UROLOGY LECTURE NOTES

Course Organiser

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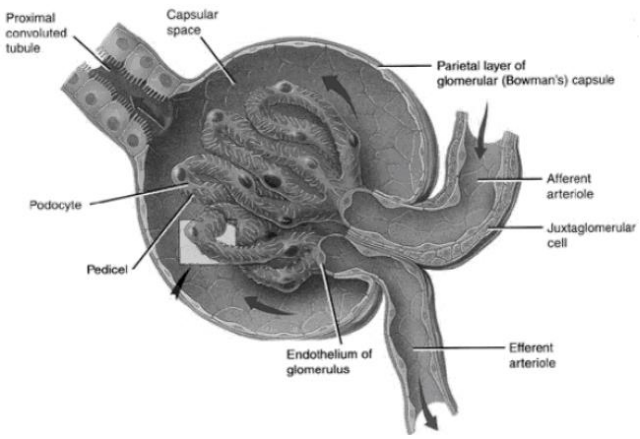

INTRODUCTION TO RENAL DISEASE

Renal function

Regulate water balance – conserve water
Excrete nitrogenous waste
Regulate electrolytes and acid base
Production of erythropoietin and activation of vitamin D

Definition of terms

Renal insufficiency

Refers to a loss of renal concentration ability
Occurs when the function of between 66 – 75% of nephrons is lost
SG < 1.030 (dogs) or 1.035 (cats)
Results in polyuria and consequent polydipsia

Renal failure

Refers to the clinical syndrome that occurs when the kidneys are no longer able to maintain regulatory, excretory and endocrine functions resulting in retention of nitrogenous waste products and derangements of fluid, electrolyte and acid-base balance
Occurs when the function of > 75% nephrons is lost
Accumulation of nitrogenous waste products
Azotaemia

Azotaemia

Elevated urea and creatinine
Prerenal azotaemia is a consequence of reduced renal perfusion
Post renal azotaemia results from interference with excretion of urine from the body
Primary renal azotaemia is caused by renal parenchymal disease
Combinations of prerenal with primary renal or post renal azotaemia are common

Uraemia

Refers to the clinical syndrome of severe renal failure associated with a critical loss of functional nephrons and includes the extrarenal manifestations of renal failure
- Vomiting
- Depression
- Anorexia
- GI ulceration
- Halitosis
- Renal secondary hyperparathyroidism
- Anaemia
- Uraemic seizures

Due to accumulated nitrogenous waste, acidosis etc

Renal disease

Refers to the presence of morphological or functional lesions in one or both kidneys regardless of extent

Clinical evaluation

History

Onset (acute or gradual)
Progression (improving, unchanged, worsening)
Previous trauma, illness or surgery
Response to previous therapy eg surgery, diet and drugs (antibiotics, corticosteroids, NSAID's)
Vaccination history
Animal's immediate environment (indoor, outdoor or both)

Exposure to other animals
Type of diet
Travel history
Use of a litter tray (number, location, litter substrate, cleaning schedule)
Urination (frequency, volume, abnormal urine)
Water intake
Exposure to nephrotoxins eg ethylene glycol, Easter lily (cats), aminoglycosides, non-steroidal anti-inflammatory drugs

Physical examination

Evaluate state of hydration for interpretation of laboratory results especially urine SG (loss of skin turgor, dry mucous membranes, sunken eyes)
Oral cavity examined for pallor of the mucous membranes, ulcers and tongue tip necrosis, which can occur in uraemia
Ascites or subcutaneous oedema may accompany the nephrotic syndrome
Kidneys (both palpable in most cats, left kidney in some dogs)
Urinary bladder (unless empty palpable in most dogs and cats) assess degree of distension, pain, wall thickness and intramural or intraluminal masses
Musculoskeletal evaluation: fibrous osteodystrophy may develop in young animals with renal failure, but is rare in older dogs and is characterised by enlargement and deformity of the maxilla and mandible (*rubber-jaw*)
Presence of retinal oedema, haemorrhage, detachment or vascular tortuosity is compatible with systemic hypertension and may result in impaired vision or blindness.

Laboratory evaluation of renal function

Glomerular function

Glomerular filtration rate (GFR) is directly related to functional renal mass. GFR is the gold standard for assessing renal function and detecting renal disease progression.
Unfortunately, GFR is not measured routinely. Instead surrogates for GFR such a urea and creatinine are measured. An ideal substance for the estimation of GFR should be produced at a constant rate in the body, have little binding to plasma proteins, be freely filtered and not undergo tubular reabsorption or secretion.

Blood urea. Renal excretion of urea occurs by glomerular filtration and blood urea is inversely proportional to GFR. However urea clearance is not a reliable indicator of GFR and, in the face of volume depletion, decreased urea clearance may occur without a decrease in GFR due to increased tubular reabsorption of urea.
Production and excretion of urea are not constant: increased by a high protein diet, gastrointestinal bleeding, increased catabolism (eg starvation, infection, fever), some drugs increase tissue catabolism (eg glucocorticoids, azathioprine) and decreased by a low protein diet, anabolic steroids, severe hepatic insufficiency or portosystemic shunting.

Serum creatinine. An individual patient's serum creatinine will increase over time with progression of renal disease and increasing creatinine concentrations should not be ignored even when the results are within the reference range. Young animals have lower serum creatinine concentrations, whereas males and well-muscled individuals have higher concentrations. Cachectic animals that have lost lean muscle mass often have lower serum creatinine concentrations than they would if their muscle mass were normal. Serum creatinine is not affected by diet. Creatinine is not metabolised and is excreted by the kidneys almost entirely by glomerular filtration. Serum creatinine varies inversely with GFR.

Blood urea and serum creatinine usually both increase with renal disease progression. Neither one is more sensitive than the other. A normal urea or creatinine concentration does not exclude the possibility of renal disease. A normal urea or creatinine concentration implies that at least 25% of renal mass is functional, but how much more is functional cannot be determined by these tests. In some situations, either the urea or creatinine concentration is increased, but not both, and it is not always possible to explain these discordant results. The table below shows some of the possible reasons

Disproportionate increase in urea	Disproportionate increase in creatinine
Severe dehydration and volume depletion	Liver disease
Gastrointestinal haemorrhage	Anorexia or low protein diet
Emaciated animal	Massive muscle injury (acute)
Young animal	Well-muscled individual

Cystatin C is a protease inhibitor that is freely filtered by the glomeruli. It does not undergo tubular secretion, and filtered cystatin C is almost completely reabsorbed by the proximal tubular cells. It is produced at a constant rate in all tissues and its excretion is not dependent on age, sex or diet. However, cystatin C can be affected by the presence of inflammation or neoplasia. Its potential as a useful marker of GFR has not yet been fulfilled.

Renal clearance. The renal clearance of a substance is that volume of plasma that would have to be filtered by the glomeruli each minute to account for the amount of that substance appearing in the urine each minute. The renal clearance of a substance (x) that is neither reabsorbed nor secreted by the tubules is equal to GFR. Thus GFR = U_xV / P_x. Endogenous creatinine clearance, exogenous creatinine clearance, inulin clearance and iohexol clearance have been used to estimate GFR. Normal GFR in the dog and cat ranges from 2-5 ml/min/kg.

Radioisotopes have been used to estimate GFR in dogs and cats using both plasma clearance and dynamic renal scintigraphic methods. Scintigraphy using ^{99m}Tc-DPTA has been used most frequently in dogs and cats and is the only method that allows individual assessment of the left and right kidneys.

