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INTRODUCTION

The thoracic radiograph provides information about thoracic musculoskeletal conformation and disease, cardiac size and shape, pulmonary parenchymal and vascular disorders, and conditions involving the pleura, mediastinum, esophagus, and diaphragm. Radiographs help confirm or exclude clinical impressions, support or reject specific diagnoses, and provide important information not otherwise suspected. They help to screen for cardiopulmonary, systemic, and metabolic disorders and assist to formulate initial treatment strategies. Moreover, repeat radiographs (using the same radiographic technique and positioning as in initial exposures) supply useful comparative data. Radiographs should be evaluated in context with the history, physical examination, clinical pathology, ECG, and diagnostic imaging (e.g., echocardiogram). As such the thoracic radiograph forms the cornerstone for diagnosis and management of thoracic disease.

RADIOGRAPHY IN ASSESSING COUGHING AND DYSPNEA

Good quality chest films are very important for accurate diagnosis and effective management of the coughing and dyspneic animal. Either sign may result from cardiac or respiratory disorders, as well as inflammation, neoplasia, parasitic diseases, trauma, degenerative disorders, physical causes, and allergic states.

Dyspnea or respiratory distress refers to difficult or labored breathing. Severity may be judged based upon assessment of breathing effort, respiratory rate, rhythm, and character. Affected animals typically display a standing or sitting posture (cats rest on their sternum), with neck extended and elbows adducted. Tachypnea (polypnea) relates to an increased breathing rate, which may or may not be associated with a dyspnea. Most coughs sound alike. The cough reflex may be initiated throughout the upper and lower respiratory system (i.e., pharynx, larynx, tracheobronchial tree, and small airways). In some animals coughing is occasional and of no clinical significance, while in others, coughing is irritating and often fatiguing (both to the animal and the owner), and a harbinger of serious underlying disease. Clients may confuse coughing with gagging, wheezing, labored breathing, and reverse sneezing. Some dogs may retch or vomit after a bout of coughing and this is often misinterpreted as gastrointestinal disease. Naso-pharyngeal diseases often induce gagging which can simulate a cough. However, these cases may also exhibit nasal discharge, sneezing and snorting, ptyalism, or strider. Laryngeal diseases may result in gagging, strider and sometimes coughing. Certain generalizations have been made about coughing: tracheal disease may cause dry, honking, resonant cough (dogs) and dyspnea or strider (cats); bronchiolar disease may cause coughing that is often followed by retching; alveolar disease may cause mild cough with dyspnea, or a moist cough with gagging and expiration of frothy fluid (pulmonary edema); cats rarely cough
from pulmonary edema but do from bronchitis, asthma, heart-worm, lungworms, neoplasia, and foreign bodies. In dogs, common causes of coughing include heart failure, particularly pulmonary edema; impingement on the main stem bronchi by severe left heart enlargement; heart worm disease, large airway disease; tracheobronchitis, and pulmonary fibrosis. In cats, feline bronchial disease (including ‘asthma’) is the most common cause for coughing.

RADIOGRAPHIC TECHNIQUE

Two well-positioned radiographic views (a lateral projection and either dorsoventral or ventrodorsal projection) are essential for a complete evaluation. Films should be exposed at peak inspiration (poorly inflated lungs will appear increased in density [i.e., ‘whiter’]) using a high kVp/low mAs technique. Breed conformation, state of respiration, obesity, relative state of hydration, stage of cardiac cycle, positioning errors and effusions alter radiographic appearances. Over exposure can result in loss of important information; under exposure can cause over interpretation of lung fields.

The patient should be correctly positioned (superimpose the spine and sternum on the VD/DV and adjust the animal in the lateral view so that the sternum and spine are equidistant to the table top, the costochondral junctions and ribs are superimposed, the front legs are drawn forward). Align the with the primary beam centered approximately at the 5-6th intercostals. Oblique views will greatly distort the cardiac silhouette. Do not flex or extend the head which can result in deviations of the trachea proximal to the heart. The thorax should include the thoracic inlet and entire diaphragm. Avoid motion artifact by using short exposure times (<1/30th sec). Optimally exposed VD or DV films allows faint visualization of intervertebral spaces overlying the heart.

The ventrodorsal (VD) radiograph has the benefit of evaluating the cardiac silhouette when there is moderate pleural effusion, since fluid will gravitate along the paravertebral gutters, and avoids superimposing over the heart as occurs with the DV view. The VD view may be less stressful for severely dyspneic animals. While inspiratory films are generally desired, expiratory films can help detect dynamic collapse of intrathoracic trachea or bronchi, and demonstrate pulmonary air-trapping as occurs with chronic obstructive lung disease or emphysema.

