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Key signs of bronchial patterns

A bronchial pattern on radiographs indicates an airway-associated disease. Recognizing it helps you to refine your differential diagnoses to diseases that fit an airborne disease, whether it is inflammatory, infectious, or toxic. It can be a subtle pattern to recognize, so let's look at some of the features.

Normal bronchi

The airways are made out of cartilage which is radiolucent, but they have some surrounding soft tissue structures that can make them visible. In the area of the hilus, there are a few structures that can be mistaken for abnormal bronchi.

There are pulmonary vessels that branch from the main pulmonary artery and veins as they travel through the caudal lung lobes (Figure 1b). These are vertically oriented, and many people mistake them for abnormal bronchi. They are normal soft tissue structures; familiarize yourself with how they appear in Figures 1a and 1b.

The bronchial walls are normally visible near the heart base where the diameter is still quite large. You might see parallel thin walls with vessels on either side, or just see the airways flanked by the pulmonary arteries and veins (Figure 1c). The bronchi are visible near the hilus, but the walls are thin and sharp, and are not visible toward the periphery. Wall thickness and visible bronchi in the periphery are criteria we use to diagnose abnormal bronchi.

Mineralized bronchi

With age, many dogs develop mineralization of the airways and trachea (Figure 2). It is not a normal aging change in cats. Mineralized bronchi are recognizable because of their mineral opacity and very thin, sharp borders. The bronchi are visible farther out in the periphery than in a dog with no mineralization. But any increase in opacity is uniform and very opaque.

Bronchial pattern

In a true bronchial pattern due to infectious/inflammatory disease, the bronchial walls are thickened because of inflammatory tissue and cells surrounding the airways. This makes them easier to see, especially in the periphery of the lung (Figure 3). The parallel lines you see are called tram tracks, and a bronchus visible end-on with thickened walls is called a donut. It can also be described as a cygnet ring, as it tends to be of non-uniform thickness (Figure 4). Additionally, the bronchial walls are not as sharp or regular as normal or mineralized bronchi (Figure 5). Chronic bronchial disease can result in bronchiectasis, which is an irreversible dilation of the bronchi. They don’t taper toward the periphery, and can be saccular in appearance.

Causes of bronchial patterns

Differential diagnoses for a bronchial pattern are usually inflammatory (chronic bronchitis, eosinophilic infiltrates, parasitic infections, fungal, viral, or bacterial pneumonia). Pulmonary edema can also sometimes make the bronchi look thickened as the tissues surrounding the airways fill with fluid. Identifying additional abnormalities can help you to rank your differentials appropriately. For example, a bronchial pattern and large perihilar lymph nodes would point towards fungal pneumonia.
Figure 1a. The normal thorax has bronchial structures that are large enough to be visible near the hilus. This is an unenhanced lateral image of the normal canine thorax.

Figure 1b. Highlighted pulmonary vessels. Pulmonary vessels travel vertically near the hilus and main pulmonary artery and vein. These parallel lines can mimic thickened bronchi. Recognize the pattern and the normal course of these structures.

Figure 1c. Highlighted large bronchi. The main stem bronchi have walls that are thick enough to be seen clearly near the hilus. This is a normal finding and does not indicate bronchial disease. Look for thickened bronchial walls away from the area of the heart base, where bronchial walls are not normally seen.
Figure 2. Mineralized bronchi have thin, sharp radiopaque walls. The bronchial walls in the right image are highlighted. Identify these on the non-highlighted image on the left.

**Identifying abnormal bronchi**

Once you have ruled out normal large airways and benign bronchial mineralization as the cause for increased visibility of bronchi, search for the hallmarks of the pattern. Bronchial thickening can be a subtle finding especially in cats. Make sure to look in the periphery for donuts. They are often most visible on the v/d or d/v projection. Tram tracks are often best seen overlying the diaphragm or heart where the summation effect makes them more apparent (Figure 3). A magnifying glass can be helpful to search for small airways.

