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Essential Radiography for Veterinary Nurses Mini Series

Session Two: Thoracic and Abdominal Radiography

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Thoracic radiography

Thoracic radiography is an essential part of the diagnostic work-up of many of the clinical cases we are presented in practice. Radiography can provide essential information in a variety of clinical presentations. Indications for thoracic imaging include: coughing; dyspnoea; cardiovascular disease; thoracic trauma; neoplasia (including metastatic check); thoracic wall lesions; regurgitation and pyrexia.

We should always aim to obtain images of good diagnostic quality without compromising the patient's welfare. It is also critical to be able to make the correct interpretation of the imaging findings to help us reach a final diagnosis.

Thoracic radiography – Restraint and patient preparation

Animals that present for thoracic radiography are often afraid, in pain, dyspnoeic or all three. Considerate handling, positioning aids and sedation are often required for adequate restraining. In the UK no animal should be manually held for radiography unless there is a very strong reason why they cannot be restrained by other means. Aim for adequate restraint and positioning using adequate aids - e.g. sandbags, foam wedges, bean bags, ties and tape, cat muzzle. Sedation is desirable for most cases, unless contra-indicated by the clinical condition. Sedatives have a calming effect and induce drowsiness, making it easier to handle the patient. Quiet surroundings are important to allow for the sedation to take effect. If the animal is in pain, analgesics will also be required for the sedation to occur. With dyspnoeic cats consider placing the animal in a cardboard or plastic box to obtain a screening DV view with minimal distress.

General anaesthesia is not usually required for a standard radiographic procedure. Actually, anaesthesia can induce lung collapse which hinders correct interpretation. Nevertheless, in difficult patients anaesthesia may be necessary to obtain diagnostic studies. Many radiologists will also prefer inflated radiographs under general anaesthesia for screening of pulmonary metastases.

Thoracic radiography – Technical aspects

A long scale contrast technique with high kV together with low mAs should be used to reduce the natural high contrast of the thorax, increasing the lung detail and keeping the exposure time to a minimum. A grid needs to be used if the thorax is more than 10 cm thick. Exposure should be made at the end of inspiration to maximize lung aeration and optimize contrast. Manual inflation and breath-hold technique may be used in anaesthetized patients to achieve this. In this case the exposure factors must be reduced to avoid overexposure. When positioning the animal, the thoracic limbs have always to be pulled forward to avoid superimposition into the cranial thorax.

A complete radiographic evaluation of the thorax requires three views: two opposite lateral views and one ventro-dorsal (VD) or dorso-ventral (DV) view. A minimum of two orthogonal views – e.g. right lateral and DV view - is required to build-up a three-dimensional image, and for cardiac assessment this type of combination is often enough. Two opposite lateral views (right and left) are preferred to two orthogonal views to look for pulmonary metastases, but obviously whenever possible three views should be obtained. Dorsal recumbency for a VD view is contra-indicated in patients with severe dyspnoea, and it such patients it may be recommended to obtain horizontal beam radiographs with the patient non-recumbent first.

Radiographic positioning

Right or left lateral view

- Right lateral recumbency (R lateral view) or left lateral recumbency (L lateral view).
- Forelimbs extended and sandbagged.
- Pad under sternum.
- Sandbag to hold hindlimbs and neck.
- Centre midway between the sternum and the spine; level with the caudal border of the scapula.
- Collimate to include the front of the shoulder and the edge of the sternum.
- Take the radiography on inspiration.

Ventrodorsal view

- Patient placed in dorsal recumbency.
- Forelimbs placed in a neutral position beside the head and sandbagged.
- Centre at midline at the mid-point of the sternum.
- Collimate to include the thoracic inlet and diaphragm.
- Take radiograph on inspiration.

Dorsoventral view

- Patient placed in ventral recumbency.
- Chin supported on a pad.
- Sandbag over the neck.
- Forelimbs pulled forward.
- Centre at midline at the caudal prominences of the scapulae.
- Collimate to include the thoracic inlet and diaphragm.
- Take radiograph on inspiration.

