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Abdominal Radiology Mini Series

Session 2: Evaluating the Uro-genital Tract

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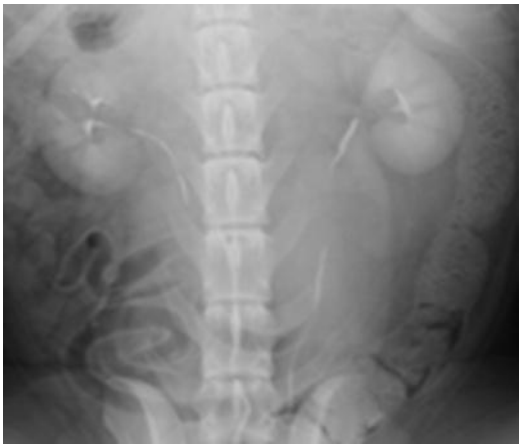


The Uro-Genital Tract (& some other small structures)

The Kidneys

Normal Anatomy

- Paired retroperitoneal organs
- Should be equal in size
- Soft tissue opacity
- In the dog
    - Typically bean shaped
    - Renal length should be 2.5-3.5 x the length of L2
    - Right kidney
        - Located approximately T12-L1
        - Cranially contacts the caudate lobe of the liver
    - Left kidney
        - Usually located slightly more caudally and ventrally
        - Separation of kidneys more obvious on a RLR view

- In the cat
    - Tend to be more oval in shape
    - Kidneys more frequently superimposed and more caudally positioned
    - Cranial right kidney is more often separated from the liver by fat and is therefore easier to see than in the dog
    - Normal renal length
        - 1.9 – 2.6 x L2 in neutered cats
        - 2.1 – 3.2 x L2 in entire cats

- Normal ureters will not be seen

Radiographic Abnormalities

Kidneys not seen

- Can be difficult to identify in deep chested dogs where they may be very cranially positioned, especially the right kidney.

- May be obscured by retroperitoneal effusion or lack of retroperitoneal fat

Altered renal size & shape

The normal canine kidneys are a smoothly marginated bean shape, with an indentation at the renal hilus. The normal feline kidneys are more ovoid in shape. In many conditions, enlarged kidneys retain their smooth outline and become increasingly rounded in shape. Right renal enlargement results in ventral deviation of the duodenum and displacement of the ascending colon towards the midline. Left renal enlargement results in displacement of the descending colon ventrally and towards the midline.

- Mild enlargement, normal shape
    - Acute nephritis, pyelonephritis (unilateral or bilateral)
    - Congenital porto-systemic shunt (dogs, bilateral))
    - Amyloidosis (usually bilateral)
    - Compensatory hypertrophy (other kidney small/absent)

- Moderate-marked enlargement, normal shape
    - Hydronephrosis (unilateral or bilateral)
    - Infiltrative neoplasia (eg lymphoma, may be unilateral or bilateral)
    - Feline infectious peritonitis (usually bilateral)
    - Perirenal pseudocysts (typically older male cats, may be unilateral or bilateral)

- Moderate-marked enlargement, irregular shape
    - Neoplasia
        - Primary, eg lymphoma, renal cell carcinoma, transitional cell carcinoma, cystadenocarcinoma (GSDs) (usually unilateral with possible metastasis to the contralateral kidney)
        - Metastatic, eg haemangiosarcoma, lymphoma (unilateral or bilateral)
    - Polycystic kidney disease (especially Persians, usually bilateral)
    - Renal haematoma / abscess / granuloma (usually unilateral)

- Small kidneys, often irregular
    - Renal hypoplasia / dysplasia (unilateral or bilateral)
    - End stage kidneys (unilateral or bilateral)

Renal mineralisation

- Calculi
    - Small, focal mineralised opacities located within the renal diverticula
    - ‘Staghorn’ mineralised opacity within the renal pelvis
        - Look for evidence of concurrent ureteral and bladder calculi & possible ureteral obstruction
        - Beware superimposed faecal material which may mimic calculi

- Nephrocalcinosis
    - Diffusely increased opacity of the renal parenchyma
    - Secondary to hypercalcaemia
        - Possible causes include chronic renal failure, hyperparathyroidism, hyperadrenocorticism, hypervitaminosis D, ethylene glycol poisoning.

