Abdominal Radiology Mini Series

Session 1: Getting the Best out of Your Abdominal Radiographs and Evaluating the Abdominal Space, Liver and Spleen

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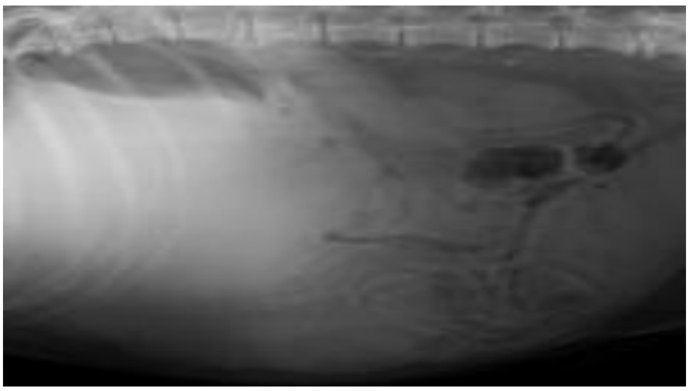


1. Getting the best out of your abdominal radiographs & evaluating the abdominal space, liver & spleen...

Abdominal radiography is indicated for a wide variety of conditions, including not only primary abdominal disease, but also many other conditions, which may involve, or extend to, the abdomen. Common indications include:

- Gastro-intestinal disease: vomiting, suspected foreign body, diarrhoea, tenesmus / dyschezia / haematochezia.
- Uro-genital disease: dysuria/haematuria, incontinence, anuria, vaginal discharge, pregnancy diagnosis & assessment, polyuria.
- Non-specific disease: abdominal pain, abdominal distension, abdominal masses or organomegaly, jaundice, pyrexia of unknown origin, anorexia, investigation of hernias and abdominal wall masses, screening for primary or secondary neoplasia.

Abdominal radiography or ultrasonography?

Radiography and ultrasonography are complementary imaging techniques, and if the equipment and funds are available, performing both will provide more information about the case. Abdominal radiography is best performed first, as this should provide a better overview of the abdominal contents, and may help to direct the ultrasound examination.

- Gas filled intestinal loops are easily appreciated on X-rays, but can hinder ultrasound evaluation. In a case with acute obstruction & multiple gas filled loops, X-ray examination may provide a rapid diagnosis without needing ultrasound.
- The information gained from an ultrasound examination is very operator dependent, & is influenced by the quality of the ultrasound equipment available.
- The general location of an abdominal mass is often easier to appreciate from X-rays, but determination of the organ of origin may require ultrasonography.
- Free abdominal fluid results in a marked loss of abdominal detail, limiting the information to be gained from radiographic examination. Conversely, free fluid allows excellent transmission of sound waves, facilitating ultrasound examination.
- Gastro-intestinal wall thickening and motility cannot be assessed on plain radiographs, but are readily evaluated with ultrasound.
- Don’t forget that any suspicion of neoplasia is an indication for thoracic radiography, looking for evidence of metastases.

Obtaining Diagnostic Abdominal Radiographs

Good radiographic technique is required to produce consistently diagnostic abdominal radiographs. In veterinary practice, challenges associated with abdominal radiography include:

- **Minimising scatter radiation**
- **Avoiding movement blur**
- **Adequate patient preparation**
- **Appropriate positioning**

Scatter Radiation is the result of scattered photons produced in the patient. These photons have no diagnostic pattern and tend to irradiate the whole area of the film, causing a marked reduction in film contrast. Scattered photons also increase the radiation dose to personnel and to parts of the patient outside the primary beam. This problem is more significant with abdominal radiography than with thoracic or distal limb radiography because of the potentially large depth of soft tissue structures involved. To minimise the effects of scatter radiation:

- Reduce the kV
    - The amount of scatter radiation increases dramatically above 70kV
    - A low kV technique also has the advantage of producing an image with higher contrast, allowing better differentiation between abdominal organs. This is especially useful in conventional film-screen radiography where the contrast cannot be manipulated.
    - However, reduction in kV will require an increase in mAs
        - Depending on the power of the X-ray generator, this may result in an unacceptably long exposure time (increased risk of movement blur), and so a compromise must be made.