Thoracic radiography – Basics of interpretation

Optimal evaluation of thoracic radiographs requires a systematic approach. You can look at the radiograph from the periphery to the centre, assessing all the different structures present: thoracic wall; pleura; lung and mediastinum (including heart). It is important to look at each radiograph fully and to look at all radiographs available. For viewing thoracic radiographs the convention is that lateral views are examined with the thoracic inlet facing to the left and DV/VD views with the thoracic inlet uppermost and the left side of the patient in the right side of the computer screen or light box.

When looking at radiographs you should look for **location of abnormalities**, **changes in opacity, evidence of mediastinal shift** and **lung patterns** that may be present.

Mediastinal shift

Refers to moving of the tissues and organs that comprise the mediastinum (heart, great vessels, trachea, and esophagus) to one side of the thoracic cavity. For instance, in an anaesthetized animal that has been on right lateral recumbency for a long time, the right lung fields will collapse with secondary displacement of the heart to the same side – mediastinal shift to the right. In case of a large mass lesion affecting the right lung fields, these will show increase in volume and will displace the heart to the opposite side – mediastinal shift to the left.

Lung patterns

Diseases affecting different pulmonary structures - bronchi, interstitium, alveoli, vessels - will present a different radiographic appearance:

- Bronchial pattern
- Interstitial pattern
- Alveolar pattern
- Vascular pattern

More than one pattern may be present in the same patient. Lung patterns are not specific for a single disease entity but help on the definition of a list of differential diagnosis. Always to be considered together with other radiographic findings, signalment, clinical history and results from other diagnostic tests.

Bronchial pattern

Increased visualisation of bronchial walls /number of visible bronchi.

Causes

- Mineralisation of the bronchial walls → age-related change.
- Thickening of the bronchus → associated with chronic inflammation or allergic process.
- Inflitration of the peribronchial tissues by oedema/inflammatory cells → acute allergic or inflammatory conditions; early stage bronchopneumonia; cardiac insufficiency.

Bronchiectasis - Bronchial dilatation with loss of normal tapering.

Interstitial pattern

Most common thoracic radiographic pattern. Results from inflammation or infiltration of the connective tissue framework of the lungs. Increase in background opacity with loss of visualization of fine vascular structures seen in well-aerated lungs.

Observed in early stages of most pulmonary diseases (so rarely specific):

- Infectious
- Neoplastic
- Cardiogenic
- Allergic

Localized vs Diffuse

Unstructured (hazy) vs Nodular (fungal disease; mets)

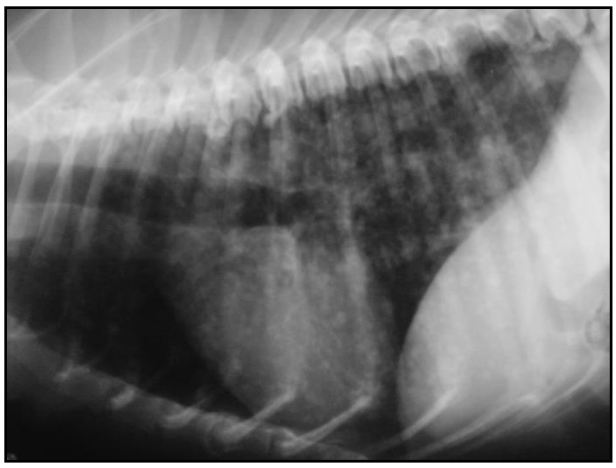

Figure 1 - Pulmonary metastatic disease.