- Dystrophic mineralisation of chronic lesions – eg neoplasia / haematoma / abscess / granuloma.

- Incidental mineralisation of the adrenals in cats may be mistaken for renal mineralisation

Renal gas opacity

- Rare. Beware the relative lucency of renal pelvic fat, especially in fat cats.

- Most commonly iatrogenic due to ureteral reflux of air following pneumocystogram.

- Pyelonephritis with gas-forming bacteria (theoretical)

Intravenous Urography (IVU)

Despite the increasing availability of ultrasound, this technique is still widely used to evaluate kidney and ureters. As well as highlighting the anatomy, an IVU also allows a semi-quantitative assessment to be made of renal function.

Indications

- Identification of kidneys and evaluation of renal size, shape and position.
- Investigation of urinary incontinence.
- Investigation of haematuria not arising from the lower urinary tract.
- Crude assessment of renal function.

Technique

- Preliminary patient assessment
    - Patients with severe azotaemia are likely to have marked renal compromise which will preclude adequate opacification of the kidneys
    - Hypertonic contrast media should not be given to dehydrated or hypotensive patients.

- 12 hour fast, cleansing enema 2 hours before the study
    - superimposed faecal material makes it difficult to assess the ureters accurately.

- General anaesthetic

- Survey lateral and VD radiographs centred on the kidneys to check patient preparation and exposure factors.

- Catheterise the bladder
    - Collect samples for microscopy, culture and sensitivity as needed
    - Drain the urine & replace with a moderate amount of air (approx 40ml in a dog)
        - Helps identify the termination of the ureters at the bladder neck.

- 600-800 mg I/kg (2ml/kg of 300-400mg I/ml contrast media) should be injected as quickly as possible via an intravenous catheter.

- Take an immediate VD radiograph centred over the kidneys (between umbilicus and xiphisternum).

- Repeat this VD radiograph at 5 minutes.

- Turn the animal into right lateral recumbency for a lateral radiograph centred at the same level at 10 minutes.

- Take another lateral radiograph at 15 minutes centred further caudally at the bladder neck.

- Proceed to a retrograde urethrogam (see later) if looking for ectopic ureters

Interpretation

- The immediate VD view, the **nephrogram**, should demonstrate uniform opacification of both kidneys, demonstrate their size, shape and position.

- At 5 minutes, contrast should be seen within the renal pelvises & ureters - the **pyelogram**
    - Limited information published about the quantitative measurements for IVUs in normal dogs
        - Pelvic width approx 2mm, pelvic recesses 1mm
        - Ureteral width approx 2.5mm
    - Interrupted filling in the ureters is a normal finding due to ureteric peristalsis
    - Both ureters should run caudally in the retroperitoneal space towards the urinary bladder.

- At 10 minutes, contrast is still present in the ureters and some should also be evident in the bladder.

- At 15 minutes, the more caudally centred radiograph should demonstrate contrast within the air filled bladder.

