The Thorax – The Ever Challenging Pulmonary Patterns

Lisa G. Britt, DVM, MS,
Diplomate American College of Veterinary Radiology,
Clinical Assistant Professor @ University of Missouri’s
College of Veterinary Medicine

The Normal Lung Field

I. Components of Lung Tissue
   A. Airways and alveoli – usually air opacity so we don’t see smaller components
      1. Mainstem bronchi have thick walls, therefore we see them
      2. See airways if the bronchial walls or lung tissue are diseased (Bronchial or alveolar pattern)
   B. Vessels
      1. Arteries are dorsal and lateral and veins are ventral and medial
      2. Normally see as they taper in size to the periphery of the field
   C. Interstitium - not normally seen
      1. Lymphatics
      2. Supporting framework for vascular and bronchial structures
      3. Interalveolar septa
      4. See if thickened, infiltrated, or fluid filled
   D. Bronchi
      1. Right bronchus – 4 divisions into lobes: right cranial, right middle, right caudal, accessory
      2. Left bronchus – 2 main divisions: left cranial and left caudal. Left cranial is further divided into cranial and caudal lobes…they share a common bronchus.

II. Vessels do have natural contrast and they can be seen on plain films because of their water opacity as long as the lung fields are normal.

   A. Vessels are seen best in the perihilar area.
   B. Lateral view - arteries follow the bronchial tree and are dorsal, veins are ventral
   C. Ventral dorsal view - arteries are lateral to bronchi, veins are medial
   D. In periphery, we cannot differentiate arteries from veins
   E. Any alteration in density of the lung tissues alters the appearance of the lung field, eg: Increased pulmonary opacity causes decreased contrast between air and fluid (vessels) and therefore decreased visibility of the vessels and heart.
F. Taking multiple views of the lungs:
   A. Improves diagnostic capability
   B. Allows better localization of parenchymal changes

**Radiographic Evaluation of the Lung Field**

I. Alteration in the opacity of the lung field - Depends on the ratio between air in the bronchi and alveoli versus the soft tissue opacity in the vessels and interstitium.

   A. Increased Opacity
      1. Solitary lesions
      2. Multiple focal lesions
      3. Disseminated pulmonary disease
      4. If generalized, be sure technique is good, otherwise you may have 'kVP pneumonia', ie. incorrect technique such as underexposure.

   B. Decreased opacity
      1. Circumscribed (bullae, pneumatoceles, cysts)
      2. Generalized

II. Changes in opacity are rarely pathognomonic because organs have limited number of ways to respond to disease and the same disease may appear differently at different time.

**Classification of Pulmonary Disease**

I. Grouped by morphological similarities which correspond to the involvement of a particular component of the lung.
   A. Alveolar - Fluid or cellular material occupies the alveolar lumina, or the alveoli have collapsed.
B. Interstitial - The amount of interstitial tissue has increased, or fluid or cellular material has accumulated in interstitial space.

C. Bronchial - The collagenous and cartilaginous tissue and associated mucous glands have proliferated and/or contain fluid or cellular infiltrates.

D. Vascular pattern - The amount of blood in the larger venous or arterial structures is increased or diminished.

E. Mixed patterns - Two or more patterns are present, which is often the case.

II. After recognizing a radiographic pattern, think of the differential diagnoses.

A. Alveolar
   1. Edema
   2. Pneumonia
   3. Hemorrhage
   4. Atelectasis
   5. Tumor

B. Interstitial
   1. Fibrosis
   2. Tumor
   3. Pneumonia
4. Edema
5. Allergy
6. Granuloma
7. Hemorrhage

C. Bronchial
1. Bronchitis
2. Bronchiectasis

D. Vascular
1. Hyperperfusion
2. Hypoperfusion
3. Passive congestion
4. Vascular dilatation
5. Vascular occlusion

E. Mixed
1. Small airway disease that can progress to eosinophilic pneumonia (P.I.E. = Pulmonary Infiltrates with Eosinophilia is the old term) in dogs.
2. Feline asthma

**Disseminated Pulmonary Diseases**

I. Alveolar Pattern - Primary condition in which pulmonary alveoli are filled with exudate or transudate or in which the alveoli are collapsed.

A. Radiographic signs
1. Increased opacity of lung parenchyma
2. Fluffy and coalescing opacities
3. Air bronchograms
4. Vascular structures can no longer be seen
5. Lobar margination – usually homogenous throughout a lobe
6. Lung silhouettes with heart and/or diaphragm

B. May overshadow another radiographic pattern that is present

C. Very labile - Can change in a matter of hours - acute diseases.

D. The location and distribution of the alveolar pattern as well as the changes in other organs can often help in differentiating the cause of the disease.

