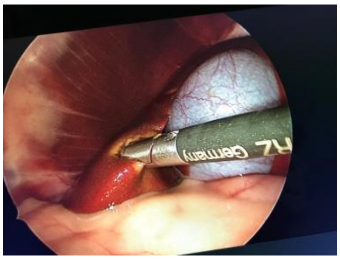
Minimally Invasive Surgery for Advanced Practitioners Mini Series

Session Two: Minimally Invasive Management of Urethral and Ureteral Obstructions

Matteo Rossanese DVM SPSA
CertAVP MSc MRCVS



Management of ureteral obstruction

Anatomy

The ureters are paired fibromuscular tubes that transport urine from the renal pelvis to the urinary bladder via peristaltic activity. The length and diameter of normal ureters are poorly documented and vary among species and breeds. The luminal diameter of a non-obstructed distal feline ureter is approximately 0.4 mm, whereas the normal diameter of the canine ureter likely varies depending on the size of the dog, a general guideline of 0.07 times the length of the body of the second lumbar vertebra whereas a computed tomographic (CT) study demonstrated an ureteral diameter of 2.0 to 2.5 mm in six dogs weighing 20 to 30. The diameter of a single ureter when distended measures 0.6 to 0.9 cm; the length of the ureter depends on the size of the animal but ranges between 12 and 16 cm. The ureters run caudoventrally; the right ureter lies just lateral to the caudal vena cava and may pass dorsal to the vena cava before returning to its typical course. Just cranial to their vesicular attachment, the ureters recurve slightly, resulting in a "J shape". The ureters then run obliquely within the wall of the bladder (intramural portion) toward the trigone before emptying into the lumen through slit-like or "horseshoe-shaped" orifices cranial to the internal urethral sphincter.

The ureteral blood supply originates from the cranial ureteral artery (coming from the renal artery) and the caudal ureteral artery (coming form the prostatic or vaginal artery). Autonomic nerves to the ureter arise from the celiac and pelvic plexuses.

Pathophysiology

The series of events that occurs after ureteral obstruction is complex, and even after relief of the obstruction, changes continue to occur. The degree and duration of obstruction affect the kidney's response and its recovery from obstruction. After unilateral obstruction, ureteral pressures increase and peak by 5 hours and remain increased 12 to 24 hours after obstruction, whereas renal blood flow diminishes to 40% over the first 24 hours and continues to decrease to 20% by 2 weeks. The increase in pressure is accompanied by a decrease in glomerular filtration rate whereas there is a compensatory increase in glomerular filtration rate in the contralateral kidney.

The duration of ureteral obstruction is inversely proportional to the degree of recovery of the kidney. In dogs that have suffered 1 week of obstruction, glomerular filtration rate returns to 65% of control values with a maximum recovery by approximately 5 weeks. Whereas dog that suffered of 2 weeks, glomerular filtration rate returns to only 46% of normal over 4 months. Slight, moderate, and severe tubular dilatation with interstitial fibrosis occur after 1, 2, and 3 weeks of obstruction, respectively. Based on these findings, early intervention to relieve obstruction seems critical to maximize recovery of renal function. Ideally, acute complete obstructions should be resolved within 4 days and partial obstructions within 14 days. Many of the animals with ureteral obstruction likely have some degree of underlying chronic kidney disease (CKD). Hence, preservation of all function should be a priority, because the baseline number of functional nephrons may be reduced before the initiation of the acute obstructive insult.

The improvement in GFR of obstructed kidneys after contralateral nephrectomy of a normal kidney is interesting. This finding suggests that there may be functional reserve present in the kidneys even after extended recovery periods. Obstruction of the ureter, particularly in cats, is increasing in veterinary medicine and this may be caused by a true increase in incidence or by better recognition of the condition.

Ureteral obstruction

History and clinical presentation

Clinical signs in cat suffering of ureteral obstruction are vague such as vomiting, lethargy, hyporexia, and weight loss. If the patient is severely azotemic then signs of uremia may be present such as polyuria, polydipsia, vomiting, anorexia, oral ulcerations, weakness. Dysuria is normally not observed unless an obstruction is present in the urethra or in the trigonal area. Pain during abdominal palpation of the affected kidney is more commonly seen in acute obstructions.

Clinical signs in dogs with a ureteral obstruction are typically associated with dysuria (incontinence, stranguria, hematuria, polyuria, pollakiuria) and systemic illness (vomiting, inappetance, depression, lethargy).

