Thoracic radiology review: seeing the hidden stuff

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Introduction

As a technician you will likely be the first person to view a patient's radiograph. A radiograph should be reviewed twice: first for technique and second for the medical condition of the patient. Taking a good quality film is a requirement in order for the radiograph to be diagnostic. Being able to understand normal and abnormal thoracic anatomy on a radiograph will help provide faster and complete medical care to the patient.

Brief overview

Sedation should be used when appropriate to help minimise motion, stress on the patient and radiation exposure to the staff. Though ventral/dorsal (V/D) views are usually preferred, many animals with thoracic injuries or heart disease will not tolerate such a position. The V/D position gives better detail when pleural effusion is suspected. It is important to remember not to struggle with any patient having difficulty breathing. Sedating or allowing the patient to stay in a dorsal/ventral position may be the better option. With any animal experiencing dyspnoea, it is important that they are stabilised first prior to causing them more stress in the radiology room.

Anatomy

There are four main areas of the thorax: pleural space, pulmonary parenchyma, mediastinum and extra-thoracic. The pleural space is composed of two mesothelial layers called the parietal and visceral pleura. The parietal pleura lines and is fused with the thoracic wall and diaphragm. The visceral pleura covers the lungs. The pleural space normally does contain a small amount of fluid, but it is not visible radiographically. The pleural space is divided up by fissures. In patients with disease or traumatic injury, the fissures may fill up with fluid or air causing them to become visible on a radiograph.

The pulmonary parenchyma is made up of two lungs (each comprising about 50% of the chest), the pulmonary arteries and veins and the bronchi. The right lung is divided up into the cranial, middle, caudal and accessory lobes while the left lobe is divided up into the cranial and caudal lobes. Obese or recumbent animals may have an increased interstitial pattern of the lungs because they will often ventilate poorly causing partial atelectasis of the lung. The overlying fat from an obese animal may cause an increase in opacity on the radiograph.

The mediastinum contains all of the structures between the pleural sacs and can be divided into three regions: cranial, middle and caudal. The cranial mediastinum contains the oesophagus and trachea, the middle contains the heart and part of the oesophagus and the caudal contains part of the oesophagus. The heart can have a varying degree of 'normals' as well. Very generally the heart is 'egg' shaped and should be tilted upwards at roughly a 45-degree angle. Older animals tend to have a heart that falls forward rather than stands upright. This is more common in cats and will often exaggerate the aortic arch. In obese animals the heart may appear enlarged, but this is simply because of the decrease in lung size because of increased pericardial and thoracic fat. Besides the heart, the mediastinum also contains the structures of the trachea and oesophagus. Though the trachea is visible on a radiograph, the oesophagus is not normally visible unless it is gas or fluid filled.

The extra-thoracic area is comprised of the body wall, spine and ribs. This area of the thoracic is often overlooked, however it can be equally as important when diagnosing an animal. When reviewing a radiograph, it is important to remember to view all four main areas of the thorax.

Lungs

In order to determine if what you are seeing is an abnormal pulmonary pattern, you should first ask “are the lungs too lucent or too opaque?” If you answered that the pulmonary field is too lucent, then you should be sure to look for overexposure or overdeveloping of the film. Hyperinflation of the lungs or severe emaciation of the patient can also cause the film to lack detail. Other causes of a too lucent film can include bulla, pneumothorax, or feline asthma complex. If you answered that the radiograph is too opaque, then you are likely seeing a pulmonary pattern, the presence of pleural effusion or a mass. There are four classifications of pulmonary patterns that can be diagnosed on radiograph: alveolar, bronchial, vascular, and interstitial. Some radiologists do not advocate the classifications of patterns, but they can serve a purpose to help classify certain diseases.

An alveolar pattern occurs when there is fluid within the alveoli of the lungs. The pulmonary alveoli are the primary sites of gas exchange with the blood. With an alveolar pattern the pulmonary vessels typically are not seen because they are obscured by the fluid in the alveoli. This pattern is usually classified by an air bronchogram, which is an increase in opacity of the alveoli. Typical alveolar pattern causes include: blood (contusions, thromboembolism, trauma), neoplasia, lung collapse or left sided heart failure with oedema.

