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ABDOMINAL ULTRASOUND

Veterinary Abdominal Ultrasound: Basics, Technique and Normal Values (PDF)

A veterinary abdominal ultrasound is several skills stacked on top of each other, and most guides teach only one of them. Inside: 24 labelled figures, 13 reference tables and a 37-question self-test.

Contents

The 15 sections of this guide, in order.

IN SHORT

A **veterinary abdominal ultrasound** is several skills stacked on top of each other, and most guides teach only one of them. This one runs the whole stack: **how the machine makes the picture** (and therefore which knob fixes which problem — frequency, depth, gain, power, TGC, focus); **how to prepare and position the patient**; **a repeatable organ-by-organ sequence** so nothing is missed; **what normal looks like** in dogs and cats, with the **actual measurements** rather than adjectives; and **which things on the screen are artefacts** rather than findings. Illustrated throughout with labelled ultrasound images and anatomical plates. Free printable quick-reference PDF included.

KEY POINTS

1. **Every artefact is a broken assumption.** The machine assumes sound travels in a straight line, at a constant 1540 m/s, and only along the main beam. Break one of those and you get a shadow, a mirror, a duplicate or false sediment.
2. **Gain and power are not the same control.** Gain amplifies echoes after the fact; power is the energy going into the patient. Use the least power that works.
3. **A dark far field is a TGC problem, not a gain problem.**
4. **Start with the liver** — the deepest organ — then reduce depth, power and gain as you work caudally.
5. **Scan the same sequence every time**, whatever the referral question. Missed splenic disease is almost always a sequence failure, not a knowledge failure.
6. **Find the vessel, then the gland.** The left adrenal sits on the aorta, the right on the caudal vena cava; the portal vein is dorsal to the body of the pancreas.
7. **Cats are not small dogs.** Bilobed gallbladder, thick falciform fat, an echogenic renal cortex, a spoke-wheel stomach and visible ileocecocolic nodes are all normal in the cat — and reading them with canine expectations produces confident diagnoses of disease that is not there.
8. **Canine kidney size is a ratio, not a length** — kidney : aorta 5.5–9.1.
9. **For lymph nodes, shape beats size.** A short : long axis ratio above 0.7 is a feature of malignancy — but not in the jejunal node.
10. **Non-visualisation of the pancreas rules out a mass and nothing else.**

About the images

The ultrasound images, transducer-placement photographs and labelled anatomical diagrams are reproduced for educational reference from *Small Animal Diagnostic Ultrasound*, 4th ed. (Mattoon, Sellon & Berry, Elsevier) and *Abdominal Ultrasound in Cats and Dogs: An Illustrated Reference Value Guide* (Meirelles & Aguillera). Each figure is credited beneath it; copyright remains with the original authors and publishers. Every measurement quoted in the reference tables comes from the latter.

Most people learn **veterinary abdominal ultrasound** the same way: someone shows you where to put the probe, you copy them, and for about six months you produce grey pictures you cannot quite interpret. The missing piece is almost never anatomy. It is that nobody explained *how the machine turns sound into that picture* — which is what tells you which knob to reach for when the image is wrong, and which of the things on screen are not in the patient at all.

So this guide is built as a stack, and it is the part of **veterinary ultrasound basics** that usually gets skipped. First the physics you actually use, then the machine settings that follow from it, then patient preparation and orientation, then a scanning sequence you can repeat on every patient, then what normal looks like organ by organ — *with numbers* — and finally the artefacts. If you already scan confidently, the normal-measurement tables and the cat-versus-dog differences are probably what you came for.

It assumes you know the regional anatomy; if that is shaky, read our dog abdominal anatomy guide alongside this, because ultrasound is more dependent on anatomical knowledge than any other imaging modality — you cannot recognise what you cannot name.

01 What abdominal ultrasound can and cannot tell you

Ultrasound gives you **cross-sectional, real-time, non-ionising** imaging of the peritoneal cavity, the great vessels, the abdominal viscera and the lymph nodes, usually without sedation and with no confirmed adverse biological effects at diagnostic settings. It shows internal architecture that radiography cannot — layering in a gut wall, the corticomedullary junction of a kidney, the contents of a gallbladder — and it shows movement, which is why peristalsis and blood flow are available to you and not to a radiograph.

What it does not do is see through gas or bone. Every practical difficulty in an abdominal scan comes back to that single limitation: the gut is full of gas, the ribs are in the way of the cranial abdomen, and the patient may be panting. Radiography and ultrasound are complementary for exactly this reason, not competitors.

The honest limitation to state up front

Ultrasound is *operator-dependent* in a way radiography is not. A radiograph is a permanent record that a second person can re-read; an ultrasound examination is a series of decisions about where to point a beam, and the images you save are only the ones you chose to look at. That is why a fixed sequence matters so much, and why "normal scan" from an inexperienced operator carries less weight than it sounds like it does.

02 How the picture is made — the physics you actually use

You do not need the mathematics. You need four ideas, because every image problem and every artefact in this article traces back to one of them.

One: the image is built from reflections at interfaces. The probe sends a pulse and listens. Wherever the beam crosses a boundary between tissues of different **acoustic impedance**, some energy comes back. A big impedance mismatch sends back a lot — at a soft-tissue-to-gas boundary about **99%** of the beam is reflected, which is why gas is an impenetrable wall and not merely an inconvenience.

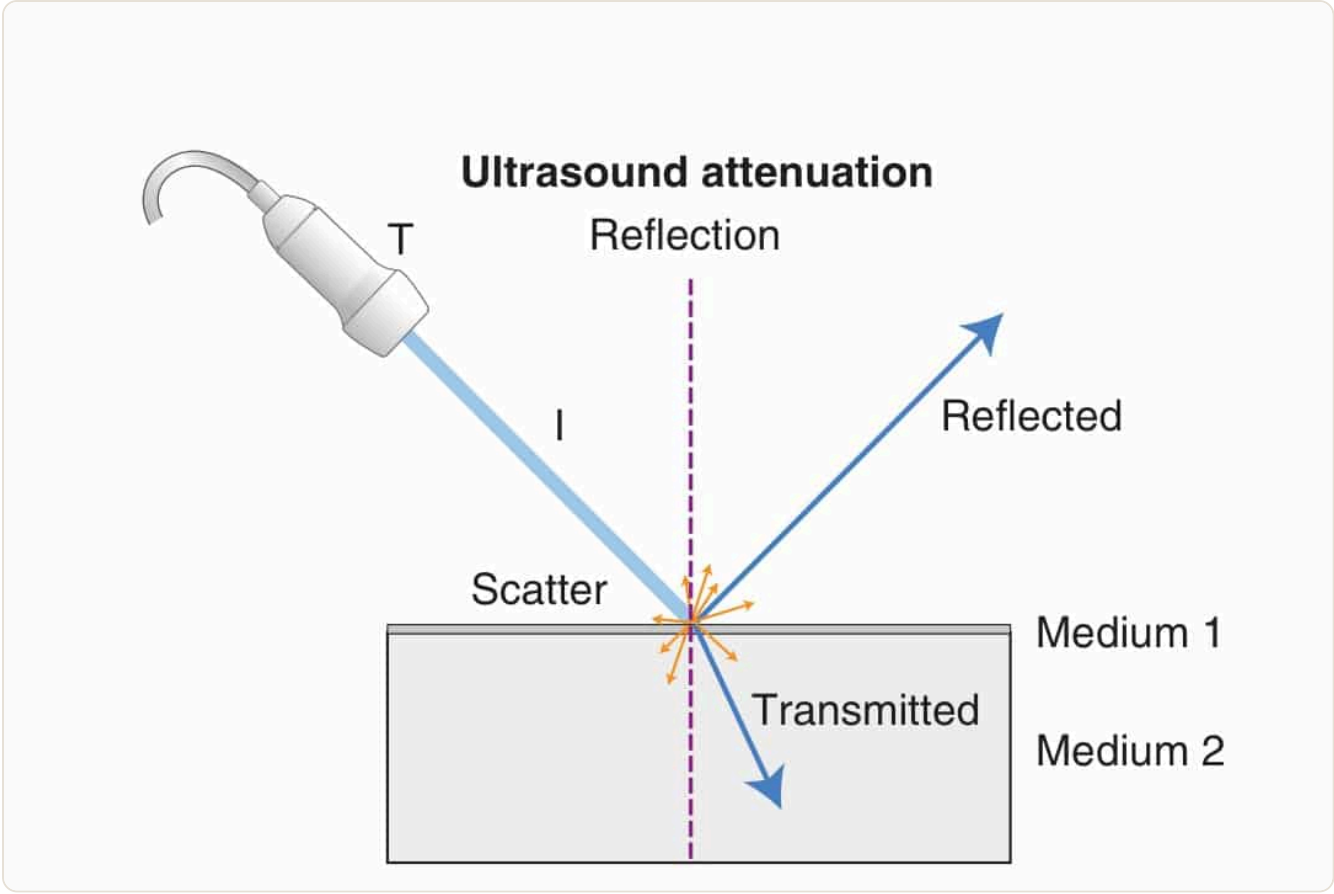

Fig 1 — What happens when the beam meets an interface. Three things at once: part of the beam is **reflected** straight back (this is what builds your image), part is **transmitted** onward but bent — **refracted** — because the two media conduct sound at different speeds, and part is **scattered** in all directions. Refraction is not an academic detail: it is the direct cause of edge shadowing and of the duplication artefacts later in this article.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 1.43. Reproduced for educational reference.

Two: depth is paid for in resolution. Higher frequencies resolve finer detail and are absorbed faster. Attenuation runs at roughly **0.5 dB/cm per MHz**, and that is over the *round trip* — out to the reflector and back again — so a 10 MHz beam loses energy ten times faster per centimetre than a 1 MHz beam. Every transducer choice you make is this trade, and the correct answer is always *the highest frequency that still reaches the far side of your target*.

Three: the machine makes four assumptions, and every one of them is sometimes false. It assumes sound travels in a straight line; that it travels at a constant **1540 m/s**; that echoes come only from the main beam; and that echo strength reflects the tissue's real reflecting properties. *An artefact is simply one of those four assumptions being violated.* Once you hold that sentence, the artefact section stops being a list to memorise and becomes something you can derive.

Four: brightness is relative, always. There is no absolute unit of echogenicity. Every description is a comparison — and if you do not say what you compared with, you have not said anything.

TERM	WHAT IT MEANS ON SCREEN	TYPICAL EXAMPLE
Anechoic	Black. Nothing came back — the structure did not reflect the beam	Urine in the bladder, bile in the gallbladder, blood in a vessel, a simple cyst
Hypoechoic	Darker than the tissue you are comparing it with	Renal medulla against renal cortex; a normal adrenal gland; most lymph nodes
Hyperechoic	Brighter than the comparison tissue	Normal spleen against liver; renal cortex against medulla; the submucosal layer of gut
Isoechoic	The same brightness, so the border disappears	Falciform fat against liver in a cat — the classic trap

TERM	WHAT IT MEANS ON SCREEN	TYPICAL EXAMPLE
Echotexture fine or coarse, uniform or not	The size and spacing of the speckle, judged separately from brightness	Spleen is **finer** than liver. Say "heterogeneous echo*texture*" or "heterogeneous echo*genicity*" — never just "heterogeneous", which tells the next reader nothing

The vocabulary trap

"Heterogeneous" on its own is not a finding. Echogenicity (how bright) and echotexture (how coarse the speckle) vary independently, and a report that does not separate them leaves the next reader guessing. Write *heterogeneous echotexture* or *heterogeneous echogenicity*, and name the reference tissue.

03 Setting the machine up: the six controls that matter

Modern machines have presets, and a preset is a reasonable starting point — selecting "cat abdomen" loads sensible defaults for a cat or similarly sized small dog. But a preset cannot know what you are looking at, and the difference between a diagnostic study and a grey blur is usually three or four deliberate adjustments.

CONTROL	WHAT IT ACTUALLY DOES	HOW TO SET IT
Frequency i.e. which transducer	Higher frequency buys resolution and costs penetration. Attenuation runs at roughly **0.5 dB/cm per MHz over the round-trip distance**, so every extra megahertz is paid for in depth	Pick the **highest frequency that still reaches the far side of the liver** in that patient. Large dogs may need **5 MHz**; most medium and small dogs and all cats do well at **10–11 MHz or higher**. An 8–10 MHz curved array images well to about **8 cm** — which covers every cat and small dog abdomen
Depth field of view	How far into the patient the screen represents	The whole organ in the picture — and not much more. In a 40 lb dog the liver needed **8 cm**; 5 cm cut off its dorsal part, and 15 cm shrank it into the top third of the screen, throwing away most of the pixels you paid for
Gain	Amplifies echoes **after** the image has been formed — it is post-processing. It cannot recover information that never came back	Enough for a uniform grey scale, no more. Turn it **down** for the bladder and for the superficial feline spleen
Power acoustic output	The intensity of the beam going **into** the patient — the volume knob rather than the amplifier	The **least** that works. Power is the setting with a biological cost (mainly heat), and it distorts the image too. Pictures are better when neither power nor gain is at maximum
TGC time-gain compensation	Gain applied per depth, to undo attenuation. The curve on the right of the screen shifts **left** for less gain at that level and **right** for more	**Pull the near field down; hold or lift the far field.** Correct TGC gives the same brightness from top to bottom. Do not fix a dark far field by winding up overall gain — that brightens everything, including the noise
Focal zone	Where the beam is narrowest, and therefore where lateral resolution is best	Put it at your area of interest. Multiple focal points sharpen more of the image but **drop the frame rate** — which matters for anything that moves

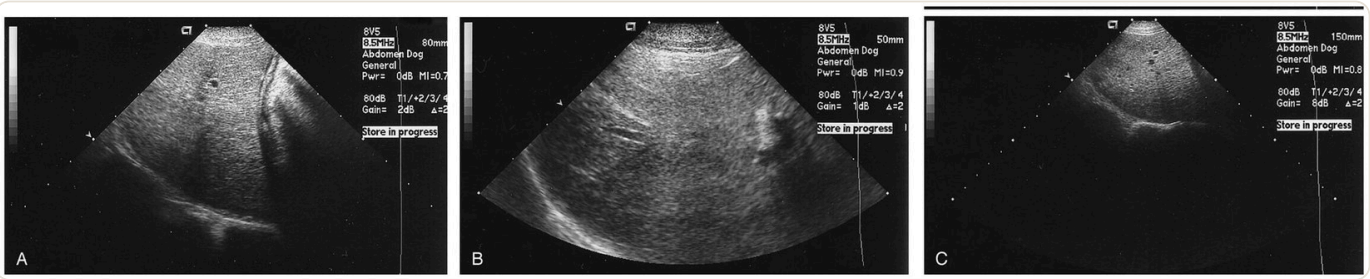

Fig 2 — Depth of field, in a 40 lb dog. A — correct: the whole liver is in the field of view, which needed **8 cm**. **B** — too shallow at 5 cm: the dorsal liver is simply not in the picture, and whatever is there cannot be reported. **C** — too deep at 15 cm: the liver now occupies only the top third of the screen, so you have thrown away two thirds of your pixels and made every subtle change harder to see. Depth is not a safety margin — too much of it costs you resolution where you need it.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 4.5. Reproduced for educational reference.

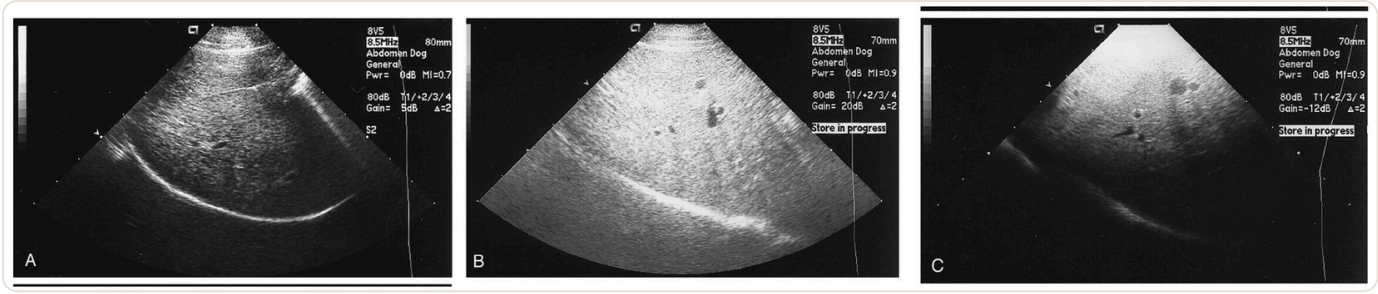

Fig 3 — Time-gain compensation, and the two ways to get it wrong. A — correct TGC: the grey scale is uniform from near field to far field. Overall gain is only 5 dB; the near-field part of the curve is shifted left to cut brightness and the far field shifted right to boost it. **B** — overall gain raised to 20 dB with the TGC curve untouched: the whole image is uniformly too bright. Note that this is *not* a TGC error; it is the wrong control being used. **C** — genuine TGC error: the top third has been over-boosted, the middle is correct and the far field is nearly anechoic — and overall gain is actually **−12 dB**, which shows how completely a bad TGC curve can hide a sensible gain setting.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 4.6. Reproduced for educational reference.