Diagnosis

On physical examination it is common to palpate 1 enlarged kidney and 1 small kidney in cats, whereas in dogs renal pain is more common and is typically associated with the concurrent pyelonephritis and capsular inflammation. Cats are often anemic (48%) due to concurrent CKD or from excessive blood sampling during previous hospitalizations. Dogs often have a moderate to severe neutrophilia due to pyelonephritis and thrombocytopenia has been reported in 44% of dogs (possibly secondary to sepsis or immune-mediated thrombocytopenia). Azotemia is common (83% of cats and 50% of dogs with unilateral obstruction) however the degree of azotemia does not appear to be associated with outcome if early decompression is undertaken.

Other findings in cats are hyperphosphatemia (54%), hyperkalemia (35%), hypercalcemia (14%), and hypocalcemia (22%). On urinalysis crystals were observed in the urine of 29% of cats (amorphous crystals and calcium oxalate being most common). Concurrent urinary tract infections are common in dogs (77%) but not in cats (33%). The most common cause or ureteral obstruction in dogs and cats is ureterolithiasis, however in dogs this is much less common if compared to cats. Other causes included congenital or acquired strictures, iatrogenic ligation, trauma, and solidified blood calculi. Calcium-containing stones are present in 98% of cats and greater than 50% of dogs. Compared to cats a much higher incidence of struvite uroliths exists in dogs, with a prevalence ranging between 20% and 30% of all nephroliths and ureteroliths. These differences in stone composition are important to consider when making treatment and prevention recommendations. Medical dissolution can be attempted in case of non nonobstructive struvite nephroliths and ureteroliths, whereas, given the negative consequences of ureteral obstruction on renal function, in case of obstructive nephropathy medical dissolution should not be attempted.

Diagnosis of ureteral obstruction often relies on routine imaging, including abdominal radiographs and abdominal ultrasound. Sensitivity to identify obstruction has been reported to be 60%-81% with radiographs and 77%-100% for ultrasound whereas specificity was 100% for radiographs and 30% for ultrasound. When the two modalities were combined sensitivity was 90%.

The benefit of the radiographs is to document stone size, number, location, and the presence of concurrent nephrolithiasis. Ultrasound is ideal for the documentation of hydroureter, hydronephrosis, and the exact location of the obstructive lesion. In case of stricture, blood clots or specific lesion within the ureter can be difficult to see. Bilateral ureteral obstructions are present in 19% of cats and 12.5% of dogs and one study documented 62% of cats had concurrent nephroliths are common in cats (62%) and in dogs (50%)

It is important to differentiate a real mechanical obstruction to other pathology causing renal pelvic and ureteral dilation such as diuresis, pyelonephritis, chronic kidney disease, and ectopic ureter. In a study a renal pelvis width greater than 13 mm in cats and dogs was only found in obstructive disease, even if a specific lesion is not seen on imaging. In cats, a ureteral diameter greater than 6 mm is likely consistent with obstruction. Occasionally obstructions in cats may be associated with minimal renal pelvic or ureteral distention. In equivocal cases where a diagnosis is not reached but an obstruction is still suspected, antegrade pyelography should be performed. Percutaneous antegrade pyelography allows better visualization of the renal pelvis and ureters than excretory urography, especially in cases of complete obstruction (100% sensitive and specific) and allows localization of the ureteral obstruction and aids in determining whether a complete or partial obstruction is present. Reported complications include renal hemorrhage, renal pelvic laceration, and renal pelvic clot formation. The use of diagnostic antegrade pyelography has declined tremendously as it is instead performed intraoperatively during obstruction relief.

Retrograde ureteropyelography is performed via cystoscopy and fluoroscopy by cannulating the UVJ and injecting

Contrast, in order to document ureteral patency, space occupying lesions, stone disease, tortuosity of the ureter, and the ureteral diameter. This seems to be more accurate than IV pyelography (IVP).

Computed tomography can be performed preoperatively and IV contrast can aid in concurrent differentiation of partial or complete obstructions. IVP is often not useful in animals with ureteral obstructions due to the poor filling of an obstructed kidney and the nephrotoxicity risk of the contrast material.

Treatments

Treatment options include medical management, surgery, and placement of stents or subcutaneous ureteral bypass devices (SUBs), renal transplant.

Medical management

It should be initiated following diagnosis of a ureteral obstruction, as stabilization is often required and a majority of cats will present with concurrent kidney disease and azotemia. Medical management may consist of intravenous fluids, diuretics, pain medications, and a1-antagonists. Medical management alone has been shown to be effective in a minority of cats; 13% responded based on decreases in creatinine concentration and 17% showed movement of the ureteral stones. Although the chance of complete stone passage it typically under 10%, medical management should be considered for 24 to 48 hours, unless contraindicated, because of risks involved with other interventions. If medical management is not successful in relieving the obstruction within 48-72 hours, more aggressive interventions should be considered to avoid excessive loss of renal function. Medical management consist of aggressive intravenous fluid therapy (careful about overloading the patients), the use of an osmotic diuretic (mannitol). Other medical considerations include amitriptyline, a-adrenergic blockade (prazosin or tamsulosin), or glucagon therapy.