- Collimate tightly to the area of interest
    - If less of the animal is exposed to the primary beam, there is less tissue to produce scatter radiation.

- Compression of the patient
    - Reduced patient volume produces less scatter
    - Technique rarely used

- Use a grid
    - Indicated for all animals with an abdominal depth >10-15cm
    - Uses thin lead strips to absorb scatter radiation
    - However, the use of a grid requires an increase in mAs
        - Compromise between increased exposure time and reduced scatter

Movement blur can occur due to gross patient movement, respiratory movement and the movement of the GI tract due to peristalsis.

- Appropriate sedation will avoid gross patient movement.

- Taking the exposure during the expiratory pause will minimise respiratory movement.

- If possible, increasing the mA will reduce the exposure time needed for an equivalent mAs.

- Not using a grid and increasing the kV will reduce the exposure factors and therefore reduce the exposure time needed, but will increase scatter.

Adequate patient preparation is important in order to get the most information from an abdominal radiographic examination.

- 12 hour fast before elective abdominal radiography to ensure that the stomach and small intestine are relatively empty.
- Allow the patient a chance to defaecate and urinate prior to radiography.

- If performing urinary tract studies, give a cleansing enema 2 hours before radiography to ensure the large intestine is empty.

Appropriate patient positioning is most easily achieved in a sedated or anaesthetised animal.

- Animals should only be restrained manually in very exceptional circumstances (Ionising Radiation Regulations 1999)
    - the use of positioning aids (sandbags, foam wedges, ties, troughs etc) and patience should enable adequate positioning in most cases.

- For a lateral view, draw the hindlimbs caudally and secure with ties
    - In some situations, eg evaluation of the perineum and canine male urethra, the hindlimbs may need to be drawn cranially.

- Use radiolucent foam wedges as needed to prevent rotation around the long axis

- For a VD view, a trough or sandbags should be used to support the patient in dorsal recumbency.

- A 'frog leg' position for the hindlimbs will help prevent the superimposition of skin folds.

- If possible, use a cassette large enough to include the entire abdomen
  - For larger animals, separate radiographs of the cranial and caudal abdomen may be required.

Other Factors to Consider

- Make and use an exposure chart (see earlier notes)

- Exposure factors may needed to be adjusted slightly for contrast studies
  - Increased exposure (approx 5kV) for positive contrast studies
  - Decreased exposure (approx -5kV) for negative contrast studies

- Ensure that the radiographs are adequately labelled (L/R, date and patient id).

- For conventional radiography, use standardised developing techniques (consistent darkroom procedures, regular replenishment of chemicals, regular servicing of automatic processors etc).

- Conventional radiographs should be read using a viewer (and bright light as necessary) in a darkened room.

- For digital radiographs, selection of the correct algorithm and use of a high resolution viewing screen are important.

Radiographic projections

Although it is becoming common practice to obtain only a single lateral view of the abdomen before proceeding to abdominal ultrasound, thorough radiographic investigation of the abdomen requires a minimum of two views, typically a lateral and ventro-dorsal projection. In some cases, such as the investigation of a suspected foreign body, adding the opposite lateral and a dorso-ventral projection is indicated in order to alter the distribution of intestinal gas and fluid, therefore providing more information about gastro-intestinal contents.

Lateral Views

- May be a right (RLR) or a left lateral (LLR) view.

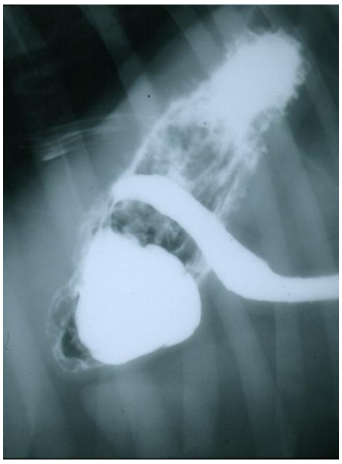
- Either may be used, but the appearance of the abdomen will differ slightly between views, so it is recommended that one recumbency is selected & used consistently.
- RLR is more commonly used in the UK

- Kidneys more ‘separated’ and easier to evaluate individually
- Gas in fundus of stomach, fluid in pylorus

- LLR
  - Gas in pylorus and proximal duodenum, fluid in fundus

- Centre the X-ray approximately 2cm caudal to the last rib, half way between the umbilicus and lumbar spine & collimate to include the diaphragm & greater trochanters of the femur for a single lateral abdominal view in cats & smaller dogs.

