MANAGEMENT OF FELINE URETERAL OBSTRUCTIONS: AN INTERVENTIONALIST’S APPROACH
Dr. Allyson Berent, DVM, DACVIM
The Animal Medical Center, New York, NY

Ureteral disease can create a significant dilemma in our feline patients. The relatively common incidence of ureteral disease, combined with the invasiveness and morbidity associated with traditional surgical techniques, makes the investigation of minimally invasive alternatives appealing. Interventional radiologic (IR) and interventional endoscopic (IE) techniques, like ureteropyelography, percutaneous nephrostomy tube placement, ureteral stenting and subcutaneous ureteral bypass (SUB), have aided tremendously in the ability to simultaneously diagnosis and treat ureteral obstructions in a minimally invasive manner. Endourologic procedures are considered standard of care in human adult and pediatric surgery and are currently being applied in veterinary medicine. This talk will focus on the diagnosis, management and treatment of cats with ureteral obstructions of various causes through the use of interventional approaches as an alternative treatment modality. Data from over 100 consecutive cases treated interventionaly will be reported and discussed.

HUMAN URETERAL INTERVENTION

In human urology, the development and improvements in ureteroscopy, ureteral stenting, extracorporeal shockwave lithotripsy (ESWL), laser lithotripsy, laparoscopy, and percutaneous nephroureterolithotomy (PCNUL) have almost eradicated the need for open ureteral surgery for stone disease, strictures, trauma, and neoplasia. Currently, ureteroscopy is the first line evaluation of ureteral neoplasia, upper tract essential hematuria, ureteral calculi > 5mm, and evaluation for ureteral obstructions. Ureteroliths < 5 mm have a 98% chance of spontaneous passage with medical management alone. For larger stones, or those that do not pass spontaneously, ESWL is effective in 50-81% of cases, though most of the literature suggests this number is closer to 50-67%. Ureteroscopy has a near 100% success rate when Holmium: YAG laser lithotripsy is used. PCNUL has been successful for large proximal impacted ureteral stones. Ureteral stenting was first introduced in 1967 for evaluation of human patients with malignant ureteral obstructions. They are still widely used to treat both benign and malignant obstructive disease and this is considered standard-of-care. Ureteral stenting for stone disease is typically done after ureteroscopy for post-scoping spasm and edema, and in children a stent is routinely placed prior to ureteroscopy to allow for passive ureteral dilation in anticipation of immediate ureteral bypass, spontaneous stone passage, or the ease of extracorporeal shockwave lithotripsy.

The use of a subcutaneous nephrovesicular ureteral bypass device has been reported in approximately 50 human patients. The first reports were focused on the use of this device for malignant neoplasia where reconstructive surgery or ureteral stenting had failed or was not possible. More recently, this device is reported for use after renal transplantation induced ureteral strictures and in cases where stenting or surgery is not a feasible option. The use of this device was met with very few complications and long-term patency rates were considered excellent.

FELINE URETERAL OBSTRUCTIONS

Greater than 98% of feline ureteroliths have been documented to be composed of calcium oxalate, which is a trend from decades prior. This means that these stones will not dissolve medically, and either need to pass spontaneously, remain in place, or be removed. Once medical management fails (traditionally: intravenous fluid therapy, mannitol CRI and alpha-adrenergic blockade +/- amitryptilline or glucagon therapy), partial obstructions are often monitored and left in place due to the risk benefit ratio of attempted surgical removal. If there is a complete ureteral obstruction, decompression of the renal pelvis becomes imperative in order to preserve renal function to the ipsilateral kidney. Following a ureteral obstruction, studies have shown the ureteral pressures increase immediately resulting in dramatic changes in both renal blood flow and glomerular filtration rates (GFR). This increase in pressure generated by the ureteral obstruction is transmitted to the entire nephron and a decrease in glomerular filtration rate (GFR) occurs via concurrent vasoactive mediator release,
leukocyte influx, and subsequent fibrosis. The longer the ureter remains obstructed, the more damage that occurs, which is irreversible. In a study of normal dogs, it was found that after 7 days of obstruction the GFR was permanently diminished by 35%. When the obstruction lasted for 14 days the GFR was permanently diminished by 54%. These numbers were in a normal dog model without any pre-existing azotemia, chronic interstitial nephritis, or chronic obstruction. Extrapolation of a worse outcome might be expected in our feline patients, making aggressive and timely intervention worth considering.