- Ideally the ureters should be seen hooking around to terminate at the bladder trigone
- Not always possible to identify
- An oblique VD radiograph may be useful in avoiding superimposition of the ureteric terminations on the lumbar spine

Radiographic Abnormalities

Abnormalities of the nephrogram

Poor or non-opacification of the kidneys

- Inadequate dose of contrast
- Renal aplasia
- Absence of functional tissue
- Polyuric renal failure (inadequate concentration of contrast)

Persistent or increasing renal opacification

- Contrast medium induced renal failure
- Hypotension

Filling defects within the nephrogram

- Well defined areas of non-opacification
  - Renal cysts
  - Abscesses
- Less well defined areas of non-opacification
  - Neoplasia
  - Renal infarcts (typically wedge shaped and peripheral)
  - FIP
- Marked rim of non-opacification
  - Subcapsular fluid, perirenal pseudocyst

Abnormalities of the pyelogram

Renal pelvic and ureteral dilation

- Hydronephrosis
  - Idiopathic
  - Secondary to ureteric obstruction
    - Calculus, adjacent neoplasia, inadvertent ligature
    - Dilation can be very marked

- Ectopic ureters
  - Dilation due to ascending infection

        - Usually not dramatic
    - May be possible to see abnormal termination, most frequently into the urethra
    - Retrograde studies and sometimes fluoroscopy often needed for confirmation

- Chronic pyelonephritis
    - Dilation usually not dramatic

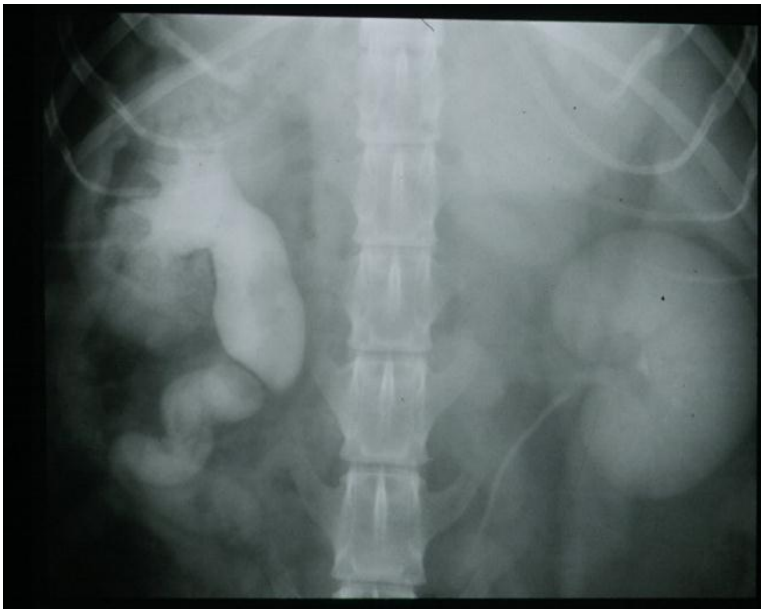
- Ureterocoele
    - Focal dilation of the terminal urethra

Filling defects in renal pelvis

- Blood clots
- Neoplasia
- Calculi (mineralised calculi should be recognised on plain films)

Ureteral rupture

- Likely to be an accumulation of urine within the retroperitoneum resulting in a local loss of detail
- Look for ureteral disruption and leakage of contrast



Marked dilation of the R renal pelvis and ureter highlighted by contrast. The L kidney and ureter appear unremarkable. This appearance is very suggestive of ureteric obstruction.

The Bladder

Normal Anatomy

- Seen as a homogenous soft tissue opacity within the caudo-ventral abdomen
- Usually lies in the midline on the VD view
- Only fixed point the is bladder neck, so easily displaced by changes in adjacent structures
- Typically an ovoid pear shape in the dog, has a longer bladder neck in the cat

Radiographic Abnormalities

Changes in bladder position

- Cranial displacement of the bladder may be seen due to:
    - Cranial migration of a very full bladder
    - Prostatic enlargement in male dogs
    - Obesity in cats

- Caudal displacement of the urinary bladder may be seen due to
    - An unusually short urethra (especially in female dogs)
    - Retroflexion of the bladder into a perineal hernia (male dogs, usually entire)

- Ventral displacement of the bladder
    - Within the abdomen
        - Sublumbar lymphadenopathy, constipation, uterine enlargement
    - Ventral to the body wall
        - Inguinal hernia, ventral body wall rupture