- For larger dogs, where the entire abdomen cannot be included on one cassette
  - Centre on the costal arch for the cranial abdomen
  - Centre midway between last rib & pelvic inlet for the caudal abdomen



LR: fluid in pylorus

LLR: fluid in fundus

VD views

- Preferable to DV as the abdominal contents tend to spread out, and the abdomen is shallower (less depth of soft tissue).

- Fluid in fundus, often gas in pylorus.

- Support the patient in dorsal recumbency using a radiolucent trough or foam wedges supported by sandbags. Allow the hindlimbs to fall into a frog legged position.

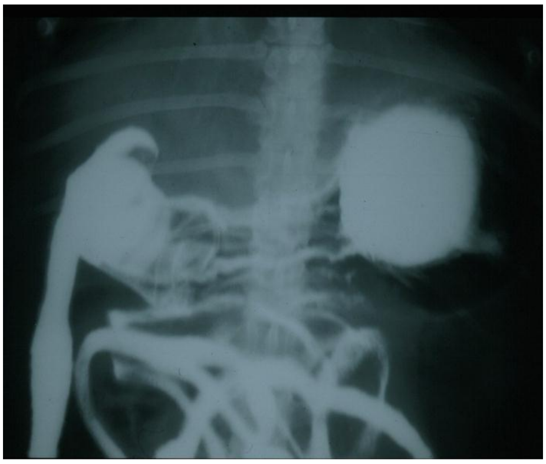
- Centre & collimate cranio-caudally as for the lateral views & collimate laterally to the skin margins.

DV views

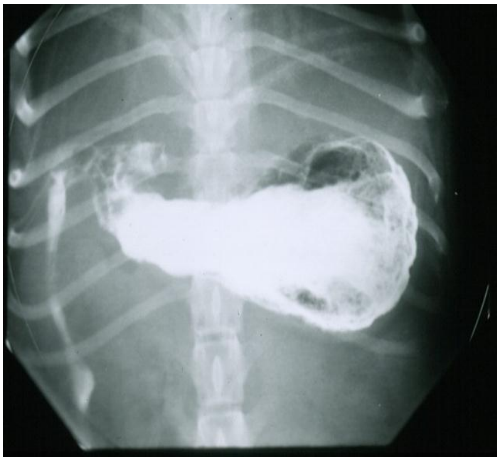
- Gas in fundus.

- Changing from VD to DV alters the distribution of gas and fluid within the GI tract & may allow identification of previously occult lesions.

- Centre and collimate as for VD views



VD: fluid in fundus



DV: gas in fundus

Horizontal Beam Decubitus View

- Indicated for detecting small quantities of free peritoneal gas which should collect at the highest point under the uppermost ribcage.

- Animal in left lateral recumbency.

- Horizontal beam
  - Check Local Rules to see if horizontal beam work allowed
  - Extra care with radiation safety

Abdominal Contrast Studies

- Contrast media are used to allow the visualisation and differentiation of body tissues which would otherwise be indistinguishable from each other.

- Especially useful in the abdomen, where there may be limited or no contrast between the soft tissue organs and where the fluid contents of hollow organs such as the gastro-intestinal tract and the urinary system cannot be distinguished from the soft tissue opacity of their walls.
- Positive contrast media is more radio-opaque than the surrounding structures, while negative contrast media is more radio-lucent than the surrounding structures.

