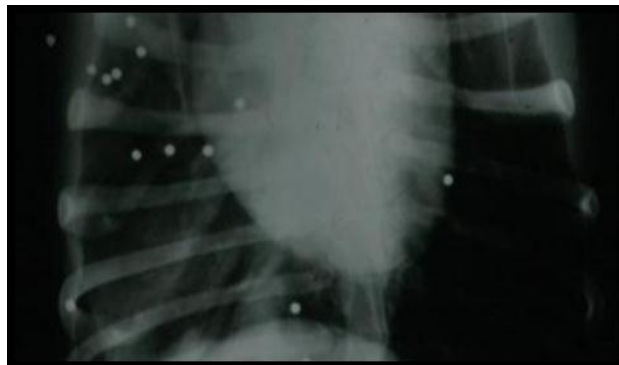


Thoracic Radiology Mini Series 2016

Session 3: The Pleural Space, Mediastinum and Thoracic Boundaries

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The Pleural Space, Mediastinum & Thoracic Boundaries

The Pleural Space

Normal Anatomy

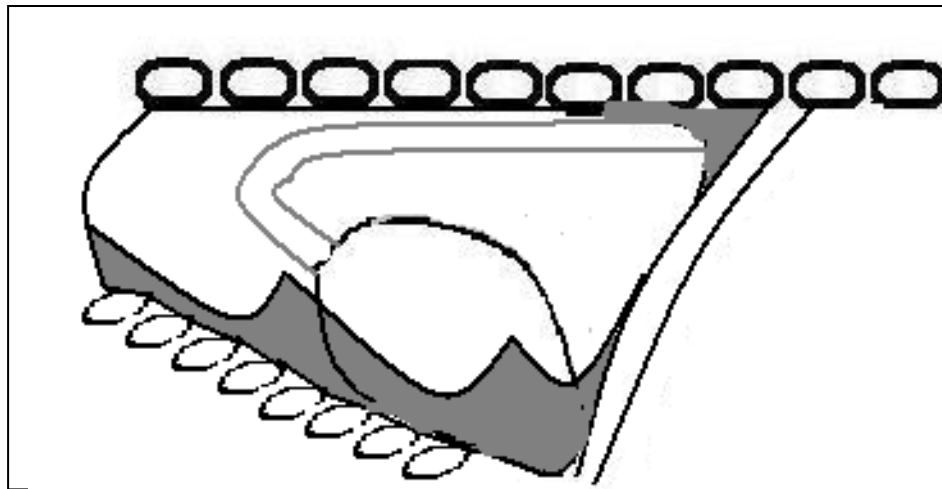
- The pleural cavities consist of the space (usually < 1mm across) between the visceral & parietal pleura, with a tiny amount (2-3ml) of lubricating pleural fluid
 - Visceral pleura lines the surface of the lung & forms the interlobar fissures
 - Parietal pleura lines the thoracic wall laterally, the mediastinum medially & the diaphragm caudally
- In dogs, right and left pleural cavities are connected via fenestrations through the caudoventral mediastinum
- In cats the parietal pleura forming the mediastinum is more often intact
 - Hence unilateral pleural disease is more common
- In the normal cat/dog the pleural space is not visible
 - Fine radio-opaque lines corresponding to the folds of visceral pleural between the lung lobes are occasionally seen if positioned exactly parallel to the X-ray beam
 - Thickening or calcification of the pleura in older cats & dogs can make it more visible

Radiographic Abnormalities

Pleural effusion

- Characterised by the collection of fluid (soft tissue opacity) in the pleural space
- The more fluid there is, the easier it is to recognise
 - <100ml (dog) or <50ml (cat) unlikely to be radiographically apparent
- Seen as a homogenous soft tissue opacity within the pleural space
 - Small amounts cause blunting of the costo-diaphragmatic recess (VD view) and the thoraco-diaphragmatic recess (lateral view)
 - Beware normal retraction of lungs from the spine in the cat
 - With more fluid there is scalloping of the ventral lung lobes (lateral view) and widening of the pleural fissures (lateral and VD)
 - These fissures are consistent in location
 - The cardiac silhouette merges with the fluid and becomes obscured
 - Differentiate from sternal fat which is seen ventral to the heart and lungs, but is more radiolucent than the heart