The single most useful habit

When the image looks wrong, ask *which* part looks wrong. Uniformly too bright or too dark → overall gain. Bright at one depth and dark at another → TGC. Blurry only in the far field → frequency too high, or the focal zone is in the wrong place. Nothing visible at all beyond a bright line → gas, and no setting will fix it — move the probe.

04 Preparing the patient

Preparation is where most avoidable non-diagnostic scans are lost, and none of it is technically difficult.

STEP	WHAT TO DO	WHY IT MATTERS
Fast the patient	Wherever the case allows it	A stomach full of food, gas or sheer bulk sits between you and the liver. Gas is the single commonest reason an abdominal scan is non-diagnostic
Do not let them urinate first	If the urinary tract is the question	Wall thickness can only be judged in a **distended** bladder. An empty bladder has an artefactually thick wall that both mimics and masks disease
Clip generously	A No. 40 blade, from the costal arch cranially to the inguinal region caudally, and out laterally along the body wall	Thin- or short-coated patients may only need wetting. Too small a clip is exactly what stops you reaching an **intercostal window** at the moment you need one
Plenty of gel	Over the whole clipped area, applied by hand or with the probe	Gel *is* the acoustic coupling. A film of air between probe and skin reflects almost the entire beam and you see nothing
Position	Dorsal recumbency on a padded or V-trough table is the usual choice; lateral recumbency and standing both work well	Standing is genuinely useful for giant breeds, for large-volume effusion, and to make gravity-dependent sediment or calculi move so you can tell them from a fixed mass
Sedation — usually unnecessary	If you must sedate: **avoid morphine and its derivatives**, and **avoid xylazine**	Opioids cause panting and aerophagia and fill the gut with air; xylazine causes gastric atony with rapid gas accumulation. Either one sabotages the study you sedated for

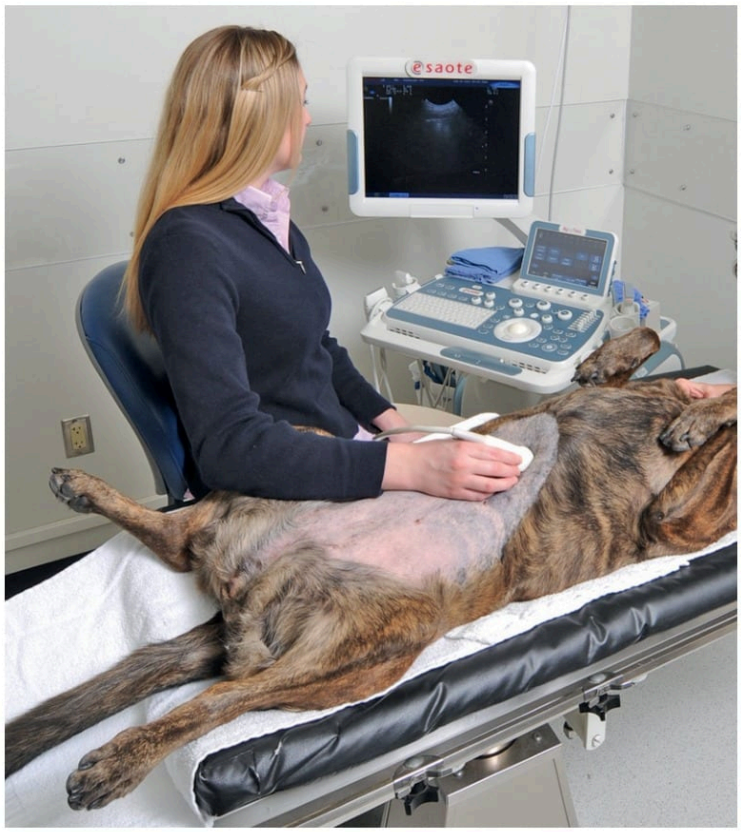

Fig 4 — Positioning the sonographer, the patient and the machine. This looks like a detail and is not. For a right-handed sonographer the patient goes on your **right**, the machine **in front of you** and within reach, so the probe is in the right hand and the left hand is free for the controls. The point is that you face the screen. Scanning while turned toward the patient and looking sideways at the monitor causes neck and shoulder fatigue and spasm, and is a recognised route to cervical nerve injury over a career.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 4.1. Reproduced for educational reference.

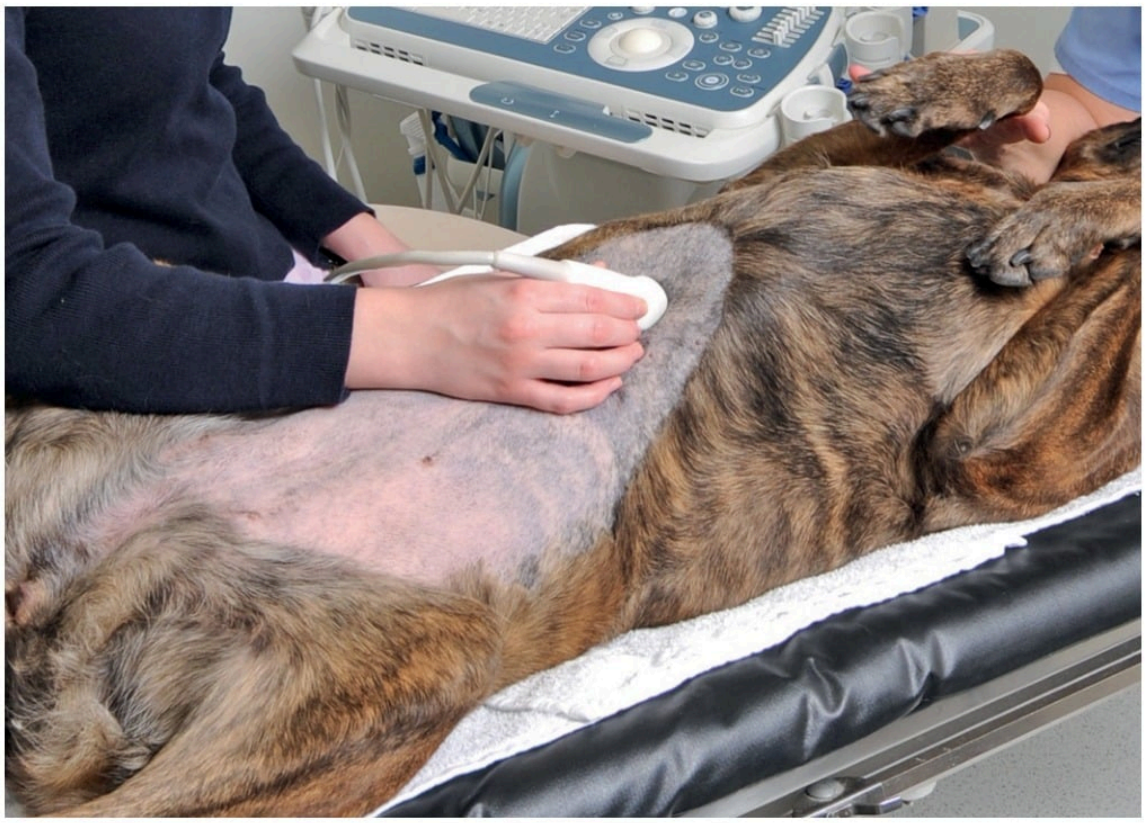

Fig 5 — Dorsal recumbency in a padded V-trough. The commonest position for a routine abdominal study, and this patient needed only minimal physical restraint. A **shallow** V-trough with a thin pad is better than a deep foam one, because a deep trough blocks the lateral probe access you will want for the spleen, the left kidney and any intercostal window. Note the generous clip. Lateral recumbency and standing are both legitimate alternatives — and in a *potentially unstable* patient, dorsal recumbency should be avoided altogether.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 4.2. Reproduced for educational reference.

05 Orientation, image planes and probe movements

Image orientation is a convention, and the convention exists so that anyone can pick up your saved images and know which side they are looking at. It matches radiography deliberately.

PLANE	WHERE THE PROBE MARKER POINTS	WHAT SITS ON THE LEFT OF THE SCREEN
Sagittal and **dorsal**	Cranially, toward the thorax	**Cranial.** Caudal is to the right — the same way you read a lateral radiograph
Transverse short axis, cross-section	To the patient's **right** — that is, toward you when you stand on their right	The patient's **right** side — the same way you read a VD radiograph

If the indicator mark on your screen is on the right instead of the left, most machines will flip the display electronically — do that once, at the start, rather than mentally reversing every image for the rest of the study.

Three movements do all the work, and they are worth naming because they get confused constantly.

MOTION	WHAT YOU DO	WHEN YOU NEED IT
Slide a distance motion	The probe travels along the body wall — cranio-caudal, side to side, or dorso-ventral	Covering a large organ. The canine spleen usually needs two or three overlapping longitudinal sweeps because it is wider than the field of view

MOTION	WHAT YOU DO	WHEN YOU NEED IT
Fan or rock non-distance, angular	The contact point stays put and the beam angle changes	Sweeping through the whole thickness of an organ, and reaching under the costal arch for the cranial liver in a deep-chested dog. In a small patient this often replaces sliding entirely
Rotate non-distance, rotational	Turning the probe on its own axis, often by only a millimetre or two	Getting a small structure into true long axis before you measure it. Off-axis error is directional and cuts both ways: a **length** taken off-axis reads short, while a **wall** cut obliquely reads thick

Scan the screen, not the patient

The single most useful technical tip for a beginner: when you follow a long organ such as the spleen, *watch the monitor and let your hand follow the image*, rather than watching your hand travel across the abdomen. Sonographers who look at the patient lose the organ; sonographers who look at the screen keep it.

06 The tour: a repeatable sequence

Any consistent sequence is better than an inconsistent one, because the purpose is not elegance — it is that you cannot skip something you always do. The order below is widely used, and it has an internal logic: the liver is the deepest and largest organ, so you set depth, power and gain at their maximum requirement and then reduce as you work caudally.

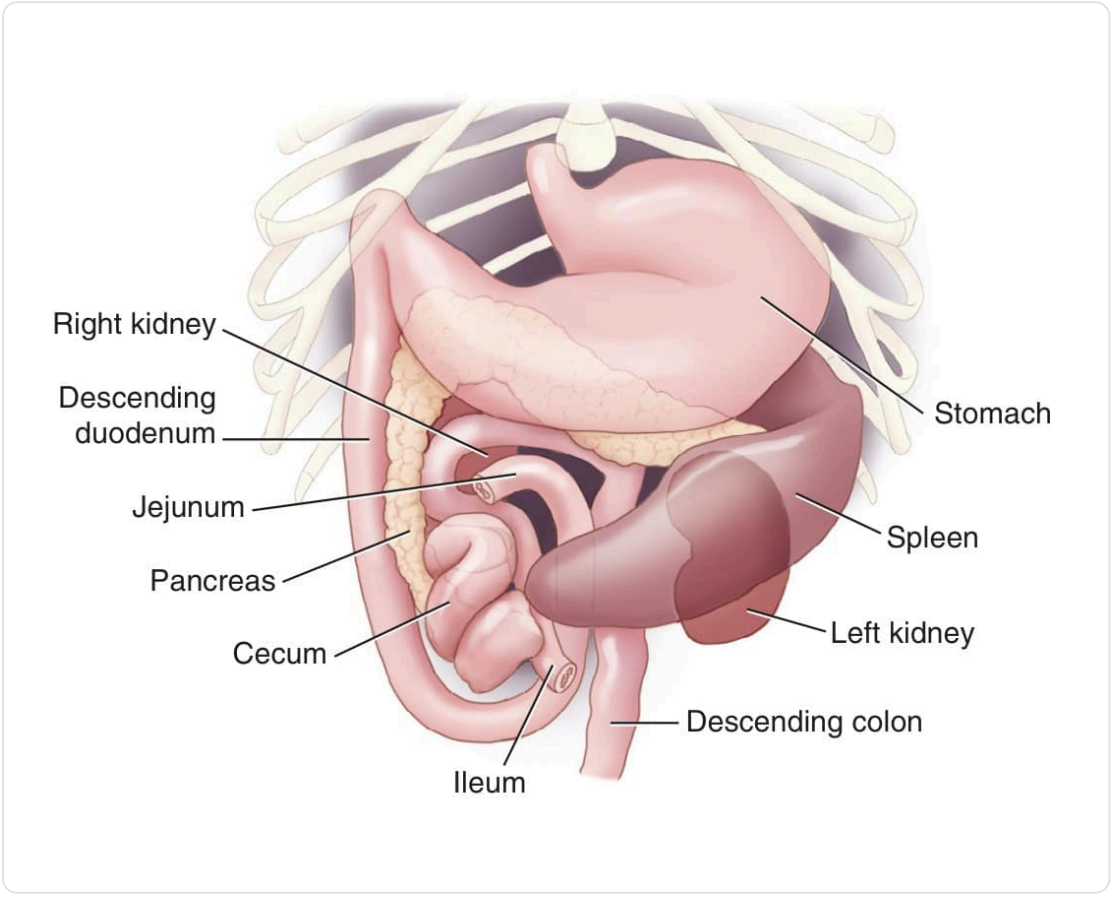

Fig 6 — The map you are scanning. Every landmark in the sequence below is on this one plate: the **stomach** lying across the cranial abdomen, the **spleen** down the left, both **kidneys** dorsally, the **pancreas** draped between the greater curvature of the stomach and the duodenum, and the **descending colon** running down the left toward the pelvis. You navigate by relationships rather than by a whole picture, because you never see more than one slice at a time — which is why what you actually hunt for is the **landmark**, not the organ.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 4.18. Reproduced for educational reference.

ORDER	STRUCTURE	WHERE THE PROBE GOES, AND WHAT YOU ARE CHECKING
1	**Liver & gallbladder**	Ventral midline just caudal to the **xiphoid**, marker cranial. The bright curved **diaphragm–lung interface** is your cranial landmark. Divide the liver into near, mid and far thirds and re-optimise for each. Then move right of midline for the gallbladder, and use a **right intercostal window** for the right liver, porta hepatis, bile duct, portal vein, caudal vena cava and aorta
2	**Spleen**	Head of the spleen along the **left** body wall, then follow the body and tail across the abdomen. It is superficial: drop the near-field gain, use a shallow depth (4–5 cm dog, 2–3 cm cat), and a light touch
3	**Stomach & duodenum**	Caudal to the liver. Follow the body round to the **pyloric antrum**, then into the descending duodenum — in the dog, the most lateral small-intestinal loop on the right. A right intercostal approach rescues deep-chested and brachycephalic patients
4	**Pancreas**	Not found by scanning where you think the pancreas is, but by finding its **landmarks**: the left lobe between the greater curvature of the stomach and the transverse colon; the right lobe in the mesoduodenum between duodenum and right kidney; and the **portal vein** lying directly dorsal to the body of the gland
5	**Kidneys**	Left kidney through the **spleen**, used as an acoustic window. The right kidney is more cranial and dorsal and often needs an intercostal approach in deep-chested dogs. Scan each in **three** planes: sagittal, transverse and dorsal
6	**Adrenal glands**	The **dorsal** plane finds them most reliably. Left gland lateral to the **aorta**; right gland against the lateral wall of the **caudal vena cava**. Find the vessel first, then the gland — not the other way round
7	**Urinary bladder**, then prostate	Caudal abdomen cranial to the pubis, sagittal then transverse. Gain **down**. Check the cranioventral wall, the dorsal wall and the trigone as three separate jobs. The prostate is a caudal continuation of the same sweep
8	**Medial iliac lymph nodes**	Dorsal plane over the **aortic trifurcation**, using the bladder as a window. These are the most consistently identifiable abdominal nodes and the ones you will be asked about
9	**Remaining intestine & other nodes**	A systematic sweep of every quadrant, sagittal then transverse, cranial to caudal — judging diameter, wall thickness, layering, luminal contents and peristalsis

Two windows worth practising deliberately

The **right intercostal window** is the answer to a deep-chested dog: from it you can reach the right liver, the gallbladder, the pyloroduodenal junction, the proximal duodenum, the body and right lobe of the pancreas, the bile duct, the portal vein, the caudal vena cava and the aorta — which is to say, most of the structures beginners find hardest. The second is **standing**: it uses gravity as a diagnostic tool, letting you separate mobile calculi and clots from adherent masses.