All these options have not been widely documented. When medical management fails, or the patient is unstable (hyperkalemic, overhydrated, or oliguric) then immediate intervention should be considered.

Surgical management

Traditional surgical techniques include ureterotomy, neoureterocystostomy, and ureteronephrectomy however because of the reported morbidity and mortality associated with ureteral surgery (procedure-associated complications over 30% and mortality rates from 18% to over 30%, depending on the type of procedure performed or management necessary) and low success rate of medical management in the cat, other treatment modalities have been investigated including nephrostomy tubes, ureteral stents, and SUBs. Nephrostomy tubes are mainly used for short-term stabilization of animals before definitive therapy when prolonged anesthesia is contraindicated.

Ureteral stents are commonly used in dogs to relieve ureteral obstruction. The goals of ureteral stenting are:

- to divert urine from the renal pelvis into the urinary bladder
- to bypass a ureteral obstruction
- to encourage passive ureteral dilation which helps prevent reobstruction
- to decrease surgical tension on the ureter after/during surgery and prevent postoperative leakage
- to aid in extracorporeal shockwave lithotripsy for large obstructive ureteroliths or nephroliths that could result in serial ureteral obstructions if the stones do not completely pass down the ureter passively (Steinstrasse)
- to prevent the migration of nephroliths resulting in future ureteral obstruction.

Indications include treatment of benign and malignant ureteral obstructions. Endoscopic or percutaneous placement is commonly performed in the dog, whereas surgical placement is typically recommended in cats. The main type of ureteral stent used in veterinary medicine is an indwelling double pigtail ureteral stent

Ureteral stent placement

Ureteral stents are most often placed cystoscopically in dogs and, when possible, in female cats. This is done in a retrograde manner through the ureteral orifice at the ureterovescicular junction (UVJ) using cystoscopic and fluoroscopic guidance. They can also be placed antegrade, through the renal pelvis percutaneously or surgically.

Surgical stent placement is most common in cats via pyelocentesis (antegrade), a cystotomy to access the UVJ (retrograde), or through an ureterotomy (antegrade or retrograde).

The retrograde technique typically uses cystoscopy concurrently with fluoroscopy. An angled guidewire is advanced into the distal ureter from the UVJ and an open-ended ureteral catheter is advanced over the wire for a retrograde ureteropyelogram. When the catheter is in the renal pelvis, the catheter is marked at the level of the cystoscope port, then pulled back at the level of the UVJ and marked again at the cystoscope port. The two marks represent the length of the stent we need. The catheter is then completely withdrawn and an indwelling double pigtail ureteral stent is placed over the guidewire in the renal pelvis and the other curl is pushed into the urinary bladder with the entire shaft sitting in the ureteral lumen. A pusher over the wire is used to advance the stent into the renal pelvis and to push the remaining stent into the bladder.

The antegrade technique requires percutaneous or surgical pyelocentesis with a renal access needle or over-the needle IV catheter (18-G in dogs; 22-G in cats) under ultrasonic or fluoroscopy guidance or via surgical palpation. The guidewire is passed down the ureter guided by an ureteropyelogram, into the urinary bladder and out the urethra. This
is the typical approach when the ureteral orifice cannot be identified cystoscopically or where cystoscopy for retrograde ureteral access is not possible. The stent is then placed in a retrograde fashion over the wire, as previously described. Survived to discharge ranges from 92 to 98%. Long-term complications included recurrent infections (13-58%), tissue proliferation at the UVJ (6-42%), stent encrustation (4-8%), and stent migration (4-8%), ureteritis (6%) stent exchange (23%). Success rate for ureteral stent placement is 98% in dogs and 94% in cats

Given the minimally invasive nature of the procedure, stenting should be considered as an initial therapy for ureteral obstruction in dogs. Stents can typically be removed endoscopically if they are not needed long term or if complications occur. They are well tolerated in dogs with minimal lower urinary tract signs occurring.
In cats ureteral stents have been used in case of ureterolithiasis (71%), stricture (13%), stone and stricture (15%), and purulent plug (1%). Stenting was successful in 95% of ureters. 8.7% developed uroabdomen. Perioperative mortality was 7.5-9%. Long-term complications included reobstruction of ureters (11-19%), stent migration (6-14%), and dysuria (37%), chronic infections (26%), stent exchange (16-27%) for occlusion, migration, or irritation.
Ureteral stenting in cats can be performed successfully with reduced perioperative mortality compared with ureteral surgery alone. However ureteral stenting in cats is technically challenging and sometimes requires ureterotomy or neoureterocystostomy to complete because of the small size of the normal feline ureter (0.4 mm).

