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Emergency Surgery Mini Series

Session 3: Blocked Bladders and Bleeding Spleens - Emergency Surgery of the Abdomen

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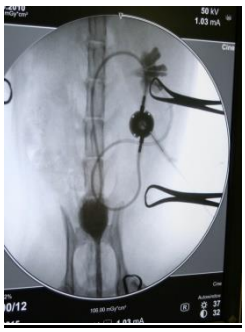

Webinar notes: Emergency surgery of the abdomen

Introduction:

So far in our webinar mini-series we have looked at triage of trauma and common problems identified in small animal trauma patients and also management of gastrointestinal emergencies. This final webinar discusses management of the haemoabdomen, feline ureteral obstructions and management of both canine and feline urethral obstructions.

Management of the haemoabdomen:

Patient history: Owners may report previous episodes of acute onset lethargy, inappetance or "off days" which may equate to previous episodes of haemorrhage which were self-limiting. However signs can also be reported to be acute or peracute in onset with collapse being the most commonly reported clinical sign during active haemorrhage.

Presenting signs: Patients may be ambulatory or collapsed/obtunded. Heart rate varies with patient breed and size and therefore it is not possible to give one universal figure which should raise concern. You should also assess non-invasive blood pressure, pulse quality, mucus membrane colour and capillary refill time e.g. a heart rate of 130bpm may be inappropriate in a Great Dane but not in an anxious Jack Russell Terrier. When palpating peripheral pulses start in the most distal location and work your way to a more central location if you cannot palpate a pulse more peripherally. Note not only the presence of the pulse but also the quality of it. Abdominal distension can be difficult to assess depending on the size and body condition score of your patient but abdominal palpation should be performed to look for both the presence of an abdominal mass and also a fluid thrill.

What baseline data do we need?

- Rectal temperature, heart rate and respiratory rate
- Blood pressure (arterial line placement is preferable but can be challenging in the conscious patient. Oscillometric and Doppler blood pressure measurement represent credible alternatives)
- PCV/TP/urea/creatinine and electrolytes as a minimum. Haematology and biochemistry profiles are useful if available rapidly.
- In house blood smear to assess platelet count (>10 platelets per oil immersion field is equivalent to around 150x109/L). Be aware that in house haematology analysers can be inaccurate when it comes to assessing platelet numbers so a manual count is preferable if you are in doubt.

The priority is stabilisation by restoration of circulating volume. Place two large bore peripheral intravenous catheters or a central line (although this usually requires general anaesthesia). Our aim is to restore perfusion and oxygen delivery to organs, restore circulating volume, improve cardiac output and increase oxygen content of blood. A continuous recording ECG should be attached to the patient and oxygen supplementation provided. Analgesia is usually indicated and opioids represent the best choice. If an opioid alone is inadequate, other options for analgesia include either a ketamine constant rate infusion (CRI) or a lidocaine CRI. Intravenous paracetamol can also be considered (10mg/kg as a slow intravenous infusion over 15-30 minutes). Non-steroidal anti-inflammatory drugs e.g. meloxicam should be avoided in hypovolaemic, hypotensive patients as there is an increased risk of renal toxicity and gastric ulceration.

Crystalloids represent the mainstay of initial fluid resuscitation although it should be remembered around 75% of the volume given will be lost to the interstitium within one hour of administration. A balanced electrolyte solution is preferable to 0.9% saline as the latter can lead to metabolic acidosis secondary to elevated chloride levels.

Rather than considering “shock-rate” fluids, it is preferable to give intravenous fluids in incremental boluses (10-20ml/kg given over 15 minutes) and monitor heart rate (which should reduce) and blood pressure (hypotension should improve) to assess response. Please note these doses may not be appropriate in patients with concurrent structural cardiac disease. Hypertonic saline can also be used (although the author has limited experience of it) and causes expansion of circulating volume by dehydration of the interstitium. It must therefore be followed by an isotonic solution.

In patients which are unresponsive to crystalloid therapy or where it is anticipated that large volumes of fluid supplementation will be required, colloids should be considered. Options for colloid therapy include hydroxyethyl starches and gelatins. Hydroxyethyl starches come in a variety of molecule sizes and therefore have variable duration of effect. There has been significant research efforts within human medicine over the past few years looking at the morbidity and mortality associated with the use of hydroxyethyl starches in critically ill patients. Recent randomised trials in human medicine have suggested that the use of hydroxyethyl starches in critically ill patients can lead to significant acute kidney injury and mortality; particularly in sepsis. This has led to a move away from the use of such colloids in veterinary medicine also although the same research has not currently been duplicated. At the present time, the use of hydroxyethyl starches in human medicine is limited to management of haemorrhage. Coagulopathy is reported as a side effect of hydroxyethyl starches due to a reduction in the concentration of factor VIII and von-Willebrand factor but this is not frequently recognised clinically. Gelatins are generally smaller sized molecules than those contained in hydroxyethyl starch solutions but are present in larger numbers. As the molecules are smaller, they do not remain in the circulation as long as the hydroxyethyl starch molecules. Increased anaphylaxis is reported in humans treated with gelatins than hydroxyethyl starches but this is not very common in dogs. Colloids are usually administered in 5ml/kg boluses up to a maximum of 50ml/kg/24 hours.