Traditional intervention for ureterolithiasis has been accomplished surgically via ureterotomy, neoureterocystostomy, ureteronephrectomy, and renal transplantation. Kyles et al. reported two nice retrospective studies in a large number of cats. There were high procedure associated complications (over 30%) and mortality rates (18-39% depending on the type of management) documented. This study was from two universities that have extensive expertise with ureteral surgery (UC Davis and NCSU). The morbidity and mortality may be higher in environments where operating microscopes and microsurgical experience is not as available. Many of the associated complications with surgery are due to site edema, recurrence of stones that pass from the renal pelvis to the surgery site, stricture formation, and ureterotomy-associated or nephrostomy tube-associated urine leakage. In one study, over 10% of cats that survived their complications required a second surgical procedure during the same visit and 30% of those cats were then subsequently euthanized or died for serial complications associated with their ureteral stones/surgeries. Of the cats that had long term imaging follow-up, 40% had evidence of ureteral stone recurrence. Eighty-five percent of the cats with ureteral stone recurrence had evidence of nephrolithiasis at the time of the first ureteral surgery. The number of animals that did not have stone recurrence with prior nephrolithiasis was not evident in that study. Chronic kidney disease was found to be common at the time of diagnosis (>75% were azotemic with a unilateral obstruction), and persistent azotemia is a widespread problem after a successful intervention (over 50-80% of cats). Though, with all of the surgical concerns, the survival rates were dramatically higher for cats that had surgical intervention performed when compared to those treated with medical management alone. Medical management has been shown to be effective in a minority of cases (8-17%), but should be considered prior to any intervention, particularly for stones in the distal 1/3 of the ureter, and for stones smaller than 2-3 mm. This large series was in cats in which surgery was performed or attempted. Over the past 5 years the number of stones found in the ureter and kidney have been much greater (median of 6 stones per ureter in our study, Berent et al, ACVIM 2009, ECVIM 2011), with over 85% of cats having evidence of associated nephrolithiasis. This has made a majority of the cases (nearly 80%) not considered good surgical candidates.

Feline ureteral strictures were recently reported in 10 cats. Ureteral strictures can occur for various reasons, some of which include secondary to a previous surgery of the ureter for stone disease, from a stone getting embedded in the ureteral mucosa, as a congenital abnormality, or as an idiopathic process, possibly associated with a circumcaval ureter. Most ureteral strictures were found to occur in the very proximal ureter (<2.5 cm from the renal pelvis), in which traditional surgical approaches were difficult requiring re-implantation with renal desensus and psoas cystopexy or a ureteral resection and anastomosis. With a cat ureter being 0.4 mm in luminal diameter, this can be a very challenging situation, particularly in a potentially unstable patient.

Finding an alternative that results in immediate decompression and stabilization of the kidney, while concurrently allowing patency to be established for any cause of ureteral obstruction (stone, numerous stones, stricture, debris, blood clots, blood stones, etc) is ideal. The use of interventional radiologic techniques, either minimally invasively, or with surgical assistance, has aided in circumventing the complications of ureteral surgery alone (peri-operative leakage, stricture, re-obstruction, etc), particularly in cases that are not considered good surgical candidates. IR techniques have allowed successful and efficient stabilization of the patient regardless of the cause of ureteral obstruction, while decreasing renal pelvic pressure and stopping the cycle of pressure induced nephron damage and loss.
EQUIPMENT

Flexible and rigid endoscopes are needed for endourologic ureteral procedures. Rigid cystoscopy can be used in female cats to gain retrograde ureteral access and aid in stent placement. The rigid endoscope that we use is approximately 12 French with a 30 degree lens angle. This is more commonly used in dogs than cats, but has been successful in female cats as well.

A traditional fluoroscopic C-arm is sufficient for visualization and ureteral intervention. A mobile C-arm has the ability to move the image intensifier and gain various tangential viewing of the renal pelvis and ureter. Ultrasonography is useful for percutaneous renal access in order to cannulate the ureter in an antegrade manner, to perform percutaneous nephroureterolithotomy, or for the placement of a percutaneous nephrostomy tube. In cats, most of the procedures we will discuss are done with surgical and fluoroscopic assistance, making ultrasound unnecessary. Various guidewires and catheters are also needed to maintain access across the ureter, with a 0.018” hydrophilic angle-tipped hydrophilic guidewire the wire of choice for ureteral stent placement.