RADIOGRAPHIC INTERPRETATION

Thoracic Wall

The chest wall includes the spine, ribs, sternum and related soft tissues, and is framed by the caudal cervical vertebrae cranially, and diaphragm caudally. Evaluate symmetry in both views (altered by pectus excavatum, scoliosis, trauma). Look for lytic lesions indicative of neoplasia or infection, fractures (trauma), masses, changes in opacity, and subcutaneous emphysema. Some chest wall lesions may intrude into the thoracic cavity and exhibit extrapleural signs.

The Mediastinum

These are potential spaces between cranial and caudal pleural cavities. In the cranial mediastinum lie the heart, ascending aorta, main pulmonary artery, cranial vena cava, thoracic duct, nerves, trachea, esophagus, lymph nodes, and thymus. In the caudal mediastinum are the posterior vena cava, trachea, descending aorta, nerves, and lymph nodes. Because the mediastinum communicates with fascial planes of the neck and retroperitoneal space, pneumomediastinum may result in contrast and thus, visualization, of mediastinal structures, as well as subcutaneous edema or pneumoretroperitoneum. Often, both edges of the ventral trachea will be apparent when pneumothorax is present. Observation of mediastinal shift (VD or DV view) may accompany pneumomediastinum, diaphragmatic hernia, pleural effusion, masses, or atelectasis. Widened cranial mediastinum may result from lymphadenopathy, thymoma, megaesophagus, and neoplasia. Widened caudal mediastinum may occur with caudal vena caval obstruction, or esophageal dilation, hernia, or mass.
Pleural Space

This potential space located between the parietal pleura and visceral (pulmonary) pleura is occupied by the lungs. Pleural thickening associated with disease may allow visualization of pleural fissures. Diseases which increase pleural space opacity include pleural masses and effusions. Pleural effusion is generally free standing and moves across the right and left pleural spaces. Occasionally, effusion is loculated or trapped and involves the region of a cranial lung lobe or right middle lung lobe. Small volumes of free pleural effusion may cause blunting (rounding) of the costophrenic angles, accentuation of pleural fissure lines, and might be best visualized on the DV projection. Larger volumes silhouette the heart and diaphragm, cause retraction of lung borders from the chest wall, result in cranial and caudal mediastinal widening, a ‘scalloped’ effect with lung lobes, and marked rounding at the costophrenic angle. Increased opacity conferred by pleural effusion causes an apparent increase in the opacity of lung lobes surrounded by superimposed fluid. Chronic effusions may result in pleural fibrosis with radiographic changes that include markedly rounded and attenuated lung lobes, especially caudal lobes. Pneumothorax decreases pleural space opacity.

The Diaphragm

Altered diaphragmatic symmetry may occur with diaphragmatic or peritoneopericardial hernia. Severe peritoneal fluid, cranial abdominal mass, or lobar collapse may result in cranial diaphragmatic displacement. Severe pneumothorax and emphysema causes the diaphragm to displace caudally. Diaphragmatic hernia and pleural effusion may obscure the diaphragmatic border.

The Heart and Great Vessels

In the lateral canine view, the heart is oriented at approximately a 45 degree angle, is situated between the 3rd-8th thoracic vertebrae, occupies about 3 intercostal spaces, and measures about 8.5-10.6 (average, 9.7) vertebral bodies (T4) wide using the vertebral heart score method. In the VD or DV view it has a roughly elliptical shape with a curved right ventricular and relatively straight left ventricular border. Breeds often influence anatomic contours. Anatomical structures include (clockwise); aortic arch (extending from 11 to 1 o’clock); main pulmonary artery segment (1 to 2 o’clock); left auricular appendage (2 to 3 o’clock); left ventricle (2 to 6 o’clock), and right heart (6 to 12 o’clock). In the right lateral view, the left atrium is superimposed over the caudal-dorsal one-third of the heart just distal to the tracheal bifurcation. When significantly enlarged, the left atrium may compress main stem bronchi and contribute to coughing. In the lateral feline view, the heart is oval and narrower than the dog (2.5 to 3 intercostal spaces wide), varies from vertical to nearly horizontal, and is separated from the diaphragm by 1 or 2 intercostal spaces.

