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THORACIC RADIOLOGY: WHAT CAN WE EXPECT?

Regine Hagen
Vetsuisse Fakultät, Universität Zürich, Diagnostic Imaging
Winterthurerstrasse 260, 8057 Zürich, Suiza

To say the least: We can expect a lot! Radiology of the thorax is the standard primary diagnostic tool in veterinary medicine when thoracic disease is suspected. Radiographs of the thorax allow us to diagnose pathology of the pulmonary parenchyma, pulmonary vasculature, heart and great vessels, the pleura and pleural space, mediastinum and the thoracic wall. Radiography is available in most small animal practices in Europe and 'traditional' film-screen systems as well as digital systems are used, both allowing accurate diagnosis of disease. Radiography is time and cost effective and the basic principles of good radiographic technique are easily learned. However, many diagnoses need further imaging such as ultrasound, CT or MRI.

TECHNIQUE

As with all radiography, good technique yields good thoracic radiographs: The preparation of the patient, judgement of its physique and adjusted exposures as well as use of appropriate size of cassettes, standard film-focus distances and the absolute must of at least two orthogonal projections are of utmost importance. A grid should be used for thoraxes wider than 10 cm. Depending on the disease process under evaluation, additional and/or non-standard projections may be required. Sandbags, ties, foam wedges and -troughs help with positioning. Correct centring and collimation and the use of L/R markers complete preparation. A well-inflated lung exposed with high kV and low mAs technique allows for optimal visualization of parenchyma and differentiation of changes within and outside the lung. To improve image quality exposure at peak inspiration, during respiratory pause is recommended. Assessment of the dynamic behaviour of lung or trachea requires inspiratory and expiratory projections. Pulmonary vessels and lesions are better visible in the non-dependent, better ventilated part of the lung (Lat and DV/VD). Using the same technique for follow-up radiographs is necessary for comparison! Animals can be restrained manually or sedated/anaesthetised. Extra care has to be taken with dyspnœic animals and they may need to be radiographed in standing or sternal position using a horizontal beam.

ARTEFACTS

Common artefacts are nipple shadows, dirt on the hair coat, collars or medical equipment between the patient and the imaging system. Body condition and patient age influence the overall opacity of the lung fields. Artefacts are tricky as they may mimic lung pathology, but they can be avoided or at least reduced: The dependent lung lobes rapidly become atelectatic, thus sternal position prior to radiography and performing DV or VD prior to lateral projections should be adopted. Especially in sedated or anaesthetised animals dependent lobes rapidly collapse. R middle and L cranial lobes collapse first (greater surface: volume ratio).
INDICATIONS

Many clinical presentations and conditions warrant thoracic radiography: Coughing, dyspnea, cardiovascular disease, thoracic trauma, hunt for neoplasia (primary thoracic, multicentric or pulmonary metastases), thoracic wall lesions, regurgitation, systemic disease such as pyrexia of unknown origin or polytrauma.

RADIOLOGY OF THE LUNG FIELDS

Once good quality radiographs are obtained, systematic examination of the lungs is recommended. Consider: Radiographic quality (positioning, centring, exposure), the effect of patient position, inspiration vs expiration and the patient (body condition, canine breed, cat vs dog). There is wide overlap between normal and pathologic radiographic features. Also, we always look at a two dimensional representation of a three dimensional structure and thus have to deal with superimposition. This may only be overcome by cross-sectional methods such as CT or MRI and partially by ultrasound. Quantity, quality and distribution of abnormalities should be judged.

PULMONARY PATTERNS

INTERSTITIAL

Overall increased opacity of the lung fields with reduced visibility of the peripheral pulmonary vessels. 'Ground glass', 'hazy' appearance. Beware: Expiratory or underexposed views and thoracic radiographs of obese animals may appear similar. Cellular (inflammatory, neoplastic, haemorrhage) or fluid infiltration or fibrosis/scarring of the lung. (Multi)Focal: Miliary (<5mm) to nodular (>5mm) changes. Granulomatous (parasitic, fungal) or neoplastic disease. Focal: Abscesses, granulomata, fluid filled bulla (-e). Individual nodules need to be at least 2-5mm to be visible. CT allows identification of smaller nodules.

