Interpretation of radiographs can be challenging. Many factors are involved, but these steps all relate to one central idea … be systematic. It begins with production of good quality radiographs, moves to detection of radiographic abnormalities, coalesces into creation of differential diagnoses and a radiographic diagnosis and concludes with a plan for achieving a definitive diagnosis.

Making quality radiographs involves correct radiographic technique. Using a technique chart that is tailored to your x-ray machine and film/screen combination or digital detector best facilitates this task. Proper patient positioning is important for consistent projection of anatomy. Even slight obliquity of structures may create a very different appearance of normal anatomy.

A significant part of image interpretation is pattern recognition. To facilitate pattern recognition, images should be displayed in the same manner every time. A complete radiographic study has a minimum of 2 radiographic projections allowing for more precise localization of lesions. Making only one radiographic projection often leads to more questions than it answers. Viewing images in a dark room without extraneous light is ideal.

A systematic approach starts with pattern recognition from which a list of differential diagnoses is derived. Next the list of differential diagnoses is prioritized based on signalment, physical examination findings, clinical data and other radiographic signs. Sometimes, the diagnosis is evident after this step, but often a plan must be formulated to arrive at a more definitive diagnosis. This plan may involve more imaging (contrast medium procedures, ultrasound, CT, MRI), additional lab tests or tissue aspirates/cytology. Without prioritization of the differential list, the correct plan for definitive diagnosis cannot be formulated.

The ability to describe lesions will lead the interpreter to the correct conclusion. The best method for describing lesions is using Roentgen signs. The Roentgen signs are number, size, opacity, position/location, margin/contour, and shape. These signs should be described for all anatomy on the radiograph. Thankfully, most of the structures on a radiograph are normal and are usually not described. Next, each type of radiographic series is reviewed in a systematic manner to ensure that all structures are evaluated. Many methods for evaluating each study are available and should be tailored to the individual. A method for evaluating the thorax, abdomen and musculoskeletal system are provided below.

Ideally, radiographs are interpreted without knowledge of clinical history. This helps avoid bias when interpreting radiographs. However, this is impractical for most veterinarians. One must be cautious and not try to make radiographs fit other clinical signs or laboratory data.

Each set of radiographs record a disease process at one specific, short instant in time. Comparing the current radiographic study to any and all radiographic studies of the same patient helps establish trends. One can evaluate if a disease is improving, worsening or staying the same.

Thorax
A systematic approach for interpretation of thoracic abnormalities is as follows: extra-thoracic soft tissue structures, bones (spine, sternum, ribs, front legs), cranial abdomen, pleural space, mediastinum (trachea, esophagus, lymph nodes) cardiac silhouette, pulmonary blood vessels and lungs. Each region should be evaluated for changes in Roentgen signs. Once all the Roentgen signs are described, a prioritized differential list is created and then a radiographic diagnosis is formulated.

Pleural space
1. Normal Pleural Space
   a. Potential space between thoracic wall and lungs
   b. Not visible radiographically
      i. unless X-ray beam strikes the pleura tangentially
   c. Contains a very small amount of fluid for lubrication
   d. Chest wall conformation of chondrodystrophic dogs mimic pleural effusion
      i. Dachshunds and Bassett Hounds
      ii. inward curve of wall at costochondral junction
      iii. mistaken for pleural effusion

2. Pleural Effusion
   a. Presence of fluid within the pleural space
      i. exudate, transudate, modified transudate
      ii. need cytology for definitive diagnosis
   b. Radiographic Signs for Pleural Effusion
      i. Linear or triangular soft tissue opacity within interlobar fissures
         1. best visualized on DV/VD projections
ii. Blunted costophrenic angles

iii. Separation of lung margins from thoracic wall
   1. depends on volume of fluid and lung compliance

iv. Increased soft tissue opacity dorsal to sternum
   1. scalloped ventral lung margins

v. Increased unstructured interstitial pattern in lungs
   1. Atelectasis due to incomplete aeration
      a. masks underlying lung pathology

