Pulmonary Patterns and How to Use them in Radiography
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Pulmonary patterns
Radiographic evaluation of lung pathology is challenging. Good quality radiographs are essential. Once high quality thoracic radiographs are made, one approach to interpreting lung disease is by determining which pulmonary pattern predominates. Once a predominant pulmonary pattern is established, differential diagnoses for these patterns can be looked up in a table. These differential diagnoses are ranked in order of likelihood based on signalment, history, clinical exam findings, laboratory data and other radiographic findings.

The pulmonary patterns are vascular, alveolar, bronchial and interstitial. Interstitial patterns are divided into structured (nodular) and unstructured patterns.

Vascular pattern
This is caused by a change in size of pulmonary blood vessels. Enlargement of pulmonary arteries, veins or both cause an overall increase in soft tissue opacity of the lungs (too white). Reduction in size of pulmonary blood vessels decreased the overall opacity of the lungs making them look hyperlucent (too black).

Alveolar pattern
This occurs when fluid displaces air from the alveolar spaces. The hallmark radiographic sign of an alveolar pattern is an air-bronchogram. An air-bronchogram occurs when fluid or cells silhouette with the pulmonary blood vessels leaving gas filled bronchi surrounded by soft tissue. Alveolar patterns may involve the parts of a lung lobe or the entire lung lobe. A variation of the alveolar pattern occurs when the bronchi are flooded with fluid and the entire lung lobe is of soft tissue opacity. Diagnose causes of an alveolar pattern using transtracheal wash, bronchoalveolar lavage or needle aspiration.

Unstructured interstitial pattern
Occurs when fluid (or less likely cells) is present in the interstitial space. The soft tissue opacity of the lung is increased. The lungs look hazy or like “a fog” invaded. The pulmonary blood vessels are harder to see than normal, but one can still make out the margins of the pulmonary blood vessels.

Structured (nodular) interstitial pattern
Occurs when cells invade the interstitial space. Radiographic signs are spherical soft tissue nodules or masses of various sizes. If the nodule or mass contains gas it is considered cavitated. Diagnose the cause of the structured interstitial pattern using fine needle aspirates (FNA).

Bronchial pattern
Occurs when fluid and/or cellular material invades bronchial wall, bronchial lumen, and/or peribronchial space. This commonly associated with chronic inflammation and hypersensitivity. The radiographic appearance is doughnuts (end-on bronchi) and tram-lines (bronchi running parallel to the film). Dilation of the bronchi, called bronchiectasis, is a variation of the bronchial pattern. Diagnose the cause of the bronchial pattern using a transtracheal wash.

Artifacts mimic pulmonary disease and should be ruled out first. Underexposure mimics an unstructured interstitial pattern and makes the lungs look too white. Making thoracic radiographs during expiration also mimics an unstructured interstitial pattern. Overexposure makes the lungs look too black and hides pulmonary pathology.

Structured (nodular) interstitial patterns
Non-cavitated, structured interstitial patterns
Pulmonary metastases are soft tissue nodules of various sizes and locations.
Fungal pneumonia is soft tissue nodules often of similar size. Thoracic lymphadenopathy may accompany the nodules
Primary lung tumors are usually solitary soft tissue masses. Bronchogenic carcinomas are more commonly found in the caudal lung lobes.

Cavitated, structured interstitial patterns
Pulmonary abscesses are not common in small animals. These masses usually have thick, irregular walls that can be seen because the masses contain gas. Using horizontal beam radiography, the gas in the masses rises to the top and a distinct fluid/gas interface is seen.
Pulmonary bulla may be congenital or result from trauma. Lung bulla are thin walled structures. If caused by trauma, they may contain blood and look similar to an abscess. If pulmonary bullae rupture, a pneumothorax ensues.