07 Organ by organ: what normal looks like

Liver and gallbladder

Normal hepatic parenchyma is **echogenic, homogeneous and of medium echotexture**, threaded with anechoic round and tubular vessels. Distinguishing those vessels is a small skill with a large payoff: **portal veins have more echogenic walls** than hepatic veins, because their walls contain thicker, less organised connective tissue. In the dog the portal veins dominate the hepatic background; in the cat neither is as prominent, but the portal veins are still the brighter-walled pair.

Cranially the liver is bounded by an intensely bright curved line. Call it the **diaphragm–lung interface** rather than "the diaphragm", because it is an interface and not the muscle: you only see the true diaphragm, and its thickness, when there is *both* pleural and peritoneal effusion outlining it. Do not just study the parenchyma — examine the **margins** for protruding nodules and surface irregularity, the **porta hepatis**, and the contour of that diaphragmatic line.

Identify the gallbladder on *every* examination. It is round or oval, anechoic, thin-walled, and shows strong distal **acoustic enhancement**. Position varies. Follow its neck into the cystic duct where you can; the **bile duct is ventral to the portal vein**, and the caudal vena cava lies dorsal and to the right of the portal vein — a three-structure relationship worth committing to memory, because it is how portosystemic shunts are hunted.

Falciform fat: the mistake that gets a normal liver biopsied

Falciform fat lies in the near field between the peritoneum and the ventral liver. In *most* cats it is thick — in lean cats as well as obese ones — and it can be hypoechoic, isoechoic or hyperechoic to liver, usually with a coarser texture. The thin echogenic **capsule** separating them is your landmark, and in cats it is subtle. Two errors follow from missing it: reporting hepatomegaly that is not there, and aspirating fat while believing you are sampling liver.

Spleen

The spleen is **hyperechoic to liver with a finer texture**, and it is superficial. In the dog its size and position vary greatly because it is a blood reservoir; only the head is reliably where you expect it, along the left body wall. Because the sector is usually narrower than the canine spleen is wide, plan on **two or three overlapping longitudinal sweeps** rather than one pass, and keep a known margin in view throughout each sweep so you know which strip you have covered.

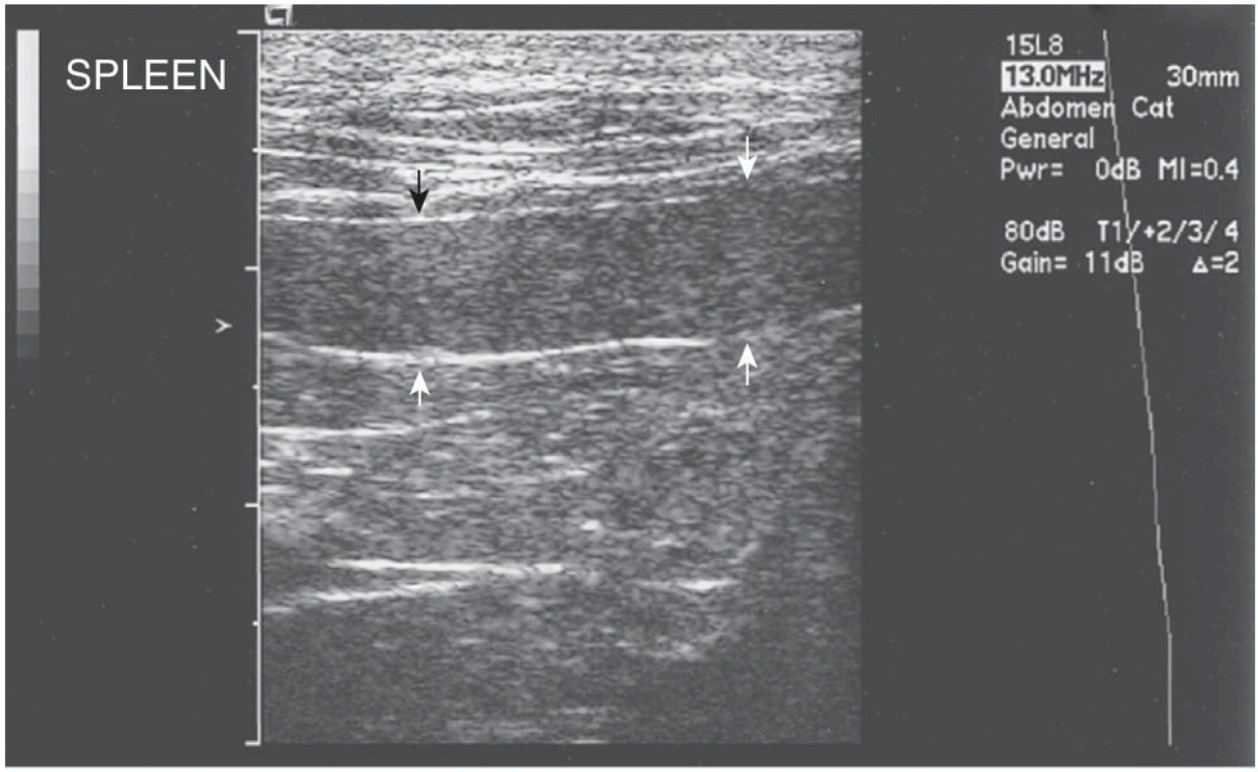

Fig 7 — The normal feline spleen — and why it gets missed. A normal cat spleen imaged with a **13 MHz linear array**; this one measured **5 mm** thick. The capsule (arrows) is a crisp thin line right across the image because a linear-array beam meets it perpendicularly along the whole width. The clinical point: the normal feline spleen is thin and very superficial, so with a sector probe, too much near-field gain and firm probe pressure it is genuinely easy to *overlook an organ that is right under the transducer.* Light touch, shallow depth, near-field gain down — and a linear probe if you have one.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 4.17. Reproduced for educational reference.

Stomach, duodenum and the rest of the gut

The stomach's appearance is **entirely dependent on its contents**, which is the first thing to accept about it. Gas rises to the near field, creating shadowing and reverberation that hides everything deep to it. An empty stomach shows rugal folds as a striated or **"spoke-wheel"** pattern — especially marked in cats, whose submucosa carries fat. Assess **peristalsis**, wall thickness and continuity of layering: the stomach and proximal duodenum contract roughly **four to six times a minute** (the two standard references quote 4–5 and 5–6), the rest of the small intestine one to three times, and the descending colon does not visibly contract at all.

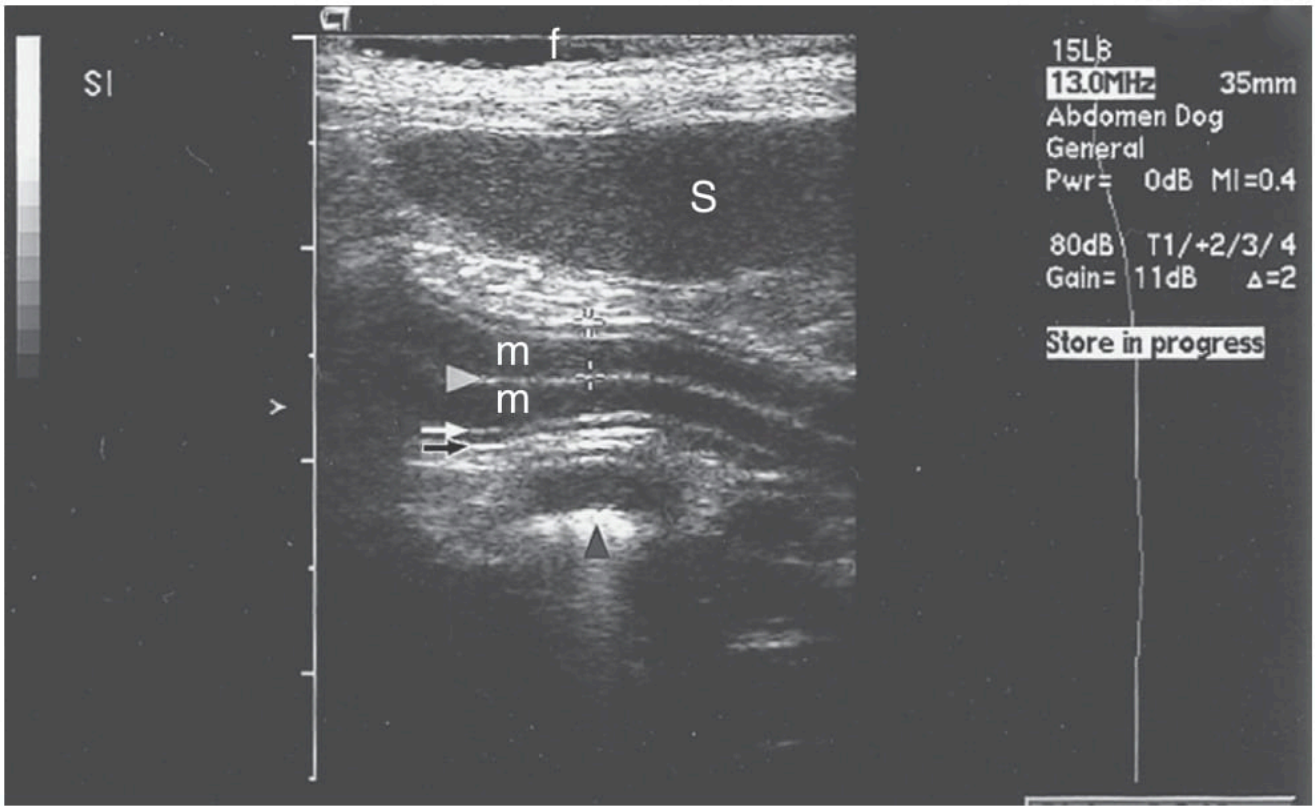

Fig 8 — The five layers of the intestinal wall. The single most useful interpretive image in an abdominal scan. From the lumen outward: a bright **mucosal–luminal interface** (white arrowhead); the thick hypoechoic **mucosa** (**m**) — by far the thickest layer; a thin bright **submucosa** (small white arrow); a thin hypoechoic **muscularis**; and a bright outer **serosa** (small black arrow). Total wall thickness here is **2.5 mm**. In the far field a loop of gas-filled intestine (black arrowhead) throws strong reverberation and its far wall cannot be seen at all — a normal loop rendered uninterpretable by its contents. Note also the acoustic enhancement on the left from a little subcutaneous fluid (**f**). **S**, spleen.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 4.25. Reproduced for educational reference.

Loss of that layering is one of the more meaningful abnormalities in abdominal ultrasound, which is why recognising the normal five-line pattern matters more than memorising thickness values. Assess every segment for uniformity of diameter, wall thickness, discrete layers, luminal contents and peristalsis.

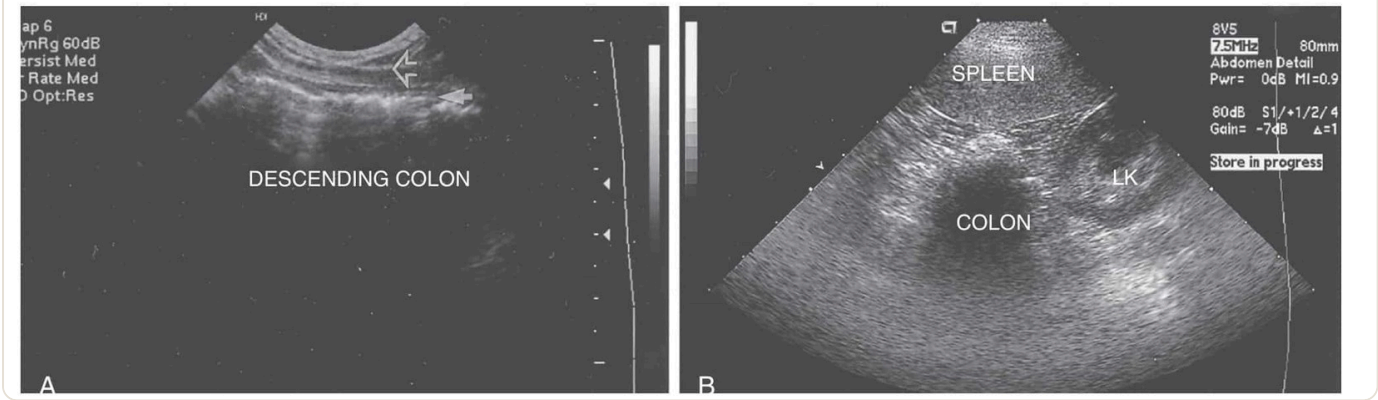

Fig 9 — The colon, and why you must be able to recognise it. A — sagittal descending colon: a thin wall (arrow) sitting directly against the body wall (open arrow), with irregular echogenic luminal gas throwing an **acoustic shadow**. **B** — the transverse colon in cross-section through the left cranial abdomen, with the spleen and left kidney (**LK**). The colon has thinner, less obvious layering than small intestine and shows no normal peristalsis; you recognise it by its consistent position and its strong artefacts. This matters clinically because the descending colon runs right alongside — and then dorsal to — the urinary bladder, so a gas-filled colon can convincingly **mimic cystic calculi or a bladder wall lesion**.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 4.26. Reproduced for educational reference.

Pancreas

The pancreas is a thin, elongated, V-shaped, hypoechoic organ, and the right and left lobes are **the most difficult abdominal organs to image routinely**. You do not find it by looking where it should be; you find it by finding its landmarks. The left lobe lies between the greater curvature of the stomach and the transverse colon — identify both as curved echogenic structures in cross-section and the pancreas is the flat hypoechoic band between them. The right lobe lies in the mesoduodenum between the descending duodenum and the right kidney. The **portal vein sits directly dorsal to the body**, and the splenic vein dorsal to the left lobe; both are excellent vascular signposts.

> **Two statements that are both true**
>
> *Non-visualisation of the pancreas does not rule out pancreatitis.* In many normal dogs and cats it is not seen at all, because its acoustic impedance matches the surrounding mesenteric fat. And equally: *visualising the pancreas does not imply pathology.* Both errors are common, and they point in opposite directions.

Kidneys and adrenal glands

The renal **cortex is hyperechoic to the medulla**, with a distinct curvilinear boundary between them. The medulla can be hypoechoic enough that beginners mistake it for hydronephrosis. Scan both kidneys in **three** planes, and use the spleen as an acoustic window for the left. The right kidney is more cranial and dorsal and sits against the renal fossa of the caudate liver lobe in the dog; in deep-chested dogs it may need an intercostal approach between the 12th and 13th, or 11th and 12th, ribs.

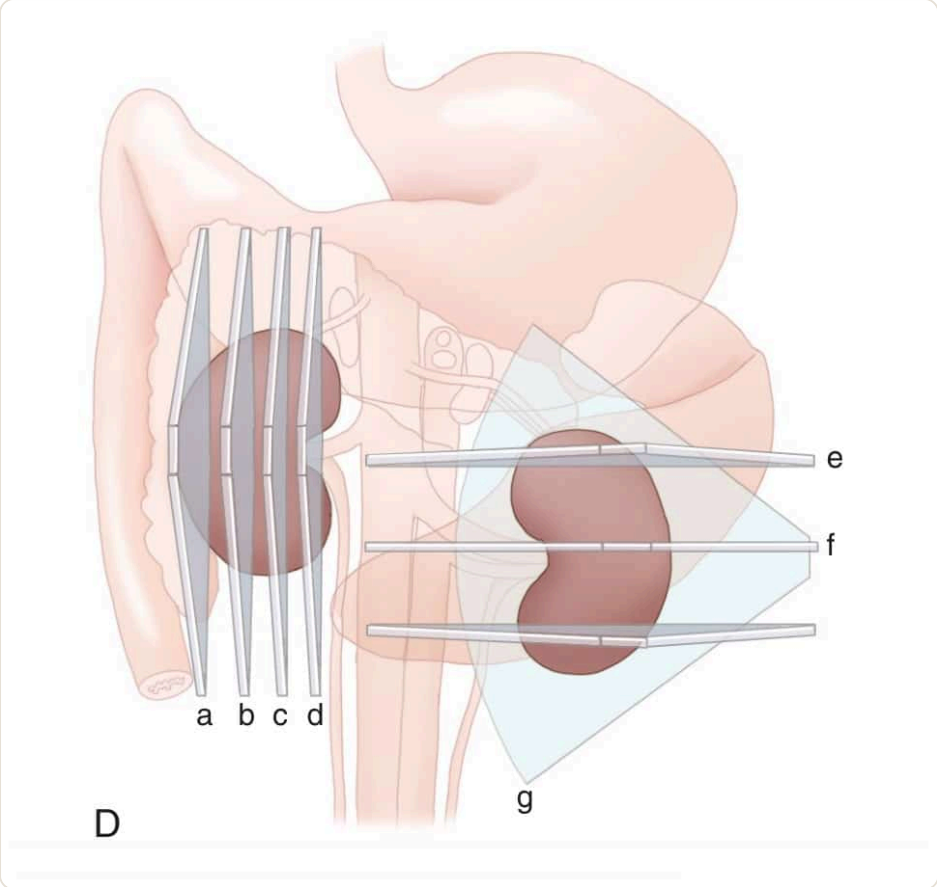

Fig 10 — Renal scan planes — and the artefact that mimics kidney disease. Sagittal planes **a**–**d**, transverse **e**–**f**, and the dorsal plane **g**. Look carefully at how differently the same normal kidney reads in each. A sagittal slice taken far **laterally** (plane a) contains no medullary tissue at all, so it looks *small and uniformly echogenic* — exactly like a chronically diseased kidney. Slice near the hilum and an echogenic disc of hilar fat appears centrally; slice further medially still and the kidney appears almost divided in two by the hilar indentation. The dorsal plane **g** is the one that shows the normal renal pelvis along the medial border, and it is also the plane that finds the adrenal glands.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 4.23, D. Reproduced for educational reference.