Serum phosphate. Measurement of serum phosphate can provide information about renal function in addition to urea and creatinine. Increased phosphate concentration is not seen until >85% of nephrons are non-functional. Phosphate is filtered by the glomeruli and reabsorbed by the tubules. Tubular reabsorption is regulated by PTH and renal secondary hyperparathyroidism maintains serum phosphate concentration within the normal range by promoting excretion of phosphorus into the urine until renal disease is advanced. Serum phosphate that is disproportionately increased relative to serum creatinine may be observed in acute renal failure, but is mostly seen as a marker of chronic renal failure. Serum phosphate concentrations can be high in immature animals as a consequence of bone growth. Thyroxine increases proximal renal tubular reabsorption of phosphate and may contribute to hyperphosphataemia in cats with hyperthyroidism.

Urine protein. The presence of protein in the urine may indicate a disease process anywhere in the urinary tract, or may be a consequence of genital contamination. When the urinary sediment is inactive, the presence of protein in the urine is suggestive of renal disease. Dipstick screening measures mostly albumin and often produces positive results (trace to +) in highly concentrated urine. If persistent proteinuria is present in the absence of haematuria and pyuria, the severity of the proteinuria should be assessed by measuring a urine protein-to-creatinine ratio (U_{Pr}/U_{Cr}).

Microalbuminuria may be an early indicator of glomerular damage and loss of normal glomerular barrier function. Microalbuminuria is defined as an albumin concentration >0.01 g/l and <0.30g/l. Microalbuminuria presumably precedes the development of overt proteinuria and monitoring is warranted in at risk individuals (diabetes, hypertension).

SDMA (symmetric dimethylarginine). SDMA is a new renal biomarker that should be run alongside urea and creatinine. It is a methylated form of the amino acid arginine, which is released into the circulation during protein degradation. SDMA is almost exclusively eliminated by glomerular filtration. It increases earlier than creatinine in chronic kidney disease, when more than 40% of nephron function is lost and is not affected by extrarenal factors (eg lean muscle mass).

Tubular function

Normal urinary concentrating ability is dependent on the ability of the hypothalamic osmoreceptors to respond to changes in plasma osmolality, release of antidiuretic hormone

(ADH) from the neurohypophysis and response of the distal nephron to ADH. Additionally, medullary hypertonicity must be generated and maintained by the countercurrent multiplier and exchanger systems of the kidney and an adequate number of functional nephrons must be present to generate an appropriate response to ADH.

Urine specific gravity (USG) and urine osmolality (U_{osm}). Urine SG is defined as the weight of a solution compared with an equal volume of distilled water and is dependent on both the number and the molecular weight of the solute particles, whereas U_{osm} depends only on the number of osmotically active particles regardless of their size. There is normally a linear relationship between urine osmolality and urine specific gravity. If urine contains appreciable amounts of larger molecular weight solutes such as glucose, mannitol or radiographic contrast agents, these substances will have a proportionately greater effect on USG than on U_{osm}. Isothenuric urine refers to urine of the same total solute concentration as glomerular filtrate.

	Specific gravity	Osmolality
Isothenuric urine	1.008 – 1.012	300 mOsm/kg
Hypothenuric urine	1.001 – 1.007	<300 mOsm/kg
Hypersthenuric urine	>1.015	>300 mOsm/kg

Water deprivation test. Indicated in the evaluation of animals with polydipsia and polyuria of unknown cause. Animals require very requires careful monitoring during the test and the test should not be performed if renal function is compromised or if the patient is dehydrated or azotaemic. The test should stop if the animal loses more than 5% of body weight.
Technique -

1) Collect urine (and plasma if measuring osmolality)
2) Weigh patient
3) Withhold fluid and food
4) Collect urine and plasma after 6 to 8 hours and then at 2 hourly intervals
5) Stop test if patient demonstrates adequate concentrating ability or becomes dehydrated as evidenced by loss of 5 per cent or more of its body weight.

In diabetes insipidus, urine specific gravity < 1.010 after 12 hours. Seldom safe to continue beyond 12 hours.
If measuring osmolality take blood as well as urine. Urine osmolality will not exceed that of plasma, i.e. $U_{osm} < P_{osm}$
To minimise the effects of renal medullary washout, progressive water restriction for 3 days is recommended before carrying out a water deprivation test if psychogenic polydipsia is suspected.

Fractional excretion of electrolytes. The fractional excretion (clearance) of electrolytes is defined as the ratio of the clearance of the electrolyte in question to that of creatinine:

$FE_x = (U_xV/P_x) / (U_{Cr}V/P_{Cr}) \times 100 = (U_x P_{Cr}) / (U_{Cr} P_x) \times 100$

Normal values for fractional excretion of electrolytes		
	Dog	**Cat**
Sodium	<1%	<1%
Potassium	<20%	<24%
Chloride	<1%	<1.3%
Phosphorus	<39%	<73%

Diagnostic imaging of the kidneys

Radiographic anatomy of the kidneys

The kidneys are retroperitoneal and can be identified due to perirenal and retroperitoneal fat. The right kidney is cranial to the left.
In lateral recumbency, the lower kidney moves cranially, thus the kidneys are best separated in a RLR expiratory film. The upper kidney falls down exposing the hilar notch and becomes bean-shaped. The left kidney is more mobile than the right.

Dog:

2.5 - 3.5 x L2 in length.
Right kidney touches caudate lobe of the liver so cranial pole may be unclear T13 - L3.
Left kidney caudal and more ventral L2 - L5.

Cat:

2.4 - 3 x L2 in length.
More rounded and further caudally than in dog.
Right kidney L1 - L4
Left kidney L2 - L5

Normal size does not necessarily mean normal renal function.

The kidneys may be displaced by other enlarged organs e.g. adrenals, or may be ectopic (in the peritoneal cavity, pelvis or thorax).

Ultrasound is invaluable in assessing internal structure of the kidneys (see below).

Contrast techniques for kidney

1. Intravenous Urography

Positive contrast may be used to opacify the kidneys during its excretion (<1% is excreted by the liver and small intestines). It also provides a crude test of renal function.

Preparation for intravenous urography is very important:
starve for 24 hours ± mild cathartic
soapy water enema 2 to 3 hours prior to the examination
withhold water for 12 hours to improve kidney opacification, except in renal compromise

a) Bolus IVU (high concentration, low volume)

60-70% iodinated water soluble contrast media e.g. IOHEXOL 360, CONRAY 420. Dose 600-800 mg I/kg BW. Inject warmed medium rapidly into peripheral vein using a catheter (patient should be anaesthetised or heavily sedated as this induces nausea and vomiting).

If patient is lying in dorsal recumbency then the more useful VD view can be taken first to catch the angiogram and nephrogram phases.

Phases: **angiogram** - first few seconds
nephrogram - prolonged phase of opacification. May delineate cortex from medulla
pyelogram - 2 minutes onwards.
Compression may be used to increase pelvic opacification but will cause distension and distortion.

b) Infusion IVU (low concentration, high volume)

20-30% iodinated water soluble contrast media e.g. UROGRAFIN 150. Dose 1200mg I/kg BW. Infuse into peripheral vein via a catheter over 5-10 minutes. This technique is better for the ureters, but angiogram phase is not seen. Image intensification is valuable for seeing ectopic ureter endings.

2. Renal angiography

A more invasive technique, used particularly for failing kidneys where opacification would be poor. Patient is anaesthetised and the femoral artery catheterised. The tip of catheter is advanced up to renal arteries. 2-5ml of 60% iodinated water soluble contrast media injected as a bolus will demonstrate the renal vessels even if no excretion occurs. Rapid, serial films are useful.

Renal roentgen signs: number, size, shape, density.