Subcutaneous ureteral bypass (SUB)
The SUB device (Norfolk Vet Products) has been designed to improve management of ureteral obstructions mainly in cats. The use of a SUB device for feline and canine patients with a ureteral obstruction can be considered a functional option for the treatment of all causes of ureteral obstruction. There is far more information on its use in feline than canine patients to date, and ureteral stents are still considered a less invasive and highly effective treatment option for canine patients
It consists of a locking-loop nephrostomy catheter placed in the renal pelvis or proximal ureter, a multi-fenestrated locking-loop cystotomy catheter placed at the apex of the bladder, and a subcutaneous port that connects the system allowing percutaneous access for flushing and drainage.

SUB placement
A surgical guide to the SUB procedure can be found on this link:
http://norfolkvetproducts.com/PDF/SUB/SUB2_Surgical_Guide_2018-03-email.pdf
A ventral midline coeliotomy is performed and the affected kidney and the bladder apex are exposed and isolated. The peri-renal fat is dissected from the caudal pole of the kidney exposing a 1-2 cm region of renal capsule. The nephrostomy catheter is placed first, under fluoroscopic guidance using a modified Seldinger technique.

An 18-gauge over-the-needle catheter is used to puncture the renal pelvis from previously exposed area of the kidney if pelvis is > 8mm (if the pelvis is < 8mm, then a ureterostomy catheter is typically placed, so an area of fat is dissected off the caudolateral aspect of the kidney). Once some urine is seen from the catheter the needle is removed, the T-port is placed A urine sample is obtained for culture before the use of the contrast. Then a syringe with contrast (diluted 50%) is used for a pyelocentesis and pyelogram. injecting into the renal pelvis to perform an antegrade pyelogram. Fluoroscopy is used to monitor the ureter to document patency and obstruction location. Then, a 0.035" J-tip guide wire is advanced through the 18-ga catheter and coiled inside the renal pelvis. The 18-gauge catheter is removed while the wire is carefully secured with a hemostat at the renal capsule to avoid losing wire access. The locking-loop nephrostomy catheter is advanced over the guide wire into the renal parenchyma. The hollow cannula is retracted as the catheter is advanced over the guide wire creating a pigtail inside the renal pelvis. Care is taken to ensure the black radiopaque marker is inside the renal pelvis as that marks the last fenestration of the catheter, which should always be within the renal pelvis. The locking string is then gently pulled to prevent catheter dislodgement.

The Dacron cuff is advanced down the nephrostomy catheter to the renal capsule and sterile cyanoacrylate glue is applied between the Dacron and the renal capsule.

The second locking-loop catheter is then placed. First, using 3-0 monocryl in a purse string suture pattern is made at the apex of the bladder. In the center of this purse string, a #11 blade is used to puncture a small hole into the bladder lumen. The locking- loop catheter is placed and the string is pulled. The string in the catheter is pulled and locked in placed, as described above for the kidney catheter. The Dacron cuff is sutured to the bladder wall and sterile cyanoacrylate glue is used to further secure the Dacron. Saline is infused through the hollow cannula and the seal is leak tested. The abdominal muscle on the side ipsilateral to the nephrostomy tube is exposed through a skin incision lateral to the laparotomy incision. The free ends of both catheters are tunneled gently through the abdominal wall and directed toward the port, with the nephrostomy catheter end toward the caudal barb and the cystostomy catheter end toward the cranial barb. Such positioning allows both catheters to maintain a gently curving transabdominal course in an effort to prevent kinking. The string end and catheter-barb junction on each side are covered with a boot, and the port is sutured to the body wall with nonabsorbable monofilament suture. Urine collection and fluid infusions through the SUB port are performed with a 22 gauge Huber needle to prevent damage to the silicone diaphragm.

Postoperative cares

After placement of any device a 2-week course of a broad spectrum antimicrobial therapy is typically recommended.

Routine urinary tract ultrasonography and radiography focusing on the renal pelvis diameter, stent location, ureteral diameter, and SUB catheters are performed to assure there is no evidence of migration, occlusion, or encrustation. Bacterial urine cultures should be obtained every 3 months for the first year then every 6 months thereafter. Flushing with sterile saline every 3 to 6 months to ensure patency and reduce encrustation. Patency can be confirmed by flushing under ultrasound guidance or with fluoroscopic pyelography. Overdistention of the renal pelvis must be avoided during flushing.

Complications of the SUB device include occlusion (approximately 13%) or blood clots (<3%), kinking (3%), and rarely urine leakage.

Infection has been reported with a rate of 8% to 10% and cats with preoperative infections are more likely to have postoperative infections. Because SUBs are often easier to place than stents in cases with minimal ureteral dilation and are associated with less dysuria, it is recommended to place SUBs rather than stents in cats with ureteral obstructions.