c. Causes: Idiopathic, Congestive heart failure, Pleuritis, Malignancy, Pneumonia, Trauma – blood, Coagulation defect, Hypoproteinemia, Mediastinitis, Chylothorax, Diaphragmatic hernia

d. DV vs. VD Projections
   i. DV projection
      1. fluid obscures heart

ii. VD projection
      1. lungs float on fluid and elevate heart

e. Unilateral Pleural Effusion - Trapped fluid, thickened mediastinum, Fibrinous fluid, Pleural mass
   i. Atypical Fluid Distribution - Lung lobes with different compliance, lung pathology, closed mediastinal fenestrations, viscous fluid

f. Remove fluid, re-radiograph

g. Positional radiography
   i. Reposition animal to move fluid away from area of interest
   ii. Horizontal beam radiography

3. Pneumothorax
   a. Gas in pleural space
      i. Traumatic
      ii. Spontaneous
         1. if no evidence of trauma is noted

b. Radiographic Signs for pneumothorax
   i. Separation of lung margins from thoracic wall
   ii. no lung markings in periphery of thorax
   iii. Separation of heart from sternum
   iv. Lung lobe collapse
      1. severe atelectasis
      2. collapse often uniform throughout all lobes

c. Causes – Trauma, lung rupture, chest wall rent, Iatrogenic, Extension of pneumomediastinum, Bulla rupture, Complication of pneumonia

4. Tension Pneumothorax
   a. Pleural pressure exceeds atmospheric pressure
   b. One-way valve allows gas into, but not out of, pleural space
   c. Mediastinal shift away from tension pneumothorax (see below)
   d. Caudal diaphragmatic displacement
   e. Requires immediate thoracocentesis

Mediastinum

1. Normal Anatomy
   a. Communications
      i. Cranial
         1. cervical fascia via thoracic inlet
      ii. Caudal
         1. retroperitoneal space via aortic hiatus
      iii. Side to side
         1. fenestrations
            a. dogs, not cats

b. Mediastinal Structures
   i. Not always visualized
      1. not large enough
      2. insufficient fat
      3. silhouette with other structures
   ii. Width
      1. usually less than 2X the width of thoracic vertebra
      2. fat accumulation mimics pathology
c. Thymus  
   i. Young animals  
   ii. Lives in cranioventral mediastinal reflection  
   iii. “Sail” sign on VD projection  
   iv. Silhouette with cranial cardiac silhouette on lateral projection
2. Pneumomediastinum  
   a. Free gas within the mediastinum  
   b. Enhances visualization of mediastinal organs  
   c. Can progress to pneumothorax  
   d. Pneumothorax does NOT lead to pneumomediastinum  
   e. Can progress to subcutaneous emphysema or pneumoretroperitoneum  
   f. Most often a self-limiting disease  
   g. Causes- extension from subcutaneous emphysema, hole on trachea, esophageal perforation, extension from retroperitoneal space, air escape from lung interstitium, gas producing organism
3. Mediastinal Shift  
   a. Movement of mediastinum away from mid-line on VD projection  
      i. Decreased lung volume  
      ii. Increased lung volume  
      iii. Increased unilateral pleural volume  
      iv. Intrathoracic mass  
      v. Rule out improper positioning
4. Mediastinal Masses  
   a. Can be confused with lung masses  
      i. Mediastinal: mid-line  
      ii. Lung: away from mid-line  
      iii. VD projection more useful than lateral projection  
   b. Can cause displacement and/or compression of trachea  
      i. Common Masses – Lymphosarcoma, Inflammation/Granuloma, Metastatic neoplasia, Abscesses, Thymoma, hematoma, heart base tumors  
      ii. Trapped Fluid  
      iii. Megaesophagus
5. Mediastinal Fluid  
   a. Increased soft tissue opacity  
   b. No tracheal deviation or compression  
   c. DDx – Blood, exudate, edema
6. Pleural Fluid vs. Mediastinal Masses  
   a. Both can cause tracheal elevation  
   b. Masses can cause tracheal compression, pleural fluid does not  
   c. Masses can deviate tracheal bifurcation caudally  
   d. Remove pleural fluid to help determine if a mediastinal mass is present  
   e. Positional radiography  
      i. Horizontal beam projection with the patient in lateral recumbency  
      f. Ultrasound before removing pleural fluid (as long as patient is stable)
7. Cranial Mediastinal Lymphadenopathy  
   a. Ventral to thoracic trachea  
   b. Increased soft tissue opacity  
   c. Possible dorsal displacement of trachea
8. Sternal Lymphadenopathy  
   a. Dorsal to sternebrae 1-4  
   b. Increased soft tissue opacity; ovoid  
   c. Sternal lymph nodes drain peritoneal cavity and diaphragm  
      i. Pancreatitis  
      ii. Carcinomatosis  
   d. Lymphosarcoma
9. Tracheobronchial Lymphadenopathy  
   a. Located at the tracheal bifurcation  
   b. Increased soft tissue opacity  
   c. Ventral deviation of main stem bronchi
Cardiovascular
Clock face analogy
Lateral Projection (head to left, spine at top)
12:00 - 2:00  Left atrium
2:00 - 5:30  Left ventricle
5:30 - 9:00  Right Ventricle
9:00 - 10:00  Pulmonary artery, Right auricle
10:00 - 11:00  Aortic arch
VD/DV Projection
11:00 - 1:00  Aortic arch
1:00 - 2:00  Main pulmonary artery
2:00 - 3:00  Left auricle
3:00 - 5:00  Left ventricle
5:00 - 9:00  Right ventricle
9:00 - 11:00  Right atrium