Figure 3. In this lateral thoracic radiograph of a cat with chronic inflammatory lower airway disease, abnormally thickened bronchi are seen superimposed on the heart as tram lines, and end-on as donuts. Donuts and tram lines in the radiograph on the right are highlighted.
Figure 4. Thickened bronchial walls appear as round structures with asymmetric shapes. These are often called “donuts” or “cygnet rings”.

Figure 5. This cranial lobe bronchus is seen in the dorsal plane on a dv radiograph. It is much more visible than usual due to the thickened bronchial walls. The primary and secondary branches are visible.

Key signs of a bronchial pattern:

» Normal bronchi are flanked by vessels but the walls are not visible.

» Mineralized bronchi have mineral opacity, sharp, uniform walls.

» Abnormal bronchi have indistinct, soft tissue opacity, non-uniform walls.

» Abnormal bronchi are visible in the periphery of the lung.
Diagnosing megaesophagus

Megaesophagus is a condition in which the esophagus has reduced peristalsis, and has poor tone at rest. The esophagus can have a mild, focal motility problem, or the entire organ may be dilated and functioning poorly. These variations in severity mean that megaesophagus can have a variety of radiographic appearances. Both focal and generalized megaesophagus can be congenital, or acquired secondary to inflammation, foreign bodies, neuromuscular disease or idiopathic causes. Since a radiograph is a snapshot in time of the dynamic process of swallowing, it can be hard to decide what is a variation of normal, and what qualifies as an esophageal motility problem.

Variations of normal

There are a few variations in the normal appearance of the esophagus that you should recognize. The first one is a small amount of air in the cervical esophagus, just caudal to the cricopharyngeus muscle. It often outlines the cricopharyngeus muscle, or upper esophageal sphincter, that lies dorsal to the laryngeal cartilages (circled, Figure 1). The muscle appears oval, and the air is usually triangular in shape. The cricopharyngeus sometimes gets mistaken for a foreign body because of its large size and distinct border. This transient accumulation of air occurs more commonly in animals under general anesthesia, but can be seen in conscious radiographs as well. The second variation of normal is a triangular pocket of air in the thoracic esophagus, just cranial to the heart base (Figure 2). Small amounts of air such as these should clear with the next swallow, and are usually not seen on other radiographs of the same series.

Finally, if you are taking three-view thoracic series, you’ll often see some fluid in the caudal esophagus on the left lateral projection (Figure 3). This is because the esophagus and cardia of the stomach are on the left, and the increased pressure from abdominal organs causes some reflux of gastric contents. The key to recognizing all of these variations of normal is that they are transient. If you take another radiograph, they should be cleared.

Figure 1. The cricopharyngeus muscle (circled), or upper esophageal sphincter, is outlined by air in the cervical esophagus.
Figure 2. A normal, transient collection of air cranial to the heart (between arrows). The esophageal walls are not visible, only the radiolucent air contained in the esophagus.

Figure 3. Fluid often collects in the caudal esophagus (outlined by arrows) on a left lateral projection. This may be because the cardia and lower esophageal sphincter are on the dependent side, causing increased pressure for reflux. This finding should be transient.

Figure 4. Thorax of a dog with generalized megaesophagus and aspiration pneumonia. In megaesophagus, a large portion of the esophagus (outlined by arrows) is dilated with air. This is usually present on multiple radiographs of a series, in contrast to the transient findings in Figures 1-3. This dog also has an alveolar pattern in the right middle lung lobe (*) from secondary aspiration pneumonia.
Megaesophagus
Focal or generalized megaesophagus can cause persistent accumulations of air, or larger amounts of air to accumulate in these sites or other portions of the esophagus. The most common appearance of generalized megaesophagus is to see two diverging or parallel soft tissue lines dorsal to the trachea and caudal vena cava, and ventral to the aorta (Figure 4). The dilated portion of the esophagus can also fill with fluid or food material, especially in the case of an obstructive process such as a stricture or vascular ring anomaly. A diagnosis of megaesophagus is also supported if you have more than one radiograph with the same abnormality indicating persistent dilation.