Abnormalities in Cardiac Size and Shape

Conformation, respiration, hydration, stage of cardiac cycle, positioning errors and effusions alter radiographic appearances. Pleural effusions may obscure the cardiac silhouette. Cardiomegaly usually results from congenital or acquired lesions causing volume overload (e.g., valvular insufficiency or shunts), pressure overload (e.g., valvular stenosis), myocardial disease (e.g., cardiomyopathy), pericardial disease, or respiratory conditions (e.g., cor-pulmonale). The cardiothoracic distance decreases in the DV or VD view but this can also be influenced by phase of respiration and pleural disease. Cardiac function cannot be directly assessed by radiography.

Radiographic Lung Patterns

Conditions which affect the trachea, large bronchi, small airways, vessels, alveoli, or pulmonary interstitium may affect the relationship between soft tissue parenchyma and air within alveoli and airways, affecting the radiographic opacity of the lungs and related structures. Increased lung opacity (i.e., "whiter"
appearing lungs) may be associated with pleural effusion, parenchymal disease (e.g., pneumonia), and over circulated lungs (e.g., left to right shunts such as PDA or AV fistulas). Increased opacity may also result from under exposure, expiratory films, and obesity. Decreased lung opacity (‘blacker’ appearing lungs) may result from pneumothorax, diseases associated with air trapping (e.g., emphysema), and hypoperfusion (e.g., shock, severe hypovolemia). Additional causes include thin, emaciated animals or over exposure. Radiographic interpretation of pulmonary parenchymal disease includes a pattern-based approach. Many diseases cause mixed patterns which are classified according to the major pattern, or specified as a combined patterns, such as bronchoalveolar).

ALVEOLAR PATTERNS indicate alveolar collapse or filling (with blood, pus, or water). Findings include: 1) patchy, poorly defined, increased densities with fluffy, indistinct margins which tend to coalesce, 2) air bronchograms (i.e., air-filled [and therefore radiographically grey or black] branching tubes surrounded by abnormal radiographically opaque [i.e., whitish] opacities, and 3) silhouetting of pulmonary vessels and bronchial walls by lung alveoli and interstitium containing fluid. Alveolar patterns are typically fluffy and indistinct, and coalesce. Cranioventral distribution is most associated with bronchopneumonia; perihilar distribution (in dogs) is most associated with congestive heart failure. Noncardiogenic edema usually occurs in dorso-caudal lung fields. Diffuse or patchy alveolar distribution may be seen with bronchopneumonia, pulmonary edema, hemorrhage (often lobar), and atelectasis.

INTERSTITIAL PATTERNS indicate involvement of pulmonary interstitium. One form includes increased nodular densities having distinct, well defined margins (e.g., neoplasia, chronic granulomas). The second form causes a nonspecific localized or generalized "grayness" without distinct features, (e.g., pulmonary edema, pulmonary fibrosis, some neoplasia, interstitial pneumonia or hemorrhage); vasculature and bronchi are blurred.

BRONCHIAL PATTERNS result when bronchial walls become more opaque due to thickening or when surrounded by fluid or cellular infiltrate. These appear in cross section as circular, whitish or grayish thickened or calcified rings (‘donuts’); when viewed in longitudinal section they are linear, parallel thickenings or lines. Bronchial disease may progress to bronchiectasis that appears as thin-walled, cylindrical or saccular bronchial dilation with enlarged bronchial lumens that lose their distal tapering; emphysema appears as saccular or coalescing airways.

Radiographic Vascular Patterns

Cranial lung lobe vessels are best assessed from the lateral projection; arteries are dorsal and veins are ventral to related bronchi. Caudal lobar vessels are best assessed from the VD or DV view (arteries are lateral and veins are medial to associated bronchi). Normally, arteries and veins are approximately the same size. Hypervascularity refers to arteries and/or veins which may be enlarged together in states of increased pulmonary blood flow (left-to-right shunts), high output states (thyrotoxicosis, severe anemia, fluid overload), left-sided CHF from severe mitral insufficiency or canine dilated cardiomyopathy (i.e., chronic pulmonary venous dilation with secondary pulmonary hypertension). Increased pulmonary artery size and shape suggest pulmonary hypertension (usually dirofilariasis; occasionally, right-to-left shunts, idiopathic pulmonary hypertension). Pulmonary venous congestion is associated with left-sided CHF. Hypovascularity (hypoperfusion or under circulation) creates thin arteries, veins and radiolucent interstitium and may accompany low cardiac output [shock, dehydration, caval syndrome, cardiac tamponade, acute blood loss, hypoadrenocorticism, restrictive pericarditis, severe myocardial failure), or right to left shunts.

REFERENCES

- Burk R, Ackerman N. Small Animal Radiography and Ultrasonography. 2nd Ed, WB Saunders, 1996

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