Changes in renal size and shape

a) Large, smooth kidneys
compensatory hypertrophy e.g. single kidney or portosystemic shunt
acute hydronephrosis
acute glomerulonephritis / renal amyloidosis
single renal cyst, abscess or infiltrating neoplasia
cystic renal disease
(subcapsular urine or haemorrhage)

b) Large, irregular kidneys
focal: single tumour (primary or secondary)
abscess, cyst or haematoma
multifocal: polycystic, lymphoma or FIP

c) Normal size and shape
normal though renal function could be impaired
amyloidosis, glomerulonephritis, acute pyelonephritis

d) Normal size but irregular
focal: infarct
focal inflammation
abscess or cyst
multifocal: polycystic, chronic pyelonephritis

e) Small kidneys usually irregular in outline
end-stage (chronic glomerulonephritis, chronic interstitial nephritis, chronic pyelonephritis, chronic hydronephrosis, renal dysplasia, chronic amyloidosis)
infarct.

Changes in renal density
nephrocalcinosis (lymphosarcoma, hyperadrenocorticism, chronic renal failure, antifreeze toxicity, hyperparathyroidism)
neoplasia
calculi.

Ultrasonography of the kidneys

A 7.5 MHz transducer is best for dogs and cats, although adequate images can be obtained with a 5.0 MHz probe. The abdomen is prepared by clipping the hair and applying acoustic gel to the skin. The kidneys sometimes can be obscured by fat or bowel gas, if the ventral approach is used. The lateral approach is considered best using the lateral intercostal approach for the right kidney. The animal may be placed in lateral or dorsal recumbency.

Renal cortex is slightly hypoechoic when compared to the liver and clearly hypoechoic when compared to the spleen (left kidney to spleen and right kidney to liver - compare echogenicities on the same scan). Renal medulla is echolucent except for the arcuate arteries and major collecting ducts. Fat in the renal pelvis is sharply echogenic, causing shadowing of deeper structures. This may be confused with renal mineralisation or calculi, however, adjusting the incident angle of the transducer will cause the shadows to disappear if they are caused by fat.

Orientation of the long axis of the kidney to the transducer greatly affects the appearance of the kidney.

Assessment should include: echogenicity, size, number of kidneys, focal and diffuse parenchymal changes and abnormalities of the renal pelvis and collecting system.

Focal parenchymal changes. Distortion of the renal contour by an intrinsic mass is easily demonstrated with ultrasound. The sonographic appearance and internal characteristics of the mass do not usually permit a definitive diagnosis except in renal cysts and some cases of focal lymphosarcoma. Solid renal masses are commonly neoplastic and may appear hypoechoic, isoechoic or hyperechoic, however many renal masses have a complex sonographic appearance.

Diffuse parenchymal changes. Diffuse changes can be divided into those that cause increased cortical echogenicity with enhanced corticomedullary definition and those that result in decreased definition between the cortex and medulla. Increased cortical echogenicity can be found with glomerulonephritis, acute tubular necrosis, nephrocalcinosis and ethylene glycol toxicity which can result in extremely echogenic renal cortices. Reduced cortical echogenicity is seen with renal lymphoma. Increased overall renal echogenicity and reduced corticomedullary definition is seen with chronic inflammatory diseases and endstage kidneys.

A hyperechoic band at the corticomedullary junction in the dog is suggestive of hypercalcaemic nephropathy. This hyperechoic band may be normal in cats.

Intrarenal resistance to blood flow may be assessed and evaluated by the calculation of the resistive index. Values for the resistive index in normal, unsedated dogs are approximately 0.6.

Colour flow Doppler ultrasonography can be used to determine patency of renal arteries, evaluate focal areas of blood flow (eg infarcts) and evaluate areas of increased blood flow (eg some tumours).

Evaluation of diffuse renal disease generally requires biopsy. The caudal pole of the left kidney is site of choice.

Clinical syndromes

1. Acute renal failure
2. Glomerulonephropathy
3. Chronic renal failure

Other conditions affecting the kidney, which may occur in the absence of renal failure e.g.

Neoplasia - fairly rare. Usually renal adenocarcinomas in dogs, which present with haematuria. Lymphomas, which mostly affect cats, tend to produce signs of renal failure since they affect both kidneys.

Pyelonephritis - often asymptomatic until late stage. Always suspect in cases of recurrent urinary tract infection. Ultrasound can be helpful in the diagnosis.

Renal calculi - uncommon compared with cystic calculi

Hydronephrosis - may be acute or chronic associated with complete or partial obstruction. May also be associated with infection.

ACUTE RENAL FAILURE

Renal pathology

Glomerular filtration rate (GFR) is a function of the cardiovascular system. Renal blood flow accounts for about 20 per cent of cardiac output.

Factors contributing to decreased GFR and reduced tubular flow include:

i) **Decreased glomerular permeability** - swollen podocytes, alterations in the endothelial cell fenestrae and reduced surface area for filtration may account for reduced permeability.

ii) **Renal vasoconstriction** - afferent glomerular arteriolar constriction (and/or efferent arteriolar dilation) will result in reduced glomerular capillary hydrostatic pressure and reduced GFR. Afferent arteriolar constriction is often a physiological response to hypovolaemia and/or hypotension.

iii) **Tubular back leak** - occurs when filtrate leaks across damaged tubular epithelial cells into the interstitium. This can contribute to the oliguria and apparent decrease in GFR.

iv) **Tubular obstruction** - Tubular obstruction may be intraluminal or extraluminal. Intraluminal obstruction may occur due to swollen tubular epithelial cells, cellular debris or protein forming casts. Extraluminal obstruction may be due to compression from inflammation in the renal interstitial tissue. Tubular obstruction leads to increased intratubular pressure, which reduces GFR by opposing glomerular capillary hydrostatic pressure.

Renal failure results when the glomerular filtration rate has been reduced by >75% i.e. when the function of over $^{3}/_{4}$ of the nephrons has been lost. Unfortunately, routine measures of renal function are insensitive indicators of renal compromise until substantial damage has already occurred.

Types and Causes:

1. **Pre-renal failure**
   - severe dehydration, hypovolaemia, haemorrhage, shock

2. **Acute intrinsic renal failure**
   - i) Acute tubular necrosis
     - a) renal ischaemia resulting from pre-renal causes
     - b) nephrotoxins e.g. certain antibiotics, analgesics, cytotoxics, gaseous anaesthetics, paraquat, ethylene glycol, heavy metals, Easter Lily (cats), grape and raisin toxicity (dogs), hypercalcaemia
     - c) crush syndrome
     - d) intravascular haemolysis
   - ii) Acute interstitial nephritis - including leptospirosis
   - iii) Acute glomerulonephritis
     - a) immune complex
     - b) autoimmune
   - iv) Acute on compensated chronic renal disease

3. **Post-renal failure**
   - Obstruction: calculi, adhesions, tumour
   - Trauma: ruptured bladder / ureter / urethra

Clinical signs

Depression, anorexia, persistent vomiting, sometimes, diarrhoea which may be blood-stained

Dehydration associated with loss of skin turgor, dry injected mucous membranes, and thready pulse

Acidosis associated with fast, shallow breathing

Oral ulceration/halitosis

Rectal temperature variable sometimes subnormal

OLIGURIA or very occasionally anuria. If the animal survives, polyuria develops in the convalescent stage. Polyuric acute renal failure is seen with gentamicin toxicity and hypercalcaemia

Uraemic fits - usually terminal

Laboratory findings

The hallmark of acute renal failure is azotaemia in the presence of poorly concentrated urine
Blood urea and creatinine concentrations are elevated
Urine urea: blood urea ratio provides good prognostic guide
normal about 30
reversible > 12
irreversible < 8
Fractional excretion of sodium (FE_{Na}) > 1%

$$FE_{Na} = \frac{UNa}{PNa} \times \frac{PCr}{UCr} \times 100$$

Plasma potassium concentrations rise. Hyperkalaemia is a frequent cause of death
Urine specific gravity is usually high in pre-renal failure (> 1.030) and low in established renal failure (< 1.030)
Renal biopsy may give guide to prognosis

Diagnostic imaging

Ultrasound examination of the kidney may give some useful information particularly in ethylene glycol poisoning where there is increased cortical echogenicity and hypercalcaemic nephropathy where there is a hyperechoic line at the corticomedullary junction.

