MINIMALLY INVASIVE MANAGEMENT OF FELINE LOWER URINARY TRACT DISEASE:
LASERS, STENTS AND BALLOONS
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Feline lower urinary tract disease is a common problem seen in veterinary medicine. Feline lower urinary tract disease or feline urologic syndrome (FLUTD/FUS) is the most common condition seen in male cats that is typically self-limiting unless associated with an anatomical obstruction like stones or infection. Aside from FLUTD other conditions we are faced with routinely include urethral tears, strictures, stone obstructions, bladder stones, ectopic ureters, and transitional cell carcinoma. This talk with focus on some of the methods we utilize in clinical practice to provide a minimally invasive option for our feline patients.

EQUIPMENT
Various flexible and rigid endoscopes are used for traditional interventional endosurgical procedures. Rigid cystoscopy is commonly performed in female cats for urethral, bladder, and ureteral access. The recommended diameter is the 1.9 mm rigid scope (with the largest diameter actually measuring nearly 11- to 12-French) with a 30 degree lens angle. Flexible ureteroscopes are used for urethral and bladder access if the rigid scope does not fit in a female cat’s urethra or if bladder/urethral access is gained percutaneously, in an antegrade manner through the bladder wall, for urethral and bladder evaluation. Different types of intracorporeal lithotrites and lasers are available for various procedures including: ultrasonic, pneumatic, electrohydraulic, and holmium:YAG lasers which can be used for stone fragmentation, and a diode laser which is most often used for tissue coagulation or resection (i.e: lasering intramural ureteral ectopia or cauterizing polypoid masses or superficial transitional cell carcinoma lesions).

For many of the more commonly performed IR procedures, a traditional fluoroscopy unit is sufficient. A C-arm fluoroscopy unit has the advantage of mobility of the image intensifier, permitting various tangential views without moving the patient. Ultrasonography is useful for percutaneous needle access into the renal pelvis or urinary bladder. Guidewires of various sizes, shapes and stiffness are needed for each procedure (see below). Urinary catheters and stents can be used for various purposes to divert urine throughout the entire urinary collection system. Catheters are defined as flexible or rigid hollow tubes employed to drain fluids from body cavities. Most “catheters” in the urinary system are used for temporary drainage of the urinary bladder (cystostomy tubes). Urinary catheters are classically soft, comfortable, polyurethane type tubes that have an open lumen, permitting temporary drainage. Stents are defined as small tubes, often expandable, inserted across a blocked lumen to restore patency. Urinary “stents” are typically used for permanent or long-term diversion in the urethra. Stents are most often completely indwelling tubes that can be placed for various purposes, most commonly to bypass a malignant obstruction or stricture. Stents come in different materials (metal, polyurethanne, plastic, rubber, etc), shapes, and sizes. Understanding the urinary tract anatomy is very important in cats prior to considering the various treatment options, as this is uniquely different to the canine patient.

LASER LITHOTRIPSY
Laser lithotripsy is an innovative technique involving the intracorporeal fragmentation of uroliths, which is assessed using a rigid or flexible cystoscope or ureteroscope. The first report of holmium laser lithotripsy was in 1995 in human medicine. The holmium:YAG (yttrium, aluminum, garnet) laser is a sold-state pulsed laser that emits light at an infrared wavelength of 2100 nm. The energy is absorbed in less than 0.5 mm of fluid, making it safe to fragment uroliths in tight locations, as within the urethra, ureter, renal pelvis or urinary bladder, with limited risk to urothelial damage. It combines both tissue cutting and coagulation properties, as well as the ability to fragment stones upon contact. This technology has been performed and reported in dogs, pigs, humans, horses, goats, steers. To date, the procedure has become widespread in both dogs and cats.

Small diameter fibers (200, 365, 550 microns) are guided through the working channel of small diameter flexible or rigid cystoscopes/ureteroscopes. Although the various commercial models of lithotrites vary slightly, the pulse duration of the holmium laser ranges from 250-750 microseconds, the pulse energy from 0.2-
4.0 J/pulse, and the frequency from 5-45 Hz, averaging a power from 3.0-100 W. The power that one chooses is based on the application one is using it for.

