed by these
structures (Figure 4b).

Identification of the duodenum allows identification of the right limb of the pancreas. The duodenum
may be examined from the left or right side depending on preference. However, using the approach
described in Figure 4a will help to reduce the amount of gas in the duodenum. The duodenum is
examined in both longitudinal and cross section, and the pancreas is identified slightly medial to the
duodenum (Figures 4c and 4d). The body of the pancreas connects the left and right limbs of the
pancreas and is located dorsal to the portal vein.

The pancreas is the most difficult abdominal organ to image routinely, and in some patients is not seen at all. Therefore, a complete examination of the region of the pancreas should be part of every abdominal ultrasound, even if the pancreas itself is not identified as a discrete organ.

• **Kidneys**

The kidneys should be examined in both cross-sectional and longitudinal planes. As the kidneys are located fairly superficially, the depth and gain settings can often be reduced, compared to those used for the liver. The kidneys should be evaluated for size, shape and echogenicity. The cortical tissue should be hyperechoic relative to the medulla (which appears hypoechoic) and there should be a distinct demarcation between the two.

The kidneys should be smooth in outline with a thin, hyperechoic capsule. The left kidney is caudal to the stomach, dorsal and medial to the spleen and best visualised with the transducer on the left side of the abdomen caudal to the costal arch. The right kidney is located further cranially than the left and can be more difficult to locate.

Using an intercostal window at the level of ribs 11-13 ([Figure 5a](#)) can aid in the location and examination of the right kidney. Additionally, the right kidney should be examined by positioning the transducer along the right side of the abdomen, caudal to the costal arch in a sagittal body plane and sweeping the beam slowly laterally and medially ([Figure 5b](#)).

• **Adrenal glands**

The adrenal glands can be challenging to identify – especially in large or tense dogs. The adrenals are usually examined from their respective sides ([Figure 5b](#)). The adrenal glands lie cranial to their respective kidneys and examining the area may be used to identify the adrenals. The left adrenal can be identified by following the aorta in longitudinal section cranially to the branching of the left renal artery. The area between the left renal artery and the aorta is examined closely, and the left adrenal is usually identified ([Figure 6a](#)). The right adrenal can be identified by following the caudal vena cava and aorta in longitudinal section, cranially until they diverge (usually at the level of or cranial to the right kidney). Fanning the ultrasound beam medially and laterally at this point will usually reveal the right adrenal ([Figure 6b](#)).

A potential problem when examining the adrenals is visualisation of the left adrenal from the right side and the sonographer mistakenly identifying the left adrenal as the right. This may result in right adrenal masses or pathology being missed.

• **Bladder**
The bladder should be examined in both transverse and longitudinal planes. The bladder should be thin walled with anechoic fluid contents. Care should be taken in interpreting the wall thickness of the bladder when it is small or empty as the walls will be artefactually thickened, which may mimic disease.

Ultrasound-guided cystocentesis of the bladder is a common procedure (Figures 7a and 7b). A simple and cost-effective way to practise ultrasound-guided cystocentesis is to fill a glove with water and practise locating the needle in longitudinal section within the glove. This will allow familiarity with how to position and hold both the probe and syringe, without the concern of practising on a live patient. Another option is to make a “phantom” out of an old drip bag, gelatin and some small structures, such as olives, and practise fineneedle aspiration (Figure 7c).

• **Prostate**

In male dogs the prostate is located by following the neck of the bladder caudally. The transducer is rocked or moved caudally to gain access to the prostate gland. The prostate gland is visualised adjacent to the neck of the bladder as a hyperechoic, homogenous, finely textured organ (Figure 8).

• **Uterus and ovaries**

The uterus and ovaries of nongravid cats and dogs can be difficult to image. The uterus is located dorsal to the bladder and ventral to the colon. The uterus is seen as a long, hypoechoic structure that may be less than 1cm in diameter in dogs and even smaller in cats (Figures 9a and 9b). Normal ovaries in a non-cycling patient may be identified with careful examination of the area caudal and lateral to each kidney (Figure 9c).

• **Small intestines and colon**

The small intestines are too tortuous to trace each loop individually. Therefore, the small intestines are examined by systematically sweeping the ultrasound beam over the abdomen in a sagittal and transverse fashion. The mesenteric lymph nodes are examined at this time.