The adrenal glands are found most consistently in the **dorsal plane**, and the reliable method is to find the great vessel first and then look beside it.

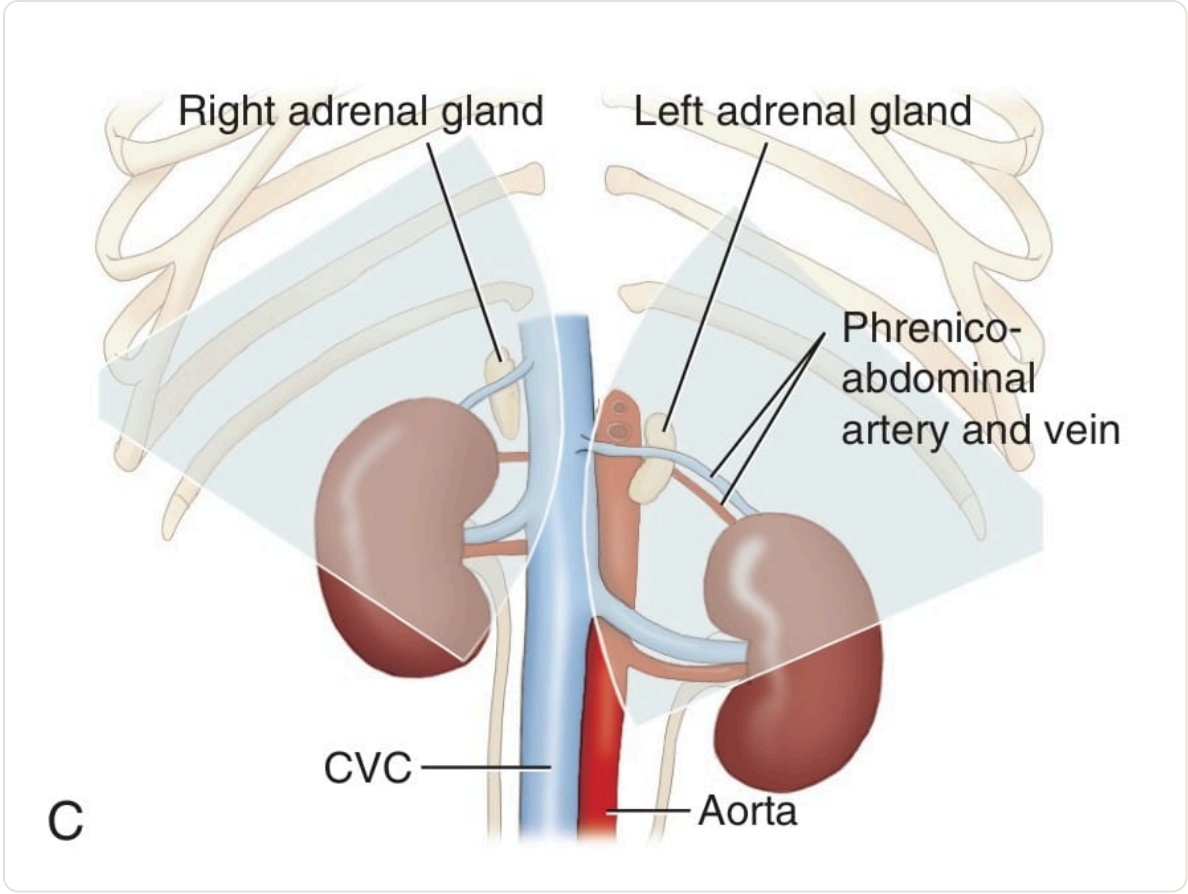

Fig 11 — Find the vessel, then the gland. The **left** adrenal lies against the lateral surface of the **aorta**, bounded cranially by the celiac and cranial mesenteric arteries and caudally by the left renal vessels. The **right** adrenal is in intimate contact with the lateral surface of the **caudal vena cava**, with the caudate liver lobe ventral to it and the sublumbar muscles and right diaphragmatic crus dorsal. The **phrenicoabdominal** arteries run dorsal to each gland and the veins cross the ventral surface, often in a small depression — visible in some patients without colour Doppler, and a useful confirmation that what you are looking at is the adrenal. The kidney is usually *not* in the plane that best shows the gland, which is why hunting for "the gland next to the kidney" fails.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 4.24, C. Reproduced for educational reference.

Shape differs by species and matters: canine adrenals are variable — peanut-shaped, thin and elongate, or V-shaped, often differing left from right — while feline glands are symmetric, bean-shaped and smaller. Watch the surrounding vessels in any case of adrenal disease, because neoplastic invasion and thrombosis of the phrenicoabdominal vein and caudal vena cava do occur.

Urinary bladder, prostate and uterus

The bladder is the easiest structure to image and one of the easiest to image *badly*. Set the gain at minimum and attenuate the near field, and often the far field too. Anechoic urine causes strong distal **acoustic enhancement** that brightens and obscures the dorsal wall and everything beyond it; meanwhile the ventral wall sits in the near field and disappears if near-field gain is left up.

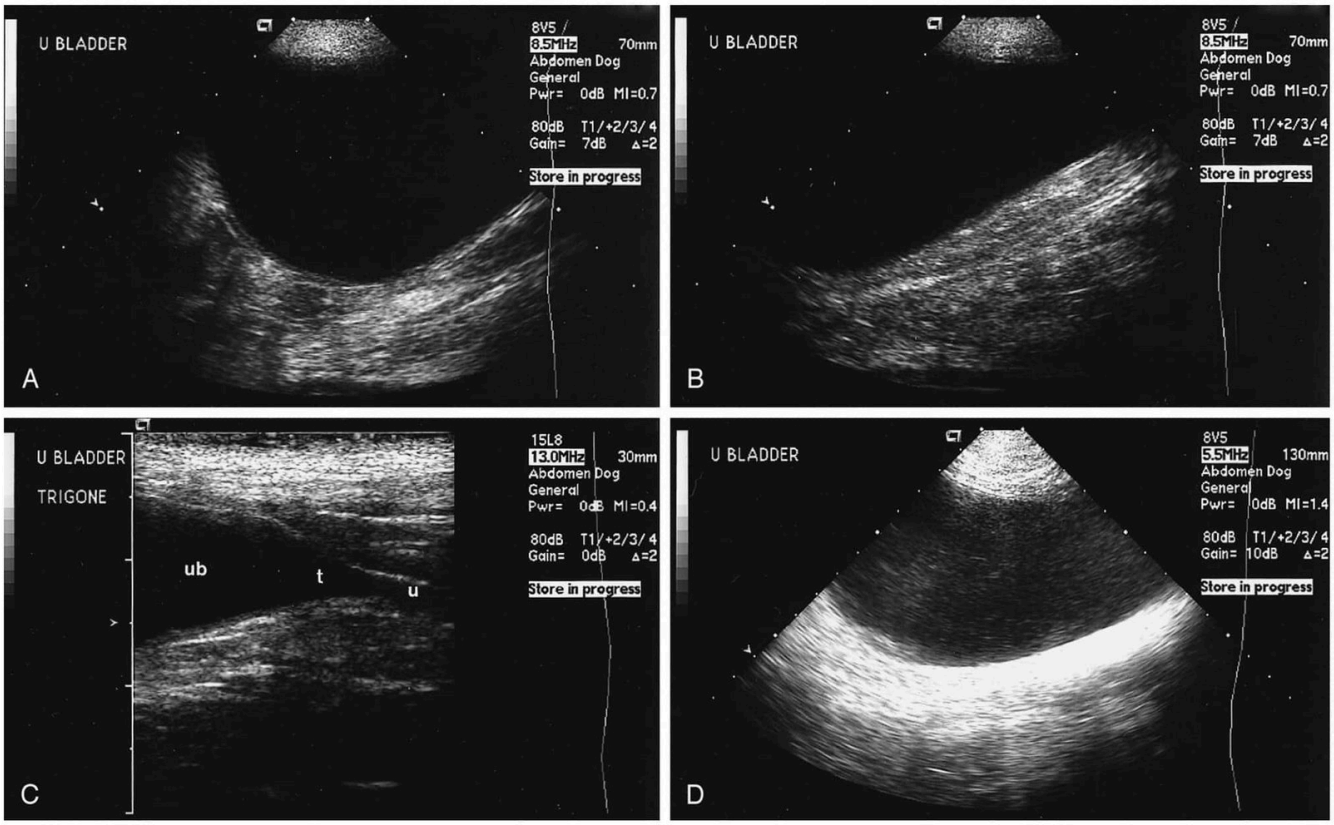

Fig 12 — The bladder — and what wrong gain does to it. A cranial bladder, moderately distended with anechoic urine. **B** mid-bladder. **C** a high-detail 13 MHz linear-array image of the caudal bladder (**ub**), neck and trigone (**t**) and urethra (**u**) — the region where neoplasia sits, and the reason a linear probe is worth having. **D** is the teaching image: **the same bladder with overall gain too high**. The wall can no longer be seen and the urine has become artefactually echogenic. If your bladder looks like **D**, the answer is never to look harder — it is to turn the gain down.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 4.28. Reproduced for educational reference.

Assess three regions as separate jobs: the **cranioventral wall** (cystitis, urachal diverticulum), the **dorsal wall** (gravity-dependent calculi and sediment) and the **trigone and proximal urethra** (neoplasia). The cranial-most wall runs nearly parallel to the beam and drops out through refraction; angle caudally from a more cranial probe position to recover it. And examine the bladder **standing** when you need to prove whether something moves.

In the male dog, the prostate is simply a caudal continuation of the bladder examination. In the entire dog it is hyperechoic, homogeneous, finely textured and bilobed on transverse images; in the neutered dog it is a small hypoechoic widening of the urethra just caudal to the trigone. The **feline prostate is not assessed sonographically** — it is microscopic. A non-gravid uterus is a small hypoechoic tube dorsal to the bladder, under 1 cm in the bitch and smaller in the queen; the horns are rarely seen when normal. Normal ovaries sit superficial, caudal and lateral to each kidney and are often isoechoic with the surrounding fat, which is what makes them difficult.

Lymph nodes and the great vessels

The abdomen contains a great many lymph nodes, divided into **parietal** (lumbar, aortic, renal, medial iliac, internal iliac, sacral, deep inguinal) and **visceral** (hepatic, splenic, gastric, pancreaticoduodenal, jejunal, colic) groups. Most normal nodes are small and isoechoic with the surrounding fat; when seen they are relatively hypoechoic and homogeneous, and occasionally so nearly anechoic that Doppler is needed to tell them from vessels.

The **medial iliac** nodes are the ones to learn first, because they are the most consistently identifiable: paired, at the level of the fifth and sixth lumbar vertebrae, sitting in the angle of the aortic trifurcation, and reached in a dorsal plane using the bladder as an acoustic window. Knowing which node drains which organ turns a passing observation into staging information.

08 Where cats differ from dogs

This is the section that saves the most false positives. A great many feline findings would be genuinely abnormal in a dog, and applying canine expectations to a cat produces confident diagnoses of disease that is not there.

ORGAN	CAT	DOG
Liver	More angular in the sagittal plane; concave caudal margin; less prominent hepatic vasculature	More rounded caudal margin, indented by the stomach across its whole caudal surface; hepatic and portal veins more visible
Gallbladder	A **bilobed gallbladder is not uncommon and is normal**. The cystic and bile duct can often be followed all the way to the duodenal papilla	Bilobed gallbladder is rare. The duct is rarely followed beyond the neck of the gallbladder unless it is distended. Echogenic bile is more often seen in normal dogs than in normal cats
Falciform fat	**Thick in most cats**, thin or obese alike, and very close to liver in both echogenicity and texture — the classic reason a normal liver is called enlarged, or fat is biopsied instead of liver	Usually thin, even in obese dogs
Spleen	Thin (about 10 mm or less), consistent position along the left body wall, finer texture, less affected by sedation	Size and position vary greatly — it is a blood reservoir. Only the head is reliably where you expect. Coarser texture, splenic veins routinely seen
Stomach	Long axis nearly **parallel** to the spine, mostly left of midline; wider pyloroduodenal angle; thick echogenic submucosal fat gives the empty stomach a **'spoke-wheel'** look	Centrally placed with the long axis roughly **perpendicular** to the spine; pylorus to the right of midline; narrow pyloroduodenal angle; thin submucosa like small intestine
Small intestine	Thinner duodenal mucosa; the **ileum** is often the thickest segment. The **ileocecocolic junction** is easy to find and its lymph nodes are routinely seen in normal cats	Thick duodenal mucosa; the **duodenum** is the thickest segment. The ileocolic junction is harder to identify; the caecum is large and usually gas-filled; ileocecocolic nodes are rarely seen unless enlarged
Pancreas	**Left** lobe larger and easier to find. The central pancreatic duct is routinely seen and is a useful landmark. Most cats lack an accessory duct	**Right** lobe larger and easier to find. The duct is rarely seen in a normal dog — seeing it usually means it is enlarged. Accessory duct and minor duodenal papilla normally present
Kidneys	More oval, similar on sagittal and dorsal axes, more consistent in size. Cortical fat deposition makes normal feline cortices **more echogenic**. More hilar fat	Size varies enormously with body size — which is why the kidney is measured against the aorta rather than in absolute centimetres. The right kidney is always in intimate contact with the renal fossa of the caudate liver lobe
Adrenal glands	Oval, 'jelly-bean' shaped, symmetric, smaller and more consistent. Layering rarely seen; mineralisation is often an **incidental** finding	Variable — peanut-shaped, thin and elongate, or V-shaped, and often different left to right. Layering often visible. Mineralisation is more often associated with **neoplasia**
Urinary bladder	Elongated neck with a gradual transition into the urethra; smaller and more consistent. Suspended echogenic fat droplets in the urine are **normal**	More abrupt transition of trigone into urethra; size inconsistent. Fat droplets are rarely seen in normal urine
Prostate	Present, but extremely uncommon to visualise. Prostatic disease is rare	Routinely seen in every male dog, entire or neutered. Prostatic disease is common

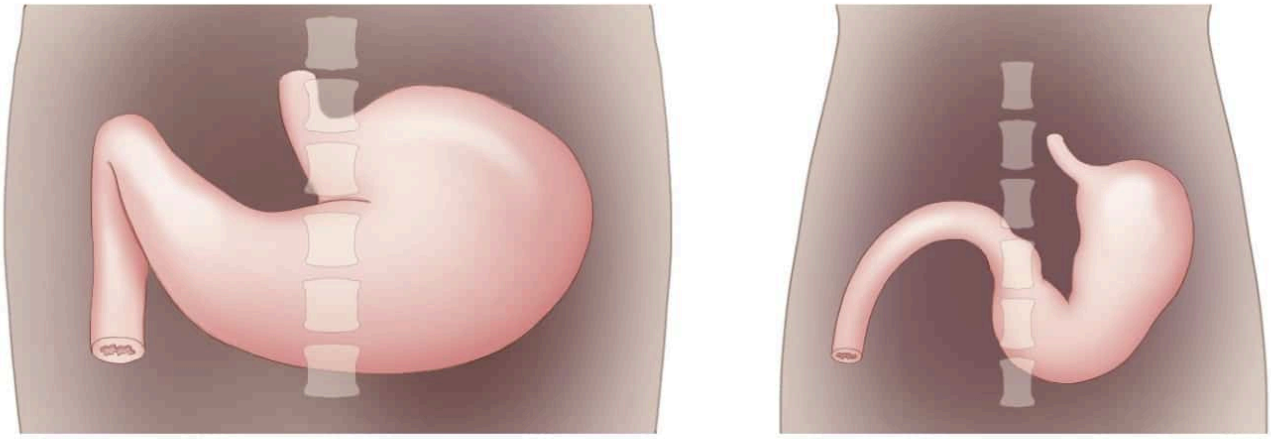

Fig 13 — The stomach sits differently in the two species. The **canine** stomach is centred in the cranial abdomen with its long axis essentially **perpendicular** to the spine, and the pyloroduodenal junction on the right. The **feline** stomach lies mostly to the *left* of midline with its long axis nearly **parallel** to the spine, and the cat has a much wider pyloroduodenal angle. The practical consequence is that a probe held in a sagittal body plane cuts the canine stomach in *cross-section* and the feline stomach closer to its *long axis* — so if you are hunting for a canine-looking transverse stomach in a cat, you will not find it.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 4.19. Reproduced for educational reference.