- Commonly used abdominal contrast studies include:

    - Studies of the gastro-intestinal tract
        - Barium swallow (for oesophageal evaluation)
        - Gastrography (positive, negative or double contrast)
        - Barium follow-through (positive contrast)
        - Barium enema (positive, negative or double contrast)

    - Studies of the uro-genital tract
        - Intravenous urography (positive contrast)
        - Cystography (positive, negative or double contrast)
        - Urethrography (positive contrast)

    - Miscellaneous
        - Mesenteric porto-venography (positive contrast)

- Contrast agents
    - **Air** is freely available
        - Used in the stomach and bladder for negative contrast studies
    - **Barium** is available as a powder and as a suspension
        - Used for positive contrast gastro-intestinal studies
        - **Do not use if there is a suspicion of intestinal perforation**
    - **Iodine** is available as an injectable sterile liquid
        - Used for positive contrast studies of the uro-genital system
        - May be used for GI studies where intestinal perforation is suspected.

- The increased availability of endoscopy and ultrasound in general veterinary practice has, in many cases, reduced the use of radiographic contrast studies.

Interpretation of Abdominal Radiographs

Consistent interpretation of abdominal radiographs requires a logical approach and a good knowledge of normal radiographic anatomy and possible variations. Before attempting to interpret the image:

- Make sure you have adequate viewing facilities (quiet, dark room, viewing box or high resolution viewing monitor, bright light & magnifying glass for film radiographs etc)

- Decide if the quality of the radiographic study is sufficient to answer the clinical question. Consider…
    - Positioning of the animal

- Exposure and development of the films
    - Selection of correct algorithm and grey scale for digital images
- Presence of artefacts
- Adequate number of projections

General Principles

There are many different approaches to the radiological evaluation of abdominal radiographs. The order in which the different structures are evaluated is not important, but you should be consistent and logical in your approach

Areas and organ systems to consider

- Extra-abdominal structures
    - Thoraco-lumbar spine, pelvis and muscles
    - Abdominal muscles and subcutaneous tissues
    - Caudal thorax, ribs and sternum
    - Perineal area

- Diaphragm

- Liver and spleen
    - Gall bladder and individual lobes not normally seen

- Gastro-intestinal tract
    - Stomach, duodenum, small intestine, ascending, transverse and descending colon, caecum, rectum, anus
    - Pancreas not normally seen

- Uro-genital system
    - Kidneys, bladder, prostate,
    - Testicles, scrotum, os penis, prepuce, vagina, vulva, mammary glands are not always seen
    - Ureters, urethra, uterus, ovaries are not normally visible

- Other structures not usually seen
    - Adrenal glands, mesentery, lymph nodes, aorta, caudal vena cava

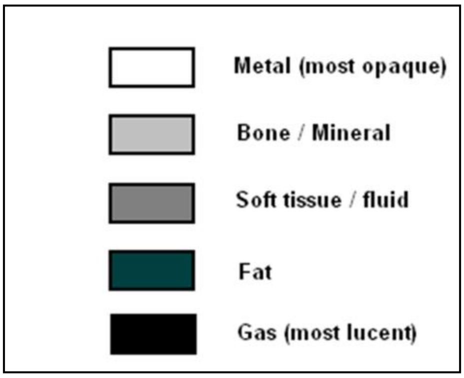
RÖntgen signs – just to remind you!!

- Size
  - Several organs can undergo considerable physiological distension: eg stomach, uterus, bladder.

- Shape
  - May be altered by physiological change (eg pregnant uterus), diffuse or focal pathology (eg diffuse hepatomegaly or a focal splenic mass), distortion by an adjacent organ (eg compression of the colon by an enlarged prostate), fibrosis & scarring in chronic disease (eg end-stage kidneys).

- Number

- Opacity
  - Radiographic opacity depends on tissue density, average atomic number and tissue thickness
  - 5 basic radiographic opacities are recognised…



- Margination
  - Abdominal organs can usually be recognised as separate from each other due to the presence of mesenteric fat, highlighting the serosal margins of the different organs (**serosal detail**)
  - Structures of the same opacity which are in contact with each other will appear to merge into one silhouette
    - Eg the loss of abdominal detail in the absence of abdominal fat or in the presence of abdominal fluid.