Alveolar pattern

Relatively homogenous increase in lung opacity and presence of air bronchograms. Radiographic sign of diseases that displace air from the distal air spaces. Alveoli fill with fluid (transudate, exsudate or blood) or tissue → soft-tissue opacity

Air bronchogram – air-filled bronchus surrounded by a relatively homogeneous soft-tissue opacity (fluid-filled alveoli)

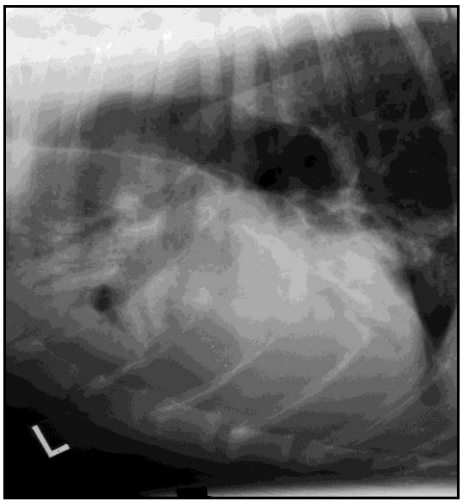

Figure 2 – Pneumonia with presence of air bronchograms.

Patchy vs Diffuse (coalescence of focal areas of oedema)

Causes

- Oedema → cardiogenic Vs non-cardiogenic

- Consolidation – pneumonia (bacterial, micotic, aspiration)
- Haemorrhage
- Atelectasis

Distribution/ location of alveolar lung pattern helpful to make a diagnosis:

- Cranioventral lung fields – associated with aspiration pneumonia.
- Caudodorsal lung fields – pulmonary oedema, haemorrhage, septicemia.

Vascular pattern

Variation in size, shape and number of pulmonary vessels. Pulmonary veins are central on DV/VD views and ventral on lateral views when compared with the adjacent arteries. Pulmonary arteries and veins at same level should have similar diameter.

- Diameter of vessels should be < 0.5-1 times proximal $^{1}/_{3}$ 4th rib (lateral view).
- Diameter of vessels should be < 0.5-1 width of 9th rib at the crossing point (DV view).

Hypervascular pattern

Congestive heart failure: enlarged pulmonary veins

Patients with pulmonary overcirculation due to L to R cardiac shunts: enlarged arteries and veins

Pulmonary hypertension: arteries > veins

Hipovascular pattern ± decreased size of heart

- Hypovolemia
- Dehydration
- Shock
- Pulmonic stenosis

Cardiac disease

What to look for when trying to rule in/out cardiac disease

- Heart size/ shape
- Vascular pattern
- Pulmonary oedema
- Pleural effusion
- Ascites

Heart should occupy less than two thirds of the width of the thoracic cavity in a DV/VD view and between 2.5 to 3.5 intercostal spaces in a lateral view. For a more accurate assessment of the heart size we can use the vertebral heart scale.

VHS – Vertebral heart scale

- Canine vertebral heart scale - less than 10.6.
- Feline vertebral heart scale - less than 8.1.

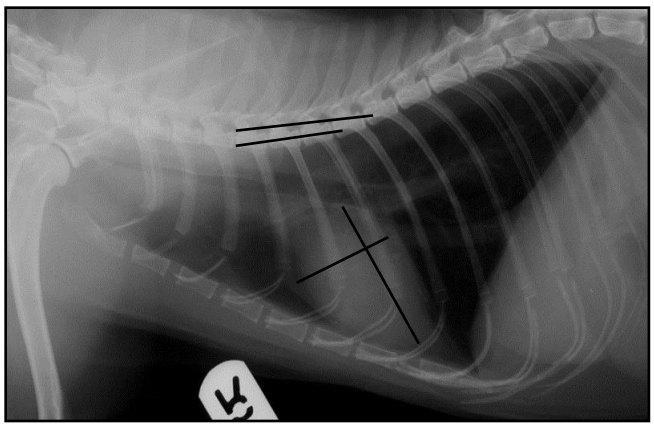

Figure 3 – Vertebral heart scale measurement in a cat.

In case of cardiomegaly we should try to assess if the enlargement is generalized, affecting only the left side or the right side of the heart. Most importantly we should look for any signs of congestive heart failure, namely: enlargement of pulmonary vessels, pulmonary oedema and pleural effusion.