Treatment

Goals for management of acute intrinsic renal failure:

- Manage uraemic crisis – initial stabilization
- Attempt to convert oliguria to nonoliguria
- Prevent overhyrdration
- Optimise excretory renal function – minimise azotaemia
- Minimise additional renal damage
- Consider dialysis early rather than late
- Perform renal biopsy if clinical course is protracted or diagnosis is uncertain

1. Restore circulating blood volume and correct dehydration. Give fluids aggressively via a jugular catheter if hypovolaemic. Maintain fluid at 2 – 3 times maintenance (130-300 ml/kg/day). Check urine output.

2. When fluid balance has been restored. Enforce a diuresis while maintaining fluid balance:
i) Osmotic diuresis e.g. mannitol, glucose
Infuse 0.25-0.5 g/kg over 3-5 min using a 20% solution. If diuresis develops, use maintenance infusion of 10% mannitol or 5% glucose to keep urine output at 1-2 ml/kg/hr. If no response in 30 min, stop infusion.
ii) Potent diuretics e.g. frusemide 2-4 mg/kg intravenously, should respond within an hour. If no response, double or triple the dose
iii) Dopamine, a precursor of noradrenaline, can be used to increase renal blood flow and thus increase GFR. Dose 3-5 µg/kg/min by intravenous infusion. Constant rate infusion:

Total dose (mg) to be administered over 6 hr = BW (kg) x dose (µg/kg/min) x 0.36

3. Correct hyperkalaemia - calcium gluconate or chloride, sodium bicarbonate, insulin and hypertonic glucose infusion. ECG monitoring is useful.

4. Correct metabolic acidosis - sodium bicarbonate (1-5 mmol/kg) depending on the severity of the acidosis, or use the following formula:

Amount of HCO_3 required (mmol/l) = 0.3 x BW (kg) x base deficit (mmol/l)

If blood gas analysis is not available, estimate base deficit: mild azotaemia 5 mmol/l, moderate azotaemia 10 mmol/l and severe azotaemia 15 mmol/l

5. Specific therapy e.g. antidotes for nephrotoxins

6. Supportive therapy - general nursing, anti-emetics, antibiotic cover, water soluble vitamins

7. Consider peritoneal dialysis, if no response to fluid therapy and diuresis

Peritoneal dialysis can be used to treat acute renal failure, including poisoning by a dialyzable toxin (eg ethylene glycol, phenobarbitone or paraquat) urobadomen or chronic renal failure. A variety of catheters are available some specific eg peritoneal lavage catheters, but a fenestrated chest drain will suffice. Dialysate fluids are introduced and allowed to equilibrate with the uraemic toxins across the peritoneum, used as a dialysing membrane, and then the fluid is removed and discarded. The process is repeated or run continuously. The electrolyte concentrations in the fluid can be tailored to the patient's specific needs if necessary.

Haemodialysis is available but expensive about £8K for 48 hours

8. Monitor fluid balance, urea, creatinine, electrolytes, acid-base balance.

Prognosis

Guarded. Mortality 40-60% in humans with established acute renal failure even with access to haemodialysis. Prevention is best.

Oliguria or anuria that persists or develops during treatment is associated with a poor to grave prognosis.

The underlying cause of acute intrinsic renal failure affects the prognosis:

Ethylene glycol carries a grave prognosis without long-term dialysis

Leptospirosis carries a fair to good prognosis with appropriate antibiotic therapy and supportive care

Bacterial pyelonephritis carries a fair prognosis with appropriate long-term antibiotic therapy

Aminoglycoside nephrotoxicity generally carries a poor prognosis

NSAID-induced acute intrinsic renal failure carries a guarded to poor prognosis

Easter lily-induced acute intrinsic renal failure in cats carries a poor to grave prognosis

MECHANISMS OF RENAL INTOXICATION

Glomerular Dysfunction:

1. Decreased RBF due to rennin-angiotensin stimulated vasoconstriction (NSAID)
2. Blockage of tubular lumen: casts, increased pressure within lumen which decreases the net flux of filtration across the capillary bed (myoglobin, haemoglobin)

Tubular Dysfunction:

Direct cytotoxicity: damage to the tubular epithelial cell (amphoteracin B, aminoglycosides)

Diagnosis:

Laboratory tests:

Urea: direct indicator of renal tissue damage but only after 70% nephron loss
Creatinine: direct indicator of renal damage
Urine analysis: elevated sodium, glycosuria, proteinuria, urine casts, enzymuria
Clearance

Clinical presentation:

Acute renal failure
Chronic renal failure

SPECIFIC INTOXICATIONS

***Salicylates**:* Aspirin-acetylsalicylic acid, Pepto-Bismol- bismuth subsalicylate, oil of wintergreen-methylsalicylate

Species: Cats are more susceptible to toxicity due to lack of glucuronidation. Single doses of 80-120mg/kg produced toxicity in cats; Dogs given repeated doses of 100-300mg/kg/day developed gastric ulcers

Clinical signs: Respiratory stimulation, hyperventilation (this phase is often missed during accidental ingestions), vomiting (usually several hours after ingestion), anorexia, depression, lethargy, fever (may occur with high doses), hypo- or hyperglycaemia, gastric irritation or ulcers, dehydration, anuria, anaemia, Heinz bodies in cats, pulmonary oedema, convulsions

Toxin: Inhibits cyclooxygenase which decreases prostaglandin synthesis. This decreases clotting, reduces pain, and decreases protective lining of stomach. Stimulates the respiratory centre leading to hyperventilation and respiratory alkalosis, bicarbonate excretion. Causes metabolic acidosis- probably not from salicylates themselves, may be from build-up of lactic acid due to inhibition of normal glycolysis and loss of bicarbonate during respiratory alkalosis; decreased renal excretion of sulphate and phosphate. Salicylates are weak acids, protonated by acidic environment of stomach, which increases absorption by gastric mucosa; well absorbed overall. Salicylates are primarily excreted unchanged and as glycine and glucuronide conjugates. Extensively protein-bound. Pseudo zero order kinetics; half-life increases as dose increases

Diagnosis: History of exposure; blood or serum salicylate levels – unclear what levels cause toxicity in animals, but concentrations of 50 mg/dl and higher will probably cause toxicity. Acidosis, anion gap

Treatment: GI decontamination and activated charcoal for recent exposures and ingestions of enteric-coated products. Large ingestions may form insoluble concretions that result in slow absorption. Treat acidosis with IV infusion of bicarbonate in fluids. This will also promote ion-trapping in the urine which will promote excretion. Diuresis with furosemide in conjunction with fluids promotes excretion. Mannitol is not recommended for diuresis. IV glucose if hypoglycaemic. Transfusion may be required for animals with significant haemorrhage or severe anaemia. Monitor body temperature, treat problems with ice-baths or heating pads. Misoprostil can be used to help prevent ulcers; sucralfate can be used to treat existing ulcers.

Other NSAIDS (ibuprofen, ketoprofen, phenylbutazone, indomethacin)

Similar to aspirin but cause more renal problems (analgesic nephropathy). May cause acute onset of oliguria.