The laser energy is focused on the urolith surface, directed via cystoscopy. Pulsed laser energy is absorbed by water inside the urolith, resulting in a photothermal effect, which causes urolith fragmentation. The holmium laser effect on the calculus is by a vapor bubble. The vapor bubble is created when the pulse of laser energy traveling through water from the tip of the fiber is trapped within a bubble (Moses effect). If the fiber tip is 0.5 mm or more away from tissue, the vapor bubble collapses, the water absorbs the energy and no impact is made. As the fiber tip is advanced less than 0.5 mm from the calculus, the vapor bubble comes in contact with and impacts the stone. The closer the fiber tip is to the target, the larger the effect. The stone is fragmented until the pieces are small enough to be removed normograde through the urethral orifice, either via voiding urohydropropulsion or with the assistance of a stone basket. This process is useful for cystic and urethral calculi in cats, as well as and renal and ureteral calculi in dogs. All stone types are able to be fragmented using laser lithotripsy. Female cats can have lithotripsy performed via transurethral cystoscopy. Male cats cannot accommodate a cystoscope large enough to have a working channel for the laser, making percutaneous cystolithotomy (PCCL) a better option.

Other urologic applications for laser therapy (particularly a diode laser 980 nm) include incision of urethral and ureteral strictures; ablation of superficial transitional cell carcinoma within the urethral lumen, and laser ablation of urinary polyps. Ectopic ureters is very rare in cats, but intramural ureteral ectopia can also be treated via cystoscopic guided laser ablation using a diode laser.

PERCUTANEOUS CYSTOLITHOTOMY (PCCL)

The most common procedure to date for the retrieval of cystic/urethral calculi in small animal patients is a traditional cystotomy, or urethrotomy if retropulsion is not possible. More recently minimally invasive procedures have shown success in stone removal including laparoscopic-assisted cystotomy and laser lithotripsy. The use of lithotripsy is limited by patient size, sex, species, stone size, and stone number. Laparoscopic-assisted cystotomy requires two incisions, a pneumoperitoneum, and additional expensive equipment. This new minimally invasive technique, termed PCCL, combines cystic and urethral stone retrieval in any size, sex or species, and is very easy to perform in cats.

In children, the treatment of choice for bladder stone retrieval is a procedure called a percutaneous cystolithotomy (PCCL). This involves filling the urinary bladder with contrast material, and under fluoroscopic guidance using a needle and guidewire to access the bladder. Serial dilations over the wire allow for a transvesicuclar sheath to be placed. Stones are then identified with cystoscopic visualization and a stone retrieval device is used to removal all cystic or urethral calculi. A suprapubic cystostomy catheter is left in place for 24 hours, and a urethral catheter is left in place for 48 hours, for a seal to form in the bladder without primary closure. For humans with large stone burdens in the bladder a PCCL (+/- lithotripsy) is recommended over transurethral lithotripsy, and has been shown to be safe, minimally invasive, and effective. This is the model used for this technique in animals.

The procedure is preformed under general anesthesia with the patient positioned in dorsal recumbency. A urethral catheter (3.5 to 5-French) is placed and sterile saline infused into the urinary bladder to accurately palpate the location of the apex. A small ventral midline skin incision approximately 1.5-2.0 cm in length is made over the bladder apex. A 1-1.5 cm incision is made into the abdominal cavity to accept one finger. The caudal abdomen is digitally palpated until the bladder is identified. The urinary bladder is deflated through the urethral catheter to confirm the vesicle location during digital palpation. The bladder apex is grasped atraumatically with Babcock forceps. Once the bladder is brought to the incision three stay sutures using 3-0 polydioxanone (1 apical and 2 lateral) are placed. The bladder is held to the abdominal incision and packed to reduce urine contamination into the abdomen. A stab incision is made into the bladder lumen between the stay sutures. A 6 mm metal screw trocar with a diaphram is advanced from the stab incision into the bladder lumen angled toward the urethra. A rigid (1.9 integrated, 30 degree lens) cystoscope is advanced through the trocar into the urinary bladder. The entire mucosal surface of the bladder and proximal urethra are visualized and the
location and number of uroliths identified. This technique can be used for evaluation of bladder polyps, ureteral bleeding, or stone retrieval. Slow saline irrigation is used to maintain bladder distension and visibility. A stone retrieval basket is advanced through the working channel of the cystoscope and guided to remove the uroliths. For any small remaining fragments that do not fit in the basket, suction is applied through the trocar as saline is irrigated through the urethral catheter. A stone retrieval basket is advanced through the working channel of the cystoscope and guided to remove the uroliths. Stones larger than the 6 mm sheath are entrapped in the basket and at the end of the procedure they are removed through the cystotomy incision after sheath removal, or broken prior to removal with the laser lithotrite. If necessary the incision is extended. The scope and trocar are removed and the incision is closed using 3-0 PDS. The bladder is leak tested via the urethral catheter and the stay sutures are removed. The abdominal incision is closed routinely in 3 layers.