E. Common diseases that can cause alveolar patterns
1. Pulmonary edema due to left heart failure (cardiogenic)
   a. Bilateral, symmetrical, perihilar – often spares periphery
   b. Enlarged heart
2. Pulmonary edema (non-cardiogenic) - Bilateral, symmetrical
   a. Electric shock
b. Toxins that alter capillary permeability

c. Mechanical obstructions causing capillary overload, variations in oncotic pressure

3. Hemorrhage
   a. Patchy, asymmetrical, depends on severity
   b. Thoracic trauma - contusions
   c. DIC

4. Bronchopneumonia
   a. Asymmetrical, peripheral, patchy distribution (appears hilar if there is lymphadenopathy)
   b. Cranioventral
   c. Peribronchial/peribronchiolar infiltrates common

5. Atelectasis
   a. Volume of lung decreased as shown by a mediastinal/cardiac shift
   b. Middle lung lobes
   c. "Weeping willow" or drooping bronchi effect

6. Neoplasia
   a. Caudal lung lobes usually affected
   b. Not labile
   c. Pulmonary metastatic disease may be present

7. Aspiration Pneumonia
   a. Can happen following anesthesia
   b. Megaesophagus or vomiting dogs
   c. Laryngeal hemiplegia is predisposing factor
   d. Mixed pattern, generalized or restricted to dependent lobes

II. Interstitial Pattern - Due to disease located in interalveolar septa, peribronchial and perivascular tissue sheaths. Interstitial opacities reflect exudates, transudates, or cellular material within the connective tissue of the lung and the septa. Can have a lacy, reticular, or linear appearance. Can cause hazy appearance of the pulmonary parenchyma with or without smudging of vascular margins.

   A. Decreases the air content of lung tissue by reducing size of the alveoli by compressing the air spaces.

   B. Two different interstitial radiographic patterns

   1. Generalized - Increase in pulmonary background opacity - Lungs look hazy with less contrast
      a. Increased density in interstitium
      b. Pulmonary vessels still seen but less well defined
2. Nodular
   a. Solitary or multiple nodules
   b. Various sizes
C. Radiographic signs - Generalized interstitial pattern
   1. Enhanced opacity or haziness of lung field
   2. Reduced contrast
   3. Smudging of the outline of the pulmonary vasculature
   4. Peribronchial cuff formation
D. Diseases which cause generalized interstitial pattern
   1. Poor radiographic technique – underexposed or expiratory
   2. Interstitial pneumonia – early and healing in disease process, or viral pneumonia
   3. Interstitial edema – usually precedes alveolar edema
   4. Interstitial hemorrhage – contusions, DIC
   5. Pulmonary fibrosis – age change or healing
   6. Parasitic pneumonia – (can also be nodular) see pleural thickening and often prominent bronchial pattern, eg. Aleurostrongylus in the cat
E. Radiographic signs of nodular interstitial pattern
   1. Miliary nodules 2-5 mm - Poorly demarcated, evenly distributed, coalesce, DDX: fungal, metastases
   2. Nodules 3 mm and up - Well-defined and rounded, variable distribution DDX: metastases, early primary tumor, fungal granuloma, bullae, parasitic granuloma
F. Diseases responsible for the presence of miliary nodules are usually associated with massive hemic and/or lymphatic dissemination of pathogens or neoplastic cells.
   1. Fungal diseases - Often with hilar lymphadenopathy
      a. coccidioidomycoses and histoplasmosis: +/- bone lesions
      b. blastomycosis
   2. Metastatic disease
      a. Mammary adenocarcinoma, hemangiosarcoma, lymphosarcoma
G. Diseases responsible for well-defined nodules 3 mm and up
   1. Primary metastatic disease - Nodules of varying sizes (versus end-on vessel)
   2. Cysts - Rare - May be cavitated
   3. Abscesses - Rare - May be cavitated
4. Primary lung tumor – usually a solitary mass (with or without smaller metastases). Increased incidence in the right caudal lung lobe

III. Bronchial Pattern - Increase opacity in the walls of the bronchi due to calcification, edema, inflammation or hyperplasia of the mucous glands.

A. Normally can be visualized in hilar area
B. In the periphery appear as end on "donuts"
C. Radiographic signs
   1. Abnormally coarse branching pairs of parallel lines which may or may not be calcified.
   2. Increased number of donut-shaped structures
   3. Uneven and varying diameters of bronchial lumina - With loss of normal tapering
   4. Most bronchial changes are concurrent with interstitial or alveolar diseases
D. Diseases responsible for bronchial patterns
   1. Chronic bronchitis
   2. Bronchiectasis - permanent irreversible change in the size and shape of the bronchi. Usually need CT (previously bronchography) to confirm.
   3. Normal aging

IV. Vascular Pattern - Reserved for changes in the size of the pulmonary vessels

A. Lateral View
   1. Evaluate the pulmonary vessels to the cranial lung lobes
   2. Arteries are dorsal to the bronchi; veins are ventral to the bronchi
   3. Paired artery and vein should be the same size
   4. The width of the vessels in the fourth intercostal space should be no larger than the upper third of the third rib and no less than one-third the width of the third rib.
   5. Characteristics in which vessels "on end" can be differentiated from pulmonary nodules:
      a. Superimposed over larger vessel
      b. Vessel is increased in opacity
      c. Distinct borders