Treat with fluids and furosemide to maintain urine output.
Dopamine can be given to increase renal blood flow
Misoprostil is also recommended for animals with acute analgesic nephropathy

Mycotoxins:

***Ochratoxin* (*Aspergillus ochraceus*)**: associated with ingestion of corn usually.
Species: poultry, cattle, sheep, pigs
Clinical signs/diagnosis: hepatotoxicity primarily; renal effects include tubular necrosis characterised by polydipsia and polyuria, elevated BUN and creatinine
Treatment: symptomatic

***Alphatoxin* (*Aspergillus flavus*)** contaminated cereal grains
Clinical signs/diagnosis: hepatotoxicity primarily; renal effects include tubular necrosis characterised by polydipsia and polyuria, elevated BUN and creatinine
Treatment: symptomatic

Miscellaneous

***Ethylene glycol**:* in anti-freeze, which is sweet tasting. Minimal lethal dose in dogs 4.4 – 13.2 ml/kg. Minimal lethal dose in cats 1.5 ml/kg
Species: cats and dogs
Clinical signs: CNS signs: 1-2h: polyuria, polydipsia, depression, stupor ataxia; CVS signs: 12-24h: tachycardia or bradycardia, tachypnoea; Renal signs: 12-72h: oliguric renal failure, polyuria, crystalluria, dehydration, vomiting
Toxin: metabolized by liver to glycoaldehyde, glycolic acid, glyoxylic acid, oxalic acid. The acidic compounds give rise to acidosis and can inhibit the TCA cycle; oxalates precipitate out when bound to calcium.
Diagnosis: history, clinical signs, clinical pathology (metabolic acidosis, increased urea, crystalluria); chemical analysis of ethylene glycol (takes time); ultrasonography (increased echogenicity of the renal cortex)
Treatment: If seen ingesting ethylene glycol and has mild signs: perform GI decontamination with emetic, activated charcoal and cathartic (saline or sorbitol). If severe signs are seen: fluid therapy to correct dehydration, give ethanol or fomepizole (48-72h; NB fomepizole is not useful in cats) to prevent ethylene glycol metabolism, correct acidosis with sodium bicarbonate. Monitor urinary pH to maintain between 7-7.5.

Cholecalciferol rodenticides: Vitamin D3; usually sold as bait preparation with 0.075% cholecalciferol. Also found in Dovonex (calcipotriol) ointment used for psoriasis and used as food supplement in diary cattle. Can cause toxicity at doses greater than 0.5mg/kg
Species: Dogs, cats (more susceptible than dogs), pigs, horses
Clinical signs: Anorexia, lethargy, weakness, vomiting, diarrhoea, polydipsia, polyuria, seizures (rarely), vasoconstriction, hypertension, ECG changes due to hypercalcaemia
Diagnosis: Elevated serum calcium (>3.0 mmol/l). May also see elevated phosphorus, urea, and creatinine. Decreased urine specific gravity (1.002-1.006) with proteinuria and glycosuria. Lesions including calcification of gastric mucosa, myocardium, coronary arteries, terminal airways, pancreas, and bladder; degeneration of kidney and heart; enlarged, pale thyroid. Radio-opaque kidneys. Kidney calcium concentrations around 1000ppm (100ppm is normal). Differentiate from hypercalcaemia due to paraneoplastic syndrome, juvenile hypercalcaemia in young animals, and hyperparathyroidism.
Treatment: GI decontamination followed by activated charcoal for recent exposures (less than 3 hours). Administer IV normal saline and furosemide (avoid thiazide diuretics as they decrease Ca excretion). Low calcium diet, avoid sunlight. Cortisone decreases bone dissolution, decreases intestinal absorption of Ca, and promotes urinary calcium excretion. Salmon calcitonin or bisphosphonates such as pamidronate (Aredia) to decrease serum Ca. Continue treatment with diuretics and glucocorticoids until Ca stabilizes in the normal range; treatment may last 2 weeks.

GLOMERULONEPHROPATHY

Glomerulonephropathy disrupts the glomerular filtration mechanism so that large quantities of plasma proteins are filtered and lost in the urine (protein-losing nephropathy). If proteinuria is sufficiently large, the nephrotic syndrome may develop. This is characterised by 4 cardinal signs:

1. Severe proteinuria due to glomerular damage - mainly albumin
2. Hypoproteinaemia or more specifically hypoalbuminaemia
3. Oedema - usually subcutaneous and ascitic. Hydrothorax may occur but dyspnoea is rare
4. Hyperlipidaemia measured as hypercholesterolaemia

Severe and persistent glomerulonephropathy can lead to acute or chronic renal failure.

Causes

i) Glomerulonephritis - immune-mediated

ii) Renal amyloidosis in dogs - hopeless prognosis. Often develop pulmonary thromboembolism, which may be acutely fatal. Amyloidosis in cats usually affects the renal tubules.

Clinical signs

Mild glomerulonephropathy is not detectable on physical examination.

Oedema in otherwise healthy animal. Some weight loss, poor exercise tolerance.

Affected kidneys may be uniformly enlarged especially with amyloidosis.

Hypertension and hypercoagulability are common and may lead to sudden blindness (retinal detachment) or pulmonary thromboembolism (hyperpnoea, respiratory distress and sudden death).

If uraemic then signs as for acute or chronic renal failure.

Laboratory findings

The hallmark of glomerulonephropathy is proteinuria.

Proteinuria is usually marked > 2 g/l, but this must be interpreted in relation to the urine concentration.

Urine protein to urine creatinine ratio gives an accurate assessment, but only measure if there is no evidence of inflammation e.g. cystitis. Protein and creatinine concentrations must be converted to the same units. Convert [protein] in g/l to mg/dl by multiplying by 100, convert [creatinine] in mmol/l to mg/dl by dividing by 0.0884. Thus:

$$\frac{[\text{urine protein g/l}] \times 8.84}{[\text{urine creatinine mmol/l}]}$$

< 0.5	Normal
0.5 - 1.0	Questionable
1.0 - 5.0	Mild protein loss - suggests pre-renal disease
5.0 - 13.0	Mild to moderate protein loss - strong indicator of glomerular disease
>13.0	Severe protein loss - animals with amyloidosis tend to have the highest ratios

Urine casts may be present.

Loss of antithrombin III results in a hypercoagulable state. Thromboelastography (TEG) may be helpful

Urine culture, if warranted, eg if microscopic pyuria, haematuria, or bacteriuria, USG <1.025, azotaemia or suspected hyperdadrenocorticism, diabetes etc exists, with possible occult infection

Plasma protein concentrations may fall below 50 g/l (albumin <20 g/l)

Hypercholesterolaemia, hyperfibrinogenaemia

Transudates are clear with low protein content

Blood urea and creatinine are usually normal, but may become elevated if GFR falls

If living or travelled to an endemic area, rule out the common infectious diseases associated with glomerulonephritis: heartworm, Lyme disease (Borrelia burgdorferi), Anaplasma, Ehrlichiosis, Leptospirosis, Leishmaniasis, Babesiosis, Bartonellosis

May also test for immune-mediated disorders if multisystem involvement eg antinuclear antibody testing (ANA), Coombs' test or Rheumatoid factor.

Renal biopsy is required for diagnosis and prognosis, preferably performed early rather late (IRIS CKD Stage IV)

Treatment

a) Without azotaemia

i) Management of proteinuria – angiotensin-converting enzyme inhibitors (ACEis eg benazepril), angiotensin-receptor blockers (ARBs eg losartan) or aldosterone-receptor blocker eg spironolactone.

ii) Dietary management - moderate protein restriction, salt-restricted diet is required to reduce overall renal trafficking of protein. Diet has a large effect on the magnitude of proteinuria, but too severe restriction of protein intake can lead to loss of body weight and reduced plasma protein concentration.