With particular respect to the haemoabdomen patient, the use of blood products is often indicated and replacement of erythrocytes will restore oxygen carrying capacity within the circulation. There is no set cut off for when a transfusion must be carried out. However it should be considered in patients which have lost >20% of circulating blood volume. The decision to transfuse should be based on the availability of blood products, the underlying cause of haemorrhage (and the likelihood of being able to control it), the volume of blood lost and the clinical status of the patient.

Patients should be blood typed and any patient which has previously received a blood transfusion (unless within the last 72 hours) should be also be cross matched. However in an emergency situation, patients which have never received a transfusion can receive either DEA 1.1 positive or negative without typing if typing is not available. Two main options exist for replacement of erythrocytes: packed red cells and whole blood transfusions. Pros and cons exist for both of these options. Packed cells are convenient and there is now increased availability through the Pet Blood Bank. Packed cells also contain higher number of erythrocytes/ml so will increase PCV more than a whole blood transfusion. However a packed cell transfusion does not replace clotting factors or platelets; both of which are actively depleted in a patient with a haemoabdomen and there is also a cost implication to the use of such products. Where whole blood has been lost and a packed cell transfusion is planned, it is wise to consider combining this with fresh frozen plasma (FFP) to replace clotting factors but this can be expensive in larger patients (ideally a ratio of one bag of FFP is administered per bag of packed cells is recommended). Furthermore this approach will not address thrombocytopaenia. In contrast whole blood provides erythrocytes, platelets and clotting factors although platelet survival in whole blood transfusions is reduced. Furthermore, although whole blood is a “free” resource, collection of whole blood requires access to suitable equipment and also a donor.

Another option for provision of blood products is the use of cell salvage. Such systems are in common use in human medicine for autotransfusion of blood within a body cavity. Cell salvage machines pump the collected blood into a centrifugation bowl where dense erythrocytes are separated from plasma proteins and lighter cellular elements.

The erythrocytes are then washed and re-suspended in 0.9% saline. This blood may then be administered to the patient immediately or stored for administration within 6hr of collection. Cell salvage systems are preferable to direct auto-transfusion of blood from the surgical field as the system removes other contaminants from the collected fluid and allows concentration of packed red cells which minimises transfusion volume. The use of such systems in neoplasia is controversial as there is the concern that autotransfusion of neoplastic cells from the ruptured spleen may lead to metastasis. Research is currently underway looking at the efficacy of leucocyte reduction filters to remove any cells which are not erythrocytes from the collected blood. In vitro studies suggest that leucocyte reduction filters may be effective in removing neoplastic cells from abdominal fluid.

Oxygen supplementation can be provided via a number of routes. Face masks provide a maximal fractional inspired oxygen concentration (FiO2) of 50-60% with oxygen flows of 8-12L/min. More commonly flows of 2-5L/min are used. There is risk of rebreathing and also a risk of hyperthermia. Nasal prongs/catheters achieve a FiO2 of ~50% can be achieved using flows of 2l per 10kg per minute. However this is often not well tolerated in clinical patients and 2-5 l/min is more commonly used. It is important to humidify gas, if possible, to prevent irritation of the nasal mucosa. Oxygen cages and incubators can achieve FiO2 of up to 60% (more commonly 40-50%) but there is again a risk of hyperthermia and patient temperature should be closely monitored.

Differential diagnoses of a haemoabdomen include:

- Coagulopathy
    - Thrombocytopaenia
    - Thrombocytopathia
    - Vitamin K deficiency
    - Hepatopathy
    - Disseminated intravascular coagulation
    - Pharmacologic anticoagulants
    - Hemodilution (dilutional coagulopathy)
- Trauma
    - Acute trauma coagulopathy
    - Active haemorrhage from an intra-abdominal structure
- Iatrogenic e.g. post ovariohysterectomy
- Neoplasia
    - Hepatic (haemangiosarcoma (HSA), hepatic adenoma/carcinoma, biliary adenoma/carcinoma, metastatic disease)
    - Splenic (HSA, leiomyosarcoma, undifferentiated sarcoma, fibrosarcoma, osteosarcoma, liposarcoma, myxosarcoma, mast cell tumor, chondrosarcoma, rhabdomyosarcoma, malignant fibrous histiocytoma, lymphoma, metastatic adenocarcinoma, and myeloproliferative disease)
    - Adrenal (phaeochromocytoma, adrenocortical tumours and metastatic disease)

Various options exist for imaging of the abdomen. Abdominal radiographs are easily achieved but the presence of significant ascites will lead to a generalised increase in soft tissue opacity. Liver and splenic masses may also be identified on abdominal radiography depending on their size. However it is difficult to identify adrenal pathology unless it is significant in size or mineralised. Abdominal ultrasound represents the opportunity to determine the source of the pathology although the presence of free abdominal fluid can make interpretation of the scan challenging. Confirmation of a haemoabdomen can be made by identification of free abdominal fluid and abdominocentesis. This is most accurate and carries the least risk when performed under ultrasound guidance but can also be performed as a “blind” tap if a large volume of fluid is present. Once fluid is obtained, a PCV should be checked on the abdominal fluid and compared to the PCV of the patient. If the PCV of the abdominal fluid is over 10-15%, there is usually a reasonable suspicion of a haemoabdomen.

If the systemic PCV and that of the abdominal fluid are comparable, this should be considered pathognomic for a haemoabdomen. CT, where available, is useful as it also provides the opportunity for staging of any suspected neoplasia.

