Evaluation of the mediastinum, pleura, and diaphragm

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Evaluation of the mediastinum and pleural space is difficult on physical examination, due to the relative inaccessibility of these anatomical areas. Thoracic radiology is the method of choice for detection of disease processes involving these extra-pulmonary spaces.

The mediastinum is a real space which separates the two hemithoraces. It is formed by the reflection of the parietal pleura around the heart and other midline structures, and although located within the thoracic cavity, is considered part of the extrapleural space. While the mediastinum does not communicate with the pleural space, it is not a completely closed space, communicating with the fascial planes of the neck cranially, and the retroperitoneal space (via the aortic hiatus) caudally. Contained within the mediastinum are the heart and great vessels, trachea, esophagus, thymus, lymph nodes (sternal, cranial mediastinal, and tracheobronchial), and various nerves and blood vessels. With the exception of the heart, descending aorta, and caudal vena cava, which are visible due to surrounding air-filled lung, the remaining mediastinal structures are not seen, either because they are too small to absorb a sufficient number of X-rays, or because they are in contact with each other leading to obliteration of their margin (silhouette sign). The lumen of the trachea is visible as it contains air.

The mediastinum is not seen as a specific soft tissue structure on the lateral view, except where a portion of the cranial mediastinum can be identified immediately ventral to the trachea, as a homogenous soft tissue density. This opacity is due to the combined opacities of the cranial vena cava, major arteries branching off the ascending aorta, lymph nodes, and thymus (in young animals). On the ventro-dorsal (VD) or dorso-ventral (DV) view, the cranial mediastinum is superimposed on the midline, and in normal animals, should be no wider than the two times the width of the spine. In obese animals, fat is deposited in the cranial mediastinum causing widening of the cranial mediastinum beyond the borders of the spine (up to 3.5 times the width of the spine). This widening is also normal for brachycephalic breeds. This should not be mistaken for a mediastinal mass. In young dogs and cats, the presence of the thymus may cause increased density of the cranial mediastinum on the lateral view, and a prominent triangular soft tissue density just to the left of midline in the VD view. The ventral aspect of the cranial mediastinum is normally relatively opaque in cats less than one year of age due to the combined densities of the thymus and mediastinal fat. These densities should not be mistaken for fluid or mass in the cranial mediastinum. Remnants of the thymus can be seen normally in some adult dogs and cats. Mediastinal reflections are frequently seen on thoracic radiographs, and should not be mistaken for pathologic
densities. The first is a reflection of the cranioventral mediastinum to the left, accommodating the extension of the right cranial lung lobe across the midline to the left, just below the tip of the left cranial lung lobe (lingual portion). This is visualized on the VD or DV view, but the same reflection is seen on the lateral view as a line of soft tissue opacity running obliquely in a caudoventral direction from the region of the distal aspect of the first rib to the sternum. It represents the mediastinum between the lingual portion of the left cranial lung lobe, and right cranial lung lobes, and can occasionally give the appearance of a hyperlucent "bullous" type lesion. Another mediastinal reflection is noted on the VD or DV view, accommodating the extension of the accessory lung lobe to the left of midline. This soft tissue opacity has been confused with the cardiophrenic ligament. The appearance of these mediastinal reflections is affected by body condition, as fat can accumulate within the mediastinum, increasing the thickness and prominence of the reflections.

The mediastinum is elastic, and can shift with uneven lung inflation. The shift may occur towards an underinflated lung, to compensate for the loss of volume, or away from an enlarged or overinflated lung. A mediastinal shift is a critical radiographic sign to recognize, as it helps differentiate increased lung opacity due to atelectasis, with a resultant loss of volume, from increased lung opacity due to infiltrative diseases such as edema or pneumonia. The mediastinal shift will occur with a loss of lung volume. The easiest way to recognize a mediastinal shift is by seeing the largest mediastinal organ, the heart, move to one side. Artifactual shift can occur with an oblique VD or DV radiograph, but can be recognized as artifactual by noting that the heart has shifted to the same side as the rotated sternum. Mediastinal shifts are best visualized on VD/DV views; they are not well seen on lateral thoracic images.

Pneumomediastinum occurs when air gains entry to the mediastinum, allowing enhanced visualization of mediastinal structures. Entry of air may occur secondary to tracheal or esophageal rupture, to dissection of air along the fascial planes of the neck after laceration, or after trauma to the lung causing parenchymal damage without rupture of the visceral pleura. Air from the injured lung can dissect along the bronchial structures into the mediastinum. Pneumothorax can occur secondary to a severe pneumomediastinum (due to rupture of mediastinal pleura), but pneumothorax cannot cause a pneumomediastinum. Mediastinal air can pass to the cervical soft tissues, and subsequently cause subcutaneous emphysema, or move into the retroperitoneal space. Dyspnea does not usually occur with pneumomediastinum unless there is a secondary pneumothorax. The air in the mediastinum may take several days to resorb.

Masses in the mediastinal space occur frequently, but are sometimes difficult to localize to the mediastinum on thoracic radiographs. A midline location and displacement of mediastinal structures by the mass makes a mediastinal location more likely. Computed tomography may be necessary in some cases to help determine the true location. In the cranioventral mediastinum (lateral view), mass lesions may cause loss of the radiolucent space cranial to the heart, elevation of the trachea, tracheal compression, caudal displacement of the heart and carina (beyond the 6th intercostal space), and a silhouette sign with the heart. On the DV/VD view, widening of the cranial
mediastinum may be seen, along with rightward displacement of the trachea and caudal displacement of the cranial lung lobes. Very large masses occupy both the cranial mediastinum and the normal cardiac area, mimicking massive cardiomegaly. The trachea and mainstem bronchi can be used to determine the true location of the heart. Thymomas, ectopic thyroid tumors, and enlarged sternal and cranial mediastinal lymph nodes are the most common causes of cranial mediastinal masses, with heart based tumors also a differential. In the perihilar area, enlarged tracheobronchial lymph nodes usually cause ventral displacement of the mainstem bronchi and carina and a mass effect at the heart base. Mass lesions in the esophagus cause ventral displacement of the trachea. In many cases, it is not possible to make a definitive diagnosis of the origin of the mediastinal mass by radiographic means, but the part of the mediastinum in which it lies, as well as its ventral or dorsal location will help limit the differential list.