When looking at a radiograph, the primary bronchi should be traced as they leave the trachea. A bronchial pattern consists of an abnormal opacity within the lungs from either fluid or abnormal cell accumulation along or within the bronchi. In geriatric animals, bronchial mineralisation can occur normally. A bronchial pattern will usually present as an excessive number of parallel lines or rings.

A vascular pattern usually means the vessels have become enlarged causing increased opacity. This can occur with animals experiencing severe heartworm disease, patent ductus arteriosus or fluid overload.

An interstitial pattern is broken down into unstructured or structured. An unstructured pattern is typically spread evenly throughout the lungs, while a structured pattern is generally localised, such as from a mass or pulmonary nodule. Nipples, ticks or dirt on the skin can cause the appearance of a structured pattern. Other causes of a structured/nodular pattern include metastatic neoplasia. However, end-on pulmonary vessels can easily be confused for pulmonary nodules. Pulmonary osteomas occur in older dogs and are small, mineralised nodules that are often misdiagnosed as metastasis. Shelties and collies appear to be prone to osteomas. Unstructured patterns may be normal in geriatric or obese animals and can also be seen in radiographs that are under exposed or have been taken during expiration. Other causes for an unstructured pattern can include lymphoma and vasculitis.

Heart

Normal heart appearance varies widely from breed to breed. A good rule is to look at the shape of your patient. If your patient is tall or thin chested, then it will likely have a heart that is thin and tall. If your dog is squat and short, then it will likely have a squat and short appearing heart. Some dog breed shapes (such as chondrodystrophoid or athletic) may appear to have a heart that looks enlarged or too round, while dogs with deep chests (greyhounds) may appear to have a heart that is too small. In order to diagnose heart enlargement, it is imperative that the radiograph is labelled properly. On a D/V view, the diaphragm is displaced cranially, causing the

heart to appear more cranial and in the left hemithorax. If incorrectly labelled, the veterinarian may diagnose the animal with cardiac disease. When in doubt, an ECG and echocardiogram should be performed by a boarded cardiologist to rule out heart disease. Determining the normal size of a heart is very controversial, but a very rough estimate can be done. In dogs the heart should be 3-3.5 times the width of an intercostal space on a lateral radiograph, while cats should be 2-3 times the width. The most accurate and objective method in determining heart size is to use the Vertebral Heart Size (VHS) scale.

On a lateral view you will see:		On a V/D view you will see:	
12-3:00 left atrium	3-6:00 left ventricle	12-3:00 left auricle	3-6:00 left ventricle
6-9:00 right ventricle	9-12:00 right auricle, aortic arch	6-9:00 right ventricle	9-11:00 right atrium

Using the clock face system, you can view the chambers of the heart. The apex of the heart is at 6:00.

Left atrium enlargement is the most common enlargement in both dogs and cats due to dilation. The most common reason for left sided dilation is mitral valve disease. This causes the leaking of blood back through the one-way mitral valve which separates the left ventricle and the left atrium. Enlargement of the left ventricle may occur because of hypertrophy or dilation. Dilation of the left ventricle is usually associated with cardiac failure. Similarly, the right ventricle may be enlarged because of hypertrophy or dilation. Hypertrophy in the right ventricle may be due to heartworm infection or pulmonic stenosis. You will rarely be able to detect right atrium enlargement from a radiograph. Generalised enlargement, causing an almost basketball shape to the heart, may indicate pericardial effusion or generalised myocardial dysfunction.

The caudal vena cava, largest vein in the body, can vary greatly in size based on respiratory and cardiac cycle. The vena cava helps supply deoxygenated blood back from the body to the heart and empties into the right atrium. The caudal vena cava can enlarge from an increase in central venous pressure (CVP), but the size of it cannot be determined if there is an increase in CVP. The aorta (the largest artery in the body) originates from the left ventricle and helps to deliver oxygenated blood to the body. In older cats, the aorta loses elasticity causing it to curve upward and dilate making it appear larger than in a younger cat. It can easily be misinterpreted as a pulmonary mass. Rarely an enlarged aorta is the finding of a disease process. However, in a V/D or D/V view an aortic bulge is commonly seen in patients with patent ductus arteriosus. The basic rule is that the caudal vena cava has a 1:1 size ratio with the aorta.