The most commonly recognised causes of haemoabdomen requiring surgical intervention are either iatrogenic haemorrhage secondary to planned surgical intervention or neoplasia. Splenic neoplasia is common in dogs and up to two thirds of splenic lesions in dogs are neoplastic and up to 73% of splenic lesions in cats depending on which source within the literature is cited. Haemangiosarcoma is the most common neoplastic lesion of the spleen in dogs and this is characterised by rapid growth and widespread metastasis due to its vascular endothelial origin (which makes access for haematogenous spread relatively easy). Potential sites for metastasis of this tumour include the liver, lungs and right atrium as well as the lymphatic system. It is unclear if concurrent atrial lesions represent synchronous primary tumours or metastatic disease. Many other tumour types are reported to occur in the spleen, both primary and metastatic, including fibrosarcoma, mast cell tumours, osteosarcoma and malignant fibrous histiocytoma. The most common splenic neoplasms in cats are lymphoma and mast cell tumours.

As the incidence of malignancy is high in patients with a splenic mass, staging should be performed prior to surgery to provide information to the owner regarding prognosis. Imaging of the thorax (via three inflated views of the thorax or CT), abdomen (ultrasound or CT) and echocardiography of the heart to assess the right atrium and aurical appendage is recommended. In the case of adrenal tumours, it is important to check for the presence of vascular invasion in to the phrenicoabdominal vein, renal vein(s) or caudal vena cava. This is best achieved by an experienced ultrasonographer or contrast abdominal CT.

Between 0.6% and 2.6% of all canine and feline neoplasms involve the liver. Tumours of the biliary system are generally less common. Hepatobiliary tumours are of four general types: hepatocellular, cholangiocellular, neuroendocrine, or mesenchymal. Metastatic tumours are more common than primary ones, with the most common types being hematopoietic and lymphoid tumours, followed by epithelial and mesenchymal tumours. Mast cell tumours are also rarely found as primary or secondary tumours in the liver. Hepatocellular carcinomas are the most common primary liver tumours in dogs, representing approximately 50% to 70% of all non-hematopoietic neoplasms. They generally present as one of three forms: massive (61%), nodular (29%), or diffuse (10%).

Once your patient is adequately stabilised (aims here include normalisation of heart rate, blood pressure and other clinical parameters as previously discussed) and a frank discussion has been undertaken with the owner, surgery is usually indicated for patients with a haemoabdomen except in cases attributable to coagulopathy or trauma (haemorrhage in the majority of trauma cases is usually self-limiting although this is NOT a hard and fast rule and patients must be assessed on a case by case basis). It is worth noting an acute coagulopathy is present on admission in 25% to 34% of human trauma patients and is associated with a four-fold increase in mortality. Though a finite definition is not yet established for this syndrome, referred to as acute traumatic coagulopathy (ATC), most human studies use a 50% prolongation in either PT or APTT as diagnostic criteria.

If there is potentially a surgical solution for the haemorrhage issue in question and you feel confident to deal with the potential findings at surgery, surgery should be performed as soon as is feasible. Surgical success can be greatly enhanced by ensuring you have adequate lightening, access and equipment. Access to cautery, suction and a Poole suction tip and an assistant will all make life much easier.

Adrenalectomy can be very challenging for several reasons; firstly and perhaps most importantly because of the anaesthesia. When emergency adrenalectomy is performed because of underlying neoplasia this is complicated by the fact that the tumour is usually not known. Adrenal masses are not uncommon; incidental adrenal gland masses are identified in around 4% of routine abdominal ultrasound scans. In this paper, Cook et al reported that malignancy was more likely in lesions > 20mm in size. Adrenal gland lesions may represent neoplasia, hypertrophy or cystic lesions. The most common types of adrenal tumour include adenomas, adrenocortical tumours (functional versus non-functional) and tumours arising from the chromaffin cells of the adrenal medulla which are known as pheochromocytomas. Functional adrenocortical tumours can produce cortisol, aldosterone or sex hormones. Cortisol secreting tumours usually lead to signs of hyperadrenocorticism. A combination of an ACTH stimulation test and low dose dexamethasone suppression test is used to confirm this diagnosis. There are no consistent abnormalities seen on routine blood and urine tests in dogs with pheochromocytomas. Measurements of urinary catecholamine concentrations or their metabolites are used to strengthen the diagnosis in patients with clinical signs consistent with such a tumour (systemic hypertension, tachycardia, weakness and excessive panting). Adrenalectomy is made challenging both by the potential effects on wound healing and coagulation as seen in cortisol producing tumours and the significant cardiac arrhythmias seen in pheochromocytomas. Pre-treatment with trilostane and phenoxybenzamine respectively has been shown to reduce intra-operatively mortality. However in cases of haemoabdomen secondary to a ruptured tumour, this is usually not practical. Access to drugs which could be used to treat intra-operative hypertension; phentolamine (alpha-antagonist) and nitroprusside (direct vasodilator), is therefore to be highly recommended for suspected pheochromocytoma patients.