Double pigtail ureteral stents come in various shapes and sizes and we recently developed a feline ureteral stent that we have found to make the procedure dramatically more efficient and successful (2.5 Fr x 12, 14 or 16 cm) (Vet Stent-Ureter: Infiniti medical, LLC). These stents are polyurethane catheters that can be easily removed if necessary. The nephrostomy tubes we recommend require the use of a 0.035” hydrophilic angle-tipped wire and a 6 French locking loop pigtail catheter, with the smallest loop possible. This is recommended to be placed under fluoroscopic guidance. The subcutaneous ureteral bypass device (SUB) is currently under development for use in cats and dogs and requires a 6 French locking loop pigtail catheter, a prototype male-male shunt, and a cystostomy catheter.

PERCUTANEOUS NEPHROSTOMY TUBE PLACEMENT

Ureteral obstructions secondary to ureteroliths or malignancy can result in severe hydronephrosis and/or life-threatening azotemia when presenting bilaterally, or in animals with concurrent renal insufficiency/failure. Some patients can be managed medically with supportive care until a ureterolith passes, others may require surgery to avoid permanent damage and/or hemodialysis for stabilization prior to a prolonged anesthesia for ureteral surgery. Ureterotomies, or other interventions, can be relatively prolonged and complicated procedures in these debilitated patients with an unclear outcome of residual renal function. One possibility is to place a nephrostomy tube percutaneously, or surgically, to quickly relieve the obstruction and determine whether adequate renal function remains before prolonged anesthesia for ureteral surgery, ureteral stent or SUB placement. A locking loop pigtail catheter is recommended (5 or 6 French) to decrease the risk of inadvertent tube removal or urine leakage. Historically, nephrostomy tubes have been met with much resistance due to the high risk of post-placement complications (over 50%). These complications were usually due to premature removal or dislodgement, urine leakage, or poor drainage. With the advent of sturdy, multi-fenestrated tubes, that form a loop that will lock the catheter in the renal pelvis, these complications seem to have declined dramatically. We recently reported on the use of the locking-loop pigtail catheter in 20 patients. One patient developed leakage into the subcutaneous space and the remaining catheters worked without complication. (Berent et al, JAVMA, in press 2011). These catheters were deemed to be safe, effective and well tolerated in both dogs and cats.

This procedure is done either surgically under fluoroscopic guidance or percutaneously under ultrasound +/- fluoroscopic guidance. A renal access needle is used for pyelocentesis and a ureteropyelogram. Then a guidewire is passed through the needle under fluoroscopic guidance, and coiled into the dilated renal pelvis. The pelvis should be larger than 1.0 cm to allow the pigtail to curl easily in the renal pelvis. The locking loop pigtailed catheter is then advanced over the guidewire into the renal pelvis and the curl is formed. Once the curl in the renal pelvis is made the pigtail is locked and the catheter is secured to the body wall for tract formation. When done surgically, a nephropexy is performed using 3-0 PDS suture. The catheter is securely sutured to the skin by a Chinese finger trap suture pattern. This should remain in place for 2-4 weeks for tract formation if done percutaneously. This allows for external renal drainage, to assess azotemia resolution, and patient stabilization prior to a more permanent fixation of the ureteral obstruction. It also allows for immediate decompression, which is worsening the renal failure due to the increased hydrostatic pressure. Hemodialysis,
which also allows for immediate patient stabilization does not decompress the renal pressure that is present. During nephrostomy tube placement, the guidewire maybe be able to be advanced down the ureter, and if it bypasses the obstruction, and through-and-through access is obtained, ureteral stenting can be attempted during the same procedure. It is recommended that this procedure be done surgically in cats and percutaneously in dogs due to the high mobility of the feline kidney.

**URETERAL STENTING**

Ureteral stenting has been performed for a variety of disorders in both dogs and cats (over 170 cases to date). The goal of ureteral stenting is to divert urine from the renal pelvis into the urinary bladder during a ureteral obstruction (ureterolithiasis, obstructive neoplasia, ureteral stricture/stenosis, dried solidified blood clots or severe obstructive pyelonephritis). Stents also encourage passive ureteral dilation (for ureteral stenosis/strictures or future ureteroscopy, extracorporeal shockwave lithotripsy [ESWL], etc). The double pigtail stent, which is the stent of choice in cats, is completely intracorporeal, and can remain in place long-term maintaining ureteral patency and passive ureteral dilation (a 0.4 mm ureter was documented to dilate to 1.5-2.0 mm within 3-7 days in over 90% of cats). Each loop of the pigtail is curled (one in the bladder and one in the renal pelvis), allowing for direct urinary diversion from the kidney to the urinary bladder, around the stones, or through the stricture.