ALVEOLAR

Characteristic air bronchograms. Reduced to completely lost visibility of the pulmonary and large vessels, cardiac and diaphragmatic contours are blurred or obliterated. Fluid (edema) or cellular (pneumonia) infiltrate. Edema should have cleared 12 hours after administration of IV furosemide.

BRONCHIAL

The bronchial wall may mineralise, thicken, its course be uneven and the lumen abnormally wide (Bronchiectasis). Cats with bronchitis may present calcified peribronchial glands and often a consolidated right middle lung lobe. Peribronchial infiltrates or ‘cuffing’ may be present in PIE, parasitic infections (aelurostrongylus), peribronchial edema or inflammatory infiltrates.

VASCULAR

Pulmonary vessels (veins/arteries) of abnormal size. Course and contour may also be abnormal (Angiostrongylus). Abnormal perfusion such as in thromboembolism is difficult to diagnose by radiography. Scintigraphic perfusion- ventilation studies or CT angiography may demonstrate such pathology.

MIXED

Any of the above patterns may occur simultaneously in one lung.

LUNG LOBE TORSION is an uncommon condition, however potentially life-threatening and requires surgical intervention in the majority of cases. Pleural effusion is found in most cases of lung lobe torsion. The cardinal signs are opacification of the lung lobe, abnormal course of its bronchus and presence of pleural effusion. There may be emphysema of the affected lobe. The right middle and left cranial lung lobes are mostly affected. CT and US may help to confirm suspicion of torsion.
CARDIOVASCULAR STRUCTURES

Position, size and contour of the cardiac silhouette and great vessels and changes thereof can be assessed. To discuss imaging of pathologies of the cardiovascular system in detail is beyond the scope of this lecture.

PLEURA AND PLEURAL SPACE

We distinguish the parietal (costal, diaphragmatic and mediastinal) and the visceral (pulmonary) pleura. In between lies the pleural space (PS) (potential space, <1mm thickness). A small amount of lubricant fluid is normal. Pleural fluid drains via the visceral lymphatics. Increased opacity of the PS occurs with fluid, cellular or fibrin accumulation. Small amounts present as fissure lines, large amounts separate the lung lobes and reduce their volume drastically. Decreased opacity occurs with pleural gas. Normal lung lobes collapse evenly, retaining their shape and contour. If pleural fluid is present, the heart is better visible in a VD projection. Entrapped or encapsulated fluid may mimic extrapleural masses (-> US). Pleural thickening produces visible lung fissures. Thickening of the parietal pleura may only be visible on ultrasound or CT. Drainage of the pleural effusion followed by radiography may show lesions that were covered by the effusion. Safe drainage benefits from ultrasound guidance.

MEDIASTINUM comprises the cranial- middle and caudal mediastinum and contents (heart, great vessels, trachea, oesophagus, thoracic duct, nerves, lymph nodes and thymus). In the normal thorax, mediastinal structures, apart from heart and great vessels, tracheal and esophageal lumina and thymus) are not visible due to lack of contrast and only become visible with pneumomediastinum. Mediastinal shift occurs due to volume change in the hemithoraces/ lungs caused by change in air content or presence of masses. Mediastinal mass; e.g. thymoma, cyst, haematoma widens the mediastinum or displaces other structures. Mediastinal effusion may be chyle, lymph, pus, haemorrhage, and transudate or modified transudate and causes reverse fissures at the heart base. To differentiate a mass from effusion ultrasound or CT are necessary.

LYMPH NODES Mediastinal lymph nodes: tracheobronchial, sternal and cranial mediastinal. Enlargement: Tracheobronchial (R, L and middle) enlargement presents as soft tissue masses displacing the trachea/bronchi or compressing the bronchi. Sternal lymphadenomegaly presents as a soft tissue mass with an 'extrapleural sign' dorsal to the second sternebra. Enlarged cranial mediastinal lymph nodes cause widening of the cranial mediastinum. The THYMUS, if present, creates a so-called 'thymic sail' sign. The thymus may be visible up to a year of age.

TRACHEA diameter can be assessed using the tracheal diameter: thoracic inlet ratio. Published normal values: Mesaticephalic dogs: 0.21±0.03; Bulldogs 0.11± 0.03; other brachycephalic. 0.16± 0.03. Tracheal displacement may be positional (neck flexion) or due to displacement e.g. by a mass. Tracheal narrowing: slack dorsal trachealis muscle (redundant tracheal membrane).Tracheal collapse may occur inspiratory/cervical or expiratory/thoracic or along the entire tracheal length. A lateral view is most useful. The craniocaudal tangential view may demonstrate collapse. Change of tracheal diameter/contour is visible with stenosis, masses and trauma.