Pulmonary vessels

Pulmonary vessels help to supply blood from the lungs to the heart. Pulmonary arteries and veins should be about the same size. In lateral views, arteries lie dorsal to veins in the cranial lobe. In the caudal lobe arteries and veins are superimposed over each other. It is easier to distinguish between the two on a left lateral radiograph. In dogs you can evaluate those vessels that lie over the 9th rib and in cats the 10th rib. Both the arteries and veins that pass over his 9th rib should be the same width as the rib. If both the arteries and veins are enlarged, you should check for an over-circulation problem such as patent ductus arteriosus or severe left sided heart failure. If both are small hypovolemia, shock or dehydration should be considered. If arteries are enlarged, but the veins are normal, pulmonary thromboembolic disease or heartworm disease can be ruled out. Lastly if the veins are enlarged, but the arteries are normal, pulmonary congestion and left sided heart disease are possible.

The pleural space

Normal pleural space is not visible on radiographs. However, when fluid is added to this space it becomes visible on radiographs and is known as pleural effusion. Pleural fissures can be seen as thin lines of fluid within the pleural space and fissures appear wedge shaped on radiographs. Typically, pleural effusion is symmetrical between the right and left pleural spaces. However, when it is unilateral, a mass, inflammation or pyothorax can be suspected. There are a variety of reasons that pleural effusion can occur and a variety of types of fluid. See the table below the most common fluid types:

Type of fluid	Differential diagnosis
Blood (hemothorax)	Trauma, neoplasia (hemangiosarcoma, mesothioloma), coagulatopathy
Serosanguinous (clear)	Heart failure, vasculitis, diaphragmatic hernia, neoplasia
Pus (pyothorax)	Abscess, infection
Chyle (chylothorax)	Mediastinal mass, idiopathic cause, heart disease

The other most common condition that can be seen in the pleural space is a pneumothorax, or air trapped in the pleural space. Lateral views easily show the existence of air in the pleural space.

The mediastinum

This is the space between the lungs and can be divided into cranial, middle, and caudal mediastinum. Typically, the only structures of the mediastinum visible on radiograph are the heart, trachea, caudal vena cava and aorta. The mediastinum is best viewed on a lateral radiograph, since in a V/D most of the structures are superimposed over the sternum. Abnormalities to the mediastinum are divided into four categories: mediastinal shift, pneumomediastinum, mediastinal masses and fluid.

A mediastinal shift occurs from a decrease or increase of volume in one lung or a presence of a mass. This causes the structures to shift from midline to one side. Typically shifts are difficult to assess on a lateral view, which is why a V/D or D/V view should be taken.

A pneumomediastinum occurs when there is free gas in the mediastinum. Gas within the mediastinum generally causes an increase in radiograph contrast for the organs located in the mediastinum. Pneumomediastinums can progress to a pneumothorax simply because the pressure within the mediastinum can become too great causing a tear in the pleura. Dyspnoea is not common with a pneumomediastinum. Common causes include tracheal and oesophageal tears, trauma, jugular venipuncture, or neck surgery.

Mediastinal masses are quite common. In the cranial mediastinum you may see an elevation of the trachea on a lateral radiograph from the mass pushing upwards. Sometimes due to the size or position of the mass, it is difficult to determine if the mass is located in the lungs or in the mediastinum.

In the mediastinum lies the oesophagus, which is not normally viewed radiographically. Megaoesophagus is the abnormal enlargement of the oesophagus and can be seen in the mediastinum on a lateral radiograph as thin opaque lines representing the walls of the oesophagus. Due to its large size, air accumulates in the oesophagus making it easier to identify on radiograph. Foreign bodies may be also detected in the oesophagus if they are radiopaque

The trachea is one of the structures of the mediastinum which is easily detected on a lateral radiograph lying nearly parallel to the spine. A V/D can help assess if the trachea is displaced

laterally to one side. Normally on a V/D view it lies slightly to the right in the cranial mediastinum. In brachycephalic or obese dogs, the trachea will appear in a V/D view to lie even more to the right. This is normal and not a displacement. If the neck is bent at all during position of a radiograph, the trachea will bend as well and should not be mistaken for a mass pushing up on the trachea. Primary tumours of the trachea are not common. In geriatric animals, mineralisation of the trachea is normal. The diameter of the trachea varies from breed to breed but is relative to the size of the animal. Tracheal hypoplasia is common in brachycephalic breeds, especially in young English Bulldogs. Tracheal collapse is the loss of rigidity of the trachea, and typically occurs in toy dog breeds and severely obese pets. If tracheal collapse is suspected, then lateral radiographs of both inspiration and expiration must be taken.