Pleural Space
Unlike the mediastinum, the normal pleural space is not visible on radiographs. It is actually a potential space formed between the visceral and parietal pleural layers, which is represented by a single line at the periphery of the lung lobes. Although the pleural space does not communicate with other body parts, the right and left pleural space can communicate via mediastinal fenestrations (pleural fluid and air is typically bilateral). Occasionally fissure lines (reflections of visceral pleura) are visualized in normal animals if the x-ray beam strikes these lines tangentially. The potential pleural space becomes a real space, and visible with the addition of air (pneumothorax), or fluid (hydrothorax, pleural effusion). Radiographic signs of pleural effusion include widening and increased radiopacity of the the pleural space, the presence of visible fissure lines (the pleural space extends between lung lobes, and individual lobes become visible when surrounded by radiopaque fluid), silhouette sign with the heart and diaphragm, and partial/complete collapse of the lung lobes with retraction of the lobar borders from the chest wall. Radiographs probably underestimate the volume of pleural effusion, as small amounts are not easily detected. Fluid filled fissure lines are only visible when the x-ray beam strikes them tangentially. The earliest indications of pleural fluid may be triangular fluid densities which represent pleural fluid extending into lobar fissures, and are best seen on VD views. As the fluid volume increases, the pleural space becomes visible as a fluid opacity band surrounding the outer lung surfaces. Individual lung lobes may be visualized as fluid surrounds them. With very large volumes of fluid, however, lung lobes may become completely collapsed and disappear completely.

The appearance of pleural effusion depends on the volume of fluid, as well as the position of the animal. In lateral recumbency, fluid accumulates ventral to the heart and lungs adjacent to the easily collapsed cranial and middle lung lobes. Retrosternal fat can mimic small volumes of pleural fluid. However, fat is radiolucent compared to soft tissue structures, and the heart borders are usually visualized through the fat. As pleural fluid accumulates dorsal to the sternum, it forms a scalloped border with the lungs as they retract away from the chest wall. Fluid will also be visible dorsal to the retracted borders of the caudal lobes as the fluid increases in volume. The heart and
diaphragm become obscured by the pleural fluid (silhouette effect). With large volumes of pleural fluid, the trachea will become elevated, mimicking a mediastinal mass. In dorsal recumbency (VD view), fluid accumulates alongside the spine, causing the mediastinum to appear widened. Fluid will cause blunting, or rounding of the costophrenic angles on this view. In sternal recumbency (DV view), fluid accumulates around the heart, obscuring visualization of the cardiac silhouette. With large volumes of fluid the trachea will become elevated (lateral views).

Most pleural effusions are bilateral due to the delicate nature or fenestrations of the mediastinum. However, some diseases, such as pyothorax or fibrinous pleuritis may seal off the mediastinum, resulting in a unilateral pleural effusion. If pleural effusion is unilateral, and the fluid is in the dependent hemithorax on lateral views, the pleural fluid may be difficult to visualize on radiographs.

Several situations can mimic the appearance of pleural effusion. Fat in the mediastinum, especially accumulating ventral to the heart, can appear similar to fluid. Pleural fissure lines are occasionally seen in normal, especially older, animals. The chest conformation of the Bassett Hound and Dachshund creates superimposed peripheral chest wall opacities that can be confused with pleural effusion.

It is not possible to determine the type of pleural fluid based only on radiographs. However, it may be possible to gain additional diagnostic information from other radiographic changes such as cardiomegaly (and effusion secondary to right heart failure), rib fractures or other evidence of trauma (resulting in hemothorax), or lytic or proliferative rib lesions (resulting in neoplastic effusions). Thoracocentesis and fluid analysis are necessary for definitive diagnoses. Complete thoracocentesis followed by repeat thoracic films will allow visualization of thoracic lesions previously obscured by pleural fluid.

Pneumothorax is the accumulation of air within the pleural space. The most common cause is traumatic injury to the lung or body wall. Spontaneous pneumothorax is rare, but can occur with rupture of pulmonary cysts (congenital, acquired, Paragonimus cysts), or bullae. Iatrogenic causes include fine needle aspirate of the lung, thoracic surgery, and placement of chest tubes. Radiographic changes seen with pneumothorax include a widened, radiolucent pleural space, atelectasis of lung lobes, and absence of vascular and interstitial markings outside the collapsed lung (may need a hot light to check definitively). The heart often appears separated from the sternum on lateral films, with free air outlining the caudal lung lobes. Radiographic changes can be enhanced by taking dorsoventral views on expiration, and small volumes of free air can be visualized more easily on horizontal beam films taken with the animal in lateral recumbency. A tension pneumothorax is the most severe form of pneumothorax, and occurs when a flap-like injury to the lung allows air to enter the pleural space on inspiration, but does not allow it to escape during expiration. Progressive pulmonary atelectasis and impairment of venous return to the heart result. The thorax appears overinflated, and the diaphragm becomes flattened. Immediate removal of the pleural air is essential in
these cases.

Pneumothorax can sometimes be misdiagnosed when skin folds are mistaken for collapsed lung lobes. In deep chested dogs, the heart may normally be separated from the sternum on lateral views, without free air in the pleural space.