Postoperative management in patients with ureteral obstructions.

All patients should be monitored carefully. Cats are at particularly high risk of developing severe postobstructive diuresis and therefore are at a high risk for fluid overload. Placement an esophagostomy tube in all cats with ureteral obstruction during their decompressive procedure and caloric supplementation is begun as soon as the animal is ambulatory. Electrolyte and creatinine concentrations are followed carefully to prevent the development of hyponatremia. Analgesia as required. A chemistry panel should be checked daily to every other day until the cat's creatinine concentration has reached its lowest point. Intravenous crystalloids are used judiciously and gradually decreased over 72 hours once creatinine concentration decreases.

Persistent azotemia is a widespread problem after a successful intervention (over 40–50% of cats and 25–50% of dogs) and careful monitoring for renal disease progression, reobstruction, urinary tract infections, hypertension, hyperphosphatemia, and device malfunction is necessary.

Prognosis: The prognosis for renal recovery is variable depending upon the chronicity of the obstruction, the species, the cause for the obstruction, the method of fixation, the degree of obstruction, and the postoperative care.

Malignant Ureteral Obstructions

Bladder tumors are uncommon in the dog and rare in the cat. In the dog, transitional cell carcinoma is most common and frequently affects the trigone region. Most dogs die or are euthanized because of local progression and obstruction of the urinary tract rather than from metastatic disease. For dogs with ureteral obstruction, stenting of the affected ureter is performed. Because tumor typically obscures the UVJ, endoscopic placement is not performed in most cases. Instead, a percutaneous antegrade approach is used.

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Minimally invasive management for urethral obstruction

Urolithiasis

Minimally invasive techniques for urolithiasis, such as shockwave lithotripsy, ureteroscopy, and percutaneous nephrolithotomy, are now standard of care techniques that constitute primary treatment options. Calcium oxalate and struvite uroliths are the most commonly types of lower urinary tract stones in dogs and cats. Clinical signs could range from none to hematuria, pollakiuria, and stranguria. In some circumstances, patients present with a urethral obstruction and require emergency intervention. Medical dissolution can be considered in cases of nonobstructive bladder stones when radiographic findings, urinalysis, and urine culture results are suggestive of a composition of struvite, urate and cystine cystoliths. Cystotomy has been the treatment of choice for lower urinary tract stone removal. However, following cystotomy, reported risk of suture-induced stone formation is up to 9%. Nowadays removal of these stones with minimally invasive techniques is recommended by the ACVIM consensus recommendations on the treatment of uroliths in dogs and cats. Techniques described include voiding urohydropropulsion, cystoscopic-guided basket retrieval, cystoscopic-guided laser lithotripsy, and percutaneous cystolithotomy (PCCL). All these techniques have the potential complication of bladder rupture or leakage of urine inside the abdomen and therefore all patients undergoing one of these procedures should have a negative urine culture before the procedure. Voiding urohydropropulsion has been described for removal of small cystoliths in dogs and female cats. Using this technique, cystoliths less than or equal to 3 mm can generally be removed in female cats and in male dogs, and those that are less than or equal to 4 to 5 mm can be voided from female dogs. This technique is not indicated in male cats. Hematuria is common following the procedure and typically self-resolves within a few hours to days. Other possible complications include incomplete stone removal and urethral obstruction. All stones removed should be submitted for analysis to allow optimal prevention strategies.

Cystoscopic-Guided Basket Retrieval

This technique can be used in dogs and female cats and involves transurethral cystoscopic evaluation of the lower urinary tract followed by urolith basket retrieval. A basket is introduced within the working channel of the rigid or flexible cystoscope and advance toward the stones, the basket is fully deployed and can be used to encircle stones. Once a urolith is grasped, the basket is closed and gently pulled back to the cystoscope, and the cystoscope and basket retrieval device are simultaneously removed from the lower urinary tract. It is important not to force the removal of stones that are too big to pass through the urethra, which could lead to urethral tears. Basket removal is not recommended in cases in which there is a large number of stones present because of the repeated trauma to the urethral mucosa as stones are being removed. Percutaneous cystolithotomy should be considered in these cases to avoid urethral trauma. Cystoscopic-guided stone basket retrieval is highly successful for the removal of uroliths.