In conclusion, abdominal ultrasonography can be daunting but, with practice, can become a valued skill. Pick up a probe and have a go today.
Figure 1a. Ultrasound transducers. From left to right: 5MHz phased array transducer (echocardiography and abdominal ultrasound of medium to large dogs); 7MHz phased array transducer (echocardiography and abdominal ultrasound of small dogs and cats); 8MHz broadband tightly curved/convex phased array (abdominal ultrasound of most dogs and cats); 5MHz broadband curvilinear transducer (abdominal ultrasound of large or obese dogs); 12MHz linear transducer (superficial structures and abdominal ultrasound of cats or small mammals).
Figure 1b. An image of the aortic bifurcation of a two-year-old golden retriever. Note the multiple focal points (white arrowheads on right side of image). The depth has been adjusted so that the region of interest fills the screen. The ATL logo at the top left of the image corresponds to the orientation mark on the side of the transducer.
Figure 1c. The time-gain compensation controls (to the right of the image) are positioned to reduce the near-field gain and preserve the far-field gain. Different operators prefer a different level of time-gain compensation.
Figure 2. An ultrasound image of a liver. Note the black structure of the gall bladder (GB), diaphragm and mirror artefact caused by the diaphragm and air-filled lungs.
Figure 3a. The transducer placement for scanning the head of the spleen. In some dogs, gentle pressure and angulation will allow visualisation of the splenic head.
Figure 3b. The transducer placement for scanning the head of the spleen. In deep-chested dogs, however, a firmer pressure and angulation under the costal arch is required.
Figure 3c. An ultrasound image of the head of the spleen.
Figure 4a. The transducer placement for the duodenum and right pancreatic limb. The patient is in right lateral recumbency. The transducer is placed underneath the patient and angled upwards towards the left side.
Figure 4b. The left limb of the pancreas in a dog (arrows) is seen as a poorly marginated, subtle, hypoechoic organ. Using the landmarks of the spleen, stomach and the colon in cross section forming a triangle, the area between them may be examined closely for the left limb of the pancreas.
Figure 4c. A cross-sectional view of the duodenum and right limb of the pancreas (arrows) in a dog. The duodenum is visualised in cross section and the right limb of the pancreas is seen as a sail-like structure medially.
Figure 4d. A longitudinal view of the duodenum and right limb of the pancreas (arrows) in a dog. The duodenum is seen coursing longitudinally across the top of the image. The right limb of the pancreas is seen as a poorly marginated structure medial to the duodenum (obtained by fanning the transducer slightly medially when the duodenum is identified).
Figure 5a. The transducer placement for examination of the right kidney using a right intercostal approach.
Figure 5b. The transducer placement for examination of the right kidney and the right adrenal.
Figure 6a. Left adrenal (arrows) in a dog. The aorta (AO) is seen to the right of the image.
Figure 6b. Right adrenal (arrows) in a dog. The caudal vena cava (CVC) is seen to the right of the image and the right kidney (RK) is seen to the left of the image.
Figure 7a. An ultrasound-guided cystocentesis. The patient is in right lateral recumbency with the syringe held in the left hand and the transducer held in the right hand. Which hand holds the syringe and transducer is of personal preference and whether the patient is in lateral or dorsal recumbency.
Figure 7b. An image of a cystocentesis. Note the needle (arrow) as a hyperechoic linear structure within the bladder.
Figure 7c. An ultrasound phantom constructed from a drip bag, gelatine, olives and glace cherries. The use of a phantom allows risk-free practice of fine-needle aspiration. Another useful phantom is a water-filled plastic glove to simulate cystocentesis.
Figure 8. An image of a normal prostate from a male entire dog.
Figure 9a. A cross-sectional ultrasound image of a non-gravid uterus (arrows) from a female entire dog. Note the position of the uterus between the bladder and the colon.
Figure 9b. An ultrasound image of the same patient as in 9a (above). The ultrasound transducer has been moved slightly cranially to show the uterine horns in cross section (arrows).
Figure 9c. An ultrasound image of the left ovary (arrows) seen caudal to the left kidney (L kid). Note the hypoechoic and poorly marginated appearance of the ovary.