**WHY IS THIS ANIMAL IN RESPIRATORY DISTRESS?**

**Introduction**
Respiratory distress in animals indicates that there is increased effort in breathing. This can result from disorders in several areas of the neck and thorax that limit the ability of the lungs to transfer oxygen. Imaging can act as a good screening tool to identify the affected portion of the respiratory system and to guide further diagnostics and therapeutics.

**Radiographic Technique**
A complete evaluation includes a lateral projection of the neck and three thoracic projections; left lateral recumbency, right lateral recumbency, and either a ventrodorsal or dorsoventral projection.

Since these animals may be severely compromised, ensure they are stable for radiography and use supplemental oxygen if needed. Ventrodorsal radiographs, or even lateral radiographs, may be contraindicated if the position worsens the respiratory distress. The first radiograph should be taken in sternal recumbency and as quickly and efficiently as possible. Further radiographs can be taken once the problem has been identified and treatment initiated.

**Upper airway obstruction**
There are developmental, degenerative, and neoplastic conditions that can affect the flow of air through the nares, pharynx, and larynx, resulting in respiratory distress. Brachycephalic breeds can have thickening and lengthening of the soft palate, laryngeal narrowing or fibrosis, and stenotic nares. Dyspnea may also be caused by compression or occlusion of the airways by mass. Endoscopy and ultrasonography are logical next steps to confirm this finding.

**Pleural space disease**
Dogs and cats with pneumothorax are often presented after a traumatic event. The radiographic signs that indicate pneumothorax are retraction of the lung lobes away from the chest wall, lack of pulmonary vessels in the periphery of the lungs, visibility of the lung pleura, and "elevation" of the heart from the sternum.

Animals with fluid in the pleural space may be affected by collections of transudate, exudate, hemorrhage, or chyle. The first step is to identify the presence of pleural effusion, which appears as an increased soft tissue opacity in the thorax, retraction of the lung lobes, and widened pleural fissure lines.

**Pulmonary disease**
Diseases affecting the pulmonary parenchyma such as infectious and noninfectious inflammatory disease and edema can result in respiratory distress. Neoplastic disease can also cause respiratory distress in some cases however it is usually late stage. Diffuse pulmonary disease causing respiratory distress is recognized by an interstitial or alveolar pattern. Interstitial patterns cause loss of definition of the normally well-seen structures of the lungs such as the pulmonary vasculature, and an overall increase in opacity of the lungs. Alveolar disease results in an increased soft tissue opacity of the lung lobe, often with the presence of air filled bronchi (air bronchograms).

**Thoracic wall disease**
In traumatic cases, injuries to the ribs and intercostal muscles can result in lack of mechanical expansion of the thorax. The extrathoracic structures should be evaluated carefully on each radiograph to look for areas of lysis, fractures, swelling, or air.

**Use of imaging in working up cases of dyspnea**
Patient stability is always the first consideration. The use of radiographs to identify the source of the abnormality is the first step, and repeat radiographs may be needed if pleural space disease is obscuring the thorax. Once the disease has been localized to an area, a list of differential diagnoses should be generated. Advanced imaging such as CT or ultrasound, as well as endoscopy, may be indicated as the next step of the diagnostic process. Repeat radiographs should also be considered to monitor progress of a disease as treatment is initiated.
WHY IS THIS ANIMAL COUGHING?

Introduction
Coughing is a common presenting sign in both dogs and cats. There are many causes of coughing involving the respiratory tract, and radiographs are a good survey diagnostic test to further evaluate which part of the respiratory tract is involved. The airways are normally a primary or secondary location of disease, and we will focus on imaging these structures.

Radiographic Technique
A complete evaluation includes a lateral neck and three thoracic projections; left lateral recumbency, right lateral recumbency, and either a ventrodorsal or dorsoventral projection. The lung on the dependent side on a lateral projection is significantly hypoinflated compared to the opposite side, and will not provide enough contrast to be able to see structures clearly. Therefore, on a right lateral recumbent radiograph, the majority of the structures seen will be in the well-inflated left lung.

Airway Collapse
The trachea and airways can be affected by many types of disorders that cause coughing. One of the more common degenerative diseases is tracheal and bronchial collapse, which affects the compliance of the cartilage in the airways. The collapse of the airways creates a mechanical obstruction resulting in cough, and inflammatory change may also be present contributing to the symptoms. Toy and small breed dogs are predisposed to this condition. Dogs can be affected by lower airway collapse alone, or in conjunction with tracheal collapse. Fluoroscopy can be used to advantage for a definitive diagnosis, as it is a real time imaging method. Radiographs are often not accurate in diagnosing the true location of airway collapse or the extent, and are not recommended for final diagnosis of airway collapse.