- **Differential diagnoses** for pleural effusion include:
 - Transudate / modified transudate, eg secondary to heart failure (especially cats), secondary to liver disease, protein losing diseases (true transudate), neoplasia, lung lobe torsion etc
 - Exudate
 - Sterile eg due to FIP, neoplasia, occasionally pneumonia
 - Septic (pyothorax) eg due to trauma, foreign material, oesophageal rupture, rupture of lung abscess
 - Chylothorax eg idiopathic, due to heart disease, cranial mediastinal mass
 - Haemothorax eg due to trauma, coagulopathy, rupture of intrathoracic mass



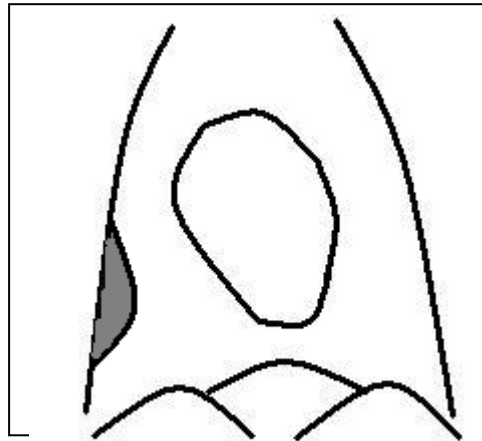
Characteristic appearance of a pleural effusion

Pneumothorax

- Characterised by the collection of air within the pleural space
- Free air results in 'elevation' of the heart from the sternum by a gas lucency on the lateral view (as the patient is in lateral, the heart is actually falling away)
- Lung margins are retracted from the thoracic wall, diaphragm & spine in both views, with no lung markings visible in the periphery
 - Usually less easy to appreciate on the DV view
 - Overexposed or overinflated lungs and skin folds can be mistaken for a pneumothorax on the DV view
 - Use a bright light to look for lung markings
- Where the lungs are partially collapsed due to the surrounding pneumothorax, they will contain less air and will appear more radio-opaque than usual
- Pneumothorax is most commonly bilateral

Extrapleural lesions

- Arise outside the pleural space, between the parietal pleura and the body wall
- Typically broad based lesions causing an 'inward bulging' of the pleural surface
- Differential diagnoses include subpleural haemorrhage and neoplasia of extra pleural structures (eg ribs)

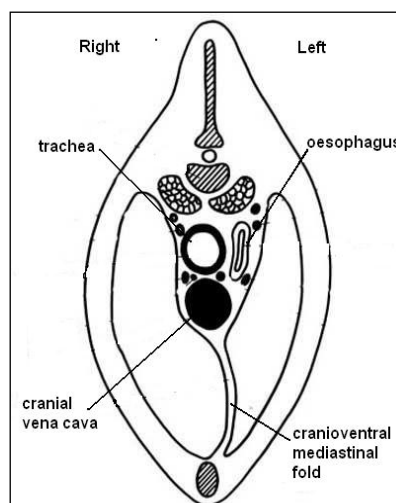


Typical broad based appearance of an extrapleural lesion

The Mediastinum

Normal Anatomy

- The mediastinum is the space between the left & right pleural cavities, communicating cranially with the fascial planes of the neck, caudally with the retroperitoneal space & enclosing the midline thoracic structures
- Anatomically divided into cranial, middle and caudal areas
- Apart from the trachea and any air in the oesophagus, all mediastinal structures are of soft tissue opacity