- Position
  - Changes are often due to changes in the size and shape of adjacent structures, the presence of an abnormal structure, or the absence of a normal structure, eg
    - Cranial displacement of abdominal contents due to a diaphragmatic rupture.

    - Caudal and dorsal displacement of SI loops due to a mid-ventral splenic mass.

- Function
  - Abdominal contrast studies allow some assessment to be made of function as well as anatomy of abdominal organs

Abdominal Masses

- A minimum of 2 orthogonal views is required for the evaluation of abdominal masses.

- The organ of origin may be easily identified & obviously abnormal or may be conspicuously absent.

- If the organ or origin is not easily identified, useful radiographic information includes:
  - The location of the mass
  - Its effect on the adjacent organs (displacement, compression etc)

- Remember that not every mass is neoplastic. However, should there be a suspicion of neoplasia, a minimum of right & left lateral inflated thoracic radiographs should be obtained to look for pulmonary metastases.

- If available, ultrasound is usually useful in providing further information about the internal structure of a mass, and in guiding samples.

The peritoneal cavity

Normal Anatomy

The peritoneal cavity is the space between and around the major organs and intestines, which is lined by peritoneum and limited cranially by the diaphragm, ventrally and laterally by the body walls, caudally by the pelvic inlet and dorsally by the membrane separating the peritoneal space from the retroperitoneum. Good radiographs of the normal peritoneal cavity should allow easy identification of the major organ systems, with the mesenteric fat outlining the serosal surface of the different structures.

Radiographic Abnormalities

- An increase in soft tissue opacity and loss of the normal serosal margins is seen in the presence of abdominal fluid
  - Transudate/modified transudate, haemorrhage, bile, urine, exudate (eg due septic peritonitis, FIP) etc
  - A lack of abdominal fat results in the same loss of detail, but typically with a very ‘tucked up’ ventral abdominal contour

- Blurring, but not complete loss, of serosal detail may be seen with small amounts of fluid
  - May be localised or generalized
  - Typically results in a patchy or mottled appearance
  - Differential diagnoses include:
    - Peritonitis, eg due to intestinal perforation, ex lap, pancreatitis
    - Diffuse neoplasia eg carcinomatosis
    - Steatitis (especially cats)
    - Mesenteric lymphadenopathy
      - Changes localised to mid abdomen where enlarged LNs can merge to create an ill defined area of soft tissue opacity
    - Some loss in detail may also be a ‘normal’ finding immediately post ex-lap
  - Loss of serosal detail may be mimicked by
    - Underexposure +/- underdevelopment
    - Excessive scatter radiation
    - An overlying wet or dirty hair coat

Mineralisation of the peritoneal cavity is uncommon and can be difficult to differentiate from mineralised material within the gastro-intestinal tract, or mineralisation of the abdominal organs.

- Possible causes include
  - Dystrophic or metastatic mineralisation of soft tissues

- Eg secondary to neoplasia, chronic inflammation, hypercalcaemia, foreign body reaction (eg retained swab)

- Leakage of positive contrast material from the GI tract

- **Free abdominal gas**

  - Gas lucency detected within the abdominal cavity but outside the GI tract

  - Most easily recognised in the cranio-dorsal abdomen, highlighting the caudal aspect of the diaphragm.

  - May be seen as small bubbles or pockets of gas outside the GI tract.

  - Horizontal beam L decubitus view sensitive for small amounts of free gas
    - Collects at the highest point usually just under right costal arch

  - Possible causes include
    - Following laparatomy, free gas may remain evident in the abdomen for 10-14 days
    - Rupture of a hollow abdominal organ (most commonly the stomach or intestines, occasionally bladder or uterus)
    - Penetrating injury to the abdominal wall

Free abdominal gas in a DSH

- Changes in the normal shape of the peritoneal cavity:
  - Distension ('pot belly') due to ascites, physiological or pathological organ enlargement, muscle weakness

  - Tucked up appearance due to emaciation, abdominal pain, displacement of viscera outside the abdominal cavity

- Changes in peritoneal boundaries:
  - Ruptures: ventral body wall, diaphragm, perineum
  - Hernias: umbilical, inguinal, hiatal, peritoneopericardial
  - Caudal displacement of diaphragm: thoracic pathology
  - Cranial displacement of diaphragm: abdominal distension

Radiographic Changes seen with Peritonitis

- Generalised or localised loss / blurring of serosal detail due to peritoneal fluid and inflammation.

