

COUGHING AND DYSPNEA. CLINICAL THORACIC RADIOGRAPHY

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CLINICAL OVERVIEW

Accurate diagnosis is best facilitated when clinical signs are integrated with medical history, physical examination, and radiographic findings, since a broad range of conditions cause or contribute to coughing and dyspnea. Clients may confuse coughing with gagging, wheezing, labored breathing, and reverse sneezing. Some dogs retch or vomit after coughing, and this is often misinterpreted as gastrointestinal origin. Naso-pharyngeal diseases often induce gagging which can simulate a cough, although these cases may also exhibit nasal discharge, sneezing and snorting, ptialism, or strider. Laryngeal diseases may result in gagging, strider and sometimes coughing.

Coughing is a sudden expiratory effort resulting in noise with expulsion of air. The coughing reflex may be initiated throughout the upper and lower respiratory system (pharynx, larynx, tracheobronchial tree, and small airways). In some animals coughing occurs just occasionally and is of no clinical significance; in others, coughing affects quality of life (both to the animal and the owner), or is a harbinger of serious underlying disease. Most coughs sound alike and more than one etiology may coexist.

Dyspnea or respiratory distress refers to difficult or labored breathing. Severity may be judged by assessing breathing effort, respiratory rate, rhythm, and character. Affected animals 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. Common etiologies for acute dyspnea include trauma, pulmonary edema, pneumonia, airway obstruction, pneumothorax, and pulmonary thromboembolism. Chronic dyspnea can occur from right-sided CHF, pulmonary hypertension, pericardial tamponade, broncho-interstitial disease, pleural effusions, anemia, neoplasia, hernia, and other causes. Inspiratory dyspnea suggests upper airway obstruction while expiratory dyspnea suggests lower airway obstruction. Exertional dyspnea may imply organic disease (e.g., myocardial failure, dilated cardiomyopathy), chronic obstructive lung disease, other parenchymal conditions, or neuromuscular or musculoskeletal disorders. Paroxysmal dyspnea suggests brady or tachyarrhythmias, especially with episodic weakness or syncope. Resolved dyspnea following cardiac drug therapy suggests heart disease.

Cardiogenic pulmonary edema in dogs usually results from left-heart volume overload (mitral regurgitation from endocardiosis) or dilated cardiomyopathy. Related cough is usually acute, progresses briskly over 24-72 hours, is relatively soft, and accompanies exertional dyspnea (in contrast to large airway disease below). When edema is fulminate, the cough may yield small quantities of frothy, pink-tinged foam from the mouth or nares. Chronic pulmonary congestion may cause mild intermittent coughing or nocturnal cough. Impingement of the left main stem bronchus by a left atrium enlarged by chronic mitral regurgitation, contributes to chronic coughing. Cats with cardiogenic pulmonary edema rarely cough (even when severe left atrial enlargement is present), but frequently cough with bronchitis, asthma, heart-worm, lungworms, neoplasia, and foreign bodies.

CADIOVASCULAR IMAGING

Cardiovascular imaging is a rapidly evolving field that requires familiarity with the appearances of cardiovascular and respiratory diseases on chest radiographs, as well as images obtained with computed tomography, magnetic resonance imaging, and angiography. 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 treatments. 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, and data base. Cross-sectional imaging of the chest with computed tomography (CT), magnetic resonance imaging, and at times, ultrasonography delineates mediastinal, hilar, and pleural pathologies.

CT IMAGING

CT scanning—sometimes called CAT scanning, is used to further examine abnormalities found on conventional radiography, help diagnose the cause of clinical signs or symptoms of disease of the chest, detect and evaluate the extent of primary or metastatic chest tumors, assess whether neoplasia is responding to

treatment, help plan radiation therapy, evaluate injury to the chest, including the blood vessels, lungs, ribs and spine. Chest CT can demonstrate various lung disorders, such as: lung cancer, old or new pneumonia, emphysema, bronchiectasis, inflammation or other pleural diseases, and diffuse interstitial lung disease. A CT angiogram (CTA) may be performed to evaluate arteries and veins as well as cardiac structures. This involves the rapid injection of an iodine contrast material while obtaining numerous, thinner CT images. Three-dimensional reconstruction of cardiac and pulmonary structures using a workstation connected to a chest computed tomography (CT) scanner may change the diagnostic strategy in patients with congenital or acquired thoracic disease as well as chest trauma. CT is capable of identifying thickened, calcified and congenitally absent pericardium, intracavitary masses, and is particularly useful to detect extracardiac and pulmonary masses when pleural effusion is present. The advantage of CT over MRI is shorter anesthesia time, and resolution of pulmonary masses that is less liable to motion artifact associated with MRI.