Changes in bladder size

- Wide physiological variation in size
- Distended bladder
    - Normal, but not recently urinated
    - Polyuria
    - Polydipsia and eventual bladder atony, eg in patients with hyper-adrenocorticism
    - Non-obstructive urinary retention
        - Neurological, psychogenic, painful
    - Obstructive urinary retention
        - Urethral calculi, prostatomegaly, urethral / bladder neck neoplasia, urethral stricture

- Small bladder
    - Recent urination
    - Anuria
    - Bladder or ureteral rupture (look for loss of abdominal +/- retroperitoneal detail due to leakage of urine)
    - Bilateral ectopic ureters and bladder hypoplasia
    - Non-distensible bladder, eg due to chronic cystitis, neoplasia

Changes in bladder shape

- Easily compressed or deformed by adjacent organs, especially if there is loss of tone in a chronically distended bladder
- Urachal diverticulae occasionally seen as a cranio-ventral outpouching
- Rupture (NB with a small rupture, the bladder may appear normal in shape)
- Extensive neoplasia

Changes in radiopacity

- Mineralised material
    - Small foci of mineralised opacity seen within the bladder lumen or along the course of the urethra are most likely to be consistent with calculi. The opacity of the calculi varies with their mineral content
        - Struvite, calcium oxalate, calcium phosphate and silicate calculi are usually radio-opaque
        - Cystine and urate calculi are usually radio-lucent and therefore cannot be seen on plain radiographs
    - Dystrophic mineralisation of the wall occasionally seen with chronic cystitis
    - Dystrophic mineralisation of bladder neoplasia may be seen, most commonly in the trigone area

- Gas opacities
    - Bubbles introduced during cystocentesis or catheterisation
    - Emphysematous cystitis
        - May see streaks of gas within the bladder wall +/- lumen
            - Uncommon, but most frequently seen in diabetic patients

Bladder Contrast Studies

Indications

- Identification of bladder location
- Investigation of possible bladder rupture
- Detection of radiolucent calculi
- Evaluation of mucosal surface

Pneumocystogram

- Cleansing enema 2 hours before study
- General anaesthesia (this study can be uncomfortable for the patient)
- Survey lateral and VD radiographs centred on the bladder
- Catheterise and empty the bladder
    - Collect samples for microscopy, culture and sensitivity as needed
- Inflate with air until moderately distended
    - Palpate the bladder during the introduction of air
    - Overinflation
        - reflux of air along ureters to the renal pelvis
        - risk of forcing air into vasculature causing air embolism
            - Positioning patient in LLR advised to reduce risk of fatal consequences of air embolism
- Take lateral and VD radiographs centred at bladder neck
    - May need to reduce kV

Positive Contrast Cystogram

- Very sensitive for detecting bladder rupture
- Initially as for pneumocystogram
- Following catheterisation and emptying, instill 50-300ml (depending on size) of 150mg I/ml into the bladder
    - Palpation is useful in judging the degree of bladder distension
- Take lateral and VD radiographs centred at bladder neck
    - May need to increase kV

Double Contrast Cystogram

- Provides best mucosal detail
- Following positive contrast study, remove as much contrast as possible and then carefully distend the bladder with air
- Take lateral and VD radiographs centred at the bladder neck

Interpretation

- Bladder wall thickness is best assessed on a pneumo- or double contrast cystogram
    - Normal wall thickness should be 1-2mm when the bladder is reasonably distended
- The bladder should be in a normal position and of a normal shape
- The mucosal surface is best assessed on the double contrast cystogram and should be smooth

Radiographic Abnormalities

Thickened bladder wall

- Bladder inadequately distended
- Chronic cystitis (especially cranio-ventrally)
- Muscular hypertrophy (secondary to chronic outflow obstruction)
- Intramural haemorrhage or oedema

