**thoracic radiograph**

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**1. Introduction**

The goals of this lecture are to provide you with techniques of radiography and radiology of the dog and cat thorax. Thoracic radiology remains the main imaging modality in the interpretation of pulmonary and other intra-thoracic diseases. These techniques should provide the basis for production of diagnostic images and ability to derive a reasonable set of differential diagnoses.

A few key points to remember:

* Radiographs provide information NOT answers
* answers are derived from proper interpretation of the radiographic signs in concert with other clinical aspects of the case
* radiographs may lead you to ask more or different types of clinical questions
* if poor quality, radiographs are a waste of personnel time and client money
* without a systematic approach to film interpretation, the information may be on the radiograph, but goes unseen
* without a good knowledge of clinical medicine, the changes are noted on the radiographs but incorrect conclusions are reached

**What is a radiograph**

Radiographs are images on photographic film by x-rays that have passed through tissue. The interaction of x-ray photons with the intensifying screen in the cassette produces photons of visible light. The light interacts with silver in the film to produce a latent image. The latent image is converted into the blacks and whites by the developing process.

The whiteness of the film is termed “opacity”. There are five radiographic opacities:

* metal
* mineral (bone)
* soft tissue
* fat
* air

The resultant opacity of the image is a function of both the object density and the thickness of the structure (which is why some end-on blood vessels can appear as opaque as a rib). The film has characteristics that allow us to image structures as varied as air-filled to metallic objects on the same radiograph. We are very dependent on proper technique, positioning, and developing for production of diagnostic images.

A radiograph is medical legal document and needs to be diagnostic, identify the patient, date, clinic name and properly marked with patient positioning (lateral views are marked by the side closest to the cassette)and anatomical sidedness (left versus right).

**2. Thoracic radiography**

Any “weak link in the chain” of positioning, technique or developing can lead to a nondiagnostic image. If hand developing then chemicals need regular maintenance. Remember to use time-temperature developing (not guesswork or “experience”). If you want consistent high quality radiographs with minimal maintenance, purchase an automatic processor. Use rare earth screens and a grid with bigger patients ( > 10 cm thick) for optimal film quality.

**a. Positioning**

The diagnostic value of a radiograph is more dependent on positioning than any other single factor. Remove all foreign objects: collars, leashes, bandages, dirt, water or blood. Restrain the patient either chemically, physically, or both. Restraint techniques are limited by clinical concerns and patient compliance. Clever use of sand bags, rope, tape and straps minimize the radiation dose to holders. The front legs need to be pulled forward so that they are not superimposed on the chest. On VD/DV views, the spine MUST be superimposed on the sternum. On lateral projections, elevation of the sternum is often necessary so that the sternum and spine are the same distance above the cassette.

* Features of the properly positioned lateral projection include:
* ribs extent equally and are parallel
* costal arches do not extend more ventral than the sternum
* ribs do not extend more dorsal than the spine (unless symmetrically)
* Features of the properly positioned VD/DV include:
* sternum superimposed on the spine throughout the entire length of the thorax
* symmetrical shape to ribs
* spine is in a straight line

**b. Views**

Enough should be taken to provide the complete set of information. Typical studies include three views; left and right lateral and VD views. Opposite laterals provide better detection for focal diseases (lobar pneumonia and nodules). The VD view “opens” the chest providing better lung disease detection. The VD view is indicated with suspected pleural effusion.

Exceptions to the above listed recommendations are important to remember. The DV view provide a “better” view of the heart base and caudal lobar vessels. The DV view may be better tolerated by dysneic patients, especially cats. Patients should not die while we attempt a diagnostic procedure.

With severely dyspneic patients:

* be judicious and efficient
* premeasure the patient before transport to radiology
* set the machine technique and gown up before bringing the patient
* position the cassette and collimate the beam before the patient arrives
* MAYBE take only one view: a lateral view is the least stressful
* MAYBE wait until tomorrow!

