Ultrasound physics

Frequency
- Standard machine has 2-15 MHz
  - 2 = great depth but poor resolution
  - 15 = great resolution but poor depth
- Probes can have multiple frequencies
  - Chose probes with around 5MHz for general practice
    - Eg use 3 for big dogs and 7 for small dogs

Probes
- Curvilinear
- Linear
- Phased array
  - Good for near field structures
  - Severely distorts structures in the near field
  - Small footprint can go between ribs

Gain
- Not the amount of sound that we admit but the amount that we collect – not how loud you are shouting but how loud you are listening
- Amplify sound returning to increase contrast of structures

Tissues
- Fluid = anechoic (no echos)
  - All sound waves go through fluid and none bounce back
  - Black on U/S
  - Acoustic enhancement - Tissues deep to fluid structures have increased echogenicity (more hyperechoic) because more sound waves reaching that tissue in comparison to a structure of similar depth where sound had to travel through soft tissue
- Air = hyperechoic
  - Acoustic shadowing - All sound reflected back to probe and none goes through to deeper tissues
  - Reverberation - If very superficial will see hyperechoic (white) lines below the gas structure due to sound waves returning to probe prematurely and bouncing back multiple times. ARTEFACT
  - White on U/S
- Bone = hyperechoic
  - Acoustic shadowing - All sound reflected back to probe and none goes through to deeper tissues
  - White on U/S
- Soft tissues
  - Part of sound travels through to deeper structures and part of the sound reflected back
  - Grey on U/S
  - Based on different tissue density and thickness the echogenicity changes between tissues. Can use to compare
    - Eg Liver hypoechoic compared to renal cortex
- Structures with rounded contours
  - Eg kidneys, bladder, gall bladder
  - Anechoic deeper structures as rounded structures change the direction of the sound waves as it bounces off the edges instead of back to the probe

Depth of structures
- Probes emit sound 1% of the time and listen for sound coming back 99% of the time
  - Short burst of ultrasound emitted and then time taken to reflect sound back measured to judge depth of each tissue structure
Radiology of the Thorax

Normal Anatomy

Atomic number
- Similar atomic number = littler contrast = unable to see on xray
  - Eg fluid and soft tissue
  - Cant see oesophagus in thorax unless pathology present
- Different atomic numbers = large contrast = visible on xray

When to take a radiograph based on respiration
- Peak inspiration maximises lung contrast
  - Lung field will look blacker
  - Structures in thorax easier to see
  - Lateral radiograph
    - Caudodorsal border of lungs at T12
    - Cranial margin of lungs at level of 1st rib
    - Cardiac silhouette separated from diaphragm
  - VD/DV radiograph
    - Caudolateral aspect of lung at T10
    - Diaphragmatic cupula at mid T8
- Expiration minimises contrast
  - Much harder to see structures
  - Heart and diaphragm touching

Ribs
- Always examine one by one – very easy to miss pathology
- Larger rib = closer to xray tube
- Smaller rib = dependant

Caudal vena cava
- Right side of the body
- Comes out of the right crus of the diaphragm

Diaphragm
- Features
  - Right crura
    - Blends with caudal vena cava
  - Left crura
  - Cupula
- Most dependant crus placed cranially

Oesophagus
- Location - dorsal to tracheal in cranial thorax
  - Dilation/distension will push trachea ventrally in lateral projection

Effect of positioning
- diaphragm
  - Left side down (left lateral view)
    - Caudal vena cava blends with more caudal crus (right crus)
    - Diaphragmatic crura may sometimes to cross over
      - Crura diverge from each other
      - Not always
    - Air within fundus visible caudal to the left crus
  - Right side down (right lateral view)
    - Diaphragmatic crura appear parallel
    - Right crura more cranial
- Air within fundus of stomach behind left crura

- Ventrodorsal view (Dog lying on its back)
  - Three separate domes structures = 2 crura + cupula
- Dorsoventral view (dog in sternal recumbency)
  - Single domed diaphragm

- Heart
  - Ventrodorsal view
    - Cardiac silhouette appears more elongated
  - Dorsoventral view
    - Cardiac silhouette appears more oval shaped and upright
  - Right lateral view
    - Cardiac silhouette oval/egg shaped
  - Left lateral view
    - Cardiac silhouette more circular

