How to perform an abdominal ultrasound.

Ultrasound is a safe and well tolerated imaging technique. It allows evaluation of the size, shape, contour and internal evaluation of organs in a non-invasive fashion. In abdominal imaging it can be used to evaluate all organs, the mesentery, peritoneum and abdominal wall, to determine the origin and extent of abdominal masses and for guiding needle aspirates or biopsies.

**Probe selection**

5-10MHz should be adequate to scan most abdomens in small animal practice. Most common is a 5-7.5MHz curvilinear probe. Deeper dogs need lower frequency for more penetration and smaller dogs and cats can be scanned at 8-10MHz for more detail.

**Control panel**

<table>
<thead>
<tr>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth: Fill</td>
<td>the screen with organ being evaluated</td>
</tr>
<tr>
<td>TGC:</td>
<td>Newer machines set it in the middle, older machines less gain for near field and more gain for further field</td>
</tr>
<tr>
<td>Focal Points:</td>
<td>Position area of interest in the focal point for detail, use up to 2 focal points however increasing focal points above 2 will decrease frame rate and reduce image quality.</td>
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<tr>
<td>Total Gain:</td>
<td>Increasing the gain makes the screen whiter at all depths. Excessive gain increases noise. Reduce gain if possible but don’t lose information by too low a gain. Working in a dark room helps.</td>
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**Patient Preparation**

<table>
<thead>
<tr>
<th>Precaution</th>
<th>Description</th>
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<tbody>
<tr>
<td>Fasting:</td>
<td>To limit the amount of food material and gas in the GIT.</td>
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<tr>
<td>Bladder:</td>
<td>Try to scan with a full bladder if looking for bladder wall lesions. However if too distended can displace abdominal organs cranially.</td>
</tr>
<tr>
<td>Clipping:</td>
<td>Necessary for optimal image quality. Clip close to the skin. Caudal costal arch to pubis. Use alcohol before coupling gel but care to protect probe.</td>
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<tr>
<td>Sedation:</td>
<td>Most abdominal ultrasounds possible without sedation but animals should be kept as stress free as possible. Use quiet clippers and reassure patient. Sedation is sometimes necessary; it reduces panting and allows ultrasound of tense abdomens. Beware of vasodilation, ACP and barbiturates can enlarge the spleen.</td>
</tr>
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</table>

**Ultrasound Image**

- **Echogenicity** or grey level of a tissue is determined by the brightness and concentration of dots on the screen. Each dot represents a returning echo. Fluid is anechoic or black.
- Tissues are variably echogenic. For example the liver is hypoechoic (darker) than the spleen.
- Mineralised structures and air are bright (hyperechoic) as they are the source of shadowing and reverberation artefacts.
- Abnormal areas within tissue parenchyma are described as lesions. They may be detected because of a change in echogenicity, echotexture or distortion of the normal architecture of the tissue.
- Lesions should be described re number, size, definition of margins, echogenicity and echotexture.
Image Quality
Resolution: Lateral and Axial. Both improved at higher frequencies
Penetration: Sufficient penetration is important to fully assess deeper structures.
Artefacts: Common artefacts include
  Shadowing: Beam attenuation by mineral (complete) or gas
  (incomplete or dirty)
  Refraction: Edges of rounded structures
  Reverberation: multiple reflections bouncing back and forth off a highly reflective surface, usually gas.
  Distal enhancement: Seen as a hyperechoic area distal to a poorly enhancing structure (e.g. bladder, gall bladder).
  Mirror Image: Occurs at a highly reflective interface, e.g. diaphragm.
  Can see liver on other side of diaphragm. Beware if looking for a DH.
  Slice thickness: Echoes in bladder mimicking intraluminal lesions.
  Change ultrasound beam angle to assess if real.
  Side-lobes: Display of a side structure as if it is actually in the image.
  Similar to slice thickness in that can mimic intraluminal lesions in bladder. Change probe angle.
Routine: Be as complete and systematic as possible. This routine begins cranially and circles the abdomen.