**c. Technique**

Technique refers to the balance of KvP and mAs. We want a high KvP-low mAs technique because the thorax has inherent very high contrast. A low mAs means a very short exposure time will stop the breathing motion. Remember that interpreting a film that is a little too grey is easier than one that is too black and white. A technique chart should be derived for all species and body parts imaged. The technique chart is based on the maximum dimension, usually at the level of the last rib. Inaccurate measurements invalidate the technique chart insuring improperly exposed radiographs. Technique charts can be constructed from standing or recumbent patient positioning. Be consistent. If the technique chart was made assuming recumbent positioning, then measure your patients in the appropriate recumbency.

**3. Thoracic radiology**

**a. Film reading technique**

Learn a system then use it! Make sure to look at the ENTIRE film. My system is listed below, but any system used consistently, is a good system:

Peripheral structures in a clockwise direction starting cranially:

* forelimb
* neck (soft tissues, spine and trachea)
* thoracic spine (spinous processes, canal and bodies)
* diaphragm
* stomach
* liver (and any other intra-abdominal structure)
* falciform fat pad and other intra-abdominal fat
* sternum

Mediastinum and pleural spaces

Ribs for symmetry

Heart

Lungs

Inevitable some portion of the films will be “dark” (overexposed). To best view these areas use a bright light. Alternatively use a “bob-o-scope” (two lightly clenched hands arranged in series or an empty paper towel roll!). Either of these devices limit the extraneous light, size of the portion evaluated and thereby, increase acuity of detecting lesions in the darker areas of the film. Bright lights are more expensive but fewer people laugh at you!

**4. Radiographic anatomy of the thorax**

**a. Introduction**

Knowledge of “what is normal” is essential for detection of lesions. “Normal” includes all the variations by age, breed, sex and body condition. Radiographic variations are as clinically important as, and more difficult to learn than, normal radiographic anatomy. Remember that cats are not little dogs.

**b. Radiological variations**

Expiration causes increased lung opacity. Decreased amount of air in the lung results in proportional increased interstitial pattern. Overlap of the diaphragm and caudal cardiac silhouette should alert you to this variation. (see comments below on obese patients)

Underexposure causes increased lung opacity. Poor penetration of the spine, especially superimposed on the scapula, should alert you to this variation. Especially a problem with obese patients if the technique is not adjusted accordingly.

Flexion of the neck causes bending of the trachea in the lateral projection. Undulation of the trachea should not be mistaken for “dorsal deviation” secondary to a cranial mediastinal mass. Repeating the radiograph with the neck hyperextended tests the validity of the tracheal positioning due to head position.

Rotation of the chest in the lateral projection makes the heart base appear larger. Without foam support beneath the ventrum, an increased opacity in the heart base mimics left atrium enlargement and hilar lymphadenopathy.

Oblique positioning on VD/DV projections distorts the cardiac silhouette mimicking chamber enlargements.

**c. Geriatric patients**

With increased age we see a large number of changes to the appearance of the thorax. The most common change in cats and dogs is increased lung opacity. This is mostly due to combined increased bronchial and interstitial patterns. The bronchial pattern is due to dystrophic mineralization in the walls. The interstitial component is thought to be due to pulmonary fibrosis. mineralized costal cartilages and costochondral junctions are seen in the ventral thorax. Spondylosis deformans is a radiographic change (more common in dogs than cats) associated with smooth bone formation extending  (= originating) from the vertebral end plates towards the adjacent vertebral end plate. This change thought to be a degenerative of the annulus fibrosis part of the intervertebral disk and, as an isolated finding, is an incidental finding. Heart orientation often changes in older patients. The heart in older animals (more common in cats) tends to be less upright (= “falls forward”,  “leans over”) than in young animals. This exaggerates the appearance of the aortic arch on both the lateral and VD/DV views.

**d. Obesity**

With increased obesity, increased lung opacity. This is mostly due to a increased interstitial pattern. This is due to relative expiration. The weight of the thoracic wall fat limits chest wall excursions and intra-abdominal fat decreases caudal movement of the diaphragm. Increase the KvP 10 to 15% compared to a normal conformation patient of the same measurements.

The heart size is apparent increased in obese patients. The smaller lung volume makes the heart appear larger (= out of proportion). This is a challenge with both the subjective interpretation and when using cardiac measuring schemes that utilize intercostal spaces or percent of chest width.