Aspiration pneumonia is a common complication of many swallowing disorders as food boluses reenter the pharynx. Three projections of the thorax are very valuable in detecting alveolar disease. The most common location for aspiration pneumonia is the right middle lung lobe (asterisk in Figure 4), which you often only see clearly on a left lateral projection. The lobe is located in a ventral position, and the pneumonia is often in the most dependent portion. Subtle disease is often hidden by the mediastinum on a d/v or v/d projection, and not visible on the right lateral projection.

Esophagrams
Sometimes megaesophagus is not visible at all on plain radiographs. If the animal has signs of a swallowing disorder, you’ll need an esophagram to make the diagnosis. When the megaesophagus is more severe or static, administering some liquid barium and taking a radiograph will be enough to show you the outline of the

Figure 5. The radiograph of this dog with megaesophagus (left) shows a small amount of gas in the esophagus and evidence of aspiration pneumonia.

Figure 6. An esophagram was performed under fluoroscopy (right). The contrast clearly outlines the dilation of the esophagus cranial to a stricture over the heart base.
dilated esophagus. Fluoroscopy is very valuable in more subtle cases since you can watch the motility in real time.

One of the most common cause of focal megaesophagus that I see is esophagitis. It usually occurs in the caudal thoracic esophagus, and can be a primary disease, or secondary to another disorder such as hiatal hernia. This focal dysmotility might only be visible on fluoroscopy. Liquid barium is usually enough to make the diagnosis of esophagitis using fluoroscopy.

Esophageal strictures are often not visible on survey radiographs. You may only see persistent, small collections of air in the esophagus, and/or aspiration pneumonia (Figure 5). Barium and fluoroscopy is often needed to diagnose esophageal strictures, and to describe their degree of stenosis, location and extent (Figure 6). Barium-soaked kibble can also be helpful in cases where there is a mild esophageal stricture. Solid food particles may slow the bolus in a stenotic area which is much less obvious when viewing a liquid bolus.

Even if you have made the diagnosis of megaesophagus on plain radiographs, keep in mind that additional radiographs or fluoroscopy could be indicated. Imaging is very useful in monitoring response to treatment for megaesophagus, or for following secondary disease such as aspiration pneumonia. Fluoroscopy can also help to diagnose additional esophageal problems such as dyssynchrony of the pharyngeal swallowing mechanism, hiatal hernia, or esophageal masses or strictures.

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**Diagnosing megaesophagus:**

- recognize variations of normal (transient)
- persistent abnormal dilation of the esophagus with gas or fluid
- if static, plain radiographs may be all you need
- use fluoroscopy in cases of less severe or dynamic disease
- follow up imaging for response to treatment and monitoring of complications such as aspiration pneumonia
Is it a skin mass or a pulmonary nodule?

Thoracic radiographs for metastatic disease are part of every day practice. A diagnosis of pulmonary nodules has an important effect on treatment decisions, and some radiographs are difficult to interpret. One scenario is a dog with one or several masses on the thoracic body wall and an anal sac carcinoma. How do you decide whether the soft tissue opacities you can see on the radiographs are on the skin or in the lung parenchyma (Figure 1)? There are a few ways you can try to distinguish them.

**Sharpness of the margin**
We can see pulmonary nodules or skin masses as separate from lung or skin because they are surrounded by air, creating a soft-tissue/air interface that has very high contrast. A mass on the thoracic wall is surrounded by air only, while nodules in the lung are surrounded by air, small vessels and pulmonary tissue, and the thoracic wall. This means that skin masses have much sharper margination than lung nodules. Compare the sharpness of the body wall mass on the caudoventral right thorax (Figure 2) to the pulmonary nodules in the images (Figure 3). This dog has multiple pulmonary metastases from a large liver mass as well as a thoracic wall mass. Digital radiographs such as these will make the margination of external masses even sharper than on film because of the increased contrast of the images.

**Completeness of the margin**
Because body wall masses are attached to the skin, the visible margin is usually incomplete. The air surrounds the mass on two or three sides, but not circumferentially. Lung nodules have margins that are visible for 360 degrees unless they are silhouetting with another structure. Check multiple nodules for completeness of the margins.