The Cranial Mediastinum

- Contains a surprisingly large number of structures including the thoracic trachea, oesophagus, cranial vena cava, brachycephalic trunk, cranial mediastinal lymph nodes, sternal lymph nodes and thymus
- Seen on the lateral view as a soft tissue band surrounding the air filled trachea and extending cranially from the heart base to the thoracic inlet
- Seen on the DV / VD view as a band of soft tissue superimposed on the thoracic spine
 - In a cat it should be no greater than the width of the thoracic spine
 - In a dog it should normally be no greater than 2x the width of the thoracic spine
 - Up to 3x in obese and some brachycephalic dogs
- The cranioventral reflection of the mediastinum
 - Seen on the lateral view as a narrow soft tissue band running towards the sternum, separating the apex of the left lung (cranial) from the apex of the right lung (more caudal)
 - Seen on the DV/VD view as a curved thin soft tissue band to the left of the spine
 - Contains the thymus, sternal lymph nodes, internal thoracic arteries & veins

The Middle Mediastinum

- Contains the heart, great vessels, azygos vein, thoracic duct, oesophagus, tracheal bifurcation and tracheobronchial lymph nodes

The Caudal Mediastinum

- Contains the descending aorta, oesophagus and caudal vena cava
- The caudoventral reflection of the mediastinum
 - Created by the right accessory lobe pushing across to the left of the midline
 - Usually seen on a VD view (less consistent on DV) as a soft tissue band to the left of the midline from the cardiac apex to the diaphragm

Radiographic abnormalities

- Change in position = **mediastinal shift**
- Change in size and/or shape
- Change in opacity

- **A mediastinal shift** is recognised by the movement of the mediastinal structures away from the midline, due to volume changes in adjacent structures
 - Recognised only on the VD/DV view
 - Mediastinal shift towards an abnormal area occurs due to volume loss on that side
 - Eg due to unilateral lung lobe collapse
 - Mediastinal shift away from an abnormal area occurs due to increased volume on that side
 - Eg large lung mass, emphysematous lung lobe, unilateral effusion

- **Changes in size +/- shape** of the mediastinum are most commonly seen due to the accumulation of fluid or the presence of a mediastinal mass
 - Fluid typically results in widening of the mediastinum +/- reverse fissures extending from the midline out between lung lobes
 - Best appreciated in the cranial mediastinum on a VD view
 - Mediastinal masses are most often seen cranially
 - VD view: widening of the mediastinum, often with a change in contour +/- tracheal displacement
 - Lateral view: increased depth of the mediastinum, dorsal tracheal displacement +/- obscuring of the cranial lung lobes
 - Lymphoma and thymoma most common
 - Very amenable to ultrasound examination

- The most frequently appreciated **change in opacity** is increased lucency due to a **pneumomediastinum**
 - Mediastinal structures not normally seen, such as the brachycephalic trunk, are highlighted by the surrounding air and can be recognised
 - Because the mediastinum connects with the fascial planes of the neck and the retroperitoneum, air can pass to/from these areas
 - A pneumomediastinum may lead to a pneumothorax, although the reverse is rarely seen

The **Oesophagus**

- Runs throughout the length of the mediastinum
- Generally not visible unless air-filled or dilated with fluid / ingesta / foreign body
 - Air within the oesophagus of a sedated or anaesthetised animal may be an incidental finding
- **Oesophageal Abnormalities**
 - **Mega-oesophagus**
 - The enlarged oesophagus is most easily identified where it is gas-filled; it may also contain food material +/- fluid
 - Air within the cranial thoracic oesophagus will highlight the dorsal tracheal wall: the 'tracheal stripe sign'
 - A dilated oesophagus will often displace the trachea ventrally and to the right and displace the heart base ventrally
 - An important secondary finding with any oesophageal disease is the presence of aspiration pneumonia
 - The cranial and middle ventral lungs lobes should always be carefully assessed for pathological change
 - **Oesophageal foreign bodies**
 - Typically lodge at the thoracic inlet, the base of the heart or just in front of the diaphragm
 - May be radio-opaque (eg bones) and easily seen or radiolucent and easily missed
 - Aspiration pneumonia & oesophageal perforation are possible complications
 - **Contrast studies** may be useful in deciding whether oesophageal dilation is general or localized
 - Liquid or powdered Barium mixed with palatable food is fed to the animal and a thoracic radiograph taken immediately
 - Remember that there is a significant risk of aspiration if a barium meal is fed to a sedated animal or to a severely dysphagic patient
 - Barium must never be used if there is a suspicion of oesophageal perforation; use non-ionic iodine instead