- Liver
- Stomach
- Spleen
- Left kidney (left ovary)
- Left adrenal gland
- Aorta and vessels
- Bladder, urethra (prostate and uterus)
- Colon
- Intestines
- Right kidney (right ovary)
- Right adrenal gland
- Right pancreas, body of pancreas, left limb

- Sneak peek of thorax/ heart through diaphragm.

Liver

Ultrasonography of the liver should be performed if liver disease is suspected even if there are no radiological abnormalities. The hepatic parenchyma, gall bladder, large hepatic and portal veins and caudal vena cava are all visible.

- The patient should be fasted but given free access to water.
- Place the transducer on the ventral abdomen at the level of the xiphisternum and angle it craniodorsally to image the liver.
- Fan the beam from left to right to span the entire liver.
- If the liver is small, image it through an intercostal approach.
**Ultrasonographic appearance of the normal liver**
- Moderately echoic with a granular appearance
- Lobes smooth in outline and sharply pointed
- Gall bladder is rounded or pear shaped. It can be dilated after prolonged periods of anorexia

Neither the common bile duct nor the intrahepatic bile ducts are usually seen in normal dogs; the cystic and common bile ducts are more commonly seen in cats.
- Portal vein enters the liver at the porta hepatis where it branches into the portal veins. These have echogenic walls and can be distinguished from hepatic veins which are seen as anechoic tubes with no borders
- The liver echogenicity should be compared to that of the spleen and the kidney at the same depth and machine settings. The normal liver is usually slightly more echoic than the renal cortex and less echoic than the spleen.
- The liver often sits on a bed of falciform fat (bright echogenicity)

**Stomach**
Food should be withheld for 12 hours for full assessment of the stomach. Offer water just before the scan as visualisation of the stomach walls are best seen in a moderately fluid distended stomach.

- Probe placed caudal to rib cage in a sagittal plane. Sweep from right to left in a cranio-dorsal direction.
- Deep chested dogs may need an intercostal approach.
- The gastric fundus is seen in left cranio-dorsal abdomen and is recognised by prominent rugal folds when empty. Follow the greater curvature ventrally and to the right and examine the body and the antrum. The pylorus and cranial duodenal flexure are caudal to the liver hilus and ventral to the portal vein.
- Excessive gas in the stomach makes imaging of deeper stomach structures difficult, so use positional ultrasonography or offer water.

The stomach wall has 5 different layers
- Hyperechoic serosa coating the outside of the stomach.
- Hypoechoic muscularis
- Hyperechoic submucosa
- Hypoechoic Mucosa
- Hyperechoic luminal-mucosal interface

Normal wall thickness is 3-5mm in dogs (between the rugal folds). Cats < 2mm.
A normal stomach (containing some food) should contract 3-4 times per minute. If empty can be quieter and if recently fed may be more active.

**Spleen**
- The head of the spleen is located in the left cranio-dorsal abdomen and is often located within the rib cage. After this has been imaged place the probe in transverse and follow the spleen down to the hilus and then the caudal extremity. Often difficult to image the entire spleen so
adopt a meandering probe technique, constantly moving the probe to visualise the entire spleen.

- The splenic parenchyma is homogenous and of a fine echotexture. It is covered by a thin, very hyperechoic capsule. It is **hyperechoic** to liver and renal cortices.
- Branches of the splenic vein are seen as tubular anechoic structures within the parenchyma and exit the spleen at the hilus. Splenic arteries are not usually seen.

**Left Kidney**

Best seen with patient in right lateral recumbency and from a left lateral approach. Also possible to scan from a ventro-lateral approach. Kidneys should be scanned from cranial to caudal and lateral to medial, in several transverse and longitudinal planes.