High dose omega 3 polyunsaturated fatty acids (n3 PUFAs) have been shown to reduce proteinuria in humans with glomerular disease. Dogs consuming n3 PUFAs have lower mortality, increased renal function, reduced proteinuria, and lower cholesterol.

iii) Antithrombotic therapy – anticoagulants:

Aspirin: Low-dose aspirin in dogs 1-5 mg/kg daily, but in cats 10-20 mg/kg every 48hr

Clopidogrel: Dose in dogs 2-4 mg/kg sid and in cats 18.75 mg ($^1/_4$ tablet) per cat sid

iv) Antihypertensives - ACE inhibitors (benazepril) or the calcium channel blocker (amlodipine), but these may reduce renal blood flow. Benazepril may also be useful in reducing proteinuria.

v) Diuretics for management of the nephrotic syndrome - beware of over zealous use of a potent diuretic as hypovolaemia will adversely affect GFR and can precipitate renal failure. Only use where organ function is critically impaired (eg ascites or pleural effusion).

vi) Immunosuppressive drugs - prednisolone may help, but side effects such as increased azotaemia, increased proteinuria, and enhanced risk of thromboembolism may outweigh potential benefits. The benefits of mycophenolate, chlorambucil, ciclosporin azathioprine, and cyclophosphamide have not been documented.

Empirical immunosuppressive/anti-inflammatory therapy should be reserved for those with severe, persistent or progressive glomerular disease in which there is renal biopsy-supported evidence of an acute immune pathogenesis and no identified contraindication to immunosuppressive therapy.

Response to treatment is measured by changes in UPC. A complete response is defined as a reduction in the UPC to less than 0.5.

b) With azotaemia -. As above and for chronic renal failure, but poor prognosis.

CHRONIC RENAL FAILURE

Pale, shrunken, fibrotic "end-stage" kidneys

Causes

i) chronic interstitial nephritis (leptospirosis? CAV-1?)
ii) chronic generalised glomerulonephritis
iii) juvenile nephropathy (renal dysplasia, cortical hypoplasia) Young animals, breed specific e.g cocker spaniels, English bull terriers, English bull mastiff, Lhasa Apso, Shih Tzu, soft-coated wheaten terrier, samoyed, standard poodle, Norwegian elkhound
iv) chronic generalised pyelonephritis
v) chronic generalised renal amyloidosis
vi) renal neoplasia or cysts. Polycystic kidney disease.

Any severe damage to the kidneys tends to lead to a progressive reduction of functioning nephrons. There is loss of the ability to concentrate urine and finally retention of waste products such as urea and creatinine. This progression tends to follow stepwise decrements in renal function rather than a gradual linear progression.

The progressive deterioration in renal function can occur for two reasons:

i) there may be repeated insults that damage the remaining functioning nephrons.
ii) adaptive responses to the loss of functional renal tissue, once this reaches a certain point, may lead to further damage and a vicious cycle ensues. These maladaptive responses include:
    - Increased secretion of PTH
    - Glomerular capillary hypertension and hyperfiltration
    - Renal adaptation to metabolic acidosis

Clinical signs

a) Compensated case - able to cope with the reduced renal function
inability to concentrate urine —> polyuria and compensatory polydipsia.
blood urea and creatinine may be normal or elevated
clinical signs are variable, but include depression, weight loss, anorexia, intermittent vomiting, and halitosis in addition to PU/PD

b) Uncompensated case - uraemic crisis
blood urea and creatinine rise rapidly
depression, weight loss, anorexia, vomiting, halitosis
marked polydipsia, polyuria —> oliguria. **Acute on chronic** crisis
acidotic
oral ulceration - less common than in acute renal failure
secondary renal hyperparathyroidism is common, although "rubber jaw" is rare
systemic hypertension – systolic pressure persistently elevated above 175 mmHg, should be treated to avoid brain haemorrhage or retinal detachments
terminally muscle twitching, convulsions

Laboratory findings

Non-regenerative anaemia
Variable degree of dehydration
Raised blood urea (> 10 mmol /l) creatinine (> 200 µmol/l) and inorganic phosphate concentrations (>1.3 mmol/l)
Hypokalaemia especially common in cats with chronic renal failure, due to renal adaptation to metabolic acidosis
Increased amylase and lipase concentrations due to lack of renal excretion
Urine specific gravity 1.010-1.014 - identical to glomerular filtrate (isothenuric), i.e. inability to concentrate (or dilute) urine
Measure urine urea: blood urea ratio

Urinary protein levels usually low. A trace of protein is of no diagnostic value
Biopsy may confirm extent of disease process

IRIS Classification of Feline Chronic Renal Disease

Creatinine	Stage I Non-azotaemic CKD	Stage II Mild renal azotaemia	Stage III Moderate renal azotaemia	Stage IV Severe renal azotaemia
μmol/l	<140	140-250	251-440	>440
mg/dl	<1.6	1.6-2.8	2.9-5.0	>5.0
Prevalence	33.3 %	37.2%	15.4 %	14.1 %

IRIS Classification of Canine Chronic Renal Disease

Creatinine	Stage I Non-azotaemic CKD	Stage 2 Mild renal azotaemia	Stage 3 Moderate renal azotaemia	Stage 4 Severe renal azotaemia
μmol/l	<125	125 - 179	180 - 439	>440
mg/dl	<1.4	1.4 - 2.0	2.1 - 5.0	>5.0
Prevalence	?	?	?	?

Diagnostic imaging

Radiographically, normal dog kidneys are 2.5 - 3.5 x length L2
Normal cat kidneys are 2.4 - 3.0 x length of L2.
In CRF, kidney shadows are small, irregular in outline and often more radiopaque than normal.
Ultrasound examination of the end-stage kidneys reveal small size with increased overall echogenicity and reduced corticomedullary differentiation.

Treatment

Non-specific treatment. Avoid conditions which may precipitate a uraemic crisis

i) **Unlimited access to water** unless vomiting

ii) Dietary management
- phosphate restriction
- moderate protein restriction
- mild sodium restriction
- adequate caloric intake
- water soluble vitamins (B and C vitamins)
- palatability

iii) Minimise metabolic acidosis - sodium bicarbonate, potassium citrate

iv) Antihypertensive therapy. Treat if systolic pressure >175mmHg. Use ACE inhibitors ((benazepril) especially if there is proteinuria, but these may reduce renal blood flow, or the calcium channel blocker, amlodipine.

v) Anabolic steroids? No control studies have been performed.

vi) Recombinant erythropoetin (Epoetin, rHuEPO and rcEPO) can be used to treat the anaemia. Dose 50-100 units/kg subcutaneously three times weekly. Monitor PCV; reduce dose when PCV reaches low normal levels.

vii) Intestinal phosphate-binding agents for those cases where the diet does not control the phoshate adequately, for example:

Aluminium hydroxide (Aludrox, sucralphate). May also help control vomiting.

Lanthanum carbonate (Renalzin) a powerful chelator of phosphorus. Renalzin also contains kaolin, a toxin binder, and vitamin E, an antioxidant. Also Pronefra.

Sevelamer hydrochloride (Renagel) an organic ion resin that binds intestinal phosphate.

viii) Appetite stimulants eg mirtazapine or cyproheptadine

ix) Control vomiting and gastritis – cimetidine, ranitidine or famotidine will reduce vomiting caused by uraemic gastritis. Maropitant and metoclopramide have also proven effective.

x) Control of renal secondary hyperparathyroidism - supplement with calcium salts and vitamin D, **but only after correcting the hyperphosphataemia.** Otherwise further soft tissue calcification will occur. Dosages:

- dihydrotachysterol, which is more potent and has a more rapid onset of action than vitamin D2 (0.01-0.03 mg/kg/day).
- calcitriol, which requires no activation and has the most rapid onset of activity (0.06 mg/kg/day) or alfacalcidol (One Alpha) (0.05 mg/kg/day).

xi) Prevent urinary tract infections – antibiotics. There is a significant incidence of ascending bacterial infection in patients with chronic renal failure.

xii) Oral potassium supplementation for hypokalaemia. Potassium gluconate best 2 - 4 mmol per cat per day. Kaminox

xiii) Avoid stress or situations which could provoke renal ischaemia e.g. sedation or general anaesthesia

xiv) Subcutaneous fluids. Cats 80-150 ml two to three times a week.