Irregular mucosal surface

- Ulcerative or polyploid cystitis
- Neoplasia
    - Transitional cell carcinoma most common, typically at bladder neck

Changes to luminal shape

- Urachal diverticulum
    - Localised cranio-ventral outpouching of bladder lumen
    - +/- chronic cystitis
- Bladder rupture
    - Positive contrast study most sensitive
    - Look for leakage of contrast and loss of local abdominal detail

The Urethra

Normal Anatomy

- Not normally visible on survey radiographs
- In the dog:
    - The female urethra is typically fairly short and relatively wide, joining the vestibule just caudal to the vestibule-vaginal junction
    - The male urethra is much longer and is comprised of intrapelvic, perineal and penile sections
- In the cat,
    - The anatomy of the female feline urethra is similar to that of the bitch
    - The male cat has a perineal penis and a relatively narrow urethra

Radiographic Abnormalities

- Radio-opaque urethral calculi are seen on plain radiographs as mineralised opacities located along the course of the urethra
- Don't forget to critically assess the entire urethra, especially in male cats and dogs, for the possible presence of calculi
    - In the male dog, a lateral view centred on the caudal abdomen, with the hindlimbs secured cranially is useful for assessing the urethra without the superimposition of hindlimbs, and in particular of the fabellae which may mimic a calculus
- Urethral obstruction by a calculus will result in marked bladder distension

Retrograde Urethrogram

Ultrasonographic examination of the urethra is limited by the bony confines of the pelvis. Retrograde urethrography remains a widely used technique of evaluating the urethra and the vagina.

Indications

- Dysuria
- Evaluation of suspected pelvis / bladder neck masses
- Investigation of possible urethral rupture post trauma
- Following an IVU, to look for evidence of retrograde filling of ectopic ureters

Technique

- An enema should be performed 2 hours before the study
- Sedation / GA
- Survey lateral radiographs centred approximately at the bladder neck
    - In a male dog, pull the hindlegs cranially and collimate to include the penile, membranous and prostatic urethra
- Place a Foley catheter into the vagina / penile urethra & carefully inflate the cuff

- Position the animal and cassette ready for a lateral radiograph
    - For a male dog, pull the hindlimbs cranially out of the way of the urethra
- Prefill the catheter with contrast, so that you are not injecting a column of air
- For a cat / bitch, inject 1ml/kg 150mg I/ml contrast
- For a male dog, inject 10-30mls depending on patient size
- Take lateral +/- oblique VD views towards the end of the contrast injection
    - Oblique views avoid the problem of the urethra being superimposed on itself and on other midline structures
    - Ensure the person injecting is wearing lead protective clothing and well away from the primary beam

Interpretation

- The male urethra should be seen as a smoothly marginated tube evenly filled with contrast
    - The penile urethra is seen ventral to the os penis
    - Slight widening of the prostatic urethra is normal
    - Peristalsis or occasionally spasm may cause symmetrical narrowing

- In the bitch
    - The vestibule and vagina will usually fill first
        - Spindle shaped, ending cranially in a spoon shaped cervix
        - If the bitch is in season, the capacity of the vagina may increase, and contrast may pass through the cervix into the uterine horns
    - The urethra is much narrower and is seen ventral to the vagina, running to the bladder neck

Radiographic Abnormalities

Intraluminal filling defects

- gas bubbles, calculi, blood clots

Intramural filling defects

- neoplasia, inflammation, stricture

Extramural filling defects

- External mass lesions

Contrast extravasation

- Urethral rupture
- Urethral fistula
- Prostatic disease

Retrograde filling of ureter/s via urethra

- Ectopic ureter (often dilated)
- Ascending pyelonephritis

The Prostate

Normal Anatomy

- Located in the caudal retroperitoneum caudal to the bladder neck and ventral to the descending colon / rectum
- Seen in the entire dog as a homogenous soft tissue opacity occupying up to 70% of the pelvic inlet (NB the normal prostate is often larger in Scottie dogs)
- Smaller and often not seen in neutered males
- Not usually seen in the cat