- Kidneys are typically bean shaped in dogs and oval in cats. Kidney length variable in dogs and in cats typically measure between 3.0cm and 4.3cm.
- Renal medulla is hypoechoic in comparison to renal cortex, which is hypoechoic to liver and spleen.
- A hyperechoic renal cortex can also be seen in dogs with normal renal function.
- Medulla separated into almost anechoic segments by interlobar vessels and diverticuli.
- Walls of arcuate arteries are seen as paired, short, hyperechoic lines at the corticomedullary junction, can generate an acoustic shadow and don’t mistake them for mineralisation.
- The cortex should be about twice the depth of the medulla and they should be easily distinguished (good corticomedullary definition).
- The renal pelvis is surrounded by the sinus which is hyperechoic (contains fat). The normal renal pelvis should be no greater than 2mm in height. Sometimes it is seen in normal animals if diuresed or on intravenous fluids.

**Left Adrenal Gland**

Clip hair from the lateral abdomen to the transverse processes of the lumbar spine, may have to go over last ribs for right adrenal.

- High frequency probes useful for more detail. Linear transducer good for left adrenal but not typically for right adrenal.
- Sedation useful as can allow more probe pressure and animal to relax especially if obese.
- Left adrenal gland is hypoechoic to surrounding fat, and has an elongated bilobed shape (peanut shape).
- Find the aorta, then the renal artery, the left adrenal is located just cranial to the origin of the renal artery. The phrenicoabdominal artery and vein pass the mid-body of the gland. The coeliac and cranial mesenteric arteries are also a useful landmark. Rotate probe until full length of adrenal gland is appreciated.
- Measure the maximum diameter of the caudal pole. It should be no bigger than 0.74cm.

**Ovary**

Intact bitches. Easier to find if in oestrus.
• Located caudally and laterally to the poles of the kidneys.
• Oval and measure approximately 2cm long in bitches.
• Appearance varies depending on time of cycle. Approximately 4 follicles/CLs can be seen on each ovary in prooestrus and oestrus.
• Hard to predict time of ovulation with ovarian size in the bitch.

**Uterus**
Hard to find healthy, non-gravid uterus in dogs.
• Uterine body is a tubular structure in caudal abdomen between urinary bladder and descending colon.
• Horns very hard to see unless gravid or a pyometra.
• Pregnancy:- Gestational sac can be seen from day 20. In practice can be seen a bit earlier. Embryo and flickering heartbeat can be discerned from day 23-25.

**Bladder and Urethra**
Clip the hair to the level of the pubic bone. Use 7.5-10 Mhz probe depending on size of patient.
• Can scan the bladder in dorsal, left or right lateral recumbency.
• A standing position can be useful in confirming the presence of calculi as they will fall towards the gravity-dependent wall.
• Scan in transverse and longitudinal planes
• Bladder should be moderately distended as bladder wall thickness increases if bladder is empty.
• Normal urine is anechoic. Echogenic urine can also be within normal limits, however urinalysis should be used to determine significance.
• Normal bladder wall is smooth apart from uretral papilla which can be seen extending from bladder wall and should not be confused as focal thickening. Can use colour flow doppler to check for uretral jet.
• Side-lobe artefacts can be confused as sludge.
• Only some of urethra can be visualised with ultrasound, use retrograde positive contrast ultrasound for visualising pelvic urethra.

**Prostate**
In male dogs the prostate surrounds the proximal urethra. More detail if use higher frequency probe.
• Prostate is of medium echogenicity and homogenous with medium echotexture and smooth margins.
• In neutered dogs ultrasound of the prostate can be challenging. It is small, inconspicuous, hypoechoic and homogenous.
• Age related changes in intact dogs include an increase in size and echogenicity.