MRI IMAGING

MR imaging uses a magnetic field, radio frequency pulses and a computer to produce detailed images of organs, soft tissues, bone and virtually all other internal structures. MRI does not use ionizing radiation. It is selected to assess masses including pulmonary neoplasia or other tissues, which either cannot be assessed adequately with other imaging modalities (typically CT) or which are particularly well-suited to MR imaging. Additional applications include determine tumor size, extent, and the degree of metastasis, assess cardiac anatomy and function and its component structures (valves, etc.), determine blood flow dynamics in the vessels and heart chambers, display lymph nodes and blood vessels, including vascular and lymphatic malformations of the chest, assess extracardiac disorders of the chest (vertebrae, ribs and sternum). Chest wall lesions include a diverse group of soft tissue and osseous thoracic diseases. MR imaging, with its superior tissue-resolving capability and multiplanar image acquisition, is an important tool for evaluating these lesions. A special form of MRI- magnetic resonance angiography (MRA) is helpful to assess vasculature. Disadvantages of MRI include its requirement for longer anesthesia time vs CT, challenges in cardiac monitoring, and special equipment needed for cardiac gating.

THORACIC RADIOGRAPHY

Good quality chest films are essential for accurate diagnosis and effective management. Both coughing and dyspnea 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 by assessing breathing effort, respiratory rate, rhythm, and character. Affected animals 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. Cough reflex may be initiated throughout the upper and lower respiratory system (i.e., pharynx, larynx, tracheobronchial tree, and small airways). Most coughs sound alike. Coughing may be occasional and of no clinical significance, or persistent, fatiguing (both to the animal and the owner), and a harbinger of serious disease. Clients may confuse coughing with gagging, wheezing, labored breathing, and reverse sneezing. Some dogs retch or vomit after coughing, and this is often misinterpreted as gastrointestinal disease. Naso-pharyngeal diseases often induce gagging which can simulate a cough, although these cases may also exhibit nasal discharge, sneezing and snorting, ptialism, or stridor. Laryngeal diseases may result in gagging, stridor and sometimes coughing. Certain generalizations have been made about the character of the cough: tracheal disease may cause dry, honking, resonant cough (dogs) and dyspnea or stridor (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, coughing commonly results from 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

Films should be exposed at peak inspiration using a high kVp/low mAs technique. Poorly inflated lungs will appear increased in density- i.e., 'whiter'. Breed conformation, state of respiration, obesity, relative state of hydration, stage of cardiac cycle, positioning errors and effusions alter radiographic appearances. Over-exposure causes loss of important information; under exposure causes 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 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. Avoid motion artifact by using short exposure times (<1/30th sec). Optimally exposed VD or VD films allows faint visualization of intervertebral spaces overlying the heart.

The ventrodorsal (VD) radiograph is advantageous to evaluate the cardiac silhouette when pleural effusion is present, since free fluid will gravitate along the paravertebral gutters, and does not superimpose 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 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 cause pleural fibrosis; radiographic changes include 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.

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 dogs. 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 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 ('blackier' 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 on radiographs-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 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 interstitial "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, restrictive pericarditis, hypoadrenocorticism, severe myocardial failure), or right to left shunts.

References

- Myer, W. Diagnostic imaging in respiratory disease. In: Birchard, SJ, Sherding, RG. eds: Saunders Manual of Small Animal Practice (second edition). Philadelphia, WB Saunders, 2000;611
- Lord, PF, Suter, PF Radiology. In: Fox, PR; Sisson, DD; Moise, NS. eds. Textbook of canine and feline cardiology principles and clinical practice (second edition). Philadelphia, WB Saunders 1999;107-129.

- Burk, R, Ackerman, N. Small animal radiography and ultrasonography (second edition). Philadelphia, WB Saunders, 1996
- Suter, PF. Thoracic radiography. A text atlas of thoracic diseases of the dog and cat. PF Suter, Wettswil, Switzerland, 1984