Thoracic Imaging: taking and reading a great X-ray

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Interpretation of thoracic radiographs can be challenging and requires high quality radiographs. In addition to the common problems with radiography elsewhere in the body (correct exposure, processing problems etc.) the thorax has several unique properties which can lead to difficulty with interpretation:

- motion artefacts due to respiration
- atelectasia of lung tissue when under general anaesthesia or sedation.
- marked variation in appearance of the thorax with phase of respiration and thoracic confirmation

Radiographic Technique

Good positioning is the first step in obtaining a great requirement and requires adequate restraint, patience and the right equipment. A range of sandbags and foam wedges is essential. The use of chemical restraint aids positioning but may make evaluation of the oesophagus difficult (artefactual dilation) and atelectasia of lung may result in problems interpreting dorsoventral radiographs. Anaesthesia has the advantage of allowing radiographs to be taken with the lungs manually inflated preventing movement blur. The decision whether to take thoracic radiographs with or without chemical restraint depends upon personal preference and the clinical signs of the animal but for the majority of studies some form of sedation is advisable.

Two orthogonal projections are mandatory in almost all cases and in dogs it is often worth taking both lateral projections. Lateral projections are usually easier to obtain than DV/VD projections and give a better view of the lungs but are inadequate for demonstrating mediastinal disease, chest wall lesions and evaluation of the heart. Pulmonary lesions are best seen in the non-dependant lung as atelectasia of the dependant lung results in loss of air within the lung parenchyma resulting in reduced contrast. If the animal is anaesthetised GA/sedation related atelectasia is extremely common and can make interpretation of the lungs difficult or impossible. GA related atelectasia occurs within a few minutes on induction and animals should be placed in sternal recumbency immediately following induction. It is
essential that the dorsoventral projection is taken before the lateral projections to minimise atelectasia.

**Positioning for the dorsoventral projection**

The most common problem is axial rotation of the chest of lateral bowing. The animal should be positioned with thorax straight and spine overlying the sternum as axial rotation may lead to the erroneous appearance of cardiomegally. Both forelegs should be pulled forward to a similar degree, the pelvic limbs needs to be flexed/extended to the same degree with no pelvic tilting. It may be helpful to place a small foam pad under the animals’ head to raise it slightly. The neck and head should be straight in line with the thorax and for deep chested dogs it may be difficult to prevent the animal tipping over to one side in which case a positioning trough is useful.

**Positioning for the lateral projection**

The animal is placed on its side with hindlegs in a neutral position and sandbag placed around them. The forelegs are pulled forward and again held in position with a sandbag, this is important to allow visualisation of the cranioventral lung lobes and potential presternal lymphadenopathy. A sandbag is placed over the animals’ neck. A small foam wedge is usually required to elevate the sternum so that it is level with the spine so that the costochondral junctions are at the same level. Cats often resent having sandbags wrapped around their front legs and in some cases it is easier to place the sandbag caudal to the antebrachium without placing it over the forelegs but to prevent caudal retraction of the front legs. The neck should be in a neutral position, hyperflexion or extension will result in bowing of the intrathoracic trachea, which may be mistaken for pathology.

**Exposure factors**

For thoracic radiography a high kVp (60 – 85 for dogs) low mAs technique is used to minimise exposure time and prevent respiratory motion. As a rule of thumb increasing the kVp by 10 allows the mAs to be reduced by 50%. In tachypnoeic animals, increasing the kVp will allow the mAs to be reduced making movement blur less likely. Using callipers to measure the depth of the thorax and an exposure chart works very well for calculating the correct exposure factors and is recommended. There is a tendency to over-expose thoracic radiographs, which results in loss of fine detail within the lungfields. The pulmonary vasculature should be easily seen without the need for a brightlight and the cranial thoracic vertebrae are normally slightly underexposed.

**When to take the exposure**
For the majority of studies the radiographs should be taken on maximum inspiration if possible to maximise contrast and aid detection of small lesions. Obtaining inspiratory radiographs may be difficult in sedated animals due to shallow respiration. Temporarily occluding the nares then uncovering them may be useful as the animal often takes a deep breath afterwards. If the animal is anaesthetised then manual inflation of the lungs should be performed. This can be safely be performed by squeezing the rebreathing bag with an assistant standing behind a lead screen or the door providing the anaesthetic circuit is long enough. When taking the exposure you should aim to take the radiograph during inspiration rather than trying to catch peak inspiration as reaction time delay invariable results in peak inspiration being missed. Expiratory radiographs may be useful in some cases to show dynamic airway collapse or air trapping due to emphysema.

**Evaluation of the radiograph**
As for any radiography the technical quality of the radiograph should be evaluated first. This is particularly important in the thorax where poor positioning is often mistaken for pathology. The phase of respiration should be evaluated – on an inspiratory radiograph the diaphragmatic crura will cross the spine at ~T12-13. There will be separation of the cardiac silhouette from the diaphragm and the small triangle lucency ventral to the caudal vena cava, heart and diaphragm that partly represents accessory lung lobe will be at least 1 intercostal space wide. The entire thorax should be on the radiograph, rotation can be assessed by comparing the level of the ends of the ribs, which should be roughly at the same level. On the DV/VD the sternum should overlie the thoracic spine. Care should be taken to assess the whole radiograph – rib, skeletal, large airway lesion and abnormalities in the cranial abdomen are often overlooked due to “tunnel vision” and concentrating on the lungs and heart.

**Normal variants, findings of minimal importance and pitfalls**
There are numerous breed and age related variations within the thorax, which can be pitfalls for the unwary.