**Aorta and Medial Iliac Lymph nodes**
Use a left lateral flank approach as aorta is closer to the probe and the colon is out of the way. Use a high frequency probe for more detail.
• Use both longitudinal and transverse planes.
• Routine use of colour and spectral Doppler is advised in thorough vascular ultrasonography.
• Branches from cranial to caudal: Coeliac artery, cranial mesenteric artery, renal arteries, external iliac arteries.
• Highly echogenic blood and turbulence should be investigated further.
• The medial iliac lymphnodes are the easiest to find in the abdomen. The left medial iliac lymphnode (LN) is adjacent to the left lateral aspect of the abdominal aorta and the origin of the left external iliac artery. The right medial iliac LN is easier to find as it is positioned on the ventro-lateral aspect of the caudal vena cava and the right common iliac vein.

Colon
The descending colon is found easily on the left side of the doro-caudal abdomen. Follow it cranially through the transverse and ascending colon to the ilio-colic junction.
• Appearance varies depending on content.
• Gas and faeces are hyperechoic typically with distal acoustic shadowing and/or reverberation artefacts.
• When distended the wall is very thin (1-2mm thick), when empty the wall collapses and can appear thick and irregular with a multi-layered crumpled appearance.

Ilio-colic junction is difficult to find in dogs because of gas in the caecum. It is easier to identify in cats and should be examined as it is a site for intestinal lymphoma. It has a “wagon-wheel” appearance.

Small Intestines
Withhold food for 12 hours prior to ultrasound exam. Allow free access to water. Shadowing and gas can be a problem so use positional ultrasonography. Use high frequency probes for detail of layers.

Normal anatomy: Layers
➢ Luminal interface - Hyperechoic
➢ Mucosa (widest layer) – Hypoechoic
➢ Submucosa- hyperechoic
➢ Muscularis – hypoechoic
➢ Serosa – hyperechoic

• Assess for overall layering, thickness, echogenicity of each layer and individual width of each layer. Note if changes are focal or generalised.
• Assess for motility (regional and general).
• Assess if luminal diameter is increased generally or proximal to a lesion.

Luminal Patterns
• Mucous pattern: empty bowel, mucus in lumen, seen as hyperechoic band.
• Gas pattern: reverberation/ shadowing artefact, moves with peristalsis
• Fluid pattern: anechoic luminal pattern, good for seeing wall
• Food particle pattern: echogenic, no shadowing (unless bone fragments).

Duodenum
• The descending duodenum can be identified ventral to the right kidney. It is usually the most laterally located loop in this region and appears straight.
• Sometimes can identify it after finding the pylorus and cranial flexure.
It measures <6mm but depends on size of the dog. In cats the average is 2.4mm. Measurements are made from Lumenal-mucosal interface to serosa.

Duodenum is thicker than the rest of the SI (due to thicker mucosal layer).

Motility: 4-5 contractions per minute

Jejenum and proximal ileum

Seen throughout the abdomen as continuous loops of small intestine

Thickness up to 4.7mm in the dog.

Motility: 1-3 contractions per minute.

Pancreas

A boomerang-shaped organ with a body, left limb and right limb. In dogs the right limb is larger than the left. In cats it is vice versa.

The pancreatic parenchyma is difficult to identify. Use a high frequency probe.

- Normally iso-hypoechoic to surrounding mesenteric fat. Normal pancreas has a homogenous, fine, granular echotexture with smooth borders.
- Position the animal in right lateral recumbency. Keeping probe parallel to the table and underneath the patient, apply gentle pressure, find right kidney, pull back slightly, see duodenum. Right limb of the pancreas sits between right kidney and duodenum.
- Left limb of the pancreas is caudal to stomach, cranial to the colon and medial to the spleen.
- The body of the pancreas is ventral to the portal vein and caudal to pyloric canal.
- Pancreatico-duodenal vein is a useful landmark, it is embedded in the parenchyma of the right limb.

Right kidney and right adrenal

- The right kidney is more difficult to visualise than the left as it sits partially under the rib cage and may be obscured by gas.
- A right lateral intercostal approach is sometimes necessary.
- The right adrenal gland is more cranially positioned than the left. It lies cranial to the right renal artery, medial to the cranial pole of the right kidney and in close apposition to the dorsal surface of the caudal vena cava.