09 Normal measurements — the numbers

Most guides describe normal in adjectives. Adjectives are not much use when you are writing a report and need to decide whether 0.62 cm is an adrenal gland or a problem. The tables below give the published reference values, and the figures show where the calipers actually go — because a measurement taken in the wrong plane is worse than no measurement.

Read these as guides, not verdicts

Reference intervals come from different populations, different machines and different techniques; where the literature disagrees, both figures are given. Use them to support a judgement, alongside the shape, margins, echogenicity and the clinical picture — not instead of it.

Urinary tract

STRUCTURE	CAT	DOG
Bladder wall thickness	0.13–0.17 cm	0.23 cm at minimal distension, 0.16 cm at mild, **0.14 cm at moderate** distension here means 0.5, 2 and 4 mL/kg respectively -- which is why the same bladder measures differently twice in one day
Kidney length	**3.8–4.4 cm** other studies 3.0–4.3 cm, occasionally to 5.3 cm; left slightly smaller than right; females smaller than males	Size varies far too much to quote a single range — use the **kidney : aorta ratio, normally 5.5–9.1** above 9.1 = enlarged; below 5.5 = small. Aorta measured caudal to the left renal artery
Renal cortex / medulla	Cortex about 0.82 cm and medulla 0.59 cm in one study; a second found a thinner cortex (0.47 cm). Left kidney has the thicker medulla	—
Renal pelvis	Up to **0.3 cm**	Up to **0.3 cm** dilation above 1.3 cm predicted obstruction in 100% of cases; a smaller pelvis does NOT exclude early obstruction
Ureter	Not visible unless dilated. External diameter about 0.1 cm	Not visible unless dilated; 0.13–0.27 cm on CT

STRUCTURE	CAT	DOG
Urethra	Lumen not visible unless the bladder is distended — if you can see it, look for an obstruction	As for the cat

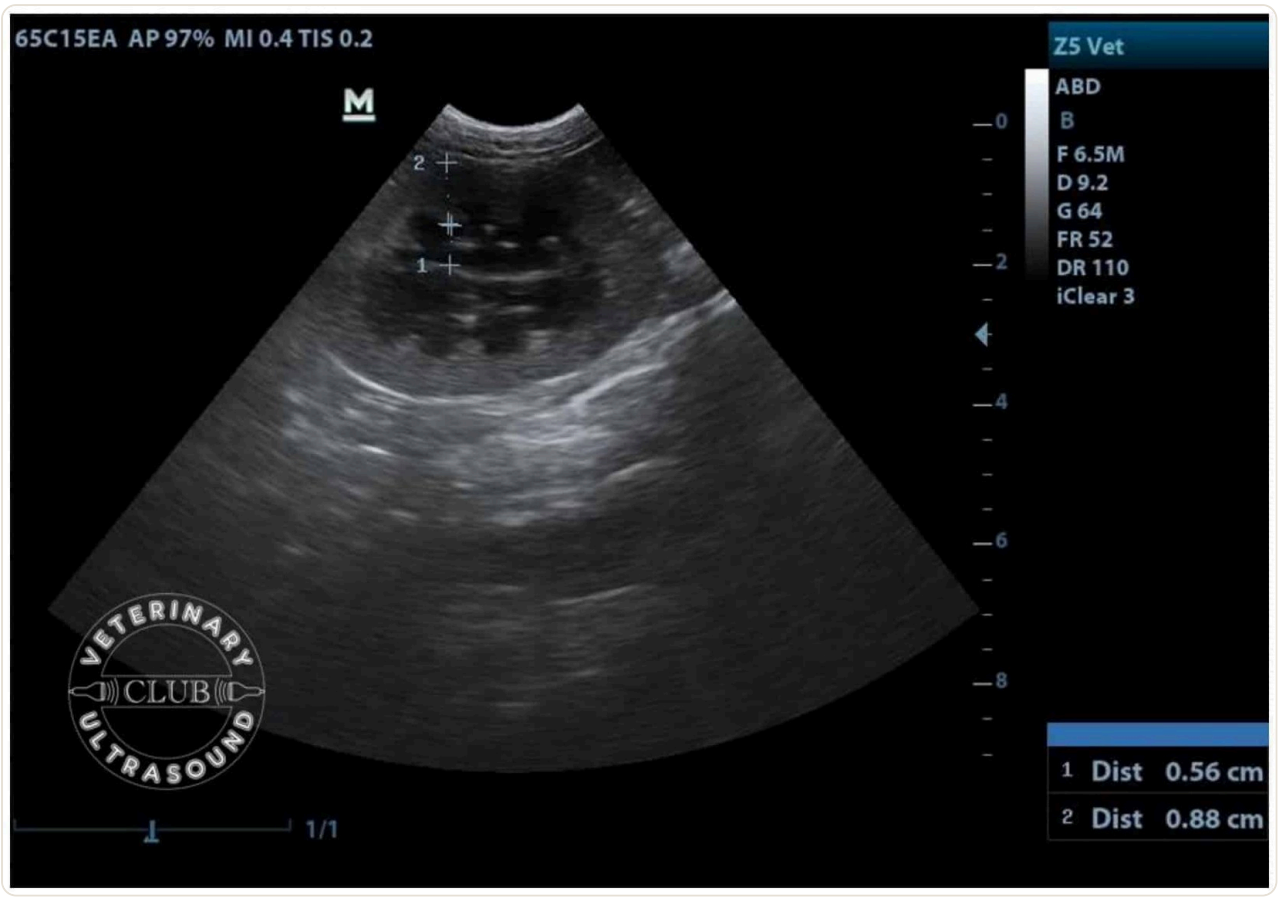

Fig 14 — Where the calipers go: feline renal cortex and medulla. Cortical and medullary thickness measured on a feline kidney — **0.88 cm** cortex and **0.56 cm** medulla in this cat. Two things to carry away. First, the **left kidney normally has a thicker medulla** than the right, and therefore a smaller corticomedullary ratio — a left–right difference is not automatically a finding. Second, a normal feline renal cortex is *more echogenic* than a dog's because of cortical fat deposition, so judging a cat by canine standards over-diagnoses renal disease.

Image — Meirelles A, Aguillera P. Abdominal Ultrasound in Cats and Dogs: An Illustrated Reference Value Guide — Figure 5. Reproduced for educational reference.

Other abdominal organs

STRUCTURE	CAT	DOG
Spleen	Thickness of the proximal third **0.71 cm** (0.51–0.91). Above 0.91 cm is splenomegaly and worth cytology; a folded spleen also means splenomegaly	Assessed **subjectively** — check extent and margins, not a number
Adrenal gland	Length 0.89–1.25 cm; poles about 0.30–0.48 cm thick	Judge **thickness of the caudal pole**, not length: up to **0.54 cm** under 10 kg, **0.68 cm** at 11–30 kg, **0.8 cm** above 30 kg one large study proposed simpler cut-offs: 0.62 cm under 12 kg, 0.72 cm at 12 kg and over
Pancreas mean thickness	Left lobe 0.54 cm, body 0.66 cm, right lobe 0.45 cm; duct about 0.1 cm	Left lobe 0.65 cm, body 0.63 cm, right lobe 0.81 cm; duct 0.06–0.07 cm thickness and duct diameter both rise significantly with body weight
Gallbladder	Wall smooth, hyperechoic, **under 0.1 cm**. Volume about 2.4 mL fasted	Wall **0.1–0.2 cm**. Volume **≤1 mL/kg** volume = 0.52 x length x height x width

STRUCTURE	CAT	DOG
Common bile duct	≤0.4 cm	<0.3 cm, and usually not visible at all
Aorta / portal vein / CVC	0.45 / 0.44 / 0.46 cm	0.55 / 0.49 / 0.52 cm weight-banded values run roughly 0.6 cm under 10 kg to 0.95 cm over 20 kg
Ovary	Under 1 cm	1–2 cm
Prostate	0.45–0.5 cm; rarely imaged	Entire: about 2.7 × 2.4 × 2.7 cm on average. Neutered: smaller and more uniform volume = 0.52 x length x height x width; size rises with age and weight in entire dogs only

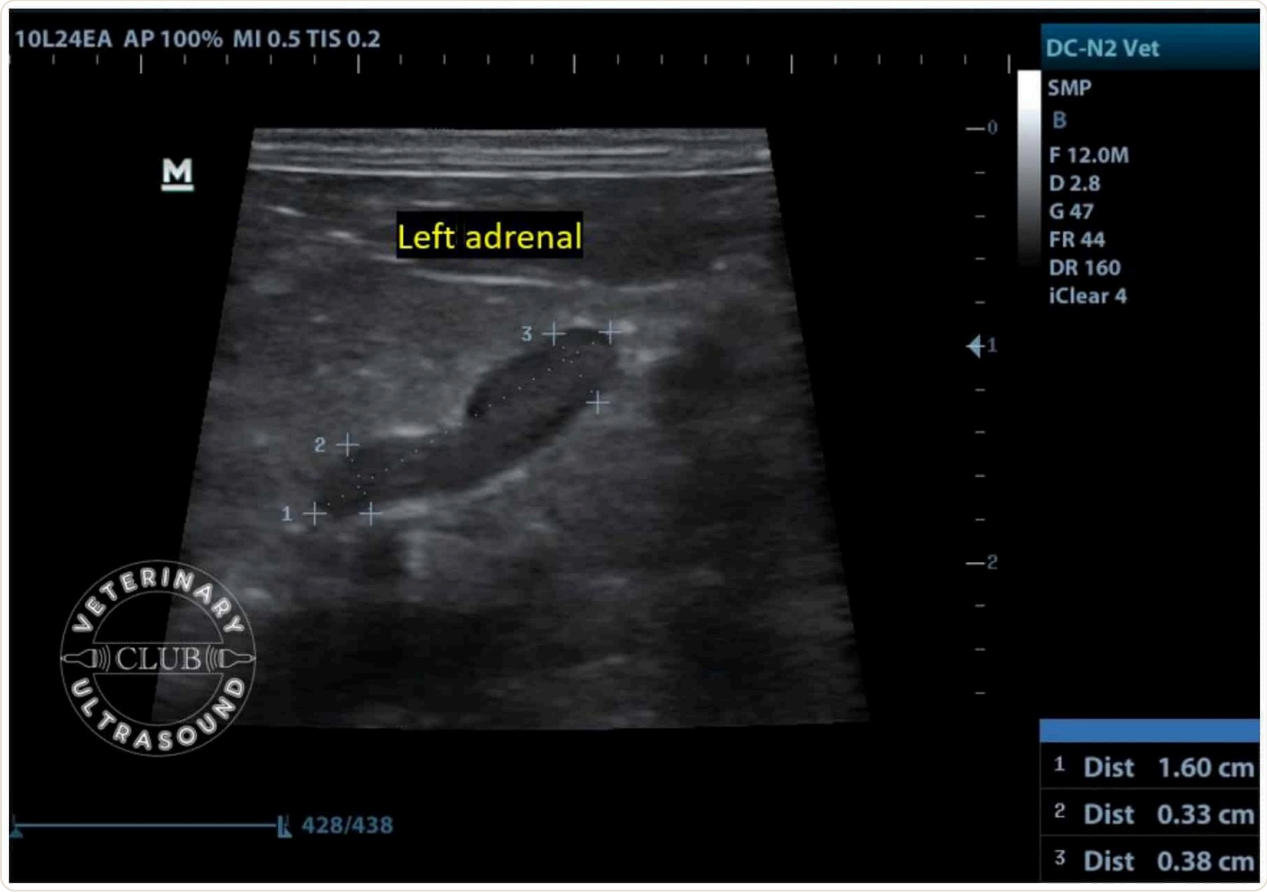

Fig 15 — Where the calipers go: the canine adrenal gland. A canine left adrenal gland measured three ways — **1.60 cm** length, **0.33 cm** cranial pole and **0.38 cm** caudal pole. Only one of those numbers is clinically useful. Canine adrenal *length* is too variable to be worth much; the measurement that carries the diagnostic weight is the **height of the caudal pole in the sagittal plane**, judged against body weight. This gland is comfortably normal.

Image — Meirelles A, Aguillera P. Abdominal Ultrasound in Cats and Dogs: An Illustrated Reference Value Guide — Figure 13. Reproduced for educational reference.

The vascular ratios worth knowing

When a portosystemic shunt is on the list, the **portal vein : aorta** ratio does real work. Every cat and dog with a ratio of **0.65 or less** in the reported series had either an extrahepatic shunt or non-cirrhotic portal hypertension; conversely, animals with **PV : Ao at or above 0.8** ***and*** **PV : CVC at or above 0.75** were found not to have an extrahepatic shunt. Measure the portal vein at the porta hepatis, and take care not to compress the caudal vena cava with the probe while you do it.

Gastrointestinal wall thickness

SEGMENT	CAT	DOG <15 KG	DOG 15–30 KG	DOG >30 KG
Stomach	0.2–0.4 cm	0.2–0.5 cm	0.2–0.5 cm	0.2–0.5 cm
Duodenum	0.22 cm	0.38 cm	0.41 cm	0.44 cm
Jejunum	0.22 cm	0.30 cm	0.35 cm	0.38 cm
Ileum	**0.28 cm** thickest small-intestinal segment in the cat	0.30 cm	0.35 cm	0.38 cm
Caecum / colon	0.15 cm	0.15 cm	0.15 cm	0.15 cm

Two patterns inside that table are worth more than the individual numbers. In the **dog** the duodenum is the thickest small-intestinal segment; in the **cat** it is the **ileum**. And canine values scale with body weight while feline values essentially do not — a 40 kg dog's jejunum is normally half again as thick as a small dog's.