**Use a marker**
If you still can’t tell if the soft tissue structure you are looking at is a skin mass or a pulmonary nodule, place a marker on the skin mass and repeat the radiograph. A dab of liquid barium or metallic adhesive markers both work well. This technique helps you to document which masses are accounted for externally.

**Location**
Since radiographs are a two dimensional representation of a three dimensional body, we need two views to pinpoint the location of a nodule. For example, the pulmonary nodule between ribs 8 and 9 on the lateral projection (Figure 3b) is visible in the same rib space on the dorsoventral projection (also superimposed over the external mass in Figure 3c). On both radiographs, this nodule is superimposed on lung tissue, which means it’s located in the lung. The skin mass is superimposed over lung on the dorsoventral projection but is ventral to the lung margin on the lateral projection. This triangulation proves that it is outside the lung.

**Practice**
Next time you look at radiographs, compare some of these features using structures outside and within the body. Notice the sharpness and incomplete margin of nipples compared to end-on vessels near the heart base, as well as their position on two projections. With practice, these small but useful details become part of your radiographic interpretation skill set.
Figure 1a. On the left lateral projection, there is a pulmonary nodule superimposed on the cardiac silhouette, as well as a skin mass ventral to the sternum.

Figure 1b. On the right lateral projection, the skin mass appears slightly more dorsal in location, and another pulmonary nodule is seen over the diaphragm.

Figure 1c. On the dorsoventral projection, one of the pulmonary nodules and the skin mass are both superimposed.
Figure 2a. Highlighted image of the skin mass. On the left lateral projection, there is a pulmonary nodule superimposed on the cardiac silhouette, as well as a skin mass ventral to the sternum.

Figure 2b. Highlighted image of the skin mass. On the right lateral projection, the skin mass appears slightly more dorsal in location, and another pulmonary nodule is seen over the diaphragm.

Figure 2c. Highlighted image of the skin mass. On the dorsoventral projection, one of the pulmonary nodules and the skin mass are both superimposed.
Figure 3a. Highlighted image of the pulmonary nodule in the right cranial lung lobe. On the left lateral projection, there is a pulmonary nodule superimposed on the cardiac silhouette, as well as a skin mass ventral to the sternum.

Figure 3b. Highlighted image of the pulmonary nodule in the left caudal lung lobe. On the right lateral projection, the skin mass appears slightly more dorsal in location, and another pulmonary nodule is seen over the diaphragm.

Figure 3c. Highlighted image of the pulmonary nodule in the left caudal lung lobe. On the dorsoventral projection, one of the pulmonary nodules and the skin mass are both superimposed.
Does poor peritoneal detail mean pathology?

One of the subtleties of interpreting abdominal radiographs is peritoneal detail. It’s a difficult region to evaluate, since it is the potential space between all the organs. It is normally filled with fat, including the falciform fat ventral to the liver, and mesenteric fat in the omentum. When we say peritoneal detail, we mean that the contrast between fat and the soft tissue of the organs in the abdomen makes the serosal surfaces of the organs visible (Figure 1). Poor peritoneal detail is the loss of this fat-soft tissue interface.

Uniform poor peritoneal detail

Causes of poor peritoneal detail are loss, or apparent loss, of fat in the peritoneal space. Thin animals have very little fat to provide contrast, so their detail is poor and the organs are not well seen. Animals with peritoneal effusion (hemoperitoneum, transudate, exudate, urine) have more soft tissue (fluid) opacity than fat because of all the fluid. In this case, the serosal surfaces are also not visible.

How do you tell the difference between lack of fat and effusion? The abdominal contour and skeleton will help you to differentiate between them. Young animals have open vertebral physes, and typically have poor peritoneal detail (lack of fat, small amount of peritoneal fluid) until 2-3 months of age (Figure 2). If the animal is thin, the soft tissues over the vertebral column have an undulating or tented appearance, and the abdomen is concave. Conversely, if there is fluid in the peritoneal space, the abdomen will be rounded (Figure 3). If you consider the animal’s age, body condition and abdominal contour, you should be able to determine if poor detail is due to lack of fat or excess fluid.