Unstructured interstitial / alveolar pattern
Diseases that cause unstructured interstitial patterns and diseases that cause alveolar patterns are very similar. The severity of the disease usually determines the predominant pulmonary pattern. And, these patterns are often seen simultaneously.
Pulmonary fibrosis results from scarring to the lungs either due to overt disease or continual exposure to inhaled pollutants. This is always an unstructured interstitial pattern that affects all lung lobes.
Pulmonary edema is divided into two categories. Cardiogenic pulmonary edema occurs secondary to left heart failure. In dogs, cardiogenic pulmonary edema is an unstructured interstitial or alveolar pattern that is most commonly found in the perihilar region of the lungs. In cats, cardiogenic pulmonary edema looks like anything. Left heart enlargement and dilation of the pulmonary veins accompany the cardiogenic pulmonary edema. Non-cardiogenic pulmonary edema results from many diseases. These diseases include the following: head trauma, seizures, electric shock, severe allergic reactions, advanced uremia, pancreatitis, inhaled irritants, and radiation damage. The distribution of the edema is usually more in the peripheral part of the lungs and the left heart and pulmonary veins is usually normal.

Atelectasis is decreased amount of air within the lung. Most cases are seen as unstructured interstitial patterns while severe cases are alveolar patterns. Compared to other lung diseases, lung lobe volume is decreased. Causes of atelectasis include the following: films made during expiration, prolonged recumbency, airway obstruction, pleural effusion, and pneumothorax.

Pulmonary hemorrhage/contusion result from blood in the lung. The unstructured interstitial or alveolar patterns have various distributions. If the pulmonary contusion is trauma induced, look for other signs of trauma. Coagulopathies result in pulmonary hemorrhage.

Pneumonia is a common cause of unstructured interstitial or alveolar patterns. The disease is most commonly distributed in the caudal ventral aspect of the thorax. In animals with vomiting or regurgitation, aspiration pneumonia is most common. Inhaled bacteria also lead to pneumonia. Hematogenous pneumonia is usually spread throughout the lungs and small nodules may accompany this type of pneumonia.

**Bronchial pattern**
Feline asthma is one of the most common bronchial patterns. The pattern is due to a peribronchial infiltrate of eosinophils and mononuclear cells. In severe cases of feline asthma, edema, seen as an unstructured interstitial pattern, may accompany the bronchial pattern. In chronic cases, pulmonary fibrosis may be present.

Bronchiectasis is dilation of the bronchi. This is usually secondary to chronic inflammation/infection. Pneumonia usually accompanies bronchiectasis because the mucociliary apparatus does not work and mucus and debris cannot be cleared from the distal airways.

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**Bacterial pneumonia**
Presents as an unstructured interstitial and/or alveolar pattern. More severe cases of pneumonia tend to be alveolar patterns; less severe are unstructured interstitial patterns. Often, bronchopneumonia is present in only one lung lobe and indistinct lobar sign is present between the diseased lung lobe and the adjacent normal lung lobe. In bronchopneumonia, the pathogens are usually spread through the airways and are most commonly found in the cranioventral aspect of the thorax. In hematogenous (septic) pneumonia, the pathogen is spread through the vascular system and has a patchy, multifocal distribution.

**Aspiration pneumonia**
Presents as an unstructured interstitial and/or alveolar pattern. More severe cases of pneumonia tend to be alveolar patterns; less severe are unstructured interstitial patterns. Aspiration pneumonia is caused by inhalation of particulate material (vomit, regurgitated material from the esophagus and less likely foreign bodies). The distribution of the lung disease depends on the position of the patient when the material is aspirated. Most commonly, the material is noted in the cranioventral aspect of the thorax, with the right middle lung lobe being most commonly affected. However, if the animal is in lateral or dorsal recumbency when the material was aspirated, these lung lobes may be more severely affected.

**Cardiogenic pulmonary edema**
As left heart function decreases, the pulmonary veins become congested and enlarged. When the hydrostatic pressure within the pulmonary veins is too high, fluid leaks out of the pulmonary veins and in to the pulmonary interstitium. As a result, cardiogenic pulmonary edema is seen as an unstructured interstitial pattern and/or an alveolar pattern. In dogs, the most common distribution of cardiogenic pulmonary edema is in the perihilar region. In cats, cardiogenic pulmonary edema can, and will, looked like any pulmonary pattern. A diagnosis of cardiogenic pulmonary edema is most commonly made based on the distribution of the lung disease and the presence of left heart enlargement and pulmonary venous enlargement. An echocardiogram is warranted to determine the cause of the heart disease and evaluate the severity of the cardiac dysfunction.