The Trachea

- The most visible structure in the cranial mediastinum
- Should be air-filled and of a consistent diameter with a smooth internal surface
 - Diameter should be $>0.2 \times$ the depth of the thoracic inlet
 - Diameter should not vary significantly between inspiration & expiration
- Some mineralisation of tracheal cartilages is a normal finding in older cats & dogs
- Divides into the mainstem bronchi at the carina
 - Normally located at the level of the 5th intercostal space
- **Tracheal abnormalities**
 - Displacement of the trachea may occur due to changes in patient positioning, adjacent masses and oesophageal dilation
 - Tracheal hypoplasia is diagnosed where the diameter of the trachea is $<0.2 \times$ the thoracic inlet
 - Can be 0.11 in Bulldogs & 0.16 in other brachycephalic
 - Tracheal collapse is seen as dynamic narrowing of the cervical trachea on inspiration and of the thoracic trachea on expiration
 - Tracheal foreign bodies may be recognised as opaque structures highlighted against the air filled lumen
 - At least 2 views should be taken for definitive localisation
 - Intraluminal masses (rare) may be similarly highlighted against the lucent background, provided they are of sufficient size
 - Differential diagnoses include parasitic nodules (*Oslerus osleri*), abscesses, granulomas, neoplasia

The lymph nodes

- Generally not seen unless enlarged
- Mediastinal lymph nodes lie ventral to the trachea in the cranial mediastinum
- Sternal lymph nodes are usually paired and lie just dorsal to the 2nd sternebra within the cranioventral mediastinal reflection
 - Occasionally normal sternal nodes are seen in big dogs
- Left, right and middle tracheobronchial lymph nodes are located in the middle mediastinum in between and either side of the tracheal bifurcation

- Lymph node enlargement
 - Cranial mediastinal lymph nodes
 - Widening of the cranial mediastinum (often with an undulating ventral border)
 - Tracheo-bronchial lymph nodes
 - Soft tissue masses in the perihilar region, with ventral deviation of the mainstem bronchi (lateral view)
 - Widening of the angle between the mainstem bronchi
 - 'cowboy legs' sign (differential diagnosis= LA enlargement)
 - Sternal lymph nodes
 - Broad based soft tissue masses dorsal to the 2nd sternebra

The Thoracic Boundaries

- Defined by the thoracic inlet cranially, the spine dorsally, the sternum ventrally, the rib cage and thoracic wall laterally and the diaphragm caudally
- The **thoracic inlet** is demarcated radiographically as the area between the first pair of ribs
 - In the dog, the apex of the left lung may extend beyond the thoracic inlet when fully inflated
 - The dog's right lung & both cat lungs should extend to the level of the 1st rib
- The **thoracic spine** should comprise 13 thoracic vertebrae characterised by long dorsal spinous processes (DSPs)
 - The anticlinal vertebrae (usually T11) has the most dorsoventrally (vertically) orientated DSP
 - Vertebral spondylosis is a common incidental finding
 - Other possible radiographic abnormalities of the vertebrae include congenital abnormalities, traumatic damage, degenerative change, infection, neoplasia etc
- The **sternum** should consist of 8 sternebrae
 - The manubrium is the most cranial and the xiphisternum (or xiphoid process) the most caudal
 - Variations in normal sternal anatomy are a common incidental finding