- +/- free peritoneal gas if there has been gastro-intestinal perforation (or ex-lap).

- Corrugation of the intestine may be seen due to irritation of the serosal surface.

- Dilated loops of intestine may be seen due to ileus.

Corrugation of SI loops in a dog with peritonitis

The Liver

Normal Anatomy

- The liver should be seen as a homogenous soft tissue organ within the cranial abdomen.

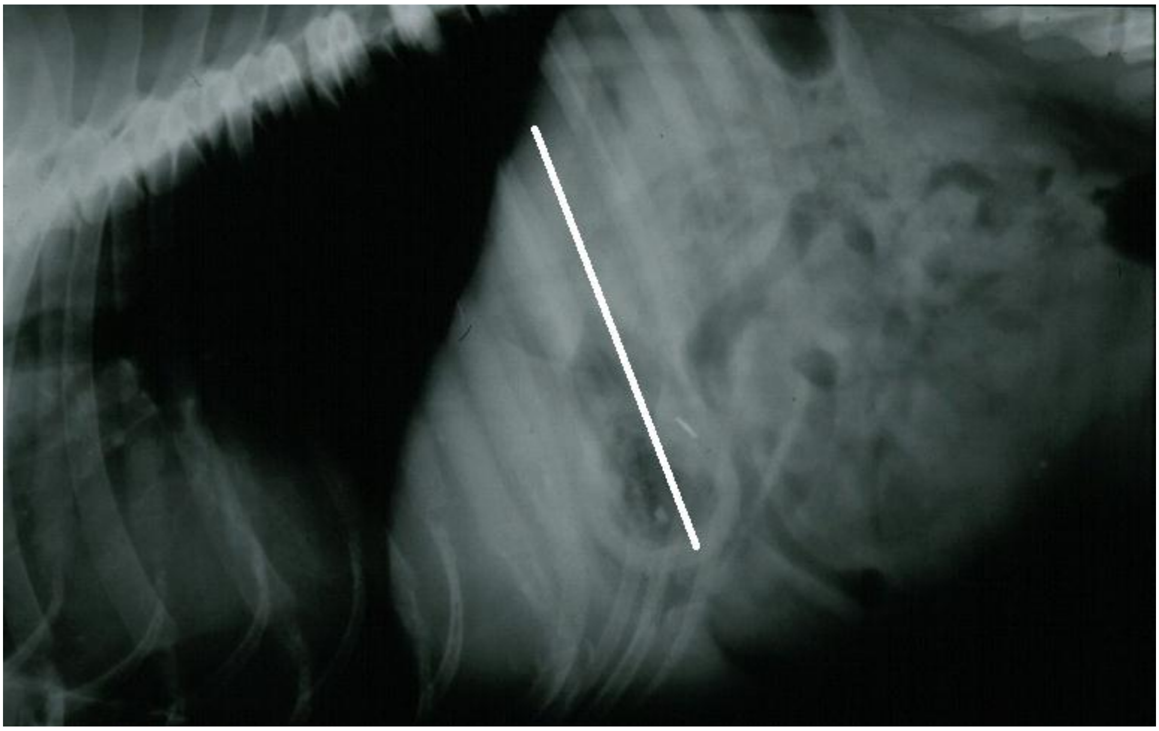
- Cranially the liver is demarcated by the line of the diaphragm.

- Caudally the liver is demarcated by the stomach
  - The axis of the stomach should lie approximately parallel to the ribs (lateral view) and perpendicular to the spine (VD view).

- On the lateral view, the caudoventral border should be well defined, with a sharp caudo-ventral angle. It is usually contained within the costal arch, but may extend slightly further caudally in barrel chested dogs and in young dogs.