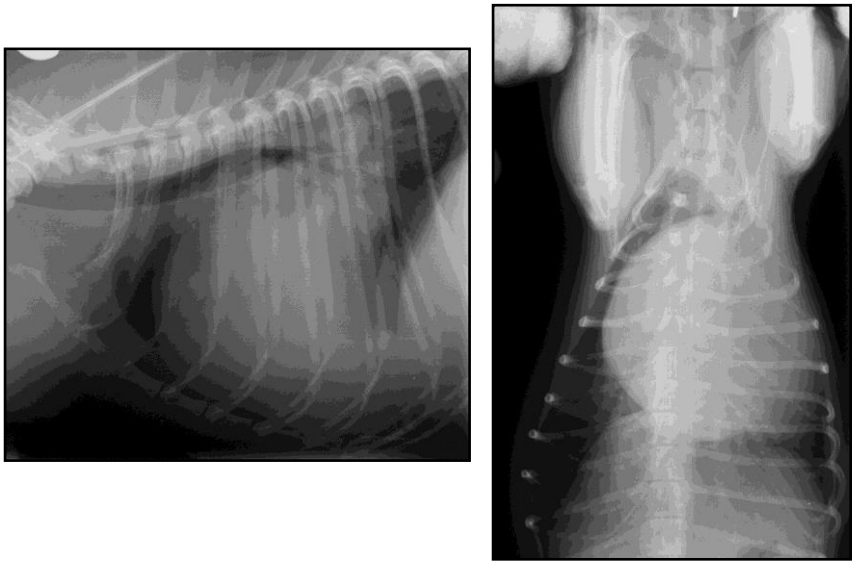

Figure 4 – Severe cardiac enlargement in a dog (orthogonal views).

Particular conditions requiring special nursing care

Pneumothorax

Retraction of lung from the thoracic wall and spine with surrounding gas lucency.

Causes

- Trauma with perforation of lung or trauma with perforation of thoracic wall.
- Spontaneous - primary if there is no underlying lung disease or secondary if there is underlying lung pathology - e.g. pneumonia, abscess,etc.
- Iatrogenic - after lung aspirates, thoracotomy, thoracocentesis, artificial ventilation.

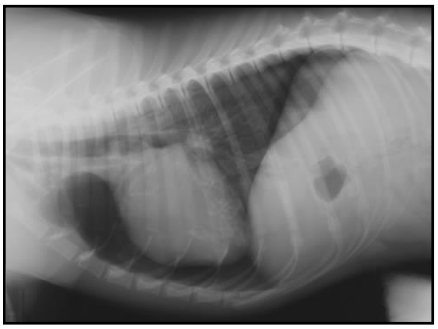

Figure 5 – Traumatic pneumothorax in a dog. Note the elevation of the heart from the sternum.

Diaphragmatic rupture

Common radiographic appearance will include loss of visibility of the heart and diaphragm with increase of intra-thoracic opacity. Abdominal organs will be displaced cranially with gas-filled stomach or loops of intestine seen in the thoracic cavity in some cases.

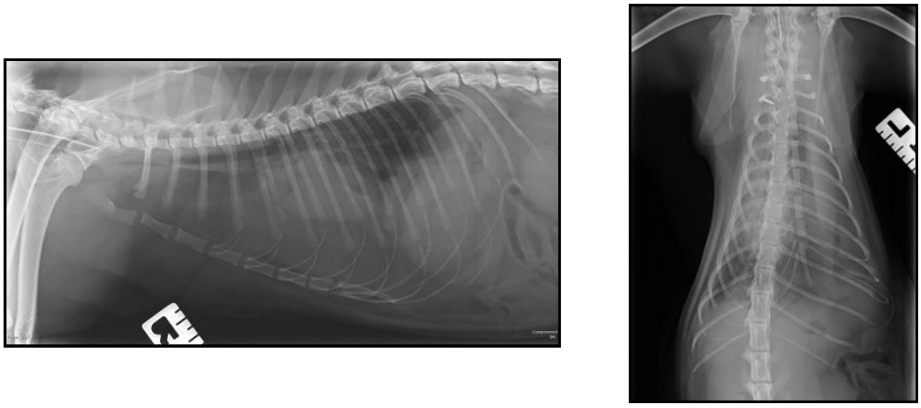

Figure 6 – Diaphragmatic rupture in a cat with herniation of the spleen into the L hemithorax.