Good access and appropriate retraction are essential for adrenalectomy, therefore an assistant is recommended. Prior to surgery it is important to know the extent of any vascular invasion and have planned appropriately to deal with this. The most common approach is a ventral midline one which allows exploration of the whole abdomen. The left adrenal gland is more easily identified at the craniomedial pole of the kidney. The right adrenal gland is often partially obscured by the vena cava and transection of the hepatorenal ligament can help with visualisation. A flank approach is also reported but is reserved for uncomplicated unilateral masses with no caudal vena caval involvement. Finally laparoscopic adrenalectomy has also been reported; again not appropriate for large masses. Dissection can be performed using a combination of blunt and scissor dissection or using bipolar sealant devices or a harmonic scalpel. The phrenicoabdominal vein should be ligated at the lateral aspect of the gland. There are usually multiple penetrating vessels on the dorsal surface of the gland. After the adrenal gland is freed from its lateral and dorsal attachments, a plane is developed between the renal vessels and the caudal aspect of the gland. As a final step, the phrenicoabdominal vein is ligated at its final entry in to the caudal vena cava. This can be very difficult to identify depending on the size of the tumour.

The reported incidence of caudal vena caval thrombi is variable depending on which paper you are reading. Overall the incidence is between 10-20% and is reported to be more common in pheochromocytomas in some papers (Massari et al, Lang et al, Barrera et al). Caval thrombi vary in size and can extent as far as the right atrium. Thrombi can be removed with a venotomy. Rummel tourniquets (loops of polypropylene passed through a section of soft cut chest drain) are passed around the caudal vena cava cranial and caudal to the tumour and also possibly separately around the renal vessels depending on the size of the tumour. The Rummel tourniquets are gently tightened to occlude blood flow through the caudal vena cava and a longitudinal incision is made adjacent to the entry point of thrombus in to the cava. The thrombus is removed and a Statinsky vascular clamp placed across the incision (but not fully occluding the caval lumen) and blood flow allowed to flow through the caudal vena cava once more. The venotomy incision is sutured using 5/0 polypropylene in a simple continuous pattern. Two separate suture lines may be required and thus use of a suture with a double needle (i.e. one on each end) can be useful. The vascular clamp should be gradually released.

There is usually some haemorrhage through the holes where the suture needle has passed through the vessel wall which stops when pressure is applied with a swab over the area. If it does not, more sutures may need to be placed.

Prognosis for adrenal tumours is reasonable even with malignancy in patients who survive the initial post-operative period. Lang et al compared 52 dogs undergoing elective adrenalectomy and 8 dogs undergoing emergency adrenalectomy for acute adrenal haemorrhage. Perioperative morality rates were 5.7% for dogs that underwent elective adrenalectomy and 50% for dogs that underwent emergency adrenalectomy for acute adrenal haemorrhage. However bear in mind these numbers are small. Median survival time was 492 days for the 53 dogs that survived the perioperative period. As there is a lack of prospective trials, there is some debate over prognostic factors but most papers agree that tumour size/volume, the presence of metastasis and the presence of an extensive caval thrombus all affect longer term prognosis.

Splenectomy is much more commonly performed in primary care practices than adrenalectomy and therefore an extensive discussion of technique is not provided. Broadly speaking there are two main techniques for ligation of the splenic vasculature. The hilar technique involves ligation of the individual splenic vessels close to their entry in to the splenic vasculature. This is a time consuming technique but does mean that there is no risk of disturbing the vascular supply to the left limb of the pancreas which is supplied by the splenic artery on its way to the spleen. In cases where the splenic vasculature can be clearly identified, a more rapid technique is to ligate the splenic artery and vein following bifurcation of the pancreatic vessels and also ligation of the short gastric arteries. Triple ligation is recommended so one ligature is removed with the splenic tissue and two ligatures remain on the tissue which stays in situ. Preservation of the left gastroepiploic and short gastric arteries is not required for preservation of gastric blood flow and therefore this technique may save time. In practice, with neoplastic cases, there is often significant neovascularisation and adhesion of the omentum to the spleen and therefore the hilar technique can, in some patients, be the safer option. The rest of the abdomen should be explored for any evidence of gross metastasis (ensure you check all surfaces of the liver thoroughly and the draining lymph nodes) and biopsies taken as appropriate. Several time saving ligation devices are now commonly available on the veterinary market:

- Harmonic scalpel: cuts via vibration. The high frequency vibration of tissue molecules generates stress and friction in tissue, which generates heat and causes protein denaturation.
- Bipolar sealant devices (e.g. Endseal or Ligasure): electrical current is passed through the tissues, denaturing proteins within vessel walls.
- LDS stapler: places two stainless steel clips to ligate the tissue within the cartridge jaw and the knife blade divides the tissue between the two closed clips

Prognosis varies significantly depending on tumour type and the presence of metastasis. Splenectomy for benign lesions such as a haematoma will of course be curative. Haemangiosarcomas are aggressive tumours and outcome depends on the tumour stage, number of gross lesions and the use of adjunctive chemotherapy. Staging of canine haemangiosarcoma depends on tumour size, presence of nodal metastasis and distant metastasis. Chemotherapy is most effective in patients with microscopic metastasis rather than gross disease. A very broad rule of thumb is a reported MST of 6-9 months with traditional adjunctive chemotherapy in patients with no gross metastasis at the time of surgery. The use of metronomic chemotherapy is also reported but discussion of this is outwith the scope of this webinar.

Nephroureterolithiasis in cats:

Recognition of nephroureterolithiasis in cats is increasing as the profession becomes more attuned to recognition of clinical signs and as newer techniques emerge for management of this disease process. Greater than 98% of uroliths identified in the upper urinary tract are calcium oxalate stones in cats (Kyles et al 2005).