- Consists of 6 lobes (left medial and lateral, right medial and lateral, quadrate and caudate lobes) and a gall bladder
  - Individual lobes are not usually individually identifiable from radiographs

  - In cats, the gall bladder is occasionally recognised as a rounded soft tissue structure extending ventrally from the liver margin into the falciform fat



A normal sized liver, with the stomach axis parallel to the ribs

Radiographic Abnormalities

- **Displacement** of the liver
  - **Cranially**
    - Diaphragmatic rupture, peritoneo-pericadial-diaphragmatic hernia
    - Reduced thoracic volume, eg full expiration
    - Increased abdominal volume, eg ascites, pregnancy, abdominal mass
  - **Caudally**
    - Increased thoracic volume, eg pleural effusion, large intrathoracic mass, hyperinflation of the lungs

- **Generalised hepatomegly**
  - Caudal displacement & anti-clockwise rotation of stomach axis.
  - Extension of the liver from beyond the costal arch, often with rounding of the caudoventral hepatic margin.
  - Hepatomegaly is a non-specific finding. Differential diagnoses include venous congestion, metabolic hepatopathy (eg secondary to hyperadrenocorticism, diabetes mellitus), diffuse primary or secondary neoplasia (eg lymphoma, mast cell tumour, malignant histiocystosis, haemangiosarcoma), acute hepatitis, nodular hyperplasia and also (in cats) lipidosis, lymphocytic cholangitis and FIP

- **Localised hepatomegaly**
  - Left sided hepatomegaly may cause caudal displacement of the stomach and spleen.
  - Marked right sided hepatomegaly may cause caudal displacement of the right kidney, pylorus and proximal duodenum (less easy to appreciate on the lateral view) with displacement of the stomach to the left on the VD view.
  - Differential diagnoses include focal neoplasia (hepatoma/ hepatocellular carcinoma, bile duct adenoma/carcinoma, haemangiosarcoma, malignant histiocytosis), cysts (including biliary cystadenoma in cats), localised nodular hyperplasia, abscesses, haematomata, granulomata and liver lobe torsion.

- **Microhepatica** is recognised by cranial displacement & clockwise rotation of the gastric axis, with a reduced amount of liver present between the stomach and diaphragm. Differential diagnoses include:
  - Normal variation (especially in deep-chested dogs)
  - Cranial displacement (eg due to a diaphragmatic defect)
  - Congenital porto-systemic shunting (typically young animals).
  - Hepatic cirrhosis.
  - Idiopathic hepatic fibrosis (especially young German Shepherd Dogs)
    - Hepatic cirrhosis and fibrosis are often accompanied by ascites

- **Hepatic mineralisation**
  - Cholelithiasis
    - Multiple mineralised opacities located in the gall bladder (right cranio-ventral liver)
    - Frequently incidental, may be seen with cholecystitis
  - Dystrophic gall bladder mineralisation
    - Eg due to chronic cholecystitis
  - Dystrophic mineralisation (often amorphous) of neoplasia, chronic abscess, granuloma or haematoma.
  - Branching mineralization is occasionally recognised as an incidental finding in older terrier type dogs

- **Hepatic gas opacity**
  - Rare!
  - Differential diagnoses for gas within the hepatic parenchyma include necrotising hepatitis, emphysematous cholecystitis & hepatic abscess.
  - Branching gas opacities may be due to:
    - Gas within the biliary tree eg secondary to duodenal reflux into the common bile duct, emphysematous cholecystitis
    - Gas within the portal system, eg due to necrotic enteritis, gastric volvulus, air embolism (eg following pneumocystogram)

Mesenteric Portovenography

- Used in the investigation of portosystemic shunts to identify the presence of an abnormal vessel between the hepatic portal and systemic venous systems.

The Spleen

Normal Anatomy

- The spleen should be seen as a homogenous soft tissue organ, relatively bigger in dogs than in cats.