B. Ventral Dorsal View
   1. Evaluate the pulmonary vessels to the caudal lung lobes
2. Arteries are lateral to the bronchi; veins are medial to the bronchi
3. Paired artery and vein should be the same size
4. The width of the pulmonary vessels should be no larger than the width of the ninth rib as they cross the ninth rib

C. Hypervascular - Enlarged pulmonary arteries and/or veins
1. Left-to-right shunts - Enlarged pulmonary arteries and veins
2. Pneumonia
3. Passive congestion from L.H.F. - Veins usually larger than arteries
4. Enlarged arteries - Pulmonary hypertension
5. Enlarged arteries with an abnormal shape - Heartworms
5. Anemia

D. Hypovascular - Small pulmonary arteries and veins
1. Right-to-left shunt - Tetralogy of Fallot
2. Dehydration
3. Addison’s disease
4. Shock

V. Mixed Patterns - Combination of any or all of the above

A. Small airway disease - Bronchial and Interstitial Patterns *
1. Radiographic signs
   a. Peribronchial infiltrates - "Shaggy donuts"
   b. Nodules with radiolucent centers
2. Allergic lung disease
   a. Allergic bronchitis
   b. Feline asthma
   c. Heartworm disease

* Alveolar patterns can also be found if overlying infection or pulmonary congestion

B. Heartworm disease - Radiographic signs
1. Right-sided heart enlargement
2. Pulmonary artery bulge
3. Enlarged, tortuous pulmonary arteries
4. Generalized interstitial disease

C. Mitral insufficiency with left-sided heart failure
1. Common causes
a. Mitral valvular incompetence  
b. Cardiomyopathy  

2. Radiographic signs  
a. Pulmonary venous congestion  
b. Interstitial edema  
c. Pulmonary alveolar edema  

D. Bronchiectasis  
1. Chronic irreversible saccular or cylindrical dilatation and constriction of the pulmonary bronchi  
a. Dilation of the bronchial lumen  
b. Accumulation of secretion in the dilated lumen  
c. Infection of the secretions  
d. Severe bronchial wall abnormalities  
2. Radiographic signs  
a. Thickened bronchial walls  
b. Increased number of "donut-like" shadows  
c. Widened bronchial lumen ending in club-like radiolucent or consolidated areas  
d. Generalized interstitial pattern  
e. Alveolar pattern due to concurrent pneumonia or atelectasis  

C. Pulmonary edema  
1. In dogs pulmonary edema is most remarkable at the heart base and in the caudodorsal lung lobes, while in cats it appears more diffuse.  
2. Types of pulmonary edema:  
a. Cardiogenic with cardiomegaly  
   (1) Left heart failure: mitral insufficiency, cardiomyopathy, L>R shunt  
b. Cardiogenic without cardiomegaly  
   (1) Feline cardiomyopathy  
   (2) Myocardial depressants  
c. Non-cardiogenic  
   (1) Altered capillary permeability – toxins  
   (2) Increased capillary pressure – fluid overload  
   (3) Decreased osmotic pressure – nephrosis  
   (4) Neurogenic – head trauma, electrocution (caudodorsal lung fields)  
   (5) Miscellaneous – DIC
Decreased Density within the Lung Field

I. Generalized Decreased Density

A. Overinflation
   1. Air trapping due to expiratory airway obstruction
   2. Compensatory hyperinflation
B. Pulmonary emphysema
C. Hypoperfusion
   1. Right to left shunts
   2. Shock
   3. Addison’s disease
D. Radiographic signs
   1. Overinflation and pulmonary emphysema
      a. Increased radiolucency
      b. Diaphragm flattened on lateral radiograph
      c. Diaphragm domed on ventrodorsal radiograph
      d. Diaphragm displaced caudally
      e. Pulmonary vessels are prominent
   2. Hypoperfusion
      a. Tetralogy of Fallot
         (1) Enlarged heart
         (2) Small pulmonary vessels
      b. Shock
         (1) Small heart
         (2) Small pulmonary vessels
         (3) Small vena cava
      c. Addison’s disease
         (1) Small heart
         (2) Small pulmonary vessels
         (3) Small vena cava
         (1) Supportive lab data +/- abdominal radiographs

II. Localized Decreased Density

A. Cysts
   1. Bronchogenic cyst
      a. Congenital disease
      b. Greatly distended or dilated bronchus
2. Pulmonary cyst
   a. Lung abscess
   b. Can be fluid filled
   c. Fluid drains through bronchi and air enters and becomes radiolucent.
   d. Well-defined wall

B. Bullae
1. Destruction of the alveolar walls and septa leads to confluence of many air spaces
2. Wall around lesion is barely perceptible

C. Cavitary Pulmonary Lesions
1. Solid lesion which develops radiolucent center due to liquefying necrosis
2. Abscesses and infectious granulomas most common cause
3. Cavitation of primary lung tumor
4. Radiographic signs
   a. Thick irregular wall
   b. Air filled center
   c. Adjacent lung abnormal

References