Megaoesophagus

Results from a motility disorder due to central nervous system disease or neuromuscular disorder. More common in dogs than in cats.

On radiographs you will see dilatation of the oesophagus that may be filled with air (most commonly) or fluid or food.

Heavy sedation or general anaesthesia can cause non-clinical transient dilatation of the oesophagus. If trying to rule-out megaoesophagus, radiographs should be taken with the dog conscious or only with light sedation.

Chronic oesophageal dilatation with regurgitation may lead to secondary aspiration bronchopneumonia!

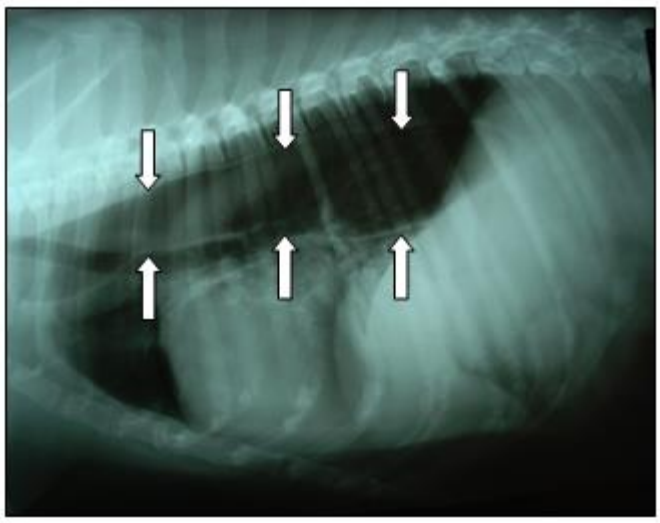

Figure 7 – Severe megaoesophagus and secondary aspiration pneumonia in a dog.

Pulmonary bullae

Spherical, localized area of emphysema usually small but sometimes large; may be multiple. Usually traumatic in origin but can be congenital. If seen in pre-GA radiographs then manual inflation of lungs and use of ventilator should be avoided because of the risk of bulla rupture and secondary pneumothorax.

Abdominal radiography

Despite the fact that ultrasound is now a popular imaging modality to evaluate the abdomen of small animals, abdominal radiography continues having a very important role in the work-up of many cases presenting with clinical signs suspicious for abdominal disease.

<u>Advantages of abdominal radiography</u>

- X-ray machines are widely available.
- Quick and easy to perform.
- Often can be done conscious or with light sedation.
- Not operator dependent.
- A R lateral and a VD (not DV!) radiographs are usually enough for general radiographic assessment of the abdomen.
- Radiographs give an excellent global evaluation of the amount and distribution of gas in the GI tract which may be difficult to evaluate with ultrasound. This is particularly important in cases of suspected gastrointestinal obstruction where abnormal dilatation of loops of intestine with gas may be present.

Indications for abdominal radiography

- Persistent vomiting.
- Abdominal pain.
- Haematuria/dysuria.
- Evaluation of abdominal mass.
- Evaluation of abdominal distension.
- Tenesmus.
- Persistent diarrhea.
- Incontinence.
- Evaluation of an external swelling.

Abdominal radiography - Technical aspects

A short scale contrast technique - low kV - should be used. A grid needs to be used if the abdomen is more than 10 cm thick. Exposure should be made at the end of expiration. Two views are usually enough for a general radiographic evaluation of the abdomen: a right (or left) lateral and a ventrodorsal view.