Lymph nodes

NODE	NORMAL SIZE	WHAT ACTUALLY MATTERS
Medial iliac dog	About 2.1–2.2 cm long, 0.46–0.48 cm high	The **short-axis : long-axis ratio**. Under **0.5** is normal; up to **0.7** is still regarded as benign; **above 0.7** is a feature of malignancy. A node that has become round has changed more meaningfully than one that has become long
Jejunal dog	Highly variable, 0.5–20 cm long	The ratio above **does not apply** here — the jejunal node is naturally elongated. Judge thickness and echogenicity instead
Superficial inguinal dog	About 1.8 cm long, 0.31 cm high	The short : long ratio is validated here as well as for the medial iliac node
Abdominal nodes generally cat	Jejunal about 2.0 cm, ileocaecal 1.2 cm, medial iliac 1.35 cm, most others under 1 cm long	Normal feline nodes — including the ileocecocolic group — are routinely visible. Seeing them is not itself abnormal
Puppies	Jejunal about 1.6 cm, medial iliac about 1.3 cm at 4–6 weeks	Nodes in puppies are **larger**, may be hypoechoic or heteroechoic, and take unusual shapes. Do not over-call them

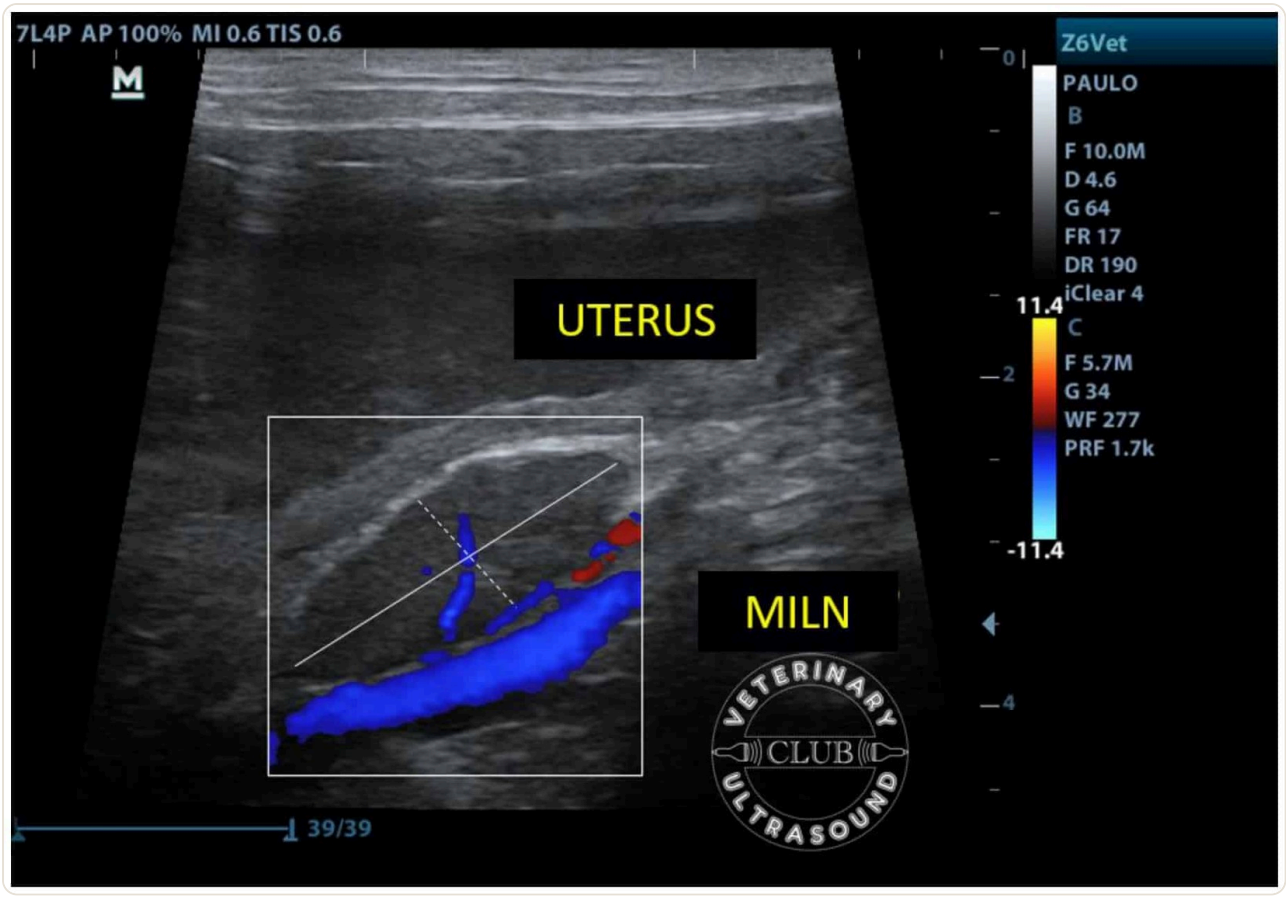

Fig 16 — Where the calipers go: shape matters more than size. A medial iliac lymph node in a bitch with **pyometra** — the enlarged uterus is labelled above it, and colour Doppler is being used to separate the node from the adjacent vessels, which is often necessary because a nearly anechoic node and a vessel look alike on grey scale. The solid line marks the **long axis** and the dashed line the **short axis**. That ratio is the measurement that matters: a node becoming *rounder* is a more meaningful change than a node becoming longer.

Image — Meirelles A, Aguillera P. Abdominal Ultrasound in Cats and Dogs: An Illustrated Reference Value Guide — Figure 33. Reproduced for educational reference.

10 Artefacts: things on the screen that are not in the patient

Artefacts are not rare events. They are present to some degree in *every* ultrasound examination, and some of them are among the most useful things on the screen — a clean acoustic shadow is how you confirm a urolith, and acoustic enhancement is how you distinguish a cyst from a solid nodule. The problem is only the ones that get mistaken for disease.

Recall the four assumptions from the physics section: straight-line travel, constant speed, echoes only from the main beam, and echo strength reflecting real tissue properties. Every artefact below is one of those being violated, which means you can derive them rather than memorise them.

ARTEFACT	WHAT YOU SEE	WHY IT HAPPENS, AND WHAT TO DO
Acoustic shadowing clean vs dirty	A dark band running away from a bright structure	At a soft-tissue–**bone** or calculus interface much of the beam is **absorbed**, so there is nothing to reverberate and the shadow is **clean** — uniformly black. At a soft-tissue–**gas** interface about **99%** is **reflected**, and the multiple reflections make the shadow **dirty**. Useful, not a nuisance: a clean shadow is how you confirm a urolith. But the rule is not absolute — gas can shadow cleanly and calcified tissue dirtily. A calculus only shadows convincingly if it sits near the **focal zone** and is at least as wide as the beam
Acoustic enhancement through-transmission	A bright zone deep to a fluid-filled structure	The beam was barely attenuated crossing the fluid, so it arrives with more energy than beams either side of it. This is how you separate a **cyst** from a hypoechoic solid nodule. It is also why the tissue deep to the gallbladder and bladder looks falsely bright

ARTEFACT	WHAT YOU SEE	WHY IT HAPPENS, AND WHAT TO DO
Reverberation with ring-down and comet-tail	Repeating, equally spaced bright lines marching into the far field, dimming with depth	The pulse is bouncing between two strong reflectors — usually gas, sometimes the probe–skin interface. **Ring-down** is the diffuse echo between the lines, from fluid trapped between gas bubbles; **comet-tail** comes from metal, such as a needle or a pellet. Occasionally these are the finding: gas reverberating **outside** the gut means free peritoneal gas
Mirror image a multipath artefact	A duplicate liver, and sometimes gallbladder, apparently sitting **inside the thorax** beyond the diaphragm	The beam bounces off the strongly curved diaphragm–lung interface, hits the liver, and returns the long way round. The machine assumes a straight line and a fixed speed, so it plots the late echoes deeper than they are. **It looks exactly like a diaphragmatic rupture.** Recognise it and you will not chase it. The same artefact turns up at the pelvic inlet and at the trachea
Edge shadowing a refraction artefact	A narrow dark streak dropping from the **margin** of a rounded structure	The beam is refracted as it passes obliquely through a curved interface. Seen at the edges of the bladder, gallbladder, kidney and even the adrenal gland. It can create a convincing **false defect in the bladder wall** — angle the probe differently and the defect moves or disappears, which a real lesion does not
Side-lobe and slice-thickness the pseudosludge pair	A layer of fine echoes lying inside a structure that should be black — false sediment in the bladder or gallbladder	Either off-axis beam energy, or part of the beam's thickness straddling the wall. Three ways to tell it from real sediment: real sediment has a **flat** surface, pseudosludge is **curved**; real sediment is gravity-dependent and **moves when you roll the patient**; and pseudosludge **fades as you drop the gain or power** while real echoes persist
Propagation speed error	A step or dent in an organ's deep margin	The machine assumes 1540 m/s everywhere, but sound travels at about 1450 m/s through fat. Echoes returning through fat come back late and are plotted too deep — classically the surface of the left kidney appears depressed where fat overlies it

Seeing them for yourself

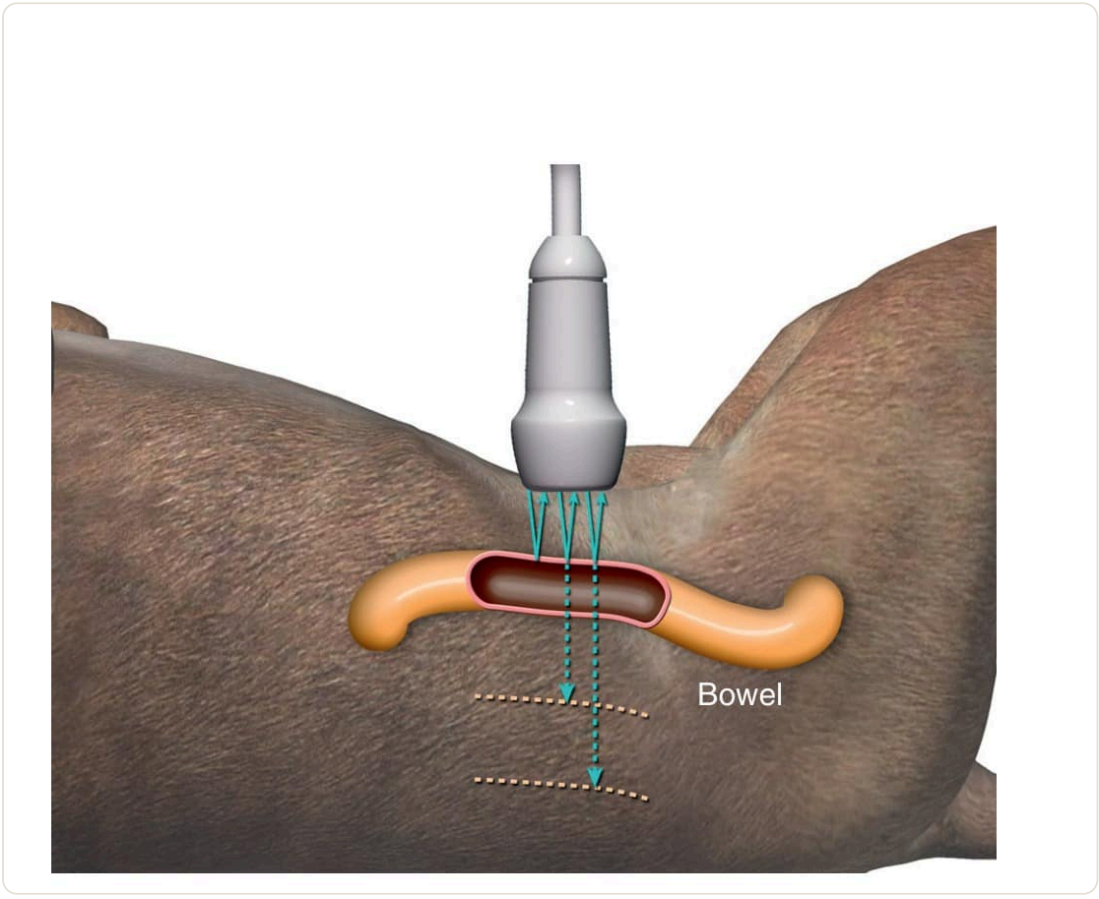

Fig 17 — How reverberation is produced. The beam strikes gas in the bowel lumen, reflects almost completely, and bounces back and forth between the gas and the transducer. Each round trip takes longer than the last, so the machine — which converts time into depth — plots each successive echo **deeper** than the one before, at regular intervals. The dashed lines show where those false interfaces land.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 1.39. Reproduced for educational reference.

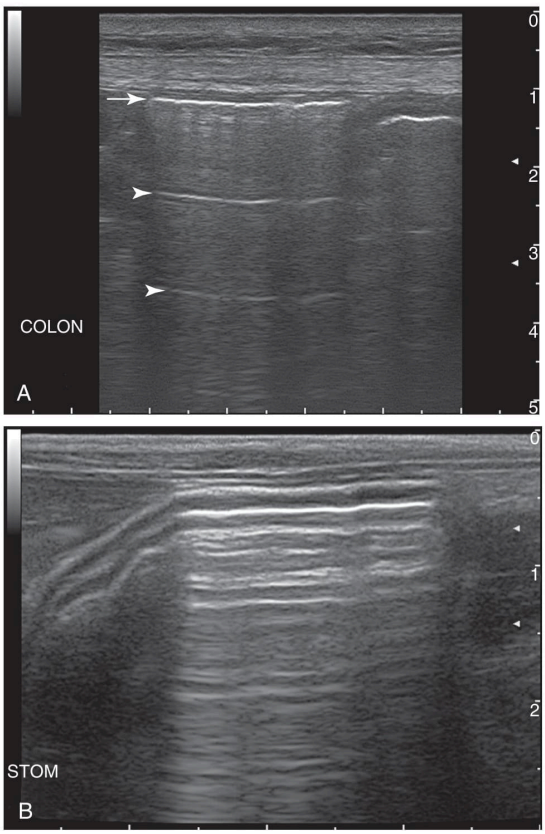

Fig 18 — Reverberation and ring-down in practice. A — the colon: the most superficial bright line (arrow) is the *real* gas interface; the equally spaced lines beneath it (arrowheads) are the artefact, dimming with depth as attenuation takes its toll. **B** — gas in the stomach: here the repeating lines are less distinct and the diffuse **ring-down** between them dominates, produced by fluid trapped between gas bubbles. In both cases everything deep to the gas is unassessable — not normal, *unassessable*, which is a different statement and the one that belongs in the report.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 1.40. Reproduced for educational reference.

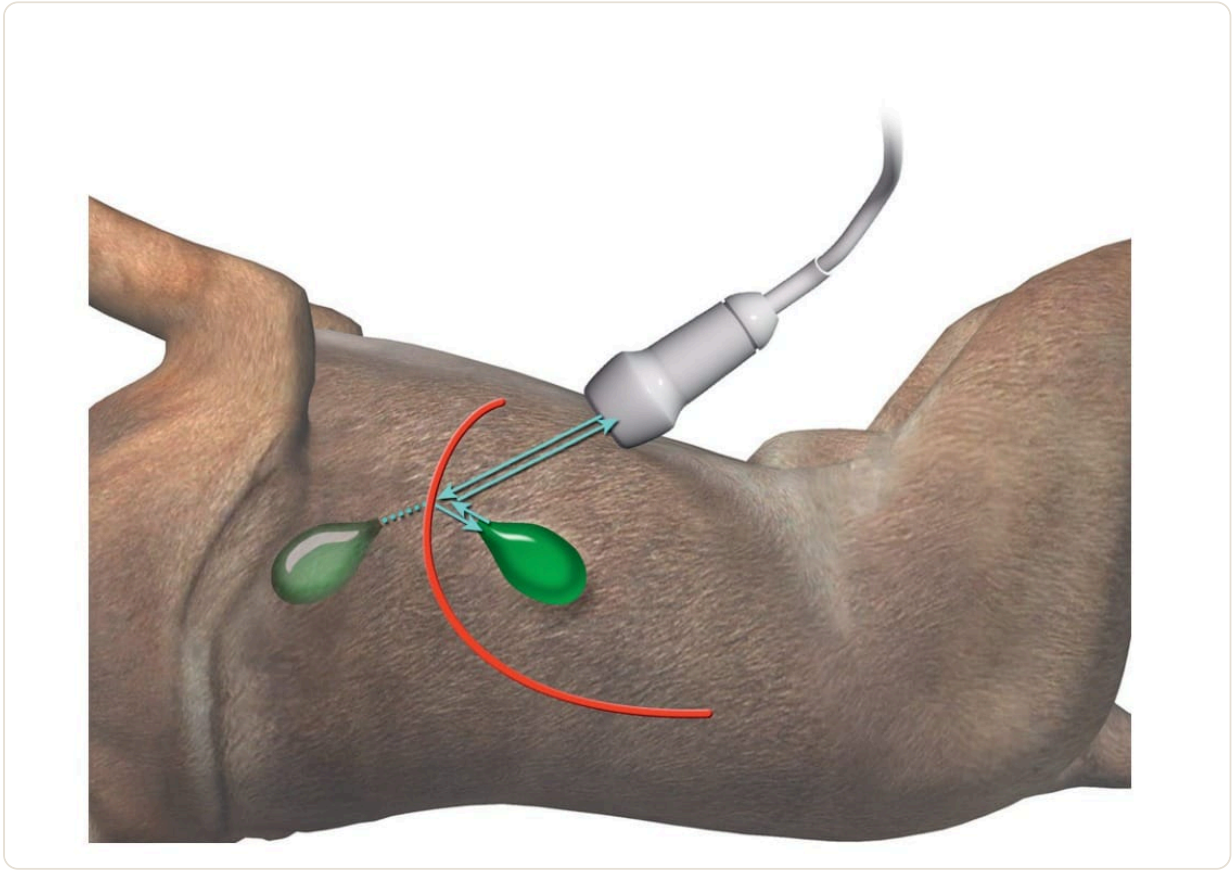

Fig 19 — How the mirror image is produced. The beam meets the strongly curved **diaphragm–lung interface**, is deflected onto the gallbladder, and the returning echoes retrace the same longer path. Because the machine assumes the echo travelled straight out and straight back, the extra travel time is read as extra depth — and the gallbladder is drawn beyond the diaphragm, in the chest.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 1.41. Reproduced for educational reference.