URETHRAL BALLOON DILATION OR METALLIC STENTING FOR BENIGN/MALIGNANT OBSTRUCTIONS

Malignant obstructions of the urethra can cause severe discomfort, dysuria and life-threatening azotemia. Transitional cell carcinoma is the most common tumor of the trigone and urethra in cats and is rarely reported when compared to dogs. Chemotherapy and non-steroidal anti-inflammatory therapy has been successful in slowing tumor growth, but complete cure is uncommon. When signs of obstruction occur, more aggressive therapy is indicated. Placement of cystostomy tubes, transurethral resections, and surgical diversionary procedures have been described in dogs, but are invasive and potentially associated with an undesirable outcome due to manual urine drainage, associated morbidity, frequent urination, and an extremely high rate of infection (>85% in dogs). Placement of self-expanding metallic stents under fluoroscopic guidance via a transurethral approach can be a fast, reliable, and safe alternative to establish urethral patency. This technique has been performed in over 150 canine patients at the author’s institution, but in only a dozen or so feline patients. Urethral stenting has also been useful in patients with benign urethral strictures when traditional therapies have failed (balloon dilation), or when surgery is refused or not indicated. Benign urethral strictures may resolve with urethral balloon dilation alone, and this has been performed in a small number of cats as well.

A marker catheter is placed inside the colon to allow for maximal urethral measurement and determination of stent size. The bladder is maximally distended with contrast and a pull-out urethrogram is performed to allow for maximal distension of the urethra with a urethral access sheath in place to prevent urinary leakage out of the urethral papilla/orifice. Measurements of the normal urethral diameter and the length of obstruction are obtained and an appropriately sized self-expanding metallic urethral stent (SEMS) is chosen (approximately 10-15% greater than the normal urethral diameter and 3-5mm longer than the obstruction on both the cranial and caudal ends). The stent is deployed under fluoroscopic guidance and a repeat contrast cystourethrogram is performed to document restored urethral patency. Currently, an appropriately sized SEMS have been developed for the feline patient (5-6 mm diameter x 20-40 mm length).

The authors typically apply a topical solution of 0.1% Mitomycin C to a stricture after it is broken with a balloon. Approximately 2-3 mL of solution is left to dwell on the stricture site following dilatation for 5 minutes and then flushed with saline. Mitomycin C is an antibiotic that is procedure by Streptomyces caespiatus. Besides being an antibiotic, it is antineoplastic like an alkylating agent, causing single-band breakage and cross-linking of DNA at the adenosine and guanine molecules. It inhibits RNA and protein synthesis. It is most commonly used for topical treatment of upper and lower tract TCC. It selectively inhibits the expression of inducible genes. As an antiproliferative agent, MMC inhibits fibroblast proliferation and decreases scar tissue formation. Its antiproliferative properties on fibroblasts have been shown in vivo and vitro. Mitomycin C has been shown in rats, dogs, and humans to be effective in reducing stricture recurrence in the urinary tract, respiratory tract, and gastrointestinal tract.