Retrograde urethrography

- The contrast filled urethra provides a landmark to help identify the prostate
- Allows assessment of prostatic symmetry
  - Should be approximately symmetrical about the urethra
- Allows evaluation of the integrity of the prostatic urethra
  - Fine opacification of the prostatic ductules can be normal, but gross extravasation of contrast is not

Radiographic Abnormalities

- Prostatic disease is rare in the cat
- In the dog, changes may be seen in prostate size, shape and radiopacity

Benign prostatic hyperplasia

- Entire male dogs
- Smooth, symmetrical enlargement
- Cranial displacement of the bladder
- Dorsal displacement +/- compression of the descending colon and rectum

Prostatitis

- The prostate may be normal in size or may be mildly-moderately enlarged
- The prostate may be irregular in shape
- Ill-defined prostatic margins are sometimes apparent due to inflammation of the surrounding tissues
- Dystrophic mineralisation is occasionally seen in cases of severe, chronic prostatitis

Prostatic neoplasia

- Prostatic enlargement is variable and may be minimal
- The prostate is often irregular in outline and the prostatic margins may be ill-defined
- Dystrophic mineralisation of the tumour may be seen
- Concurrent radiographic changes suggestive of neoplasia include:
- Reactive new bone formation along the ventral aspect of the lumbo-sacral spine and pelvis
- Sublumbar lymphadenopathy
- Contrast studies are useful in assessing the integrity of the prostatic urethra

Paraprostatic cysts

- Large cysts appear as a homogenous soft tissue opacity and may mimic a '2nd bladder' shadow
- A peripheral rim of 'egg shell' mineralisation is sometimes seen

The Uterus & Ovaries

Normal Anatomy

The normal ovaries and uterus are not usually visible on plain radiographs of the non-gravid dog or cat. Although radiography may be used for the diagnosis and assessment of pregnancy, ultrasound evaluation can provide additional information about the viability of the foetuses and does not carry the risks to the pregnancy associated with ionising radiation. A plain abdominal radiograph can however be very useful in determining whether a palpable mass present when whelping / kittening has apparently finished represents a remaining foetus.

- The normal ovaries are located in the mid-dorsal abdomen just caudal to the ipsilateral kidneys.
- The uterus lies between the descending colon and the bladder, with the cervix usually located just cranial to the pelvic brim.
- The vagina extends caudally from the cervix, through the pelvic canal to join the vestibule, which opens to the outside at the vulva.
- Although not visible on plain radiography, the vestibule and vagina, and sometimes the uterus and uterine horns may be seen on a retrograde contrast study.

The normal pregnant uterus

In the bitch

- Radiographic evidence of uterine enlargement from 30 days
- Foetal mineralisation from 41 days

In the queen

- Radiographic evidence of uterine enlargement from 25-35 days
- Foetal mineralisation from 35 days

Radiographic Abnormalities

Ovarian enlargement

- Unlike the kidneys, the ovaries are intra-peritoneal structures and when enlarged, they usually migrate ventrally further into the abdomen.
- Causes of a ovarian enlargement include ovarian neoplasia, ovarian cysts and haematoma
- Ovarian enlargement may be seen on a lateral view as a mid-abdominal mass
- On a ventro-dorsal view, the mass is usually lateralised
    - A right ovarian mass may displace the ascending colon and small intestine axially or across to the left
    - A left ovarian mass may displace the descending colon and small intestine axially or across to the right

Uterine enlargement

- The normal uterus is indistinguishable from normal small intestine until it is at least 2-3 times the diameter of the small intestine.