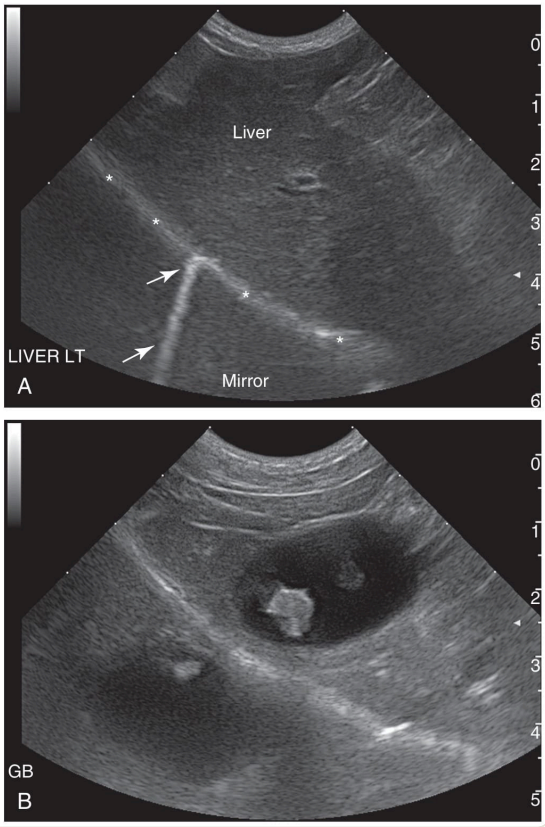

Fig 20 — Mirror image — the classic mimic of a diaphragmatic rupture. A — an anomalous liver (labelled *Mirror*) placed inside the thorax, to the left of the bright lung surface (asterisks); the arrows mark a solitary ring-down artefact indicating an irregularity of the lung surface. **B** — liver, gallbladder and even gallstones all duplicated beyond the interface. Nothing here is in the chest. If you take one artefact away from this article, take this one: it is common, it looks alarming, and it has sent more than one patient toward a surgery they did not need.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 1.42. Reproduced for educational reference.

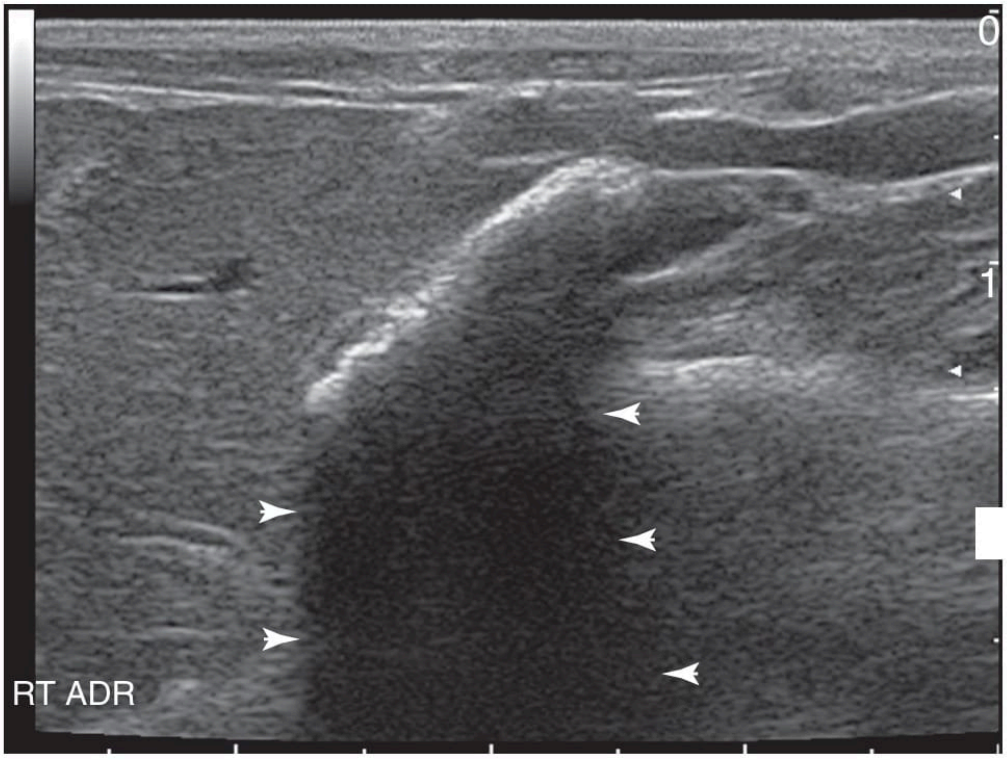

Fig 21 — A clean shadow. A mineralised right adrenal gland in a cat casting a **complete, 'clean'** shadow (arrowheads) — an anechoic void deep to the bright surface of the gland. Clean, because at a mineral interface much of the beam is *absorbed* rather than reflected, so there is nothing left to reverberate and fill the shadow with noise. Worth adding: adrenal mineralisation in the **cat** is frequently an incidental finding, whereas in the **dog** it is more often associated with neoplasia.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 1.45. Reproduced for educational reference.

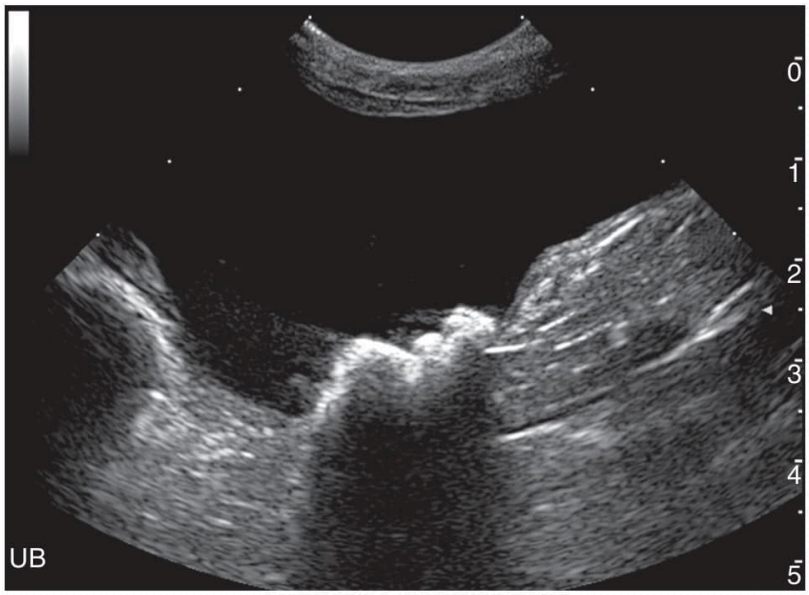

Fig 22 — The shadow that makes the diagnosis. Multiple cystic calculi throwing a complete acoustic shadow. This is the artefact working *for* you: the shadow is what confirms a bright focus in the bladder is a stone rather than sediment or a clot. But the requirements are real — a calculus only shadows convincingly if it lies near the **focal zone** and is at least as wide as the beam, so a small stone imaged at the wrong depth may cast no shadow at all. If you suspect a stone and see no shadow, move the focal zone to it before concluding.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 1.46. Reproduced for educational reference.

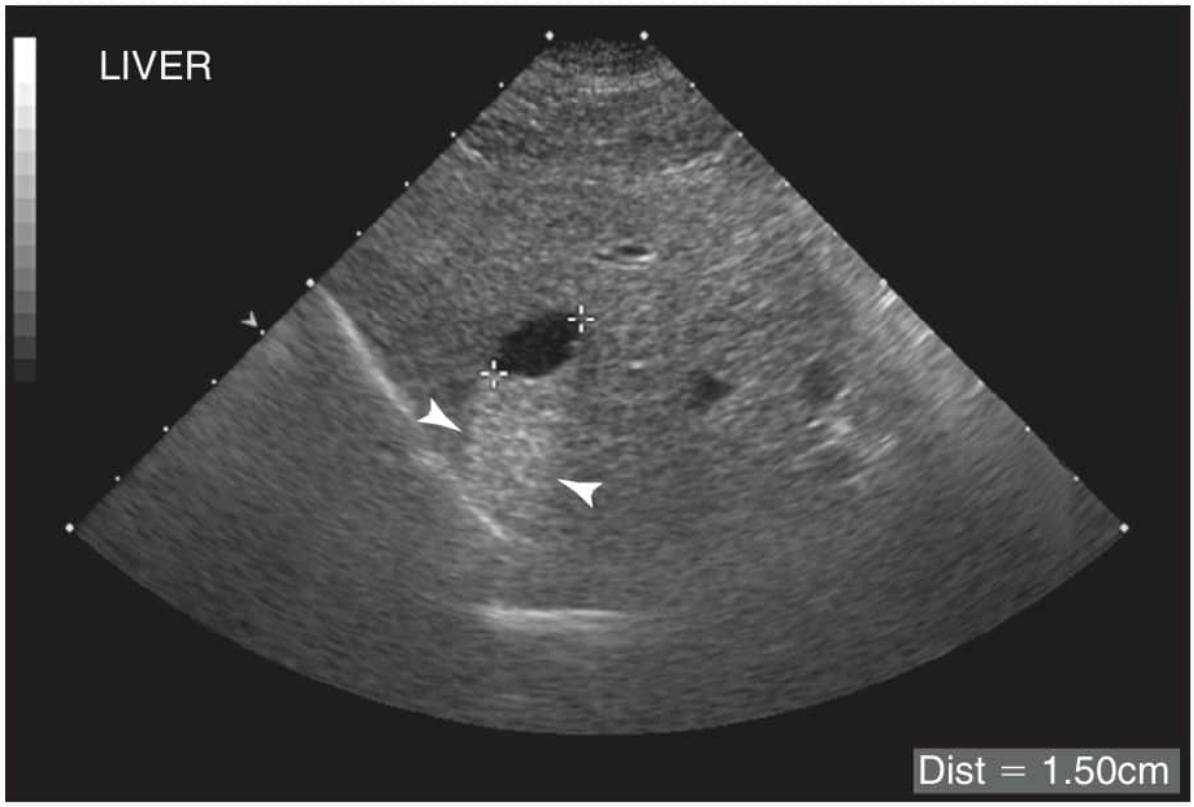

Fig 23 — Acoustic enhancement. The liver deep to a small anechoic cyst (between the electronic cursors) is distinctly **brighter** than liver at the same depth on either side (arrowheads). The beam crossing the cyst was barely attenuated, so it arrived with more energy than its neighbours. This is the everyday test for whether a hypoechoic lesion is fluid: a cyst shows distal enhancement, a solid hypoechoic nodule does not. It is also why the tissue behind the gallbladder and the bladder always looks falsely bright.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 1.49. Reproduced for educational reference.

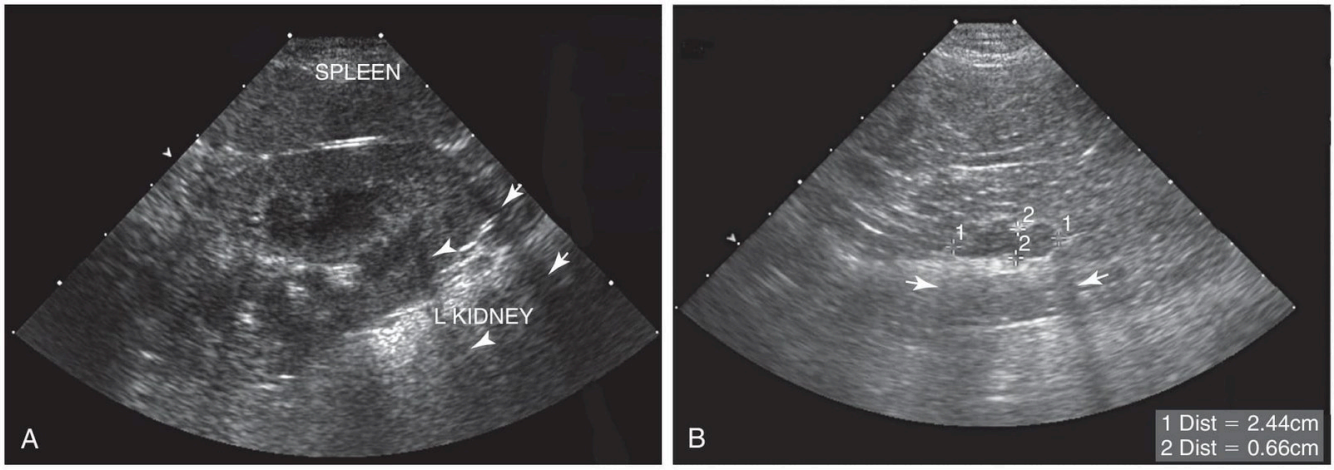

Fig 24 — Edge shadowing — small, and easy to over-read. A — dark edge shadows arising from the margins of the kidney (arrows) and from the corticomedullary interface within it (arrowheads). **B** — the same artefact from a structure as small as an **adrenal gland**, here between electronic cursors. These are refraction artefacts at curved interfaces. The reason to know them: the identical effect at the edge of the urinary bladder produces a convincing **false wall defect**. The test is simple — change your angle of insonation. An artefact moves or disappears; a lesion does not.

Image — Mattoon JS, Sellon RK, Berry CR (eds). Small Animal Diagnostic Ultrasound , 4th ed. Elsevier — Fig. 1.47. Reproduced for educational reference.

11 Colour Doppler: the minimum that earns its place

Doppler has a reputation for being an advanced topic, and the quantitative end of it is. But one small part of it belongs in a basic abdominal scan, and it is worth separating the four things the button can do before deciding which you need.

Pulsed-wave and **continuous-wave** Doppler are the *spectral* modes: they draw a graph of velocity against time and give you numbers. **Colour Doppler** and **power Doppler** instead paint a colour map over the live grey-scale image. Colour Doppler encodes *mean velocity and direction*; power Doppler encodes the *amount* of moving blood, discarding direction and velocity altogether. That trade buys something valuable: because it does not display a frequency shift, power Doppler **does not alias** and is essentially independent of the angle of insonation, which makes it markedly more sensitive to slow flow in small or deep vessels.

For everyday abdominal work, colour is doing three jobs. It tells you a near-anechoic structure is a **vessel and not a lymph node** — the exact ambiguity in the medial iliac node figure above. It confirms the **portal vein** and its direction of flow when a shunt is on the list. And it lets you steer a needle away from vessels before you sample, which measurably reduces complications.

> **Aliasing, in one paragraph**
>
> Pulsed-wave and colour Doppler sample flow intermittently, and there is a maximum frequency shift they can interpret unambiguously — the **Nyquist limit**. Exceed it and the display *wraps around*: the fastest flow appears to reverse direction, painting a confusing mosaic in the middle of a jet. The fix is not to distrust the machine but to raise the **PRF** (the velocity scale). Raise it too far, though, and the opposite error appears: slow flow inside an organ vanishes and the machine tells you a perfused structure is avascular. Both errors are settings, not findings.

12 Using ultrasound to sample, not just to look

A scan that ends with "there is a lesion" has done half a job. Real-time needle guidance is one of the main reasons the machine is worth its price, and it changes an imaging finding into a diagnosis.

There are three guidance methods. **Indirect** guidance means you measure the angle and depth on screen, then take the probe away and insert the needle — adequate for draining large volumes (abdominocentesis, cystocentesis, thoracocentesis) and poor for anything small. **Freehand** guidance — probe in one hand, needle in the other, needle watched continuously — is the most versatile and by far the most common, and it is the one to learn. A **needle-guide attachment** fixes the path electronically on screen and is useful for small or deep targets, at the cost of flexibility.

Needle choice follows the question. Cytology from a mass is usually a **21–22 gauge** needle or finer; thin fluid needs only a fine needle while thick purulent material needs a larger bore; a **tissue-core** biopsy needs **14–18 gauge**. Larger needles are easier to see and give better samples, and they carry higher complication rates — that is the whole trade.

> **Two things to settle before the needle goes in**
>
> **Coagulation.** In a large series of dogs and cats undergoing ultrasound-guided biopsy, minor complications occurred in over **20%** and major complications in **6%**; significant bleeding tracked with **thrombocytopenia**, and dogs with a prolonged one-stage prothrombin time and cats with a prolonged aPTT were more likely to have complications. Platelet count and clotting times are therefore generally indicated before a core biopsy — though routine fine-needle aspiration with a 22–25 gauge needle usually needs no special preparation unless bleeding risk is already high.

> **Sedation — and the two agents to avoid**
>
> Some aspirates and *all* core biopsies are easier under short-acting intravenous sedation, and a half dose is often enough; no local anaesthetic is needed for a fine needle. Avoid agents that promote **panting** or **splenic enlargement** — panting fills the abdomen with gas and moves the target while you are aiming at it, which is the same reason opioids are a poor choice before a diagnostic scan.

One technical point explains most failed attempts: a needle is visible because it reflects the beam back, so it shows up best when it lies **close to perpendicular to the beam**. Steepen the angle and it fades. If you cannot see your needle, the usual answer is to change the approach angle rather than to push further and hope.

13 AFAST and point-of-care ultrasound

A complete abdominal study and a focused one answer different questions, and confusing them is a real clinical error. **AFAST** — abdominal focused assessment with sonography for trauma, triage and tracking — is a rapid, structured screen performed at the cage side, and it exists to answer four specific questions:

1. Is there free fluid in the **peritoneal** space?
2. Is there free fluid in the **retroperitoneal** space?
3. Are there any obvious **target-organ abnormalities**?
4. What is the patient's **central fluid volume status**?