Masses can also cause focal, uniform poor detail by compressing the fat normally present between the serosal surfaces of organs (Figure 6). Look for evidence of a mass effect, such as displacement of structures away from the mass, and a distended abdomen (depending on the size of the mass). Peritoneal detail distant from the mass should be normal if there is no associated effusion or hemorrhage.

Figure 1. The peritoneal detail in this normal cat’s abdomen is good. The serosal surfaces of the bladder, small intestine and liver are all clearly outlined by intra-abdominal fat. Note that the retroperitoneal detail (kidney margins) is equal to the peritoneal detail.
Figure 2. This puppy of 5 months old has poor peritoneal detail because of lack of fat in the abdomen. The abdominal contour is normal, so there is no evidence of peritoneal effusion.

Figure 3. This cat has poor peritoneal detail and a distended abdomen. There is peritoneal effusion, which may be fluids such as blood, transudate, exudate, or urine.
Mottled poor peritoneal detail

There is another pattern of poor peritoneal detail that looks like a mottled or streaky increase in soft tissue opacity within the fat (Figure 4). This presentation has unique causes, and alternate differential diagnoses. The three differential diagnoses that I use for the mottled abdomen are a small amount of peritoneal effusion, peritonitis, and carcinomatosis. Generally, the abdominal contour is normal with mottled peritoneal detail. That’s because a small amount of fluid will just dissect between some of the fat folds and planes in the mesentery, and is not enough to distend it. Carcinomatosis is a diffuse neoplastic infiltration of the mesentery with multiple nodules, such as the cat in figures 4 and 5. This results in streaks or stripes of soft tissue opacity in the normally homogeneous peritoneal space. A focal peritonitis such as pancreatitis will also cause localized, mottled poor detail.

Radiographic interpretation of poor peritoneal detail

Use areas of normal fat opacity to compare to the peritoneum. The retroperitoneal space and the falciform fat ventral to the liver may remain unaffected by the peritoneal disease and give you a normal reference. Interpreting peritoneal detail involves critically evaluating the radiograph and correlating it with the signalment and body condition of the patient.

Figure 4 (left). The radiograph of the cranial abdomen in this cat with carcinomatosis has mottled peritoneal detail. The normal intra-abdominal fat (black *) is interspersed with irregular areas of soft tissue opacity that are not associated with organs (white *).

Figure 5 (right). The ultrasound of this cat showed multiple hypoechoic nodules representing areas of cancer spread within the mesentery (white *).
Differential diagnoses for poor peritoneal detail:

Generalized, uniform poor peritoneal detail, normal contour
   » Young animal (lack of fat, small amount of normal fluid)
   » Thin animal

Generalized, uniform poor peritoneal detail, distended abdomen
   » Peritoneal effusion (hemoabdomen, uroabdomen, transudate, peritonitis, neoplastic effusion)

Focal, uniform poor peritoneal detail, +/- abdominal distension
   » Mass (organomegaly, neoplasia, abscess, granuloma)
   » Inflammation (pancreatitis, devitalized bowel)

Mottled peritoneal detail, no or mild distension
   » Small amount of effusion
   » Inflammation
   » Carcinomatosis

Figure 6. This dog has a large abdominal mass (↑) that is causing a focal area of poor detail in the cranial abdomen. The margins are clearly outlined, and the caudal abdominal detail is normal, indicating that this is a mass rather than a peritoneal effusion.
Ultrasound of cats with chronic renal disease

Chronic renal disease is one of the most common ultrasonographic findings in older cats. If you’re doing ultrasound on cats, you’re sure to see signs of chronic renal changes on a daily basis.