- Generalised enlargement
    - Enlargement of the uterine body is seen as a tubular soft tissue opacity between the colon and bladder
    - Distension of the uterine horns is seen as a tortuous tubular soft tissue opacity superimposed on & often cranial to the bladder, displacing the small intestines cranially and medially
    - Causes include pyometra, mucometra, hydrometra, early pregnancy

- Segmented uterine enlargement is seen as multiple soft tissue masses along the length of the uterine horns
    - Most likely due to pregnancy
    - Differentials include loculated pyometra / mucometra / hydrometra

- Focal enlargement
    - Causes include uterine neoplasia, focal or stump pyometra, small litter
    - Focal enlargement of the uterine body will cause dorsal deviation +/- compression of the descending colon (and possibly rectum) and ventral displacement +/- dorsal indentation of the urinary bladder
    - Focal enlargement of one of the uterine horns will be seen as a non-specific mid-caudal abdominal mass, usually causing cranial and medial displacement of the small intestines

Radiographic abnormalities associated with pregnancy and parturition

- Foetal death
    - Loss of normal curvature of foetal spine
    - Malalignment of appendicular / axial skeleton +/- collapse of skull bones
    - Foetal disintegration and demineralisation
    - Mummification
        - Compacted, rolled up foetuses with overlap of bones
    - Foetal +/- uterine gas if infected

- Ectopic foetus
    - Foetus located outside tubular uterine shadow
    - Often tightly coiled
    - May be concurrent peritoneal effusion

- Dystocia
    - Foetal malpresentation
        - Foetus at pelvic inlet, but with head or limb back
    - Foetal oversize
    - Physical obstruction, eg maternal pelvic fracture

Other structures

The adrenals

- Located within the retroperitoneal space, cranio-medial to the ipsilateral kidney
- Not normally seen radiographically
- Adrenal neoplasia
    - Small adrenal masses will not be recognised, and even quite large adrenal masses can go undetected on radiography due to silhouetting of the adrenal lesion with adjacent soft tissue structures
    - The retroperitoneal location of the adrenals means that even when dramatically enlarged, they remain within the dorsal abdomen, causing caudal and/or lateral displacement of the adjacent kidney and ventral displacement of the peritoneal organs
    - May be seen as a soft tissue mass +/- wispy mineralisation
    - Differentials include adenoma / adenocarcinoma, phaeochromocytoma
- Adrenal mineralisation
    - Incidental finding in many cats

Hyperadrenocorticism

- Adrenal enlargement is rarely radiographically apparent
    - Adrenomegaly / adrenal masses may be recognised with ultrasound
- Concurrent radiographic abnormalities may include
    - Hepatomegaly
        - NB Cats do not show steroid hepatopathy, but may have hepatomegaly due to concurrent diabetes mellitus
    - ‘Pot bellied’ abdominal contour
    - Calcinosis cutis
    - Radio-opaque calcium phosphate or calcium oxalate bladder calculi

Lymph nodes

- **Sublumbar lymph nodes**
    - Located in the retroperitoneal space around the bifurcation of the aorta
    - Normal sublumbar lymph nodes and mild sublumbar lymphadenopathy will not be radiographically visible

- Moderate-severe sublumbar lymphadenopathy is identified on lateral radiographs as an area of soft tissue opacity ventral to L6-7 causing ventral displacement +/- compression of the descending colon & rectum
- Causes include lymphoma and metastatic neoplasia from the pelvis, perineum (especially anal gland adenocarcinoma) & possibly the hindlimbs

- **Mesenteric lymph Nodes**
  - Located within the abdominal mesentery
  - Normal and mildly enlarged mesenteric lymph nodes will not be seen
  - Moderate-marked lymphadenopathy may be recognized
    - Initially as increased opacity and loss of serosal detail within the mid-abdomen
    - With very marked enlargement, as an ill-defined mid-abdominal soft tissue mass causing peripheral displacement of the small intestines
  - Radiographically apparent mesenteric lymphadenopathy is most likely to be seen with multicentric neoplasia (eg lymphoma) or metastatic infiltration (eg from the intestines and/or pancreas)