In uraemic crisis treat as for acute renal failure

UROLOGICAL CASES

92 181 English Mastiff 18mth M Jasper

First ill two weeks ago
Lethargic
Vomiting food and bile, no blood
Progressive loss of appetite
Polydipsic, but always has been
Rapid deterioration in last few days
Halitosis. Dehydration. Muscle tremor/fasciculation

Car radiator burst four weeks ago.

HAEMATOLOGY

TOTAL RBC	**4.79**	**5.5 - 8.5 x 10^{12}/l**
PCV	**0.338**	**0.37 - 0.55 l/l**
HB	**12.6**	**12 - 18 g/dl**
PL.PROTEIN	**92**	**60 - 80 g/l**
MCV	**70.5**	**60 - 77 fl**
MCH	**26.3**	**19.5 - 24.5 pg**
MCHC	**37.3**	**32 - 37 g/dl**
RETICS		**0 – 1.5 %**
PLATELETS	**172**	**175 - 500 x 10^9/l**

TOTAL WBC	**18.4**		**6 - 17 x 10^9/l**
	%	**ABS NO.**	
STAB			
BAND		**0**	**0 - 0.3 x 10^9/l**
NEUTROPHILS	**92**	**16.928**	**3 - 11.5 x 10^9/l**
LYMPHOCYTES	**3**	**0.552**	**1 - 4.8 x 10^9/l**
MONOCYTES	**5**	**0.920**	**0.2 - 1.5 x 10^9/l**
EOSINIPHILS		**0**	**0.1 - 1.3 x 10^9/l**
BASOPHILS		**0**	**0 x 10^9/l**
NORMOBLASTS			

Fibrinogen 8.0 g/l (Ref. range 2 – 4 g/l)

BIOCHEMISTRY

Haemolysis.....-ve Lipaemia.....-ve Icteric.....-ve	PATIENT SAMPLE	REFERENCE RANGE
UREA	52.0	3.3 - 8.0 mmol/l
GLUCOSE	6.8	3.4 - 5.3 mmol/l
CREATININE	1742	45 - 150□□mol/l
BILIRUBIN-T		2 - 17□□mol/l
BILIRUBIN-D		0 - 3□□mol/l
CHOLESTEROL		2.5 - 5.9 mmol/l
T.PROTEINS	84.5	55 - 75 g/l
TRIGLYCERIDE		mmol/l
SODIUM	149	135 - 155 mmol/l
POTASSIUM	4.7	3.5 - 5.8 mmol/l
CHLORIDE	99	105 - 120 mmol/l
CALCIUM	1.07	2.2 - 2.7 mmol/l
MAGNESIUM		0.8 - 1.2 mmol/l
PHOSPHATE	7.04	0.6 - 1.3 mmol/l
ALK.PHOS	86	3 - 142 iu/l
ALT	65	21 - 59 iu/l
AST	122	20 - 32 iu/l
AMYLASE	5671	167 - 1457 iu/l
CK	1063	76 - 228 iu/l
LIPASE		0 - 200 iu/l
GAMMA-GT	0	0 - 10 iu/l

URINE ANALYSIS

URINE ANALYSIS		
Catheterised/~~Voided~~	**Appearance: Clear**	**pale, straw colour**
UREA	**220 mmol/l**	**SODIUM 46 mmol/l**
CREATININE	**6.3 mmol/l**	**POTASSIUM 24 mmol/l**
S.G.	**1.012**	**pH 5**
PROTEIN	**+**	**KETONE - ve**
GLUCOSE	**+**	**BILE SALTS**
BLOOD	**+**	**PIGMENT**
BILIRUBIN	**- ve**	**UROBILINOGEN - ve**
MICROSCOPY:	**a few sperm seen occ granular cast 1-3 WBC's/hpf**	

1) Is this likely to be acute or chronic renal failure?

2) What further investigations would you perform?

3) How would you manage this case?

89 1333 Red Setter 8 M Oliver

6 weeks ago went off food, then stopped eating
Polydipsic 1.3 l/ day BW 18kg
Vomited once. Motions normal
Depressed
Twitches over hindlimbs on occasions

HAEMATOLOGY

	6/7/89	10/7/89	Ref. Range
Total RBC	7.53x 10^{12}/l	5.87x 10^{12}/l	5.5 - 8.5 x 10^{12}/l
Hb	17.9 g/dl	15.8 g/dl	12 - 18 g/dl
PCV	0.51	0.44	0.37 - 0.55 l/l
Platelets		239 x 10^{9}/l	175 - 500 x 10^{9}/l
WBC	29.4 x 10^{9}/l	19.3 x 10^{9}/l	6 - 17 x 10^{9}/l
Neutros	18.9 (80%)	13.3 (69%)	3 - 11.5 x 10^{9}/l
Lymphs	4.2 (18%)	4.6 (24%)	1 - 4.8 x 10^{9}/l
Monos	237 (1%)	1.1 (6%)	0.2 - 1.5 x 10^{9}/l
Eosins	0 (0%)	0.2 (1%)	0.1 - 1.3 x 10^{9}/l

BIOCHEMISTRY

	6/7/89	10/7/89	Ref Range
Urea	**24.7 mmol/l**	**25.0 mmol/l**	**3.3 - 8.0 mmol/l**
Glucose	**3.3 mmol/l**	**3.7 mmol/l**	**3.4 - 5.3 mmol/l**
Creatinine	**205 µmol/l**	**435 µmol/l**	**45 – 150 µmol/l**
Cholesterol		**3.7 mmol/l**	**2.5 - 5.9 mmol/l**
Pl. Prot	**79 g/l**	**70.8 g/l**	**55 - 75 g/l**
Sodium	**142 mmol/l**	**151 mmol/l**	**135 - 155 mmol/l**
Potassium	**4.3 mmol/l**	**4.0 mmol/l**	**3.5 - 5.8 mmol/l**
Chloride		**110 mmol/l**	**105 - 120 mmol/l**
Calcium		**5.20 mmol/l**	**2.2 - 2.7 mmol/l**
Phosphate		**1.13 mmol/l**	**0.8 - 1.2 mmol/l**
ALP	**27 iu/l**	**40 iu/l**	**3 - 142 iu/l**
ALT	**39 iu/l**	**65 iu/l**	**21 - 59 iu/l**
AST		**39 iu/l**	**20 - 32 iu/l**
CK		**124 iu/l**	**76 - 228 iu/l**
GGT		**0 iu/l**	**0 - 10 iu/l**

URINALYSIS 10/7/89

Sp. gr.	**1.009**	**pH**	**5.5**
Protein	**-ve**	**Blood**	**-ve**
Glucose	**-ve**	**Bilirubin**	**-ve**
Ketones	**-ve**	**Urobilinogen**	**-ve**
Sediment:	**Occ sperm, WBC**		

1) What are the significant changes?

2) How would you investigate this case?

3) How would you manage the case?