Cystoscopic-Guided Laser Lithotripsy

Laser lithotripsy is a minimally invasive technique used in veterinary medicine for the fragmentation of stones that are larger than the urethral diameter. It involves transurethral cystoscopic evaluation of the lower urinary tract followed by intracorporeal laser lithotripsy in which uroliths are fragmented into smaller pieces and removed via voiding urohydropropulsion and/or basket retrieval. This treatment modality is indicated in dogs and female cats. Laser causes stone fragmentation via generation of photothermal energy. Various laser types are available, but the Hol:YAG is more commonly used and it can be used to fragment uroliths of any type located in the urinary bladder or urethra. The Holmium:YAG (yttrium, aluminum, garnet) laser as its energy is absorbed by fluid and can therefore be used in close proximity to the mucosal wall without causing significant damage, including tight locations within the urethra.

Complete removal of uroliths is reported in 83% to 100% of female and 81% to 87% of male dogs following laser lithotripsy. Based on stone location, 100% removal was documented when urethroliths were reported, 79% of dogs with cystoliths, and 76% of dogs with a combination of cystoliths and urethroliths.

Female cats and dogs are generally positioned in dorsal recumbency and male dogs in dorsal or lateral recumbency for cystoscopy and laser lithotripsy. When the stone to be fragmented is localized, the laser fiber is introduced within the working channel of the rigid or flexible cystoscope and advanced until it is exteriorized at the tip of the cystoscope. During lithotripsy, the laser fiber is advanced until it touches the stone, avoiding contact with the mucosa. Fluid irrigation is used to maintain visualization of the urolith and to dissipate heat near the tip of the laser fiber. Following stone fragmentation, voiding urohydropropulsion and/or basket retrieval are used to remove the smaller fragments.

This procedure is safe and effective in dogs and female cats. Complications typically occur during or within 24 hours of the procedure: hematuria and the need for an indwelling urinary catheter caused by urethral swelling causing a partial or complete urinary tract obstruction are the most common reported. Others include perforation of the bladder wall during voiding urohydropropulsion, urethral tear, and urethral stricture. This technique should not be recommended in animals with a large stone burden or large stones because of concerns for urethral trauma and excessive anesthesia time relative to other treatment strategies.

Percutaneous Cystolithotomy (PCCL)

It is a minimally invasive procedure used as an alternative to open surgery for bladder calculi removal. This technique can be performed in both female and male cats and dogs, of any size. PCCL allows the removal of stones located both in the bladder and the urethra.

The patients can be discharged within 24 hours following the procedure and no postoperative complications have been

reported. Advantages of this procedure include the ability to fully distend the bladder to inspect the bladder and urethra for the presence of residual uroliths while causing minimal hemorrhage, inflammation, trauma, and limiting bladder manipulation. There is an approximately 4% risk of incomplete stone removal, compared to up to 20% with a normal cystotomy. Patients are positioned in dorsal recumbency and are aseptically prepared. A urinary catheter is passed into the urethra and bladder. The bladder is fully empty and then distented with saline till the apex is palpated. A small midline skin incision (1.5–2 cm) and abdominal incision (1–1.5 cm) are made over the apex of the bladder. The bladder is grabbed and held at the level of the incision with stay sutures.

A small stab incision is made into the bladder and a threaded cannula (5-6mm) is advanced into the incision. A rigid cystoscope is then passed through the cannula to allow identification of the uroliths and evaluation of the bladder mucosa. The cystoscope is removed and the uroliths are suctioned while saline is simultaneously being infused through the catheter. For larger uroliths, retrieval of the stones via the cannula using a basket retrieval device can be used. When all uroliths have been removed, a cystoscope is used to perform a final inspection of the bladder. Ideally a flexible cystoscope is then advanced into the urethra to ensure retrograde flushing of any residual urethroliths. The bladder, abdominal, and skin incisions are closed using standard technique. Possible complications associated with this procedure include urine leakage, incomplete stone removal, and other complications reported with cystotomies.

Interventional management of urethral obstructions

Lower urinary tract obstruction is a common cause of morbidity and mortality in small animal patients. Urolithiasis in dogs and obstructive feline lower urinary tract disease (FLUTD) in cats are the most common causes of lower urinary tract obstruction, and these conditions can be managed through a combination of medical, environmental, dietary, and surgical intervention.

Other conditions causing urinary obstruction including neoplasia and benign urethral strictures. These conditions can be challenging and occasionally can need long-term urinary diversion or complex surgical interventions. The introduction of urethral stent offers therapeutic alternative to the traditional treatment methods. However patient selection is critical to improve the final outcomes. Stent placement is performed using image guidance, with fluoroscopy being preferred, although digital radiography is a described alternative.

Urethral stents are placed almost exclusively via a retrograde approach using the urethral orifice, but an antegrade access approach is also possible.