In female cats access is either attempted via cystoscopy in a retrograde manner or surgically in an antegrade manner. In most cats (male and female) the procedure is done surgically via a ventral midline incision. The affected kidney is isolated and using a 22ga. intravenous catheter the renal pelvis is punctured through the greater curvature of the kidney. Under fluoroscopic guidance, urine is sampled for culture and an antegrade ureteropyelogram is performed. Through the catheter, a 0.018” angle-tipped hydrophilic guidewire is passed down the ureter, around the obstruction and into the urinary bladder. A small (3mm) cystotomy is performed to retrieve the guidewire so through-and-through access is obtained. Once the ureter is measured, a stent length is chosen. Then a ureteral dilation catheter is advanced over the guidewire from the renal side down the ureter and into the bladder. Once this is successfully passed the obstruction and is through the ureterovesical junction (UVJ) into the urinary bladder, the ureteral stent is advanced onto the guidewire from the kidney side. This is then advanced over the guidewire as the ureteral dilation catheter is carefully removed through the bladder side. Care should be taken to gently hold the ureter at the UVJ. Once the stent is through-and-through, it is carefully placed so that the proximal loop is inside the renal pelvis and the distal loop is inside the urinary bladder and the guidewire is then removed. The details of this procedure will be expanded upon in the lecture.

This procedure requires special training and experience using wires, catheters and stents and is not recommended in all patients with a ureteral obstruction. The learning curve is very steep and the procedure should not be performed until the operator is comfortable with the risks that are associated. If the operator is not comfortable placing a locking-loop pigtail catheter for a nephrostomy tube then this procedure should not be attempted because if stent placement is not successful the ureter will experience severe edema and spasm and will be acutely obstructed, requiring another mechanism of drainage until another procedure can be performed the following few days. In over 80 cats stented to date, the success in placement is 95% (either endoscopically or surgically). Over 80% of the cases were considered poor surgical candidates based on stone number, location, stricture location, concurrent number of nephroliths and patient stability. There was a median of 6 stones per ureter and 86% had concurrent nephroliths. Ten of eighty had primary ureteral strictures and 19/80 had stones with a suspected ureteral stricture. Ninety-four percent of cases had significant improvement in their azotemia and the peri-operative mortality rate was 8%, none of which died of surgical complications or due to their ureteral obstruction. The short term complication rate (<1 month) was 9% including ureteral stent misplacement (n=1), a ureteral tear (n=2) and urine leakage at the concurrent ureterotomy or tear (n=4). All leaks resolved with closed suction drainage and time without requiring a 2nd surgery. The long-term complications (>1 month) are much less severe and include dysuria (20% with 7% persistent), stent migration (6%), ureteral stent reaction (6%), and scar tissue formation around the stent (11%). The scar tissue formation is typically associated with a concurrent ureterotomy and can occur 3-6 months post stent placement. Fifty-seven
percent of all cases that developed scar tissue had a previous stricture in their ureter at the time of stent placement. For strictured cats, we typically recommend the placement of a ureteral bypass rather than a ureteral stent.

THE SUBCUTANEOUS URETERAL BYPASS DEVICE (SUB)

The placement of nephrostomy catheters in veterinary medicine is useful when renal pelvic drainage is required, and has been met with excellent success when the appropriate device is used (see above). The biggest limitation is the externalized drainage, requiring careful management and hospitalization to prevent infection and dislodgement. The development of an indwelling SUB device using a combination locking-loop nephrostomy catheter and cystostomy catheter was modified from previous reports in human medicine allowing a nephrostomy tube to remain indwelling long-term. In humans, a similar device has been shown to reduce complications associated with externalized nephrostomy tubes and improve quality of life. The use of a SUB device has recently been described in 18 cats and 2 dogs (Berent et al. ACVIM, 2011; Berent et al. ACVS, 2010; Berent et al. World Congress of Endourology, 2010) In this report, the devices was in place a median of 7 months (range 1-24 months) and 11/18 cats are still alive with functionally patent devices. To date only 25 of these devices have been placed.

This procedure is performed through a ventral midline laparotomy. A nephrostomy and cystostomy tube are placed and connected to either the prototyped male-male adaptor under the skin or a modification of this technique inside the abdomen. This procedure will be expanded upon in the lecture.