OESOPHAGUS

Megaoesophagus, oesophagitis, stricture, diverticulum, neoplasia, oesophageal foreign body, hiatal hernia. Most of these are best diagnosed using contrast oesophagography including dynamic studies.

SUPPLEMENTARY THORACIC PROJECTIONS

DECUBITUS / HORIZONTAL BEAM VD/DV: Useful projections to depict small amounts of pleural gas or fluid. With horizontal beam consider radiation safety! Patient in recumbency (L or R) and beam travels through it horizontally in a VD or DV direction.
HORIZONTAL, STANDING When animals are in severe distress, this position may be the only one to allow for at least a lateral projection.

OBLIQUE PROJECTIONS may help identifying thoracic wall lesions, such as rib lesions (neoplastic, osteomyelitic). For thoracic wall lesions, the exposure should be reduced drastically.

CONTRAST THORACIC RADIOGRAPHY

Generally: Plain radiographs should always precede contrast studies. Imaging of the oesophagus to investigate structural (vascular ring anomaly, stricture, diverticulum, hiatal hernia) or functional (megaoesophagus, dysphagia) anomalies or pathologies such as a luminal foreign body, intrinsic mass, perforation, esophagitis, fistula or a mediastinal mass. Barium or iodinated contrast media can be used, the latter must be used in cases with open wounds, suspicion of perforation, ulcer or tracheo- or broncho-oesophageal fistula. A non-ionic iodinated contrast medium reduces the risk of pulmonary oedema should some of it be aspirated.

ANGIOCARDIOGRAPHY selective or nonselective to visualise the cardiac chambers and great vessels and abnormalities thereof.

BRONCHOGRAPHY used to visualise the bronchial tree is nowadays superseded by bronchoscopy and CT.

INTERVENTIONAL RADIOGRAPHY Fluoroscopy is used for placement of a tracheal stent, cardiac procedures. Radiographs are used to control the correct placement of catheters, drains, stents. Aspiration or biopsy are nowadays mostly performed using ultrasound or CT.

FILM-SCREEN (‘traditional’) vs DIGITAL RADIOGRAPHY?

There are two types of digital radiography; computerized radiography (CR) and direct radiography (DR). CR: The cassette contains not a film and intensifying screens but a phosphor plate that is photostimulable. The phosphor absorbs the X-ray energy and keeps it for a period of time. It is then processed in a reader using a thorax algorithm and a laser beam releases the stored energy as luminescence. This is transformed into electrical signals by a photomultiplier. Different light intensities are the signals that form the digital image. The plate is then erased and can be used again and again.

Direct radiography (DR) is different in that an image is created on a screen immediately. An imaging sensor replaces cassette and plates/film- screen (similar to a digital camera). Both CR and DR allow post-processing of the images using a computer. One advantage of digital radiography is the wide latitude of the system. This allows a much wider range of exposures to be transformed into diagnostic images. Thus more ‘faults’ in exposure are tolerated. This is positive in the sense of radiation safety as repeat radiographs are less often necessary and also saves time, which allows a greater patient throughput. Lower exposures are possible. Post-processing allows for magnification of structures, which is helpful when viewing lung parenchyma. Relatively underexposed areas may be viewed using different density curves, which makes them better visible. Lack of need for x-ray films reduces cost. Images may be stored digitally and can be reproduced if a printer is available, they may be sent to colleagues for a second opinion, to the owner or to an expert by e-mail or another form of digital data exchange. A disadvantage of digital radiographs is the expense of the system. Good systems may be expensive. Since the technology is advancing rapidly, systems may be outdated rapidly. Good, high-resolution monitors are needed to make diagnoses, and they are expensive. CR and DR come with a new set of artefacts that are different from film-screen radiography and need to be recognised and understood. A digital radiograph and a carefully produced and processed film-screen radiograph may both create exactly the same information. The spatial resolution of film-screen radiographs is (still) higher though. A poor quality digital radiograph does not yield more information than a good quality film-screen radiograph! Lastly, often ultrasound, CT or MRI are used in addition to come to a final imaging diagnosis and to perform tissue sampling or drainage of fluid safely.
REFERENCES