The normal kidney

Normal kidneys in cats are oval or bean-shaped (Figure 1). They’re shorter than canine kidneys, but also wider. The left kidney is located caudal to the spleen, and the right kidney is slightly more cranial and deeper when scanning in dorsal recumbency. The length of the kidney should be 3.8-4.4 cm, and the surface is smooth and regular. Compare the echogenicity of the medulla and cortex to the spleen and liver. The order of echogenicity, from hypoechoic to hyperechoic is medulla, cortex, liver, spleen, prostate. Try the mnemonic, My Cat Loves Sunny Places. The cortex should be about twice the thickness of the medulla, and you should be able to differentiate them easily. The ability to clearly separate the cortex and the medulla is called good corticomedullary distinction.

Chronic renal disease

One of the things you’ll hear in describing kidneys with chronic changes is “poor corticomedullary distinction” (Figure 2). If you compare the first image (normal kidney) with the second image (chronic renal disease), you’ll see that there is less difference in the shade of gray between the cortex and the medulla. The change in echogenicity implies that there is alteration of the composition of the renal tissue.

Normal echogenicity of the cortex should be similar to, or slightly hypoechoic to the liver. Compare the echogenicity of the cortex to the spleen and/or liver if possible since both the cortex (hyperechoic in Figure 3) and medulla (hyperechoic in Figure 4) can be abnormal.

Kidneys affected with chronic renal disease are usually small, and may have altered surface contour.

Figure 1. This normal sagittal image of a kidney in the sagittal plane shows good corticomedullary distinction.

Figure 2. This kidney has poor corticomedullary distinction and mineralization of the pelvis.
Figure 3. This is a small kidney with a very hyperechoic cortex (compare to figure 1). Although the corticomedullary distinction is good, the altered echogenicity indicates chronic renal disease.

Figure 4. This kidney has a hyperechoic medulla. Compare it to figure 3, where the echogenicities of the cortex and medulla are reversed. This kidney is also affected by chronic renal disease.

Figure 5. This is a sagittal image of an end stage kidney, which is about 2.5 cm in length. The anechoic central area (*) is dilation of the pelvis. The arrow indicates mineralization. These are both common findings in chronic renal disease.
Figure 6. This kidney has a wedge-shaped, hyperechoic infarct in the cortex. This causes an indentation in the contour of the kidney (arrow).

Figure 7. This kidney has poor distinction between the cortex (black ^) and medulla (white ^). The renal pelvis is anechoic and dilated (*).

Figure 8. This kidney has no corticomedullary distinction, and the renal pelvis is dilated. There is a poorly visualized calculus in the renal pelvis that is causing strong acoustic shadowing (*).
Renal infarcts look like wedge shaped, hyperechoic areas when acute (base toward the periphery), and an inward defect when chronic (fibrosis and scarring). They can drastically alter the shape of the kidney.

The kidney in Figure 5 has two other common abnormalities; pelvic dilation and mineralization.

The anechoic area in the distal third of the kidney is the dilated pelvis (asterisk). This is normally a potential space, with no visible fluid within it. Certain diuretic conditions such as fluid therapy or polyuria/polydipsia can dilate the pelvis 1-2 mm, but more than that is pathologic. Kidney with pyelectasia (renal pelvic dilation without loss of renal tissue) may have previous or current obstruction or pyelonephritis.

Mineralization can occur in the pelvis or the parenchyma. In the parenchyma, it is often an irregularly shaped, hyperechoic focus with distal acoustic shadowing. Take care to differentiate this from the arcuate vessels, which are very echogenic, but look like double parallel lines. The kidney in image 5 has some mineralization of the pelvis which is causing a faint acoustic shadow. This can be hard to tell from a pelvic stone that’s at risk for obstructing a ureter.

**The end stage kidney**

All of the changes above are chronic and progressive. Regardless of the underlying disease, the kidney tissue becomes replaced by fibrous tissue over time. The kidney gets smaller, the cortex often appears equal or greater thickness than the medulla, and eventually they become indistinguishable. A small kidney can be very hard to find, so use your anatomic and vascular landmarks (spleen, aorta, renal artery) if you need to.

Although ultrasound is able to detect changes in chronic renal disease, it is not highly sensitive. Cats can have significant renal dysfunction without ultrasonographic signs of renal disease. Conversely, many cats cope with their chronic renal disease though they have severe ultrasonographic changes. The history and blood work are important in assessing the significance of the findings. These changes are also non-specific, so the underlying mechanism can’t be determined unless a biopsy is performed.