In obese patients increased width of the mediastinum is seen. Fat infiltration in the cranial mediastinum can mimic a mass (cats and dogs). This increased width usually has parallel sides, as seen on the VD/DV view, unlike an enlarged lymph node or thymoma. In the middle mediastinum the fat adjacent to the heart may silhouette with the cardiac outline mimicking heart enlargement. Caudal mediastinal widening, between the accessory and caudal left lung lobes can be mistaken for pleural effusion.

Finally, increased distance between lung lobes or between lung and inner body wall is often noted. Fat can accumulate in pleural fissures or on the inner aspect of the chest wall mimicking pleural effusion.

**e. Breed variations**

Brachycephalic dogs often have smaller diameter to trachea (normal > other brachycephalic breeds > bulldogs). Additionally, they have apparently larger heart size (result of wide, shallow conformation). A bulldog is not a bulldog without a caudal thoracic hemivertebra. Dachshund and greyhound hearts measures big using the vertebral heart scale. Collies commonly have heterotopic bone formation in the lungs (mimic nodules).

**5. Some old techniques reinvented**

**a. How many views**

Whilst the norm may seem to be 2-views we have discovered that the 3rd view is requested so frequently that is was more efficient to always take 30views. The reason to take both laterals was because middle lung field disease is hidden when that disease is in the dependent lung. For example, right middle lung pneumonia is NOT seen in a right lateral projection.

Similarly, in dogs with suspected dynamic large airway disease, the ability to detect collapse of the intra-thoracic portions is greatly reduced on inspiratory-phase images. So, an expiratory-phase radiograph is indicated to demonstrate collapse, or at least the propensity to collapse, of the intra-thoracic trachea and larger bronchi. This is so common that it has become our traditional 4-view thorax.

In our most dyspneic patients we either add an additional view (“5-view”) or replace the expiratory view with a lateral projection of the neck, including the nasopharynx to the level of the thoracic inlet. This view provides information on the extra-thoracic trachea, larynx, pharynx and soft palate. Seeing air-filled lateral laryngeal ventricles supports normal or laryngeal paralysis. Opaque lateral ventricles supports laryngeal collapse (everted saccules) and mass-lesion diagnoses. Laryngeal inflammation and mass lesions are common in cats. In these cases the thoracic portion of the series may be normal or indicate a global thoracic wall conformation change associated wih upper airway obstruction. This conformation will be discussed in the lecture.

**b. Other views?**

The reason take other views depends on the clinical history, clinical exam findings and concurrent radiographic findings.

* Placing barium on suspected cutaneous lesion is very helpful to evaluate possible nodules seen on routine images. Ticks, nipples, skin tags and other skin lesions can show up when located in the nondependent portion of the patient, making interpretation of nodules difficult.
* Horizontal beam radiographs are indicated to more accurately determine the presence or absence, more accurately characterize the volume, and to diagnose the concurrent fluid component of a patient with pneumothorax. The VD view is the worst at detecting pneumothorax. Horizontal beam view more are more accurate than other projections at providing volume of the pneumothorax in the nondependent hemithorax and detecting the fluid component in the dependent hemithorax. This technique require the use of thick open cell foam pads (8-12 inches thick) to elevate the patient off of the radiology table and ability to 1) lower, and 2) rotate the x-ray tube to a horizontal position. Both horizontal VD views are taken with the dog in right and left lateral u
* e the cranial lung regions bilaterally. On standard VD views the scapulae are superimposed upon the left and right cranial lobes obscuring the lungs. By pulling the arms caudally, alongside the chest wall (similar to a person standing with their arms at their sides) on the VD projection, the scapulae are rotated and are no longer superimposed on the lungs. This positioning will be discussed in greater detail during the lecture.

Thoracic radiographs are powerful tools for the detection and characterization of lung, heart, mediastinal, pleural and body wall lesions. Through knowledge of normal variants (according to age, breed, species, and body conformation) differentiation of disease from a normal variant is possible. Through utilization of additional creative radiographic views, lesions are seen better or better differentiated from normal anatomy.