Stabilisation of the patient prior to any surgical intervention is mandatory

Urinary obstruction can be life-threatening due to hyperkalemia, metabolic acidosis, and uremia. Medical management is therefore critical before definitive intervention. Initial stabilization could include volume expansion (isotonic crystalloid solutions or 0.9% saline) to restore intravascular volume, treat dehydration, and rapidly dilute the elevated

concentration of potassium in the blood. Calcium gluconate works to protect the heart from the effects of hyperkalemia. Insulin and dextrose to redistribute potassium intracellularly. Sodium bicarbonate (over 30 minutes) will also help redistribute potassium intracellularly while also managing severe metabolic acidosis. Urinary diversion via a urinary catheter or cystostomy tube has a very slow effect on lowering serum potassium concentration and is generally delayed until hemodynamic stability has been achieved.

PATIENT SELECTION FOR URETHRAL STENT

The cause of the urethral obstruction must be determined: historical findings; physical examination findings, including a rectal examination to evaluate the pelvic urethra and a vaginal examination in females; radiographic; ultrasonographic; urethrocystoscopic (with biopsy); and positive contrast urethrocystographic imaging allow for the determination of the underlying cause of the lower urinary tract obstruction.

Urethral stents can be placed in case of:

- Benign urethral obstruction associated with previous urethral trauma (including iatrogenic), previous surgery, reflex dyssynergia, and proliferative urethritis.
- urethral obstruction due to transitional cell carcinoma (TCC), prostatic carcinoma, leiomyoma, or other neoplastic conditions of the urethra.
- External urethral compression secondary to metastatic intrapelvic lymphadenopathy.

It is mandatory to determine if the patient is actually obstructed. Animals with lower urinary tract neoplasia often have

stranguria and pollakiuria due to local inflammation and the presence of the mass and these signs are identical to those that are truly obstructed. Only about 10% of dogs with lower urinary tract neoplasia develop urinary obstruction. Having a large, firm, and/or painful bladder and/or a decreased urine production lead to a possibly obstruction however when only lower urinary tract signs predominate diagnosis is much more complicated.

Failure to empty the bladder or dog with a poor urine stream likely have a partial obstruction, and stent placement can be considered.

Investigation for patient with suspected partial or complete urinary obstruction should include complete blood count, serum biochemical profile, urinalysis, and urine culture. Radiographic or computed tomographic assessment of the chest and abdomen. Ultrasonographic assessment of the bladder and upper urinary tract. Dogs with concurrent ureteral and urethral obstruction will require an upper urinary tract intervention (stent or subcutaneous ureteral bypass) concurrent with urethral stent placement.

PLACEMENT OF THE URETHRAL STENT

Urethral stent placement is optimally performed with the aid of fluoroscopic guidance. Urethral stent placement can be performed in female cats using the same techniques described for dogs however male cats (with no perineal urethrostomy) may require normograde access to the urethra via the bladder due to the small urethral size, which is less than the size of the self-expanding stent delivery system. General anesthesia is required and perioperative antibiotics should be used.

The patient is positioned in either right or left lateral recumbency depending on the layout of the imaging suite where the procedure is being performed. A 5Fr marker catheter is advanced into the rectum and up the descending colon using fluoroscopic guidance. The marker should be positioned at a level from mid-bladder through the pelvic urethra. Aseptic technique with a routine surgical preparation is required.

If the patient has an indwelling urinary catheter with an open end, a 0.035” angled tip, standard stiffness, hydrophilic guidewire may be advanced up the catheter and into the bladder. The catheter is then removed over the guidewire. If

the patient does not have a urinary catheter in place, the wire may be advanced up the urethra and coiled in the bladder.

Urethrocystoscopy may also be used to facilitate wire access to the bladder if needed.

A 4 to 10 cm 6 to 8F vascular sheath and dilator should be advanced over the wire and into the urethra (male) or bladder (female). The dilator is removed and, in the male, the sheath is secured to the prepuce with suture.

The vascular sheath will serve as a port for repeated reintroduction of different devices necessary for the procedure and will also partially occlude the urethra. In the female dog, in addition to these functions, the vascular sheath is also used to perform urethrography. A percutaneous antegrade access may be required if retrograde access is not possible.

The bladder has to be distended and a cystourethrography performed. In the male dog, a 4 to 5Fr Berenstein catheter is advanced over the wire and through the vascular sheath. The wire is removed and the bladder is distended with iodinated contrast medium in saline. Failure to distend the bladder will result in an inability to discern the trigone from the proximal urethra and will result in malpositioning of the stent within the bladder. The entire urethra should be imaged retracting the catheter. The goal of this phase of the procedure is to achieve maximum dilation of the urethra such that the maximum diameter of the healthy urethra adjacent to the area of obstruction can be determined and so that the length of the obstruction can be measured.

In the female dog, the vascular sheath and dilator will usually extend into the bladder neck or bladder; the wire remains in place all the time to maintain bladder access.