- Lungs
  - Dorsoventral view
    - Lungs in a more anatomical position
    - Better visualisation on caudal lobar pulmonary vessels and bronchi
      - Cranial vessels visualised with lateral view
    - Accessory lung long less aerated than in VD
    - Better visualisation of dorsal aspects of lung (not dependant in this view)
  - Ventrodorsal view
    - Accessory lung long area btw cardiac silhouette and diaphragm is elongated
    - Better visualisation of ventral aspects of lung (not dependant in this view)
    - Better visualisation of caudal thoracic masses as lung not superimposed over diaphragm
  - Lesion location
    - In lateral recumbency dependant lung lobe collapse due to
      - Heart compressing lung
      - Reduced movement of dependant thoracic cage
      - Cranial movement of the dependant part of the diaphragm
    - Lesions may only be visualised on xray when on the non-dependant side
      - Dependant lung lobes become compressed and increase in density
      - Increase in dependant lung lobe density can mask lesions as the tissue contrast is not great enough to form an image
  - Body condition
    - Obese animals
      - Thoracic structures harder to see due to shadowing from fat
    - Thin animals
      - Thoracic structures clearly visible

**Pathology**

**Thoracic wall**

Extra pleural sign
- Cause – thoracic wall mass invading thoracic cavity
- features
  - Mass has convex margin facing lung
  - Cranial and caudal margins taper along walls - broad based
- Differentiating pulmonary and pleural masses?
  - Pulmonary mass touching thoracic wall
- Angle less than 90 degrees
- Unable to see lung vessels (surrounded by soft tissue)
  - Thoracic wall mass extending into thoracic cavity
    - Angle greater than 90 degrees

Flail Chest
- Cause – multiple rib fractures eg trauma
  - dorsal and ventral aspects of at least 2 ribs
- gross – segment of thorax depresses on inspiration (as chest expands) and expands on expiration (as chest constrcts)

Rib infection - uncommon
- cause
  - penetrating wound
  - secondary to septicaemia
- can not differentiate rib osteomyelitis from neoplasia radiographically
- bone can be lytic and/or productive
- need biopsy

Rib neoplasia
- primary
  - osteosarcoma
  - chondrosarcoma
- secondary
  - urogenital carcinoma
  - mammary carcinoma
- features
  - often lytic
  - periosteal/cortical response
  - generally spread intrathoracically instead of peripherally
  - pleural effusion common

Determining healed fracture from neoplastic bone lesion
- healed fracture
  - history of trauma
  - overrides rib margins (callus)
  - multiple adjacent ribs involved?
**Diaphragm**

**Diaphragmatic Hernia**
- **Causes**
  - traumatic diaphragmatic hernia
    - radiographic signs
      - abdominal viscera within thorax
      - cranial displacement of abdominal structures
      - displacement of thoracic structures (heart, mediastinum, lungs)
        - usually cranially and laterally
      - partial/complete loss if thoracic diaphragmatic surface outline
        - cause
          - pleural fluid
          - silhouetting of consolidated lung/abdo structures
    - other radiographic diagnostics
      - oral barium sulphate to contrast stomach and intestines
      - multiple xray views
      - remove pleural fluid and repeat radiographs
      - positive contrast medium peritoneography
  - perioneopleural diaphragmatic hernia
    - peritoneum → pleural space
  - peritoneopericardial diaphragmatic hernia
    - peritoneum → pericardial space
    - cause
      - abdo viscera herniated through congenital defect
        btw tendinous part of diaphragm and pericardial sac
    - radiographic signs
      - abdo organs in pericardial sac
        - gas
        - ingested material
        - soft tissue opacity
      - large round cardiac silhouette
      - ventral diaphragm indistinguishable
        - heart morphs with diaphragm
      - dorsal peritoneopericardial remnant on lateral view in cats
    - significance
      - may be incidental finding
      - may be associated with clinical disease
  - hiatal diaphragmatic hernia
    - part of stomach herniates through oesophageal hiatus
    - two types
      - sliding hiatal diaphragmatic hernia
        - radiographs
          - soft tissue mass adjacent to left diaphragmatic crus
          - cranial displacement of the gastric cardia
          - dilated oesophagus
          - gastroesophageal sphincter within thorax
      - paraoesophageal hiatal diaphragmatic hernia
        - radiographs
          - gastroesophageal sphincter within abdomen
Pleural effusion – fluid
- radiography
  - interlobar fissures – opaque lines define lung lobes
    - cause – fluid seeping inbetween lung lobes
  - lung retracted from thoracic wall
  - space between lung and thoracic wall is soft tissue opacity
    - can remove some fluid and take another radiograph
  - costophrenic angle blunted
  - lateral view – increased opacity dorsal to sternum
    - opacity commonly has scalloped margins
  - DV – cardiac silhouette more difficult to see
  - VD – cardiac silhouette easier to see than DV
- Pleural fluid = ALWAYS significant
  - Occasionally primary dz eg pleural neoplasia
  - Usually sign of dz elsewhere
- Pleural + peritoneal effusion = likely neoplastic/CVS dz
- Causes (cant determine cause from radiographs)
  - Congestive heart failure
    - Dogs - only every rgyht sided of right AND left combined
    - Cats - can be right or left or right and left combined
  - Pyothorax
  - Severe pulmonary disease
    - Malignant pulmonary tumours → rupture
    - Ruptured abscess
  - Trauma (haemothorax)
  - Coagulopathy → haemorrhage
    - Uncommon cause
  - Hypoproteinemia
  - Chylothorax
    - Uncommon in dogs
    - Occurs in cats w/ heart dz
  - Diaphragmatic hernia
    - Obstruction of venous return by abdo viscera → pleural effusion
  - Lung lobe torsion
  - Pulmonary contusion
  - CNS trauma
    - Not well understood pathology but thought that catecholamine release may be a contributing factor
- Asymmetrical/unilateral pleural fluid distribution
  - Usually symmetrical as mediastinum is perforate
  - Causes
    - Difference in lung lobe compliance
      - One collapses more easily
      - Eg one has previous fibrosis and scarring
    - High viscosity fluid
      - Not easily distributed to the other side
• pneumomediastinum
  • technique – if pleural fluid obscuring mediastinum
    • aspirate fluid and repeat radiographs
    • direct x-ray beam horizontal
    • ultrasound/CT instead