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**Key signs of chronic renal disease:**

» Poor corticomedullary distinction

» Small kidney size

» Altered echogenicity of the cortex and/or medulla

» Renal calculi

» Defects in the renal contour caused by infarcts

» Dilated renal pelvis
Recognize vascular thrombosis with ultrasound

Thrombosis is a complication of many diseases in veterinary medicine. Heart disease, protein losing nephropathy and steroid therapy or hyperadrenocorticism can all predispose an animal to arterial or venous thrombi. Many of the systemic vessels involved are located in the abdomen and visible on abdominal ultrasound. We can identify thrombosis during an acute episode or as an incidental finding. Here are some of the features you might see.

Appearance of the thrombus
In the acute phase, thrombi in the arterial or venous systems are typically anechoic. These can be caused by migration of a fragment of thrombus from the left atrium to the terminal aorta (such as cats with cardiomyopathy), or a portal vein thrombus that causes portal hypertension and ascites. You may see some faint echogenicity within the vessel, but these are usually diagnosed using Doppler ultrasound. The color flows around the filling defect in the vessel.

After several days, the thrombus organizes into a visible structure. It is usually intermediate in echogenicity, and can partially or completely fill the vessel (Figure 1). An older thrombus may contract so that there is flow around it (Figure 1).

Location of the thrombus
The location of the thrombus determines whether it causes clinical signs. Arterial thrombi, such as in the aorta, can occlude blood flow to distal structures. Ischemia of the hind limbs is a common complication of aortic thrombosis as the thrombus can occlude or extend down the iliac arteries. An aortic thrombus can also occlude the renal arteries causing renal ischemia. The thrombus in Figure 3 (*) is very close to the renal artery (R) but not occluding it. Portal vein thrombosis is also usually clinical because of the ascites that forms from portal hypertension. Thrombi in the splenic veins are very common, and don’t usually cause any

Figure 1 (left). This splenic vein is filled with an echogenic thrombus. A small amount of anechoic blood is seen between the thrombus and the vessel wall. Figure 2 (right). Color Doppler shows the path of blood flow around the thrombus.
symptoms. These can be an incidental finding (Figure 1 and 2), such as in this dog with lymphoma who had been treated with prednisone.

**Tumor thrombus**

Tumors can also cause physical obstruction of a vessel, usually in the caudal vena cava. Any tumor with a tributary joining the caudal vena cava can infiltrate the vessel and reach the systemic venous circulation. The most common tumor that invades the caudal vena cava is an adrenal tumor (Figure 4), with pheochromocytomas having a predisposition. The tumor thrombus starts by traveling down the phrenicoabdominal vein that runs across the mid-portion of the gland, then reaches the caudal vena cava. Renal tumors can follow a similar pattern and invade down the renal vein.

![Figure 3. An aortic thrombus (*) located very close to the renal artery (R).](image)

![Figure 4. Color Doppler demonstrates a tumor thrombus in the caudal vena cava, formed from an adrenal mass. Adrenal masses invade the phrenicoabdominal vein, which drains into the caudal vena cava.](image)

**How to evaluate thrombosis:**

- Use color Doppler to look for acute thrombi
- Evaluate the extent and location of visible thrombi
- Check for peripheral flow with color Doppler
- Look for evidence of neoplasia in the region
- Check for sequelae of thrombosis such as ischemia of distal structures or ascites
Use ultrasound to detect free abdominal fluid

Ultrasound is very sensitive at picking up free fluid in the peritoneal space. Depending on the patient, free fluid may be an important finding in diagnosing abdominal disease. The character and the amount of fluid are important indicators for the composition and cause of the effusion.