Urethral stent measurement: the location of the obstruction should be identified, and its location recorded and measured in relation to anatomic landmarks and to a marker catheter placed into the colon. Measurements of the length of the obstruction and the diameter of the normal urethra both cranial and caudal to the obstruction are obtained. If the cranial aspect of the obstruction is in the bladder, the caudal normal urethra diameter is used to determine stent diameter. Remember to calibrate the imaging system, this is a common source of error in determining appropriate urethral stent size.

Stent selection

A laser-cut, self-expanding metallic (nitinol) stents (SEMS) are most commonly used for relieving malignant urethral obstructions. It is important to remember that these stents do not foreshorten on deployment, so the length on the delivery system will be the same as their deployed length. Stent diameter should be chosen to exceed the adjacent urethral dimension by 0% to 20%. The length of the stent is chosen to exceed the length of the obstruction by approximately 1 cm on either side of it.

In case of benign urethral obstruction (stricture, reflex dyssynergia and proliferative urethritis) dogs can be treated with both balloon dilation and urethral stent placement. SEMS are generally recommended for urethral stricture; tissue ingrowth may occur in some patients resulting in recurrent obstruction and use of a covered SEMS (CSEMS) will prevent this.

Stent deployment

The external surface should be lubricated with saline and all ports flushed with saline. The stent is advanced over the wire and centered on the area of known obstruction. It is important to remember that laser cut urethral stents are not reconstrainable, they cannot be recaptured or repositioned once deployment has been initiated. The stent is deployed by simply withdrawing the outer sheath that covers the stent allowing it to expand.

If the cranial aspect of the obstruction is in the bladder neck, in which case the cranial most aspect of the stent should be advanced just into the bladder and deployed until it achieves a conical appearance (about 0.5–1 cm). Back tension is then applied to the delivery system to pull the stent back into the area of obstruction and the remainder of the stent is deployed across the obstruction. Maintaining some tension is critical to prevent the stent from being deployed into the bladder. If the obstruction extends the entire length of the urethra (often in female dogs), the only option is to stent the entire urethra or to stent approximately 2/3 to 3/4 of the urethra. If the obstruction extends into the vagina, the stent will need to be deployed to extend to the caudal most aspect of the obstruction.

Post deployment

Retrograde urethrocystography may be performed and contrast should flow unobstructed into the bladder. Once done, all devices should be removed from the urinary system. At the end of the procedure gentle pressure to the bladder should be applied to visualize unobstructed expression of urine. Urinary catheters should be avoided after stent placement to avoid trauma to the stent or entanglement of the stent and urinary catheter. Dogs should be monitored until it is confirmed that they are effectively emptying the bladder and the degree of urinary continence can be assessed. Pain medication after this procedure is generally not necessary.

Complications and outcomes

The stent only relieves the obstruction and palliates the patient. However, the period of good quality of life is prolonged.

Incontinence is a significant risk after urethral stent placement, which can range from mild to severe. Most animals will be continent after urethral stent placement and estimates of incontinence rates range from 25% to 64%. Laser cut urethral stents cannot be removed once placed. Patients that are incontinent before stent placement likely they will be incontinent after placement. If incontinence persists beyond 1 week, therapy with phenylpropanolamine or use of a bulking agent may be considered. Bladder atony can be present in cases of chronic obstruction. Once the obstruction is relieved, bethanechol may be administered to improve tone of the urinary bladder. In dogs with malignant obstruction, some degree of the stranguria present pre-procedure and intermittent haematuria may persist after procedure.

Overgrowth of tumor beyond the stent, or development of a new mass beyond the stent is probably less than 10%. Malignant masses can progress to involve ureters leading to ureteral obstruction. Chemotherapeutics and the use of nonsteroidal anti-inflammatory medications are expected to prolong life in dogs with neoplastic obstruction. Animals with benign urethral obstruction are expected to survive independent of their underlying condition.

Percutaneous Antegrade Urethral Access

Performed when standard retrograde technique is not possible. Often due to trigonal and urethral neoplasia and urethral disruption due to trauma or iatrogenic causes. Also used to gain access to the proximal urethra and trigone for stent placement in male cats where the standard delivery system may be too large to deliver the stent retrograde.

The patient is positioned in lateral recumbency. Using fluoroscopic guidance, a suitable puncture site on the ventral aspect of the apex to body of the bladder is identified. Blunt dissection will help decrease tissue drag. The bladder is punctured using an IV catheter at an angle such that the bevel is directed toward the trigone. Sterile, iodinated contrast is infused such that the trigone is clearly visible. An angled, standard stiffness, wire is advanced through the catheter and directed toward the trigone. The wire is advanced across the region of pathology and allowed to exit the urethral orifice. For retrograde catheterization, this is performed over the wire. For stent placement this can be done either antegrade or retrograde.

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