- The head of the spleen is most reliably recognised on the VD view in both cats and dogs, as a triangular soft tissue opacity adjacent to the left body wall, caudal to the fundus and cranio-lateral to the left kidney
  - The head is anchored to the stomach by the gastrosplenic ligament, so its location should be fairly consistent

- In dogs the tail of the spleen is often seen on the lateral view as a triangular opacity along the ventral body wall caudal to the liver
  - Much more variable in position than the splenic head
  - Better seen on a RLR view
  - Often not seen in cats (unless enlarged)

Splenic size

- Wide range in normal splenic size in the dog
  - GSDs and Greyhounds have especially large spleens

- Diffuse splenic enlargement is therefore difficult to recognise

Radiographic Abnormalities

- **Diffuse splenic enlargement** may occur secondary to

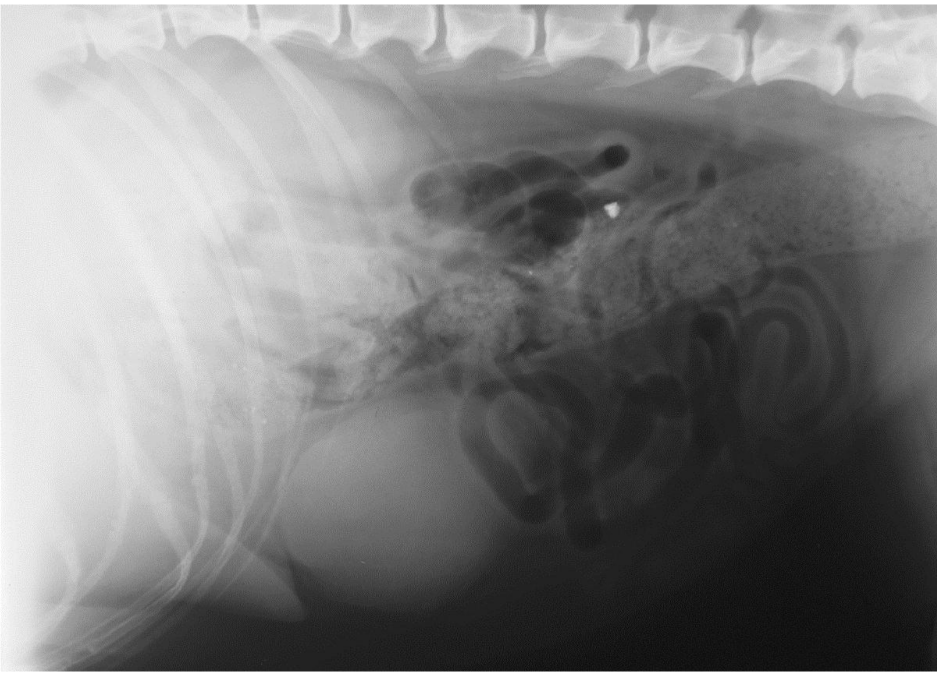
  - Normal breed variation (especially GSD & Greyhound)

  - Vascular congestion
    - Most commonly drug induced eg ACP, barbiturates
    - Severe enlargement & rounding seen due to congestion following splenic torsion.

  - Extramedullary haematopoiesis.

  - Splenic hyperplasia eg due to chronic anaemia, infection, nodular lymphoid hyperplasia
  - Neoplasia - eg lymphoma, mast cell infiltration, malignant histiocystosis

- **Localised splenic enlargement** also results in a change in the splenic shape
    - As the spleen is so mobile, splenic masses may be very variable in position
    - Splenic neoplasia arising from the splenic body or tail is the most common cause of a ventral mid abdominal mass in the dog.
    - A mass arising from the splenic head typically causes displacement of the descending colon & small intestine towards the midline, with caudal displacement of the left kidney.
    - Differential for a splenic mass include:
        - Neoplasia, eg haemangiosarcoma (+/- loss of serosal detail due to haemorrhage), malignant histiocytosis, mast cell tumours, lymphoma (diffuse or localized), haemangioma
        - Extramedullary haemoatopoiesis
        - Haematoma,
        - Abscess
        - Lymphoid hyperplasia



The typical mid-abdominal location of a splenic mass

- **Mineralisation** of the spleen may be seen due to dystrophic mineralisation of neoplasia, chronic abscesses or haematoma.

- **Gas opacity** within the spleen is occasionally recognised due to the proliferation of gas forming organisms following a splenic torsion or within a splenic abscess.