91 336 Standard Poodle 7 Mn Sam

Dribbling urine for 6 months, particularly when lying down. 1 drop every 15 sec. Variable in severity. Not progressive.
Does urinate normally
Polydipsia?
Ascites controlled with frusemide
Lethargic
Inappetent on low protein diet
Vomiting bile for last 3 weeks

HAEMATOLOGY

TOTAL RBC	**6.11**	**5.5 - 8.5 x 10^{12}/l**
PCV	**0.42**	**0.37 - 0.55 l/l**
HB	**14.6**	**12 - 18 g/dl**
PL.PROTEIN	**48.0**	**60 - 80 g/l**
MCV	**68.9**	**60 - 77 fl**
MCH	**23.9**	**19.5 - 24.5 pg**
MCHC	**34.7**	**32 - 37 g/dl**
RETICS		**0 – 1.5 %**
PLATELETS	**484**	**175 - 500 x 10^9/l**

TOTAL WBC	**14.1**		**6 - 17 x 10^9/l**
	%	**ABS NO.**	
STAB			
BAND		**0**	**0 - 0.3 x 10^9/l**
NEUTROPHILS	**68**	**9.588**	**3 - 11.5 x 10^9/l**
LYMPHOCYTES	**20**	**2.820**	**1 - 4.8 x 10^9/l**
MONOCYTES	**8**	**1.128**	**0.2 - 1.5 x 10^9/l**
EOSINOPHILS	**3**	**0.423**	**0.1 - 1.3 x 10^9/l**
PROPLASMA	**1**	**0.141**	**0 x 10^9/l**
NORMOBLASTS			

Fibrinogen 6.0 g/l (Ref. range 2 – 4 g/l)

BIOCHEMISTRY

Haemolysis.....-ve Lipaemia.....-ve Icteric.....-ve	PATIENT SAMPLE	REFERENCE RANGE
UREA	10.6	3.3 - 8.0 mmol/l
GLUCOSE	4.0	3.4 - 5.3 mmol/l
CREATININE	155	45 - 150□□mol/l
BILIRUBIN-T		2 - 17□□mol/l
BILIRUBIN-D		0 - 3□µmol/l
CHOLESTEROL	11.0	2.5 - 5.9 mmol/l
T.PROTEINS	45.8	55 - 75 g/l
ALBUMIN	19.1	25 - 45 g/l
SODIUM	155	135 - 155 mmol/l
POTASSIUM	3.6	3.5 - 5.8 mmol/l
CHLORIDE	123	105 - 120 mmol/l
CALCIUM	2.35	2.2 - 2.7 mmol/l
MAGNESIUM		0.8 - 1.2 mmol/l
PHOSPHATE	2.50	0.6 - 1.3 mmol/l
ALK.PHOS	48	3 - 142 iu/l
ALT	13	21 - 59 iu/l
AST	31	20 - 32 iu/l
AMYLASE		167 - 1457 iu/l
CK	2	76 - 228 iu/l
LIPASE		0 - 200 iu/l
GAMMA-GT	0	0 - 10 iu/l
BILE SALTS	14	0 - 5 µmol/l

URINALYSIS

Catheterised **Appearance: pale yellow**

Sp. gr.	**1.013**	**pH**	**6.5**
Protein	**+++**	**Blood**	**+**
Glucose	**-ve**	**Bilirubin**	**-ve**
Ketones	**-ve**	**Urobilinogen**	**-ve**
Sediment:	**Occ epithelial cells**		
Bence-Jones protein	**+ve**		

1) What are the significant changes?

2) How would you investigate this case?

3) How would you manage the case?

96 2149 Boxer 3 male "Nelson" 32kg

History

Stifle arthrotomy for a ruptured cruciate ligament 10 days previously.
Post op treatment Carprofen 75mg BID
Ampicillin 500 mg TID
5 days later deteriorated: became lethargic and inappetant
Taken to VS next day - injected with Synulox and carprofen
Following day started to vomit food, then vomiting continued
VS gave daily Synulox, carprofen and metoclopramide by injection prior to referral
Weight loss to 28 kg

HAEMATOLOGY

TOTAL RBC	**8.5**	**5.5 - 8.5 x 10^{12}/l**
PCV	**0.57**	**0.37 - 0.55 l/l**
HB	**19.9**	**12 - 18 g/dl**
PL.PROTEIN	**106**	**60 - 80 g/l**
MCV	**67**	**60 - 77 fl**
MCH	**23.4**	**19.5 - 24.5 pg**
MCHC	**34.9**	**32 - 37 g/dl**
RETICS		**0 – 1.5 %**
PLATELETS	**55**	**175 - 500 x 10^9/l**

TOTAL WBC		**64.4**	**6 - 17 x 10^9/l**
	%	**ABS NO.**	
STAB			
BAND	**1**	**0.6**	**0 - 0.3 x 10^9/l**
NEUTROPHILS	**95**	**61.1**	**3 - 11.5 x 10^9/l**
LYMPHOCYTES		**0**	**1 - 4.8 x 10^9/l**
MONOCYTES	**4**	**2.5**	**0.2 - 1.5 x 10^9/l**
EOSINIPHILS		**0**	**0.1 - 1.3 x 10^9/l**
BASOPHILS		**0**	**0 x 10^9/l**
NORMOBLASTS			

Fibrinogen 8g/l (Ref range 2 – 4 g/l)

BIOCHEMISTRY

Haemolysis.....-ve **Lipaemia.....-ve** **Icteric.....-ve**	**PATIENT SAMPLE**	**REFERENCE RANGE**
UREA	**42.5**	**3.3 - 8.0 mmol/l**
GLUCOSE	**6.7**	**3.4 - 5.3 mmol/l**
CREATININE	**229**	**45 - 150□□mol/l**
BILIRUBIN-T	**276**	**2 - 17□□mol/l**
BILIRUBIN-D	**185**	**0 - 3□□mol/l**
CHOLESTEROL		**2.5 - 5.9 mmol/l**
T.PROTEINS	**83.4**	**55 - 75 g/l**
TRIGLYCERIDE		**mmol/l**
SODIUM	**154**	**135 - 155 mmol/l**
POTASSIUM	**2.9**	**3.5 - 5.8 mmol/l**
CHLORIDE	**111**	**105 - 120 mmol/l**
CALCIUM	**2.95**	**2.2 - 2.7 mmol/l**
MAGNESIUM		**0.8 - 1.2 mmol/l**
PHOSPHATE	**5.17**	**0.6 - 1.3 mmol/l**
ALK.PHOS	**7548**	**3 - 142 iu/l**
ALT	**107**	**21 - 59 iu/l**
AST	**35**	**20 - 32 iu/l**
AMYLASE	**3879**	**167 - 1457 iu/l**
CK	**167**	**76 - 228 iu/l**
LIPASE	**10403**	**0 - 200 iu/l**
GAMMA-GT	**9**	**0 - 10 iu/l**
BILE SALTS	**201**	**0 - 5 µmol/l**

URINE ANALYSIS

Catheterised/~~Voided~~	**Appearance: Yellow slightly cloudy**	
S.G.	**1.015**	**pH 6**
PROTEIN	**++**	**KETONE -ve**
GLUCOSE	**- ve**	**BILE SALTS -ve**
BLOOD	**+++**	**PIGMENT -ve**
BILIRUBIN	**+++**	**UROBILINOGEN -ve**
MICROSCOPY:	**Spermatazoa ++** **60-70 RBC/hpf** **Uric acid +** **2-3 epithelial cells/hpf**	

Urine urea	**234 mmol/l**
Plasma urea	**42.5 mmol/l**

Urine creatinine	**3.51 mmol/l**
Plasma creatinine	**229 µmol/l**

Urine sodium	**154 mmol/l**
Plasma sodium	**21.9 mmol/l**

1) What are the significant changes?

2) How would you investigate this case?

3) How would you manage the case?

MEH
April 2019