**Noncardiogenic pulmonary edema**
Presents as an unstructured interstitial and/or alveolar pattern. The causes of noncardiogenic pulmonary edema are multiple and include some of the following: Head trauma or seizures, electric shock, severe allergic disease, advanced uremia, pancreatitis, erect fitting inhalants, radiation damage and acute respiratory distress syndrome. For animals with seizures or electric shock, the lesions are more common in the dorsal and caudal portions of the caudal lung lobes. Other causes of noncardiogenic pulmonary edema are more diffusely distributed.
Pulmonary hemorrhage (contusions)

Presents as an unstructured interstitial and/or alveolar pattern. The distribution of the lung disease is varied. Animals with pulmonary hemorrhage may have ingested toxins (warfarin) or may be in DIC. Animals with pulmonary contusions commonly have other radiographic evidence (or clinical) of trauma. Hemorrhax (blood in the pleural space) often accompanies this pulmonary pathology.

Atelectasis

This occurs when the amount of air within the lung lobe is decreased without a corresponding increase in fluid. As a result, the volume of the lung lobe is decreased. Making thoracic radiographs at the end of expiration is effectively partial pulmonary atelectasis. Pleural diseases, such as pleural effusion and pneumothorax, commonly lead to atelectasis. Depending on how much air is removed from the lung, an unstructured interstitial or alveolar pattern may be present.

Pulmonary metastasis

Presents as a structured (nodular) interstitial pattern. The soft tissue nodules are of various sizes and have no set distribution pattern. When pulmonary metastases are small, they must be distinguished from end on pulmonary blood vessels and pulmonary osteomas. Pulmonary osteomas often have a mineral content, thus are more opaque. End on pulmonary blood vessels should be the same diameter as adjacent, "horizontally oriented" pulmonary blood vessels. If you are having trouble distinguishing between pulmonary metastasis and end on blood vessels, re-radiographing the animal in 3 to 4 weeks may help. If one needs to distinguish between pulmonary blood vessels and pulmonary metastases sooner than 3 to 4 weeks, pulmonary CT is warranted.

Fungal (mycotic) pneumonia

Presents as a structured (nodular) interstitial pattern. Compared to pulmonary metastases, the nodules associated with fungal pneumonia are often very small and uniform. Sometimes the tracheobronchial lymph nodes are enlarged; if the pulmonary diseases severe enough, it will mask the tracheobronchial lymphadenopathy. An underlying, unstructured interstitial pattern may accompany the miiliary nodules.

Primary lung tumors

Presents as a structured (nodular) interstitial pattern. Bronchogenic carcinomas are the most common type of primary lung tumor and usually arise in the periphery of the lung and are solitary. These masses, especially in cats, may contain gas and be considered a cavitated lung mass. Primary lung tumors do metastasize to the lungs, so multiple nodules/masses may be present. Differential diagnoses for a solitary lung mass include pulmonary abscesses and granulomas. If the pulmonary mass is adjacent to the thoracic body wall and it can be detected sonographically, fine needle aspirates and or biopsy of the mass is warranted.

Feline asthma

This is one of the most common bronchial patterns. The pattern is due to a peribronchial infiltrate of eosinophils and mononuclear cells. In severe cases of feline asthma, edema, seen as an unstructured interstitial pattern, may accompany the bronchial pattern. In chronic cases, pulmonary fibrosis may be present.

Bronchiectasis

Is dilation of the bronchi. This is usually secondary to chronic inflammation/infection. Pneumonia usually accompanies bronchiectasis because the mucociliary apparatus does not work and mucus and debris cannot be cleared from the distal airways.

References/suggested reading