Medical dissolution is therefore not an option for the vast majority of such cases. These stones must therefore either pass spontaneously, be surgically removed or urinary diversion needs to be established. Ureteral stricture formation (usually occurring secondary to previous urolith obstruction) is the cause of obstruction in up to 20% of cases.

Clinical signs associated with ureteral obstruction in the cat are unfortunately non-specific (Kyles et al 2005). The most common clinical signs seen include inappetance, weight loss, vomiting and polyuria/polydipsia (Berent et al 2014). In experimental dog models of ureteral obstruction, renal blood flow diminishes by 60% over the first 24 hours, and 80% within two weeks leading to a decrease in the glomerular filtration rate. The contralateral kidney will increase glomerular filtration rate in response, as long as that kidney is normal and has the potential for hypertrophic compensation. After seven days the glomerular filtration rate is permanently diminished by 35%, and after 2 weeks by 54%. However the majority of cats with nephroureterolithiasis are prolific stone formers and therefore previous episodes of ureteral obstruction are not uncommon (Kyles et al 2005, Berent et al 2014). If only one kidney/ureter is affected, clinical signs can often be mild and therefore cats will often not present until the second ureter obstructs. This is known as “big kidney little kidney” syndrome as the previously obstructed kidney is reduced in size. Furthermore, concurrent chronic renal disease is common in cats thus making the clinical consequences of ureteral obstruction more severe.

Bloods: Pre-operative azotemia is present in 95% of cats on presentation (Berent et al 2014). It is important to remember that the magnitude of pre-operative azotemia is not correlated with longer term survival (Horowitz et al 2013, Kulendra et al 2014). Electrolytes should be monitored as hyperkalemia is a common finding. PH monitoring, if possible, is also useful as anecdotally, patients with a marked metabolic acidosis appear to have a worse prognosis. Anaemia is also present in approximately 40% of cases.

Imaging: Plain radiography is useful to document stone size, number, location and the presence of concurrent nephrolithiasis although the overall sensitivity is only moderate and gas or faeces within the colon can obscure smaller uroliths. Abdominal ultrasonography in combination with plain abdominal radiography is currently considered to be the gold standard. When hydroureter tapering to focal point and renal pelvis dilation are present, it is highly likely either a partial or complete ureteral obstruction is present. A renal pelvis diameter over 13 mm on the transverse ultrasonographic image is almost always associated with an obstruction but a diameter over 8mm should raise suspicion. It is important to remember that stricture formation can lead to ureteral obstruction and therefore a urolith is not always seen. Intravenous and percutaneous pyelography are also reported in previous studies but in the author’s opinion provide little additional information and carry the risk of further deterioration in renal function. Due to the decrease in glomerular filtration rate associated with ureteral obstruction, these techniques are also poor indicators of renal function once the obstruction has been removed. Concurrent nephrolithiasis is common in cats (60-86%) (Berent et al 2014).

Medical management: can be considered for 24-48 hours in patients which are not anuric, are normokalemic and do not have metabolic acidosis. This usually consists of intravenous fluid therapy and low dose prazocin. The use of mannitol constant rate infusions is also reported. Medical management is unfortunately only reported to be successful in up to 17% of cases (Kyles et al 2005). Progress should be monitored based both on reduction in the degree of azotemia and also improvement or resolution of the affected renal pelvis and ureteral dilation via ultrasound monitoring.

Surgical options: Surgical options include traditional approaches such as ureterotomy, placement of a double pig tailed ureteral stent or a subcutaneous ureteral bypass. It is important to remember that each individual will require a different degree of pre-operative stabilisation prior to considering surgical management of ureterolithiasis. As a general rule of thumb, surgical intervention should be performed as soon as it is safe to do so to maximise return of renal function although a slightly longer period of medical management can be considered in partial ureteral obstructions.

Anuria, severe metabolic acidosis and marked hyperkalemia are all “red flags” for rapid intervention as soon as it is practical. It is important to remember that a reasonable proportion of this population will also have concurrent conditions such as cardiac disease and this should be carefully considered when choosing an anaesthetic protocol.

1) Ureterotomy: Ureterotomy has been the mainstay of treatment for ureteral obstructions in cats for many years. The inner diameter of the feline ureter is 0.4mm and therefore any surgical intervention can prove problematic. A reasonable rate of post-operative complications is reported (31% Kyles et al 2005). An operating microscope or surgical loupes are required for closure of the ureter and small monofilament suture should be used (6-0 to 8-0 USP). Post-operative complications include uroabdomen (in up to 16% of cases), ureteral stricture formation and recurrence of ureteral obstruction (Roberts et al 2011). Roberts et al (2011) reported survival to discharge from the hospital in 79% of cases. Multi-variate analysis of pre-operative variables revealed none which were significantly associated with survival to discharge.