Tracheal or Bronchial Obstruction
Airway obstruction can produce a cough due to irritation and narrowed lumen diameter. In some regions, inhaled plant foreign bodies are occasionally encountered as causes of acute onset of coughing in dogs and cats. Granulomatous or neoplastic disease may cause coughing by compressing an airway externally or internally. Examples include tracheal lymphoma or carcinoma, or primary lung tumors with airway involvement.

Inflammatory disease
Infectious and noninfectious inflammatory diseases can result in coughing in dogs and cats. While acute infectious diseases will result in systemic signs of illness, chronic coughing is often caused by noninfectious inflammatory diseases such as chronic bronchitis and feline asthma. With either asthma or chronic bronchitis, the airways are inflamed and thickened. This often results in a bronchial pattern on thoracic radiographs. Acute bronchitis may result in neutrophilic inflammation, or eosinophilic inflammation such as eosinophilic bronchopneumopathy. Airway sampling is often recommended for diagnostics in these cases. Inflammation of the pulmonary parenchyma can also result in coughing. Dogs with pneumonia or pulmonary abscesses often have secretions in their airways that result in coughing. In these cases, we are looking for an alveolar pattern or a mass that localizes the source of inflammation.

Degenerative Disease
With longstanding airway disease, the cartilage of the airways can become degenerative and dilated. This dilation with pooling of secretions is termed bronchiectasis. On radiographs, bronchi appear not to taper normally, and may have saccular dilations or uneven diameter. This is an indicator of severe or longstanding disease resulting in permanent changes to the airways. Degenerative disease of the heart can result in pulmonary edema, causing a cough as a presenting sign. The mechanism of cough in pulmonary edema is unclear, however the reader should be alert for signs of heart disease on radiographs when examining a dog presenting for coughing. Typical radiographic signs of cardiogenic pulmonary edema are cardiomegaly, and interstitial pattern in the perihilar region.
HOW TO GET MORE OUT OF MY X-RAYS

A radiographic study is an important diagnostic test that is used in many patients presenting for evaluation beyond routine preventative care. Radiographs give an insight into the tissues and organs of the animal, and reveal changes in gross pathology in the living patient. We rely on them to localize the animal’s source of illness to a particular organ system when it’s not clear from the history and physical exam, as well as to provide specific diagnoses in cases where the abnormalities are characteristic of a condition. They are used to refine the initial list of clinical differential diagnoses, to re-order, rule out, and add additional possibilities.

Because the entire body part being imaged is represented as varying densities superimposed on each other on the radiograph, there is a wealth of information present. The standard projections used to image body areas are the workhorse of radiology and are often sufficient. However, there are many strategies that can be used in daily practice to maximize the diagnostic utility of radiographs and to gain the critical insight needed to make clinical diagnoses and decisions for patient care.

The most basic way to maximize the information visible on radiographs is to optimize technique and positioning, and obtain consistent, high quality images. Animals should be symmetrically positioned and parallel to the table and the x-ray beam for thoracic, abdominal, and musculoskeletal radiographs. Rotation and superimposition can hide abnormalities or create shadows that represent superimposition rather than abnormal findings.

In the thorax, there is significant compression of the dependent lung when taking a lateral radiograph. This decreases the air-soft tissue contrast between infiltrates and aerated lung, and can cause missed lesions. I recommend always taking a 3-view thoracic study to allow the left and right lungs to be fully inflated in the lateral position.

Positional radiographs are useful to demonstrate air-fluid interfaces, as the interface appears as a straight line parallel to the table and perpendicular to the force of gravity. If your detector is removable, it can be positioned perpendicular to the table with the animal in a lateral or sternal position. In this way, the x-ray beam is positioned parallel to the table and is able to detect any air-fluid interfaces that might be present.

Compression radiographs can be useful to evaluate suspected abnormalities in abdominal regions with superimposition of other organs. A radiolucent instrument such as a wooden spoon can be used to compress the abdomen, displacing other organs away from a small kidney or suspected cystic calculi.

While we always use a systematic approach to interpreting radiographs, there are roentgen signs specific to many diseases that warrant a focused search. Consider the differential diagnoses and evaluate the radiographs for any signs particular to that disease. By combining a systematic approach and focused search, you can confidently rule in and rule out conditions on the list of differential diagnoses.

Diagnostic accuracy depends on the availability of a “library” of images that you compare the current case with. This includes your mental library of case experience of normal and abnormal cases, and can also include atlases, textbooks, and files of cases that you have noted for reference.

The use of these techniques will help you to glean all the available information from the radiographs you interpret in daily practice. Radiographs are the foundation of veterinary diagnostic imaging that will help you to hone your clinical skills and provide excellent care to your patients.
WHEN SHOULD I USE CT?