- **Pectus excavatum** is a congenital abnormality where the sternum is deviated dorsally into the thoracic cavity, displacing the heart and ribs
- There should be 13 pairs of **ribs** which articulate with the cranial aspect of each thoracic vertebra
 - The first 8/9 ribs should articulate with the sternum via the costal cartilages (sternal ribs)
 - Except for the last rib (in the dog) or 2 ribs (in the cat), the remaining ribs fuse with the last sternal ribs to form the costal arch
 - Turning the radiograph through 90° provides a novel way of looking at the image which can help you focus on the ribs
 - **Rib fractures**
 - Recent fractures may be a significant finding following trauma
 - Healed fractures often seen as an incidental finding in older animals (especially cats)
 - **Rib tumours** are easily overlooked
 - Examine each rib for evidence of osteolysis +/- new bone production
 - Usually associated with an extrapleural mass +/- pleural fluid
- The **diaphragm** consists of the muscular right and left crura, and a central tendinous dome
 - The crura attach dorsally to the ventral aspect of L3/4
 - It is normal to see roughening of the ventral cortex of the vertebral bodies at the site of attachment
 - There are 3 openings through the diaphragm
 - Dorsal aortic hiatus (also contains azygos vein and thoracic duct)
 - Central oesophageal hiatus
 - Ventral caval hiatus (for CVC) to right of midline
 - **Diaphragmatic rupture** is characterised by
 - A loss of the clear diaphragmatic line
 - Presence of abdominal organs into the thoracic cavity
 - Absence of organs in the abdominal cavity

Other Thoracic Imaging Options

Fluoroscopy

- Best understood as 'real-time radiography'. However, instead of generating a short single exposure, a lower intensity stream of X-ray photons is generated over a longer period of time.
- Fluoroscopy has several important indications in both in the imaging diagnosis of thoracic abnormalities, including:
 - dynamic evaluation of oesophageal function
 - diagnosis of tracheal collapse,
 - identification of sliding hiatal hernias
 - image-guidance of interventional treatments (eg removal of oesophageal foreign bodies, tracheal stent placement, interventional cardiac procedures).
- The main advantage is fluoroscopy is its real-time nature, allowing more complete evaluation of dynamic processes and enabling the real-time visualisation and control of interventional procedures.
- The main disadvantages are due to increased radiation hazards created by a relatively high overall radiation dose, the frequent use of a horizontally directed x-ray beam and the fact that personnel are more likely to be within the controlled area, especially when interventional procedures are being carried out.

Ultrasonography

- Although echocardiography is a very well-established procedure, ultrasonography of the non-cardiac thoracic structures is less widely used.
- The main limiting factor for thoracic ultrasound is the availability of an appropriate acoustic window.
 - Large acoustic impedance mismatches exist at soft tissue: bone and soft tissue: gas interfaces, effectively creating a barrier to the transmission of sound waves into the patient, & is therefore not possible to ultrasound through the ribs or across air-filled lung.
 - However, pathology resulting in the presence of fluid or soft tissue around the periphery of the thorax can readily be identified with ultrasound.
- Indications for thoracic ultrasound include:
 - pleural effusion

- suspected mediastinal mass
- consolidation / masses of the peripheral lung
- suspected lung lobe torsion
- suspected diaphragmatic rupture
- thoracic wall masses.
- Ideally, a minimum of two orthogonal thoracic radiographs should be obtained prior to ultrasound examination. From these radiographs, it should be possible to identify the area of interest, which can then be examined with ultrasound.
 - An important exception to this is the severely dyspnoeic patient: in this case an initial brief ultrasound examination should be performed with the patient in sternal recumbency in order to determine whether or not a significant pleural effusion is present.
- A significant advantage of thoracic ultrasound is that it facilitates minimally-invasive sampling: fine needle aspirates or Trucut biopsies may be obtained under ultrasound guidance.

Computed Tomography

- The cross-sectional imaging and superior contrast resolution of CT make it the gold standard modality for thoracic imaging.
- The ability to manipulate the level and width of the window (shades of grey) makes CT very well-suited to displaying the inherently high contrast of the thorax (from the air-filled lung at <-1000HU to the bony ribs at >1000HU).
- Indications for thoracic CT include:
 - Detection of pulmonary metastases
 - Detailed evaluation of pulmonary parenchymal disease
 - Detection of underlying pathology in patients with pneumothorax or pleural effusion
 - Detailed evaluation of the location, size and extent of pulmonary, mediastinal and thoracic wall masses +/- surgical planning
 - Identification of thoracic lymphadenopathy
 - Identification of lung lobe torsion
 - Identification of pulmonary thrombo-embolism