It is performed through **five acoustic windows**, each named for its target organs: the **diaphragmatico-hepatic**, the **hepato-renal umbilical**, the **spleno-renal**, the **cysto-colic**, and the **hepato-renal fifth** view. In most cats and many small to medium dogs both kidneys — and therefore both retroperitoneal spaces — can be seen from the spleno-renal window alone. Findings are recorded with a **fluid scoring system** rather than as a yes/no, so that a repeat scan an hour later means something.

> **The positioning rule that matters most**
>
> **Dorsal recumbency should never be used in a potentially unstable small-animal patient.** Scan standing where you can, or in lateral recumbency — the AFAST views are designed to work from those positions. A focused scan is not worth destabilising a patient for.

AFAST is usually taught alongside **TFAST** (thoracic) and **Vet BLUE** (veterinary bedside lung ultrasound examination), and the three combined are referred to as **Global FAST**. The lung vocabulary that goes with it is small and worth knowing: **A-lines** are the equally spaced horizontal reverberation lines of normally aerated lung; **B-lines** ("lung rockets") are vertical lines that swing with respiration and obliterate the A-lines, indicating fluid at the pleural surface; the **glide sign** is the to-and-fro motion of lung against chest wall; and the **lung point** is where sliding lung recontacts the wall — useful for both diagnosing and semi-quantifying a pneumothorax. The caudal vena cava is characterised as **bounce** (normal respiratory variation), **flat** (hypovolaemic) or **fat** (fluid-intolerant), which pairs directly with the decisions in our fluid therapy guide.

None of this replaces a complete study. Global FAST and point-of-care ultrasound are explicitly first-line screening tests, and their value is speed, repeatability and the absence of ionising radiation at the cage side — not completeness.

14 Beyond dogs and cats

Everything in the first half of this article — impedance, attenuation, the frequency–penetration trade, gain against power, TGC, and every artefact in the table — is **physics, and physics does not know what species it is in**. A mirror image forms at a curved lung interface in a horse for exactly the reason it does in a dog. What changes between species is anatomy, patient size, and access.

Three practical consequences. **Size dictates frequency**: the same 10 MHz probe that images a cat abdomen beautifully will not reach the far side of a cow's rumen, so large-animal work lives at lower frequencies and accepts coarser resolution. **Route changes**: much large-animal abdominal ultrasound is performed *per rectum* or through defined intercostal windows rather than from a clipped ventral abdomen. And **the normal values in this article do not transfer** — they are canine and feline reference intervals, and applying them to another species is exactly the error the cat-versus-dog section warns about, one step further out.

If your work spans species, Ultrasound in Veterinary Medicine: Fundamentals and Applications covers the same fundamentals and then adds dedicated sections on **ruminants**, **horses** and **exotic pets**, alongside a chapter on sonographic variation between dogs and cats. Our ruminant digestive anatomy guide is the anatomical companion for the forestomach work.

15 Eight mistakes beginners make

None of these are knowledge failures. Every one is a habit, which is the good news, because habits are fixable in a week.

THE MISTAKE	WHAT IT PRODUCES	THE FIX
Scanning **only the organ you are worried about**	The lesion that changes the plan is somewhere else. Splenic disease in particular is missed when the whole spleen is not covered	Follow the same sequence every time, on every patient, whatever the referral question
Leaving the **gain up** for the bladder	The urine goes grey, the near wall vanishes into the near field, and sediment appears where there is none	Drop overall gain and pull the near-field TGC down before you even look

THE MISTAKE	WHAT IT PRODUCES	THE FIX
Pressing harder when the image is poor	In a cat this flattens and hides the spleen completely; in any patient it hurts	Poor images are almost always a settings or window problem. More gel, a different window, a different frequency — not more force
Calling the kidney **small and echogenic**	A false diagnosis of chronic kidney disease from a slice taken too far laterally, where there is no medulla in the plane at all	Confirm on a central sagittal image and check a transverse plane. A lateral slice of a normal kidney looks small and uniformly bright
Mistaking **falciform fat** for liver	A normal liver reported as enlarged — or a fine-needle aspirate of fat	Look for the thin echogenic capsule between them, and remember that in cats falciform fat is thick, coarse and almost the same brightness as liver
Reporting the **pancreas as normal** because you could not see it	A missed pancreatitis, stated with confidence	Non-visualisation rules out an obvious mass and nothing else. Equally, seeing the pancreas does not mean it is diseased
Measuring **off-axis**	Lengths read short, obliquely cut walls read thick, and serial comparisons stop meaning anything	Rotate into true long axis first. This is what the small rotational movements are for
Trusting a **single plane**	A lesion hidden in the plane you did not take	Every organ gets orthogonal views. The kidney gets three

16 Quiz: test yourself

Twenty-eight questions covering settings, sequence, normal appearances, the measurements, Doppler, guided sampling and the artefacts. Cover the answers first.

1. Which transducer frequency should you choose for an abdominal scan?**Answer:** The **highest frequency that still penetrates to the far side of the liver** in that patient. Resolution improves with frequency but attenuation costs about **0.5 dB/cm per MHz**, so large dogs may need **5 MHz** while most small dogs and all cats image well at **10–11 MHz or above**.2. What is the difference between gain and power?**Answer: Gain** amplifies the returning echoes *after* the image has been formed — it is post-processing. **Power** is the intensity of the beam entering the patient. Keep power as low as will do the job, because power carries the biological cost (mainly heat) and also distorts the image.3. Your far field is dark. Do you raise the gain?**Answer:** No — you correct the **TGC**. Shifting the far-field portion of the curve to the right boosts gain only at that depth. Raising overall gain brightens the whole image, including the near field that was already correct.4. Which way does the probe marker point for a transverse abdominal image, and what appears on the left of the screen?**Answer:** The marker points to the **patient's right**. The patient's **right** side therefore appears on the **left** of the screen — the same convention as a VD radiograph.5. Name the three transducer motions.**Answer: Sliding** (a distance motion along the body wall), **fanning or rocking** (non-distance, angular — the contact point stays and the angle changes) and **rotating** (non-distance, rotational, used to reach true long axis before measuring).6. Which sedatives should you avoid before an abdominal ultrasound, and why?**Answer: Morphine and its derivatives**, which cause panting and aerophagia and fill the gut with air, and **xylazine**, which causes gastric atony and rapid gas accumulation. Both fill the abdomen with exactly what blocks the beam.7. What is the cranial landmark for the liver, and when do you actually see the diaphragm itself?**Answer:** The bright curved **diaphragm–lung interface**. You only see the true diaphragm, and its thickness, when there is **both pleural and peritoneal effusion** to outline it.8. How do you distinguish portal veins from hepatic veins?**Answer: Portal veins have more echogenic walls**, because their walls contain thicker, less organised connective tissue. In the dog the portal veins dominate the hepatic background.9. Where does the bile duct lie relative to the portal vein?**Answer: Ventral** to it — that is, nearer the probe. The caudal vena cava lies dorsal and to the right of the portal vein.10. Which structure do you use as an acoustic window for the left kidney?**Answer:** The **spleen**. Place the probe sagittally left of midline; the spleen appears in the near field and the kidney lies deep to it.11. Why is the right kidney harder to image than the left?**Answer:** It is more **cranial and dorsal**, and the pyloric outflow tract and descending duodenum lie ventral to it. In deep-chested dogs an intercostal approach between the 12th and 13th, or 11th and 12th, ribs may be needed.12. A sagittal image shows a small, uniformly echogenic kidney with no medulla. What is the first thing to consider?**Answer:** That the slice is simply **too far lateral**. A peripheral slice of a normal kidney contains no medullary tissue and looks small and bright. Confirm centrally before calling it chronic kidney disease.13. Which plane most reliably finds the adrenal glands, and what are their vascular landmarks?**Answer:** The **dorsal** plane. The **left** adrenal lies lateral to the **aorta**; the **right** adrenal lies against the lateral surface of the **caudal vena cava**. Find the vessel, then the gland.14. List the layers of the intestinal wall from the lumen outward.**Answer:** Hyperechoic **mucosal–luminal interface**, thick hypoechoic **mucosa**, thin hyperechoic **submucosa**, thin hypoechoic **muscularis**, thin hyperechoic **serosa** — five alternating lines.15. What is the normal jejunal wall thickness in a 25 kg dog and in a cat?**Answer:** About **0.35 cm** in a 15–30 kg dog and about **0.22 cm** in a cat. In the cat the **ileum** is the thickest small-intestinal segment; in the dog it is the **duodenum**.16. How is kidney size assessed in the dog, and why not simply in centimetres?**Answer:** By the **kidney : aorta ratio**, normally **5.5–9.1**. Canine body size varies so widely that an absolute length is meaningless; the aorta scales with the patient.17. Which measurement of the canine adrenal gland actually matters?**Answer:** The **thickness of the caudal pole** — up to about 0.54 cm under 10 kg, 0.68 cm at 11–30 kg and 0.8 cm above 30 kg. Length is too variable to be useful.18. What does a lymph-node short-axis to long-axis ratio above 0.7 suggest, and where does the rule not apply?**Answer:** It is a feature of **malignancy** — the node has become round rather than merely large. The rule is

validated for the **medial iliac** and superficial nodes but **not for the jejunal node**, which is naturally elongated.19. You see a second liver beyond the diaphragm. What is it?**Answer:** A **mirror-image artefact**, produced by the strongly curved diaphragm–lung interface sending the beam on a longer path. It mimics a diaphragmatic rupture and is one of the commonest false alarms in the cranial abdomen.20. How do you tell true bladder sediment from pseudosludge?**Answer:** Three tests. Real sediment has a **flat** surface; pseudosludge is **curved**. Real sediment is gravity-dependent and **moves when the patient is repositioned**. And pseudosludge **fades when you reduce gain or power**, while real echoes persist.21. Why is a shadow behind gas 'dirty' and a shadow behind a urolith 'clean'?**Answer:** At a soft-tissue–gas interface about **99%** of the beam is **reflected**, and those repeated reflections fill the shadow with noise. At a bone or calculus interface much of the beam is **absorbed** instead, so nothing reverberates and the shadow is uniformly black. The distinction is useful but not absolute.22. What are the four questions an AFAST examination answers?**Answer:** Is there fluid in the **peritoneal** space? Is there fluid in the **retroperitoneal** space? Are there obvious **target-organ abnormalities**? And what is the patient's **central fluid volume status**?23. Which patient position should never be used for AFAST in an unstable patient?**Answer: Dorsal recumbency.** Scan the patient standing or in lateral recumbency; the views are designed for it.24. What is the difference between colour Doppler and power Doppler?**Answer: Colour** Doppler encodes mean velocity *and direction*; **power** Doppler encodes only the amount of moving blood. Because power Doppler does not display a frequency shift it **cannot alias** and is largely independent of the angle of insonation, which makes it much more sensitive to slow flow in small or deep vessels — at the cost of telling you nothing about velocity, direction or turbulence.25. What is aliasing, and how do you fix it?**Answer:** Pulsed-wave and colour Doppler sample intermittently, and above the **Nyquist limit** the display wraps around so the fastest flow appears to reverse. Raise the **PRF** (velocity scale). But raise it too far and slow flow inside an organ disappears, which can be misread as an avascular structure — both are settings errors, not findings.26. Which needle-guidance technique should a beginner learn?**Answer: Freehand** — probe in one hand, needle in the other, needle watched continuously. It is the most versatile and the most commonly used for both aspirates and core biopsies. Indirect guidance (measure, remove probe, insert) is really only adequate for draining large volumes.27. What should you check before an ultrasound-guided core biopsy?**Answer: Coagulation.** In a large canine and feline series, minor complications occurred in over **20%** of guided biopsies and major complications in **6%**, with significant bleeding tracking with **thrombocytopenia**. Platelet count and clotting times are generally indicated. Routine fine-needle aspiration with a 22–25 gauge needle usually needs no special preparation unless bleeding risk is already high.28. A cat has a bilobed gallbladder. Is that a problem?**Answer:** No — a **bilobed gallbladder is a normal variant in the cat** and is not seen in dogs. It is one of a long list of feline findings that would be abnormal in a dog.

17 Abdominal ultrasound — frequently asked questions

What is the best probe for abdominal ultrasound in dogs and cats?

A **microconvex or curved-array multifrequency probe** is the workhorse: the small footprint fits between ribs, and the frequency range lets you drop to about 5 MHz for a large dog's liver and climb to 10 MHz or more for a cat. Add a **high-frequency linear probe** if you can — for the feline spleen, the near-field bladder wall and intestinal wall layering it is markedly better, and in many cats it is the only way to assess the spleen properly at all.

Does the patient need to be fasted for an abdominal ultrasound?

Where the case allows it, yes. A stomach full of food or gas blocks the acoustic window to the liver and pancreas, and gas is the commonest single reason a study is non-diagnostic. Do not delay an emergency scan for fasting — but for an elective study it makes a real difference. If the urinary tract is the question, also ask the owner **not** to let the patient urinate beforehand.

Do you need to clip the fur?

Almost always. Air trapped in the coat reflects essentially the whole beam. A No. 40 blade from the costal arch to the inguinal region, and laterally along the body wall, is the standard clip — and clip **wider** than you expect to need, because a small clip is what stops you reaching an intercostal window later. Patients with very short, thin coats can sometimes be scanned with the hair thoroughly wetted and generous gel.

What order should you scan the abdomen in?

Any consistent order beats an inconsistent one. A widely used sequence is **liver, spleen, stomach, duodenum, pancreas, kidneys, adrenal glands, urinary bladder, prostate and medial iliac lymph nodes**, then a systematic sweep of the remaining intestine and other nodes. Starting with the liver is deliberate: it is the deepest organ, so you set depth, power and gain at their maximum requirement and reduce from there.

How long should an abdominal ultrasound take?

A normal cat abdomen takes an experienced sonographer roughly **10 minutes**; an abnormal large-breed dog can take **45 minutes to an hour**. If you are learning, budget far more than that and do not let the clock push you into skipping the sweep at the end.

Can ultrasound rule out pancreatitis?

No. The pancreas is among the hardest organs to image routinely, and in many normal dogs and cats it is not seen at all because its acoustic impedance matches the surrounding mesenteric fat. **Non-visualisation excludes an obvious mass and nothing more.** Equally, being able to see the pancreas is not evidence of disease.

What does hyperechoic mean?

Brighter than whatever you are comparing it with — echogenicity is always relative. The standard comparisons in the abdomen are spleen against liver (spleen is normally brighter and finer) and renal cortex against medulla (cortex brighter). Note that a normal **feline** renal cortex is more echogenic than a dog's because of cortical fat, so applying canine expectations to a cat over-diagnoses renal disease.

Why does the liver appear in the chest on my image?

That is the **mirror-image artefact**. The curved diaphragm–lung interface reflects the beam, which then reaches the liver by a longer route; the machine assumes a straight line and plots the late echoes beyond the diaphragm. It is the classic mimic of a diaphragmatic rupture, and recognising it saves a great deal of unnecessary worry.

Is abdominal ultrasound safe?

It is non-ionising and has no confirmed adverse biological effects at diagnostic settings, and most patients need no sedation. The one setting with a genuine biological cost is **power** (acoustic output), whose main effect is tissue heating — which is why the standing advice is to use the least power that produces a usable image and to take the rest with gain.

What is AFAST, and is it the same as a full abdominal scan?

No. **AFAST** is a focused, four-question screen — peritoneal fluid, retroperitoneal fluid, obvious target-organ abnormality, and central fluid volume status — performed through five defined windows at the cage side. It is a first-line triage tool, not a substitute for a complete study. In a potentially unstable patient, scan standing or in lateral recumbency: **dorsal recumbency should never be used.**

Do I need Doppler for a routine abdominal scan?

Not for most of it — but colour Doppler earns its place in three specific moments: confirming that a near-anechoic structure is a **vessel rather than a lymph node**, identifying the **portal vein** and its flow direction when a shunt is on the differential list, and steering a needle away from vessels before sampling, which measurably reduces complications. The quantitative spectral work is a separate skill and can wait.

Why does my bladder image look full of sediment when the urine analysis is clean?

Most likely **pseudosludge** — side-lobe or slice-thickness artefact placing false echoes inside an anechoic structure. Turn the gain down: artefactual echoes fade while real sediment persists. Real sediment also has a flat surface and moves when you reposition the patient, whereas pseudosludge stays curved and perpendicular to the beam.

How do I know if a lymph node is abnormal?

Shape changes before size does. For the **medial iliac** and superficial nodes, a **short-axis : long-axis ratio** under 0.5 is normal, up to 0.7 is regarded as benign, and above 0.7 is a feature of malignancy. The rule does not apply to the naturally elongated jejunal node, and it does not apply to puppies, whose nodes are larger and oddly shaped normally.

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