2) Ureteral stent placement: Ureteral stent placement, laser lithotripsy and ureteoscopy are the main stays of treatment of ureteral obstruction in human medicine and have almost completed negated the need for open surgical procedures. Ureteral stent placement has been gaining popularity in the veterinary field for both canine and feline patients over the past five years. Placement of a ureteral stent aims to decompress the renal pelvis and restore urine flow to the bladder, encourage passive ureteral dilation which reduces the risk of repeat obstruction and finally to reduce the risk of migration of nephroliths. An indwelling ureteral double pig tail stent is the most commonly used stent in veterinary medicine (Infiniti Medical). Cystoscopic ureteral stent placement in some cats has been achieved by very experienced operators using a small flexible cystoscope but surgical stent placement (via an exploratory celiotomy) is much more common and can either be performed antegrade via pyelocentesis, retrograde via catheterisation of the ureteral papilla or via ureterotomy. The antegrade technique requires placement of a guide wire in to the renal pelvis via surgical pyelocentesis and then down the ureter to the bladder under fluoroscopic guidance. The stent is then placed over the guide wire. The retrograde technique requires catheterisation of the ureteral papilla again under fluoroscopic guidance and again placement of the stent over the guidewire. If the stent or guide wire cannot be advanced past the obstruction, an ureterotomy directly over the point of obstruction is required and the guidewire advanced from within the lumen of the ureter. Berent at al (2014) reported their clinical experience of ureteral stenting in 69 cats (79 ureters). Ureteral stent placement was successful in 96% of cats although it is important to stress that the authors of this paper are leaders within their field. 8.7% of cats had major procedural complications with uroabdomen representing the majority of these. Peri-operative mortality rate was 7.5% and none of these were considered to be procedure related. Stent exchange was required in 27% of ureters in the longer term due to stent occlusion/encrustration, migration or irritation. Stent encrustation is not uncommon in humans but passive ureteral dilation usually occurs and therefore urine continues to pass even if the lumen of the stent becomes obstructed. Furthermore, stents are generally only used for short time periods in people. It has been suggested that passive ureteral dilation does not occur in ureteral stricture cases, thus obstruction caused by stricture rather than a ureterolith may increase the prevalence of cats requiring stent exchange.

   The most common minor complication was temporary stranguria reported in 37.7% of cases but this was persistent in only one case long term. This is suggested to be secondary to the presence of one end of the pig tail stent within the proximal urethra where the ureterovesicular junction of the cat is situated rather than the bladder trigone as in the dog. Another publication (Kulendra et al 2014) reported signs consistent with sterile cystitis in 35% of cases in the longer term. This was considered severe in three of the 26 cats.

3) Subcutaneous ureteral bypass system (SUB -Norfolk Veterinary Products): This system has been designed to ameliorate the issues seen with ureteral stent placement in cats, particularly the need for stent exchange in the longer term and issues with lower urinary tract signs. This system involves placement of a locking loop pig tail nephrostomy tube and a cystostomy tube which are connected via a Huber port which sits in a subcutaneous location to allow ongoing flushing of the system. A ventral midline celiotomy is performed and the nephrostomy catheter is placed in a minimally invasive manner under fluoroscopic guidance over a hydrophilic guide wire and the cystotomy tube under direct visualisation. The SUB system does require ongoing monitoring and the manufacturer's current recommendations are for flushing of the system either under ultrasonographic or fluoroscopic guidance and sampling for urine bacterial culture on a three monthly basis and the owners should be made aware of this ongoing expense. The newest incarnation of this system now allows replacement of the nephrostomy and cystostomy portions of the tube without disruption to the renal capsule or bladder respectively.

   The learning curve reported with this procedure is less than with traditional ureterotomy. Fluoroscopy is mandatory for placement. There is currently not a significant volume of published literature on this technique although this is likely to change rapidly over the next few years. In a retrospective analysis of 14 cats, procedure complications were relatively infrequently and included leakage (3.5%), kinking (3%) and re-obstruction with a blood clot (3%). 95% of cats survived to discharge (Horowitz 2015). Berent et al recently presented an abstract detailing placement of SUBs in 137 cats (2009–2015). 96.4% were azotemic at presentation. Perioperative complications included device leakage (3.4%), kinking (5%), and occlusion with blood clot(s) (7.5%). A 93.7% survival to discharge was reported. There was again a reasonable post-operative complication rate. Catheter mineralization occurred in 25% of systems at a median of 364 days, with 13% requiring exchange due to re-obstruction.
   Dysuria was reported in 8.2% of cats at any time after surgery and a UTI was reported in 25% of cases, 8% of which became chronic.

Prognosis:

As previously stated, no pre-operative variables, including the magnitude of creatinine elevation, have currently been shown to be an accurate predictor of outcome (Roberts et al 2010, Horowitz et al 2013, Kulendra et al 2014). The vast majority of cats who are treated for a ureteral obstruction continue to have elevated creatinine levels post-surgery. In cats following stent placement, Berent et al (2014) reported that creatinine level at three months post-surgery was predictive for longer term survival. IRIS (international renal interest society) stage one cats had a survival time of 1,262 days versus 94 days in cats which were IRIS stage four. Kulendra et al (2014) reported a median survival time of 419 days in cats undergoing stent placement for management of ureteral obstruction. For cats following SUB placement the overall MST was 827 days (range, 1–2,397) and 65% eventually died of renal-related disease. Again IRIS stage at three months post-surgery was predictive for longer term survival.