PERCUTANEOUS CYSTOSTOMY TUBE PLACEMENT

Cystostomy tubes are often placed to bypass a urethral obstruction or “buy time” while a urethral/trigonal lesion is healing. This can be secondary to malignant neoplasia (trigonal or urethral), proliferative/granulomatous urethritis, urethral strictures, urethral tears, or urethral stones that are difficult to remove surgically. There is
some thought that percutaneous cystostomy tubes may hold a place in the treatment of blocked male cats rather than irritating the urethra with a transurethral urinary catheter. With the advent of urethral stents (see above), the use of cystostomy tubes has declined for treatment of urethral obstructions and should be considered a more temporary fix. Cystostomy tubes can either be placed percutaneously or surgically. With the locking loop pigtail catheter percutaneous cystostomy tube placement has become a relatively fast and easy technique when necessary. An 18 gauge over-the-needle catheter is advanced into the urinary bladder like a cystocentesis (paramedian), until urine is draining. The stylette is removed and the hydrophilic guidewire is advanced though the catheter and into the urinary bladder. The wire is curled around the bladder 2-3 times. This can be done under fluoroscopic guidance, but this is not always necessary and ultrasound is often sufficient. Then the locking loop catheter is advanced over the wire with the stylette still in place (and the trocar removed). Once the entire loop of the catheter is well within the urinary bladder the stylette is removed and the loop is locked by applying traction to the string at the distal end of the catheter and the string is locked in place. The bladder can then be easily drained and the catheter is secured tightly to the body wall as described above. This tube would need to remain in place, since it is not surgically pexied, for at least 2-4 weeks prior to removal. Other tubes, like latex mushroom tipped catheters, Foley catheters, or Low Profile tubes can be placed either with an open or laparoscopic-assisted surgical technique. This allows for a cystopexy to be performed at the same time. These tubes should remain in place for approximately 2 weeks after placement. Cystostomy tubes are commonly associated with secondary infections (at least 86% in one study) due to the external nature of the tube and complications with the tubes have been reported in as high as 49% of patients, involving inadvertent tube removal, eating of the tube by the patients, fistulous tract formation, and mushroom tip breakage during removal. This is not ideal in circumstances where chemotherapy (for malignant obstructions) or immunosuppressive therapy (for immune mediated disease-proliferative urethritis) is being used.

ANTEGRADE URETHRAL CATHETERIZATION

Urethral catheterization is typically a fairly simple and routinely performed procedure in veterinary patients primarily used to monitor urine output, establish urine drainage in patients that are recumbent or have mechanical/functional urethral obstructions, or to provide urethral patency following urethral or urinary bladder surgery. Occasionally, standard retrograde catheterization can be difficult in very small (female) patients, female patients with obstructive tumors, or feline patients with urethral tears following trauma or attempted serial catheterizations from urethral obstructions. Antegrade urethral catheterization performed under direct fluoroscopic visualization can be performed rapidly, easily, and safely. Urethral tears are most commonly seen in male cats, and occur most often while trying to unblock the patient or from vehicular trauma. This is ideal for male cats with urethral tears, because the tear is usually longitudinal and made in a retrograde manner. Longitudinal urethral tears will usually heal within 5-10 days without surgical intervention, and the catheter should be maintained for that length of time.

Under general anesthesia cystocentesis is performed using an 18gauge over-the-needle catheter as described above for cystostomy tube placement. Contrast is injected to define the urinary bladder and urethra. Under fluoroscopic guidance, a guidewire is advanced antegrade into the bladder and down the urethra until exiting the penis or vulva. A urinary catheter (open-ended or pig-tail) is advanced over-the-wire in a retrograde fashion into the urinary bladder and the guidewire is removed. It is important to remember to cut the tip off a closed-ended catheter to allow for it to be advanced over the guidewire. The urinary catheter is secured in place in a routine fashion. When placing a 5-French catheter over the guidewire, a 0.018” or 0.035” guidewire is recommended, as compared to a 3.5-French catheter would require a 0.018” guidewire. The 0.018” guidewire can be placed through a 22 gauge over-the-needle catheter vs. the 0.035” guidewire can be placed through an 18 gauge catheter as described above.

CONCLUSION

The use on non-invasive therapy options for the treatment of feline lower urinary tract disease is becoming progressively more appealing and clients are seeking these options for their pets. With the use of
newer options, cystoscopy in male cats and good quality assessment of the urinary tract of all feline patients, regardless of size, is now available.

**REFERENCES**
Available upon request

**Key Words:**
Feline cystoscopy, cystostomy tube, laser lithotripsy, PCCL, urethral stenting