• **Masses based on location**
  • craniodorsal mediastinal mass
    • causes
      • oesophageal dz
      • neural/neuroendocrine tumours
      • paravertebral tumours
    • radiography
      • ventral displacement of the trachea
      • silhouette sign of the aorta
        • can’t define aortic borders as adjacent mass removes air/soft tissue contrast
  • cranioventral mediastinal mass
    • causes
      • must rule out obesity!
      • Lymphoma
      • Thymic lesions
        • Thymoma, thymic lymphosarcoma, thymic brachial cysts
      • Cranial sterna lymph node enlargement
      • Mediastinal cysts
      • Ectopic thyroid/parathyroid tissue
    • Radiography
      • Elevation of trachea +/- compression of trachea (not always)
      • Increased opacity of cranioventral thorax
      • Widening of cranial mediastinum on DV/VD
      • Caudal displacement of heart
      • Caudal displacement on cranial lung lobes
  • Middle (Perihilar) mediastinal masses
    • Causes
      • Tracheobronchial lymphadenopathy eg Lymphosarcoma
        • Mass dorsocaudal to tracheal bifurcation on lateral view
      • Chemodectoma/Heart base mass
        • Inconspicuous (most of mass contained in cardiac silhouette)
          NB heart base mass = heart base tumour, enlarged pulmonary a or enlarged right atrium
    • Radiography
      • Increased perihilar opacity
      • bronchial obstruction
      • widened caudal mainstem bronchi
      • Tracheobronchial LN
        • Accentuated ventroflexion of the distal trachea
          • large dip down instead of the normal small one
        • impingement/cranioventral displacement of the carina and principle bronchi
      • heart base tumours
        • right displacement of the trachea (cranial to carina)
  • caudodorsal mediastinal mass
    • cause
      • Esophageal lesions
      • Neural tumors
      • Hiatal hernia
        • Stomach in mediastinum
• Diaphragmatic lesions (abscess, masses, hematoma)

  o Caudoventral mediastinal mass
    ▪ Cause
      • Hernias/Diaphragmatic rupture
      • Diaphragmatic lesions
    ▪ Radiography
      • Caudal vena cava displaced, impinged or silhouetted
      • Caudal border of heart and diaphragm silhouetted
        o Can not distinguish borders
        o Appear to be connected

• Mediastinal shift
  o Ipsilateral shift – same side as lesion
    ▪ Cause
      • Unilateral decrease in lung volume
  o Contralateral shift – opposite side as lung lesion
    ▪ Cause
      • Unilateral increase in lung volume
        o Eg unilateral tension pneumothorax
      • Presence of intrathoracic mass

• Mediastinal fluid
  o Causes
    ▪ Feline infectious peritonitis
    ▪ Trauma
    ▪ Coagulopathy
    ▪ Underlying mass
  o Radiography
    ▪ Mediastinal masses
    ▪ Widening of the mediastinum
    ▪ Enlarged cardiac silhouette
    ▪ Reversed fissures – going from mediastinum into lungs

• Pneumomediastinum
  o Causes, in decreasing order of likelihood:
    ▪ Air escaping into the lung interstitium from sites of alveolar rupture
      • Blunt thoracic trauma
      • Hyperinflation during anesthesia or resuscitation
    ▪ Puncture wound in the neck
    ▪ Tracheal rupture
      • Trauma
      • Erosion from neoplasia or inflammation.
      • Cats - overdistention of the ET tube cuff
    ▪ Esophageal perforation
      • Trauma
      • Neoplasia
      • Inflammation
    ▪ Extension of retroperitoneal gas into the mediastinum
    ▪ Presence of a gas-producing organism
      • Clostridium
  o Radiography