Radiographic positioning

Right or left lateral view

- Lateral recumbency.
- Forelimbs and hidlimbs sandbagged.
- Pad unter sternum.
- Centre at the 11th/12th intercostal space, just cranial to the last rib.
- Collimate to include diaphragm and cranial pelvis.
- Take radiograph just after expiration.

Ventrodorsal view

- Patient placed in dorsal recumbency.
- Sandbags over carpi.
- Ensure that there is no rotation.
- Centre on the midline at the level of the umbilicus.
- Collimate to include diaphragm and cranial pelvis.
- Take radiograph just after expiration.

Abdominal radiography – Basics of interpretation

As for any other body part, adequate evaluation of abdominal radiographs requires a systematic approach. The exact way you look at each radiograph can vary according with personal preference – e.g. from the periphery to the centre or from cranial to caudal - as soon as all the different structures present are evaluated. It is important to always look at each radiograph in its full extent and to look at all the radiographs available. For viewing abdominal radiographs the convention is that lateral views are examined with the diaphragm facing to the left and DV/VD views with the diaphragm uppermost and the left side of the patient in the right side of the computer screen or light box.

Common radiographic signs of abdominal disease

A careful evaluation of abdominal radiographs of diagnostic quality will permit ruling out or ruling in specific changes that may help us reach a final diagnosis or at least allow us to decide which other tests and exams may be required. The most common radiographic signs of abdominal disease are:

- Decreased serosal detail – Lack of contrast with difficulty to visualise the margins of the different abdominal organs. Several different causes possible as described below.
- Pneumoperitoneum – Presence of free air in the abdomen - i.e. air not contained within a hollow viscus structure like the gastrointestinal tract. Unless the animal underwent a laparotomy recently, this is almost always a sign of severe abdominal disease – e.g. rupture of the gastrointestinal tract.
- Gastrointestinal distension +/-obstruction – e.g. secondary to ingestion of a foreign body.
- Mass effect – Enlargement of an abdominal organ, for example due to a mass, will displace the surrounding organs changing their normal position.

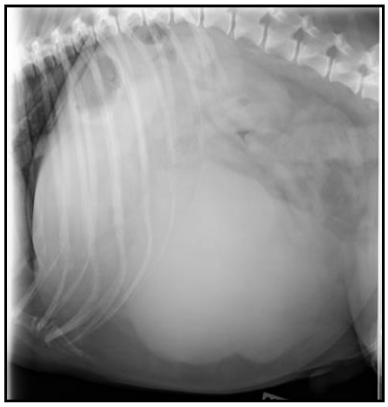

Figure 8 – Splenic mass in ventral abdomen causing displacement of surrounding organs.

Decreased serosal detail

Normal/ non-pathological

- Lack of intra-abdominal fat.
- Young animal.
- Underexposed radiograph.
- Superimposed material – e.g. blanket wrapped around the patient.

Pathological

- Effusion or ascites
- Peritonitis
- Peritoneal neoplasia
- Mass leading to organ crowding

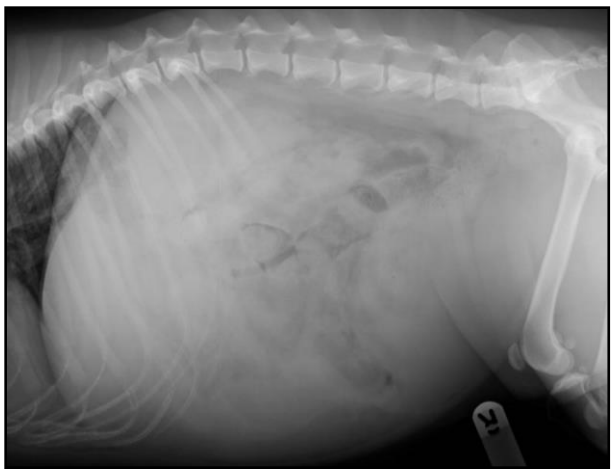

Figure 9 – Loss of abdominal serosal detail secondary to ascites.