**Degenerative sternebral and costochondral changes** – should not be mistaken for bone tumours/infection

**Bronchial/tracheal mineralisation** – normal ageing changes – the mineralised bronchi are thin and sharply marginated unlike thicker more ill-defined bronchial markings seen with bronchial disease.
Nipples/skin nodules – may be mistaken for lung nodules – outlined by air therefore appear opaque. Usually rather irregular or globular shape rather than typical round appearance of most small lung nodules. May be poorly margined on one side as merge with skin. Nipples can often be seen to be outwith the lungfields. If in doubt examination of the skin will show nipple/skin mass. Can mark skin mass with barium or paper clip and re-radiograph.

Anaesthesia/sedation related oesophageal dilation – extremely common and entire oesophagus may be dilated. Does not usually result in ventral deviation of the trachea or drape ventrally to the trachea as is often seen with genuine megaoesophagus. If genuine megaoesophagus is a possibility radiographs should initially be taken conscious.

Pericardial fat – in obese cats may be mistaken for right atrial enlargement on DV, GA/Sedation related atelectasis – see scruffy increase in opacity in dependant lung (most marked ventrally overlying the cardiac silhouette) and mediastinal shift on the DV towards the side of increased lung opacity due to reduced lung volume. Should not be mistaken for alveolar lung disease. Can minimise by taking DV before lateral to minimise false mediastinal shift and ventilating lungs well to reinflate the lungs before taking the exposure.

False pneumothorax – skin folds overlying the chest on the DV maybe mistaken for pneumothorax. Skin folds can be followed beyond the ribcage and close examination shows lung margins extend to the periphery of the thorax.

Dilated oesophagus – common in anesthetised animals – megaoesophagus should not be diagnosed radiographically in an anaesthetised animal in most cases. If you suspect a megaoesophagus repeat radiographs with the animal conscious.

**Pulmonary Disease**

Diseases of the lung are generally divided into either generalised or local and diseases which cause and increase in opacity and those which cause a decrease in opacity.

The basic principles for radiographic interpretation of the lungs are similar to that for any other part of the body. The shape, size, position and opacity of the lungs are evaluated. Often overlooked are changes in lung lobe position and size.

Lung volume is easiest to evaluate on a DV/VD provided the animal is positioned in a straight line, by assessing the position of the mediastinum.
Reduction in lung volume – reduction in lung volume results in diffuse increase in opacity of the affected lung lobe (due to loss of air) and may occur either due to atelectasis (most common cause esp. if animal anaesthetised or sedated or has been recumbent for a while), secondary to obstruction of a bronchus or rarely due to increased pleural pressure (tension pneumothorax, extrinsic masses). With atelectasis/lobar collapse there will be a usually mediastinal shift towards the affected lung and possibly cranial displacement of the diaphragm on the affected side.

Increased lung volume – an increase in lung volume indicates and expansile lesion such as a tumour or granuloma. Most causes of increased lung volume result in an increase in opacity but air trapping and emphysema result in an increased volume with decreased opacity. With an increase in lung volume there is a mediastinal shift away from the affected side and possibly caudal displacement on the affected side.

In addition to the classical lung pattern approach the lungs can more simply be evaluated as being too lucent or opaque. If the radiograph is good technical quality and the radiograph is too dark then this suggests there is reduced soft tissue or increased air within the thorax. If the lungs are too opaque this suggest loss of air or increase soft tissue/fluid. The distribution of the changes and then the lung pattern can be used to create a differential diagnosis list,

**Radiographic Lung Patterns**

The 4 radiographic lung patterns (vascular, bronchial, interstitial and alveolar) often cause confusion but are useful from a descriptive point of view and may help in planning further investigation. The lung patterns are based on a human classification system, which aims to provide a rough pathological correlation. In many diseases there is more than classical lung pattern present. The differential diagnosis and investigation is based on the predominate pattern. The significance of the different lung patterns varies – alveolar is the lost significant lung pattern, bronchial is the least significant.

**Radiology of the heart**
Radiology of the heart is problematical in dogs due to the marked breed variation. The complex shape of the heart makes the shape of the cardiac silhouette subject to large variations with alterations in projection. The cardiac silhouette is evaluated on the right lateral and DV projections as the shape is more consistent. A DV projection is necessary for evaluation of the heart as specific chamber or vessel enlargement may not be apparent on the lateral. Despite attempts to come up with a simple measurement scheme for the heart evaluation is still often subjective. Echocardiography is the method of choice for investigation of the heart but thoracic radiography has a role in allowing evaluation of the pulmonary vessels and lungs for evidence of congestive heart failure. With cardiac disease it is important to evaluate the pulmonary vasculature, lungs, caudal vena cava and abdomen for signs of congestive heart failure. Left sided failure results in enlargement of the pulmonary veins initially then the arteries later and perihilar oedema. Right-sided failure results in enlargement of the caudal vena cava (if the CVC is >1.5 times the width of the aorta) +/- hepatomegaly and ascites/pleural effusion.

**Measurement of the heart size**

**Vertebral heart scale**

This method attempts to minimise the effects of breed variation and subjective assessment. The suggested normal range in dogs is 9.7 +/- 0.5 and 7.5 +/- 0.3 in cats. Unfortunately there is still breed variation using this method with Boxers, CKCS and Labradors having larger VHS than other breeds. Studies have shown that using the VHS alone does not improve accuracy in diagnosing heart disease compared with subjective assessment and its main use is for monitoring progression of heart size within an individual.