Management of urethral obstructions:

Dogs:

There are a number of possible aetiologies underlying urethral obstruction in dogs and these include: urethral calculi, neoplasia (prostatic/urethral), granuloma, stricture, urethral trauma, prostatic disease and reflex dyssynergia. Of these urolithiasis is the most common and a number of significant risk factors have been identified depending on the stone type; urinary tract infection (e.g. struvite uroliths), sex (e.g. cysteine uroliths), breed (e.g. calcium oxalate uroliths in Yorkshire Terriers), obesity and urine retention. Struvite and calcium oxalate uroliths remain the most commonly reported. Clinical signs associated with urethral obstruction include polliakuria, unproductive stranguria, haematuria, an inability to produce a normal stream of urine, lethargy, bladder distension, abdominal discomfort and a previous history of urolithiasis or urinary tract infection. Total obstruction results in uremia within two to three days and subsequently death. Upon presentation, intravenous access should be obtained and appropriate fluid therapy and analgesia should be provided. As discussed previously, a NSAID would not be an appropriate choice of analgesic in a case such as this.

Diagnosis is usually made on the basis of contrast radiography. Haematology and biochemistry profiles may be normal unless the obstruction is complete or there is concurrent disease. Ionised calcium measurement should be performed if available as hypercalcemia is a risk factor for formation of calcium oxalate urolithiasis. Urinalysis including sediment examination and urine bacterial culture should also be performed. If a persistent urinary tract infection is suspected and cannot be proven with a routine urine culture, a bladder mucosal biopsy can be considered as this is a more sensitive method for confirmation of infection. The tissue sample should be wrapped in a section of sterile swab which has been moistened with a small volume of sterile saline to prevent the tissue drying out during transit.

Approximately one quarter of plain radiographs produce false negative findings when looking for uroliths and urethral calculi are the most commonly missed stones. Abdominal ultrasound can be used to identify uroliths in the upper urinary tract and bladder but cannot be used to accurately image the whole urethra. Documentation of the presence of bladder wall pathology, however, is very useful. Contrast radiography (retrograde (vagino)urethrogram or abdominal CT is therefore essential to determine the location and number of urethral stones. Be aware an accurate urolith count is only achieved approximately 50% of the time when radiography is performed. Once the location of the obstruction has been identified, an attempt should be made to retropulse the stone back to the bladder lumen for ease of removal. If the bladder is overly distended, decompressive cystocentesis can be performed prior to retrohydropulsion. This should be performed under general anaesthesia and a combination of warm saline and water soluble lubricant is the ideal mix.

For retrohydropulsion, a well lubricated rigid dog catheter should be inserted to the level of the obstruction. The size of catheter will vary with patient size but as large a size as possible should be chosen to ensure maximal urethral distension. An assistant should insert a lubricated gloved finger in to the rectum, identify the urethra and occlude the lumen. The surgeon should then distend the urethra with the saline/lubricant mix (compressing the tip of the penis to prevent back flow of the fluid). This creates a fixed section of urethra and distension of this will lift the urethra mucosa from the stone surface. When the assistant can feel distension of the urethral lumen under their finger, they should be instructed to release the luminal compression, allowing an influx of fluid retrograde towards the bladder lumen with a viewing the propelling the stone back to the bladder. This should be repeated multiple times to return all uroliths back to the bladder. A retrograde urethrogram should be performed once a urethral catheter passes easily to the bladder lumen to confirm all stones have been repositioned. Passage of a urethral catheter alone does not prove a completely unobstructed urethral lumen.

If the uroliths cannot be repositioned, options for management are either to obtain temporary urinary diversion for 24-48 hours to allow any urethral mucosal swelling to reduce via placement of a temporary cystostomy tube or urethrotomy to remove the stone from the urethral lumen.

If retrohydropulsion is successful and the uroliths are successfully returned to the bladder, they should be removed via a caudoventral midline celiotomy and cystotomy. Place stay sutures in the apex and lateral aspects of the bladder to minimise handling of the mucosa. If a positive bacterial culture has not been obtained prior to surgery, a small sample of the bladder wall mucosa can be submitted for bacterial culture. Bear in mind that uroliths will likely have fallen back in to the proximal urethra during positioning for surgery. Therefore it is important to flush the urethra from the tip of the penile urethra advancing the catheter slowly and flushing every few centimetres and repeat this several times. It is possible to pass a catheter past a urolith under some circumstances – ensure the catheter passes EASILY in both antegrade and retrograde directions prior to closure of your cystotomy.

If uroliths remain lodged in the urethra (most commonly at the caudal end of the os penis) and cannot be moved, an urethrotomy should be performed. This cannot be performed if the obstruction is within the os penis itself unless it is at the caudal end in which case sometimes a small pair of forceps can be passed from an urethrotomy incision caudal to the end of the os penis. Urethrotomy incisions can be performed in the perineal region but be aware the dissection is challenging and there is a significant amount of vascular corpora cavernosa tissue. For a pre-scrotal urethrotomy a 2cm skin incision is made caudal to the os penis and cranial to the scrotum. The retractor penis muscle is identified and retracted laterally. The urethra can be identified as a purple structure 3-4mm wide which is bordered in either side by white corpora cavernosa tissue. Incise over the urolith or catheter if possible (expect profuse haemorrhage which can usually be controlled with direct pressure) and remove the obstruction. Advance your catheter and flush both in both antegrade and retrograde directions. Cystic calculi can then be removed via a cystotomy if present. The author prefers to suture urethrotomy incisions (4/0 or 5/0 poliglecaprone or polydioxanone) in a simple interrupted or simple continuous pattern but second intention healing is also reported. More haemorrhage is reported when the urethrotomy incision is not closed. It should not be necessary to leave an indwelling urethral catheter in situ.