Radiographs and ultrasound are the mainstay of diagnostic imaging in daily practice. They provide valuable insight into the pathology present in the animal and organ system we are evaluating. However, radiographs are a two-dimensional representation of three-dimensional structures. Superimposition of shadows, as well as limitations of radiographic densities depicted, can hide pathology that is present, or limit the detail of the examination. Ultrasound images provide thin slice images that avoid the problem of superimposition of structures but are unable to depict the three dimensional anatomy in a standardized plane as a whole. Computed tomography (CT) has the advantage of imaging thin slice images of the entire 3D volume in a standard plane that can be reviewed and understood by any reader after the examination is complete. Radiographs, ultrasound, and CT are all complimentary modalities and can be used to narrow the list of differential diagnoses for a patient and aid in treatment planning.

CT has supplanted radiographs as the imaging modality of choice in diseases of the nasal cavity. The nasal cavity, sinuses, and turbinates are complex structures that hinder radiographic interpretation because of superimposition artifacts. Where CT is available, it is often used as the first imaging modality in animals with nasal discharge, sneezing, and other clinical signs of nasal disease. The imaging characteristics of nasal neoplasia, fungal rhinitis, and non-fungal rhinitis are fairly characteristic, and a firm imaging diagnosis can be made in most cases, with follow-up rhinoscopy and biopsy for tissue sampling.

CT provides excellent detail in the musculoskeletal system, and can be used to investigate complex structures such as the elbow, carpus, and tarsus. Congenital orthopedic disease such as elbow dysplasia and osteochondrosis, as well as traumatic injuries, are well depicted on CT by eliminating the superimposition of structures seen on radiographs.

CT is becoming more available and affordable to both general and specialty practice. By becoming familiar with its strengths and the opportunities it provides to refine imaging diagnoses, clinicians can advise their clients how best to approach cases and provide excellent patient care.

Abnormalities found on abdominal ultrasonography can be more completely characterized using CT, which is often used to confirm the imaging diagnosis, and to aid in surgical planning. Examples include invasive adrenal masses with tumor thrombus extending into the caudal vena cava and/or phrenicoabdominal vein, ureteral calculi, and hepatic masses. Portosystemic shunts can also be completely characterized using CT angiography, especially those that terminate in the phrenic or azygos veins and are difficult to image with ultrasound.

Case selection for neurologic disease include animals with trauma to the cranium or spine, intervertebral disc disease, conditions affecting the integrity of the axial skeleton, and extra-axial tumors that are outside the blood-brain barrier and therefore enhance strongly with contrast.

CT provides good contrast between air filled structures and soft tissues, and is therefore a good choice in diseases of the pharynx, airways, and lungs. The high sensitivity to changes in density compared to radiographs, and thin slices that avoid superimposition, provide great detail in these regions. Foreign bodies in the pharynx, soft tissues of the neck, and airways can be visualized if surrounded by air, or their migration can be followed by contrast enhancing tissue in the path of the foreign body. Pulmonary nodules are seen in the lungs at a much smaller diameter than on radiographs, which can be critical in animals with cancer in which metastatic disease changes the treatment plan.
Why is This Abdomen Painful?

Approach to interpretation of abdominal radiographs

The painful abdomen has many causes, including trauma, neoplasia, inflammatory disease, obstructive disease, and malposition of organs. Identification of the organ involved is an important first step, which can be often identified on survey radiographs.

An abdominal radiographic study is an excellent tool to gain an overview of the abdomen in an animal presenting with acute abdominal pain. Abdominal pain may originate from many organ systems including the gastrointestinal tract, urinary system, peritoneal space, or parenchymal organs. Each of these may be evaluated for gross changes using abdominal radiographs, in order to formulate a list of differential diagnoses and plan for further diagnostic tests.

The systematic approach to an abdominal radiograph is to perform the evaluation of the extra-abdominal structures first, such as the soft tissues and musculoskeletal system, and the portion of the thorax included. Then proceed to evaluate the abdominal boundaries and body wall contour, peritoneal and retroperitoneal detail, liver, spleen, kidneys, and urinary bladder. Abnormalities should be described in terms of the radiographic findings of size, shape, opacity, location, contour, and number. Keep in mind any specific radiographic signs that may be present in diseases included in the initial list of differential diagnoses developed during the physical examination.

The next step is to make a prioritized list of differential diagnoses for your findings. If you have one main finding, list differentials that could be causes. For example, hepatomegaly could be caused by inflammatory, metabolic, or neoplastic disease. When you have more than one finding, such as an enlarged kidney and ureteral calculus, try to link the findings together, such as a ureteral obstruction with hydronephrosis. If a single disease process doesn’t fit for two radiographic diagnoses, you can list differentials for both findings. It’s also helpful to list the most significant findings first, and incidental findings last.

Your list of differential diagnoses may be different than the original set formulated prior to the radiographs. Some radiographs result in a clear diagnosis and plan, such as surgery in the case of a gastric dilation and volvulus. If there are several possible causes for the findings, suggest further imaging studies that could help to narrow the list. Ultrasound, cross-sectional imaging, and fine needle aspirates of lesions are all possible recommendations.