The diaphragm

There are only three main openings between the thoracic and abdominal cavities through the diaphragm: aortic hiatus, oesophageal hiatus and caudal vena cava foremen. When reviewing a thoracic radiograph, only a small portion of the diaphragm can be viewed, but it should appear as a unified structure extending from cranioventral to craniodorsal. The shape itself will change depending on inspiration, expiration or intraabdominal pressure. If there is an increased opacity in the diaphragmatic border lung masses, pleural effusion or a hernia should be suspected. The most common disease associated with the diaphragm is a hernia. There are two types of hernias associated with the diaphragm: congenital or traumatic.

There are two main types of congenital hernias: peritoneopericardial diaphragmatic (PPDH) and hiatal. A PPDH occurs when the abdominal contents herniate into the pericardial sac of the heart through a congenital hernia in the diaphragm. A PPDH is something the animal is born with but may not be detected until later in life. A hiatal hernia occurs when part of the stomach enters the chest cavity through the oesophageal hiatus. Though normally due to a congenital deformity (Shar-peis are predisposed), these can sometimes occur from trauma. Hiatal hernias can also be an intermittent finding with little to no clinic significance.

Traumatic hernias can occur from a variety of traumas including vehicular, bite wounds and penetrating wounds. Traumatic injuries rarely cause true diaphragmatic hernias. The most commonly reported herniated organs (in order of prevalence) are the liver, small bowel, stomach, spleen and omentum. Due to the number of organs penetrating into the chest cavity, the heart and lungs may also become displaced. Air filled intestines in the chest are the easiest to diagnose on a film. Pleural effusion may occur during a traumatic hernia making it difficult to diagnose the hernia. Aspiration of the fluid may be necessary in order to detect a hernia radiographically.

The body wall and ribs

Not to be forgotten about, the body wall and the ribs are not only important to help rule out diseases, but also help to determine if the radiograph technique is good. The body wall and ribs' appearances will vary greatly with dog breeds but tend to be more consistent between species of cats. Dogs and cats have 13 pairs of ribs; however some animals have one less or one more pair of ribs, which is generally incidental. As animals age, mineralisation of the costal cartilages is normal. When evaluating the ribs a V/D or D/V view is more valuable than a lateral. Both sides should be symmetrical. Fractures are one of the most common injuries to the ribs and can occur from trauma or neoplasia. Looking at each rib, you should look for broken, fuzzy areas or decreases in opacity. One trick to help detect fractured ribs is to turn the radiograph upside down on a D/V or V/D, which will help make the ribs stand out more. Degeneration of the sternum is also normal in older animals.

Like the ribs, the spine should be a crisp white colour. Spacing between the vertebrae should be equal. In the spine, spondylosis is common in older animals and hemivertebrae are common in brachycephalic dog breeds. Both primary and metastatic neoplasms can occur in the spine and are generally characterised by lysis or proliferation of the vertebrae. Metastatic neoplasia occurs most commonly to the T3 vertebrae.

Depending on an animal's weight, the appearance of the thoracic body wall may vary. Sometimes soft tissue swellings or subcutaneous emphysema can be noted on radiographs. Lumps, ticks, dirt and nipples on the body of the animal may appear as nodules in the chest. By placing a dot of barium paste or a metallic marker on the questionable areas on the animal's body, you can easily determine if what you are viewing is actually a nodule in the chest or merely something on the surface.

Conclusion

All animals with thoracic injuries or diseases should be stabilised prior to radiographs being taken. Chest films can cause a lot of stress to already stressed animals, and sedation should be used when appropriate. Being able to identify diseases on radiograph and alerting a veterinarian to life threatening ailments will expedite appropriate patient care. The more radiographs that you take and review, the better you will be become at both technique and recognition of normals versus abnormals.

References available upon request