Permanent damage to the distal urethra, a persistent luminal obstruction or a history of repeated urethral obstruction due to chronic urolithiasis may lead the surgeon to opt to pursue permanent urinary diversion. In male dogs, urethrostomy can be performed at pre-scrotal, scrotal, perineal and prepubic locations. Scrotal urethrostomy is preferred as the urethra is relatively superficial and wider at this location and less haemorrhage is seen post-operatively. Expect profuse haemorrhage from the urethra upon incision but do not attempt to cauterise this. Firm pressure with a swab can help stem such haemorrhage. Take care not to traumatise the mucosa on the dorsal urethral wall when making your incision as this can lead to further haemorrhage. Ensure precision apposition of the urethral mucosa to the skin as this will reduce persistent haemorrhage post-surgery – start at caudal end as this is place which is most likely to be subject to subcutaneous urine leakage. At the end of surgery it should be possible to easily advance a catheter from the stoma site to the bladder.

An elliptical incision is made around the base of the scrotum or scrotal remnant and a standard castration and scrotal ablation performed. The retractor penis muscle is identified and freed from its attachments to the urethra then retracted laterally. The tunic of the penis is then tacked to the subcutaneous tissue using two rows of simple continuous suture to reduce dead space. A small incision is made through ventral wall of the urethra on the midline (ideally over a catheter) and the incision is then extended using fine scissors to 2.5-4cm length to ensure adequate stoma size post healing. The urethral mucosa is then apposed directly to skin using fine 4/0 or 5/0 non-absorbable suture (author prefers simple interrupted pattern).

Post-operative management and client education is important following scrotal urethrostomy. A rigid protection collar must be in place at all times. Haemorrhage from surgical site at the end of urination or at excitement should be expected on average for 3-7 days post-surgery and owners should be made aware of this as although it is usually self-limiting, it can be very dramatic and sedation can be required. Therefore it may be worth considering hospitalising patients during this period. The stoma should not be cleaned as this will lead to further haemorrhage. Short term complications include persistent haemorrhage, subcutaneous urine leakage which requires a second surgery and stricture formation. Long term complications include urine scalding of skin (pre-scrotal and pre-pubic locations) and an increased risk of urinary tract infection.

Uroliths should be submitted for analysis to determine the type. Spilt feeding is advised to reduce urine pH swings associated with eating and a specific diet should be chosen based on urolith analysis if appropriate. Increase water intake (aim for a USG of less than 1.020). If infection was previously documented, repeat cystocentesis and urine bacterial culture seven days after antibiotic course finishes to confirm resolution of the infection. Advise owners about weight reduction in obese patients and consider neutering in entire male dogs with cysteine uroliths (as androgens are a pre-disposing factor). Increase exercise to ensure more frequent urination and ensure regular urine sediment monitoring – initially monthly. Samples should be examined within one hour of collection (i.e. done in house) and not sent to an external laboratory for analysis as crystals may form during transit.

Urethral obstruction in cats is most commonly associated with urethral spasm and feline lower urinary tract disease (FLUTD). A full and frank discussion of FLUTD is beyond the scope of this webinar. Other causes of urethral obstruction in cats include urethral plugs, uroliths, stricture and trauma. Upon presentation, correct fluid and electrolyte disturbances and ensure adequate opioid analgesia. Attempted urethral catheterisation should be performed under general anaesthesia if at all possible. If the bladder is very full, consider cystocentesis prior to catheterisation. The site of obstruction is usually the penile urethra as it is the narrowest portion of the feline urethra. It is therefore useful to massage the penis within the prepuce to try and dislodge any urethral plugs. If a catheter will not pass, try to pass a blue Jelco catheter first and flush the urethra with sterile saline. Catheter selection is very important; rigid Jackson cat catheters lead to significant trauma and should be avoided if at all possible. Ideally a silicone cat catheter is recommended, particularly if you plan to leave the catheter in situ. Once the obstruction has been relieved, a retrograde urethrogram should be performed to identify any other pathology such as stricture or uroliths. The bladder should be lavaged with sterile saline or another such isotonic solution.

The duration of catheterisation remains controversial and a decision must be made on a case by case basis depending on the underlying pathology and the duration and severity of clinical signs. Eisenburg et al suggested a longer duration of catheterisation was positively associated with a reduced risk of repeat obstruction. The IDUC should be sutured in situ (if desired) and connected to a closed drainage system. Leaving an IDUC open to the environment is unacceptable and significantly increases the risk of urinary tract infection. Adequate analgesia should be provided and meloxicam can be introduced at an appropriate juncture depending on renal function. The use of a smooth muscle relaxant such as prazocin is also recommended. Diazepam can cause liver injury in some cats (Beusekom et al 2015) and therefore it's use should be carefully considered. Post-obstruction diuresis is a common finding after relief of a complete urethral obstruction and close monitoring of both electrolytes and fluid requirements is necessary. Cooper et al (2010) reported a technique for managing urethral spasm in male cats without placement of a urethral catheter due to financial constraints. This technique, involving use of sedation, analgesia, a calm environment and decompressive cystocentesis was successful in 11 of 15 cats. In cats with a recurrent history of obstruction or with an obstruction which cannot be relieved, permanent urinary diversion can be achieved via a perineal, transpelvic or pre-pubic urethrostomy. Owners should be made aware that such surgeries do not prevent clinical signs associated with FLUTD, they simply aim to avoid the life-threatening emergency of urethral obstruction.

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