**Small amount of anechoic fluid**

The best places to detect a small amount of effusion are between the liver lobes (Figure 1), or next to the bladder. Near the liver, the fluid dissects between liver lobes or between the liver and the diaphragm, allowing you to see these structures separately. A small amount of anechoic effusion will be located in the cranial, caudal or dependent portion of the abdomen, or may appear as small triangular areas between bowel loops. Young animals often have a small amount of normal fluid in the abdomen as a normal finding. In older animals, hypoproteinemia or overhydration can cause a transudate or modified transudate to form. Mild systemic disease such as inflammatory bowel disease is another potential cause of a small effusion. If the amount of fluid is minimal, anechoic, and there is no evidence of abdominal disease, it is most likely to be a benign cause.

**Moderate/marked amount of anechoic fluid**

A more concerning finding is a moderate amount of anechoic fluid. Although the amount is subjective, moderate fluid levels are easy to see, and obviously separate the liver lobes and infiltrate between the intestine and other organs. Anechoic fluid is often of low cellularity, and can be a transudate or modified transudate. Causes such as heart failure can be supported by evaluating the hepatic vein size and the history of the animal. Enlarged hepatic veins are readily visualized using ultrasound, and indicate right heart failure. Hypoproteinemia from gastrointestinal or renal disease can also cause effusion. It’s worth checking the liver

![Figure 1](image1.png) (left). A small amount of anechoic fluid can be seen separating two liver lobes in the cranial abdomen (arrow).

![Figure 2](image2.png) (right). There is a large amount of echogenic effusion (EFF) surrounding the bladder. Compare it to the anechoic urine (UB).
and portal vein for evidence of portal hypertension, such as a nodular liver, hepatofugal blood flow in the portal vein, or thrombosis. Portal hypertension causes fluid to exude from the liver itself because of increased hydrostatic pressure. Acute inflammation can also cause an anechoic effusion, though inflammatory effusions are often echogenic by the time the ultrasound is performed. The history and lab findings are often helpful in narrowing down the differentials and focusing the ultrasound exam.

**Moderate/marked amount of echogenic fluid**

Echogenic fluid has small suspended particles that look like flecks of white and swirl with agitation or breathing (Figure 2). It can be helpful to compare the effusion to the urine in the bladder (Figure 2), as the urine is normally anechoic. An echogenic effusion often means that the fluid is cellular, such as a suppurative, hemorrhagic or neoplastic effusion, or is proteinaceous. For the dog in Figure 2, the echogenic effusion was a modified transudate with 4.9 g/dl protein and 20,000 red blood cells/ul.

Secondary findings are very helpful in determining the origin of the effusion. A splenic mass or hepatic mass would lead you toward diagnosing a hemorrhagic effusion, while an intestinal mass with surrounding hyperechoic mesentery and localized effusion indicates ruptured bowel and suppurative effusion. The key points are to decide if it is generalized or localized, to look for a mass (non-GI or GI), and to evaluate the mesentery. Neoplastic effusions can form from carcinomatosis, which results in a mesentery that is diffusely thickened with ill-defined hypoechoic nodules. Primary sites of neoplasia leading to carcinomatosis include bladder, GI and prostate.

For a definitive diagnosis of the composition of the effusion, paracentesis is required. The best places to aspirate small amounts of fluid are in the cranial and caudal areas of the abdomen. I often orient the transducer parallel to the table, and search for a pocket in the dependent part of the abdomen. Fluid pockets often form near the bladder or between the bowel and body wall. Take care not to touch nearby bowel and bladder when placing the needle for an ultrasound-guided paracentesis.

There are many causes of peritoneal effusion, and ultrasound is very sensitive at detecting them. In general, anechoic effusions tend to be more benign, and echogenic effusions more infectious/inflammatory or malignant. If you detect effusion, focus your ultrasound examination on focal change that could cause effusion, or for signs of more general disease leading to a hydrostatic cause for effusion.

**Detecting free fluid with ultrasound:**

- Look between liver lobes, bowel loops, and near the bladder for small amounts of fluid
- Determine if the fluid is anechoic or echogenic
- Determine if the fluid is focal or generalized
- Look for causes of effusion e.g. mass, thrombus, hepatic congestion, carcinomatosis
- Obtain a fluid sample for diagnosis