The authors’ have performed this procedure in 25 ureters for various reasons to date, most commonly for proximal ureteral strictures. Patency of the device is evident long-term in all cats and dogs until the time of death, which were followed for a median of >215 days (range: 30-717 days), with improvement in the creatinine concentrations in 24/25 patients after placement. No SUB was seen to encrust or obstruct and all were well tolerated. Complications included immediate leakage at the nephrostomy tube site (3 cats) that was addressed with a change in suture material and the addition of tissue glue; hemorrhage during nephrostomy tube placement and ultimate obstruction with a blood clot (1 cat) requiring infusion of tissue plasminogen activator; and leakage at the junction of the port and the catheter (1 cat) requiring a small skin incision to tighten the boot. Overall, the use of a SUB for cats with a ureteral obstruction can be considered a functional option when other traditional therapies have failed or are contraindicated. The authors currently consider this a salvage procedure, as complications can be severe if they occur. Further investigation into the use of this device in both feline and canine patients is currently underway.

EXTRACORPOREAL SHOCKWAVE LITHOTRIPSY (ESWL) FOR URETEROLITHIASIS

Extracorporeal shock-wave lithotripsy is another minimally invasive alternative for the removal of ureteral calculi. ESWL delivers external shockwaves through a water medium directed under fluoroscopic guidance in 2 planes. The stone is shocked anywhere from 1000-3500 times at different energy levels to allow for implosion and powdering. The debris is then left to pass down the ureter into the urinary bladder over a 1-2 week period. This procedure can be performed safely for ureteroliths smaller than 5 mm in dogs and 3-5 mm in cats. For larger stone burdens, an indwelling double pigtailed ureteral stent is placed prior to ESWL to aid in stone debris passage, ureteral imaging, and immediate relief of the ureteral obstruction prior to ESWL treatment. For stones of larger sizes, or those imbedded in the ureteral mucosa, PCNUL or ureteroscopy may be necessary. In cats, ureteral stent placement prior to lithotripsy is ideal to aid in stone identification and passage as well as passive ureteral dilation. This procedure has been effective in only a small number of feline cases (30%) and is ideal for very distal ureteroliths, or small stones <3 mm in diameter. It is important to remember that the feline ureter is normally only 0.4 mm in diameter and the ESWL unit will break stones to approximately 1 mm in diameter. Without ureteral dilation most of these stones will not pass. In addition, feline stones are typically embedded into the ureteral mucosa, so even if the stones fragment well with ESWL, they do not pass as effectively as they do in dogs.
PERCUTANEOUS NEPHROURETEROCYSTOSCOPY

Ureteroscopy can be performed in an antegrade manner via renal access for proximal ureteroliths or nephroliths. This technique is more commonly performed in dogs, but can certainly be attempted in cats if the ureter and pelvis is significantly dilated to accommodate a flexible ureteroscope (2.7 mm). A renal access needle is advanced into the renal pelvis through the renal parenchyma under ultrasound or fluoroscopic guidance for a pyelocentesis and pyeloureterogram, as described above. A guidewire is advanced through the needle, down the ureter, into the urinary bladder, and out the urethra. A renal balloon dilator, or serial vascular dilators, are then advanced over the wire, pre-loaded with an access sheath that is large enough to fit the cystoscope (11 french) or ureteroscope (8 fr). The balloon is inflated through the renal parenchyma and the sheath is then advanced over the balloon for a smooth transition into the renal pelvis. The balloon is deflated and removed over the wire. The endoscope is then advanced over the wire toward the stone. Once the stone is identified a stone basket can be used to remove the stone through the access sheath, or the stone can be fragmented with the laser lithotrite. This is not commonly performed in cats to date.

CONCLUSION

The ureter is a frustrating area to gain access to for both diagnosis and treatment of disease, particularly in cats. With the recent advances in veterinary interventional endourologic techniques, diagnosis and treatment has become less invasive, more effective, and safer. Proper training and the availability of specialized equipment are needed to help these procedures become more available in the future. With these new minimally invasive modalities in veterinary medicine, we are hoping to find better alternatives for these problematic conditions, as we have seen in our human counterparts. These techniques are not meant to replace traditional surgery, but instead offer an alternative option when traditional surgery fails or is contraindicated.

REFERENCES
Available upon request

Key Words:
Ureteral stenting, Ureteral obstruction, Subcutaneous ureteral bypass, lithotripsy