Vertebral Heart Scale -Normal dog – 9.7 ± 0.5; Normal cat – 7.5 ± 0.3

Vessel size
- Lateral Projection- diameter should not exceed the smallest diameter of the fourth rib
- DV Projection - diameter should not exceed the width of the ninth rib
- Pulmonary arteries should be the same size as their respective pulmonary veins

Cardiomegaly
- Cardiac silhouette exceeds expected normal size range
  - very subjective
  - easier to detect moderate to severe enlargement
  - must be enlarged on both views
  - use history, physical exam, ECG, etc., to determine if abnormality exists
- Causes
  - muscular hypertrophy
  - chamber dilation
  - mild pericardial effusion
- Echocardiography needed for specific diagnosis

Left atrial enlargement
- Lateral Projection
  - increased prominence in 1:00 – 2:00 region of cardiac silhouette
  - dorsal deviation of left main-stem bronchus
- DV Projection
  - divergence of main-stem bronchi
  - prominent left auricle
  - 2:00 - 3:00
- Due to chamber dilation

Left ventricular enlargement
- Lateral Projection
  - elongated cardiac silhouette
  - dorsal deviation distal trachea
- DV Projection
  - rounding of left side of cardiac silhouette
- Causes
  - muscular hypertrophy
  - chamber dilation
Right atrial enlargement

- Lateral Projection
  - difficult to assess
  - cranial vena cava, pulmonary artery, aortic arch and right auricle superimposed
- DV Projection
  - not visualized unless it becomes severely enlarged
- Due to chamber dilation

Right ventricular enlargement

- Lateral Projection
  - increased sternal contact
- DV Projection
  - increased convexity of right side of cardiac silhouette
- Causes
  - muscular hypertrophy
  - chamber dilation

Aortic arch enlargement

- Lateral Projection
  - prominence in cranial aspect of cardiac silhouette
  - silhouettes with cranial mediastinum
- DV Projection
  - prominence in cranial aspect of cardiac silhouette
  - silhouettes with cranial mediastinum
- Causes
  - aortic stenosis
  - patent ductus arteriosus

Main pulmonary artery enlargement

- Lateral Projection
  - silhouettes with cranial mediastinum
- DV Projection
  - prominence at 1:00 - 2:00
- Causes
  - pulmonic stenosis
  - patent ductus arteriosus
  - heartworm disease

Lungs – see Pulmonary patterns and how to use them in radiography in these Proceedings

References/suggested reading