SURGICAL MANAGEMENT OF UROLITHIASIS

Lori Ludwig VMD, MS, DACVS
Veterinary Surgical Care
Mount Pleasant, SC

The most common calculi seen in dogs and cats are struvite, calcium oxalate, urate, cystine and silicate. Table 1 shows the mineral composition of these calculi with the associated patient signalment, laboratory findings, and radiographic density. Medical management must be continued after surgery to prevent recurrence. Risk factors and recommendations for prevention of recurrence of the three most common uroliths are listed at the end of this handout.

CLINICAL PRESENTATION

Patients usually present with a history of dysuria, stranguria, and/or hematuria. If complete urethral obstruction is present, the patient may have a distended and painful abdomen with a history of anuria. Patients with complete obstruction for several days may be recumbent and show signs of shock. Physical examination often reveals a distended urinary bladder that cannot be manually expressed. Large calculi may be palpable in the bladder on abdominal palpation, or in the urethra on rectal palpation. Male cats with obstruction may have a visibly extruded and inflamed penis.

DIAGNOSIS

Urinalysis, urine culture, radiography and ultrasonography may be required to differentiate patients with uroliths from those with urinary tract infection, neoplasia, polyps, granulomatous urethritis, prostatic disease and blood clots.

Urinalysis

Urinalysis may show signs of urinary tract infection and crystalluria. Crystalluria may be detected in dogs without uroliths and absent in dogs with uroliths. Several variables affect crystal formation; therefore, fresh urine samples that have not been refrigerated should be evaluated. When crystals are detected in a fresh urine sample, there is a risk of urolith formation. In addition, if urate crystals are detected in dogs other than Dalmations or English bulldogs, this may be indicative of a portal vascular anomaly or other hepatic disorder.

Blood work

Results of a complete blood cell count and serum chemistry profile are usually normal when patients present acutely. An increased BUN, increased creatinine, hyperkalemia and acidemia may be present with complete urethral obstruction. Hypercalcemia associated with primary or secondary hyperparathyroidism may be present in patients with calcium oxalate calculi. A decreased BUN, decreased glucose, and increased liver enzymes may be seen in patients with urate calculi associated with liver disease.

Imaging

A lateral radiograph usually provides the diagnosis of urolithiasis. The kidneys, ureters, bladder and urethra should be carefully evaluated. The radiograph should include the entire abdomen of the patient in addition to the perineum, so that the entire urethra can be evaluated. Urethral calculi tend to lodge at the ischiatic arch or base of the os penis in male dogs. In male

cats, calculi, sand and mucous plugs most commonly obstruct the distal urethra. If radiolucent urethral calculi are suspected, contrast radiography is indicated. A catheter is inserted into the distal penis and 5 to 15 mls of a water soluble, iodinated contrast agent are injected while the tip of the penis is pinched against the catheter. If radiolucent calculi or calculi < 3 mm in size are suspected in the bladder, a double contrast cystogram or ultrasonography should be performed. For double contrast cystography, the bladder is catheterized and emptied and 5 to 10 mls of water-soluble contrast material is flushed into the catheter. The bladder is then distended with air or preferably carbon dioxide, at a dose of 8 to 10 ml/kg. Bladder filling should be monitored by palpation and stopped if resistance to injection is encountered or if air begins to reflux around the catheter. Calculi will be seen as filling defects in the center of the contrast puddle; whereas air bubbles will be located in the periphery.

EMERGENCY MANAGEMENT

Patients with urethral obstruction may be azotemic and/or hyperkalemic. A serum potassium and creatinine should be performed on presentation. An ECG should be monitored, especially in severely depressed patients, for signs of hyperkalemia (bradycardia, peaked T waves, widened QRS complex, flattened P wave, atrial standstill, ventricular fibrillation.) If hyperkalemia is sufficient to cause arrhythmias (>7 mEq/L) then treatment in addition to fluid diuresis should include one of the following.

(1) Insulin (0.5 to 1 units/kg IV) followed by dextrose (2G dextrose/unit of insulin IV followed by a 2.5% infusion) will drive potassium back into cells and carries little risk aside from hypoglycemia.

(2) Sodium bicarbonate (0.5 – 1.0 mEq/kg or 0.3 X body weight (kg) X base deficit) also drives K+ back into cells in exchange for H+ but carries a risk of hyperosmolality, hypokalemia, hypocalcemia, and CSF acidosis.

(3) Calcium gluconate (10%) given at a dose of 0.5 ml/kg slowly IV does not alter serum K+ but is cardioprotective. Arrhythmias may result from rapid administration.

The obstruction should be relieved as soon as possible. If a catheter cannot be passed, a urethrotomy may be needed. Alternative methods of bypassing an obstruction include a prepubic cystostomy or emergency urethrostomy.

Techniques for urethral catheterization with obstruction

In dogs, sedation with a narcotic (i.e. morphine) combined with valium is cardioprotective and reversible if needed. Cats often require sedation with ketamine and valium. In cats, the distal penis should be massaged prior to catheter placement to remove any urethral plugs that may be lodged there. If the bladder is large, a cystocentesis may be performed using a small gauge needle (butterfly catheter or extension tubing attached to a needle is preferable) placed near the neck of the bladder so that it can be completely emptied. This will relieve back pressure to make catheterization easier. A variety of catheters can be used (rigid/soft, small/large, short/long) and often when one type is unsuccessful, another type will work. The catheter should be passed to the level of the obstruction and sterile saline flushed into the catheter while the distal penis is pinched against the catheter. The saline can be mixed with KY jelly to aid in dislodging the calculus. If this is unsuccessful, a finger is placed in the rectum to apply pressure to the urethra while the catheter is flushed. This causes maximum dilation of the urethra so that when the digital pressure is released, calculi that are lodged in the urethra will be flushed back into the bladder.

Urethrotomy

Urethrotomy can be performed in male dogs with an obstructing calculus that cannot be flushed back into the bladder by the techniques for urethral catheterization listed above. The urethral calculus to be removed is located by a combination of radiography, catheterization and palpation. In male dogs, the calculus is usually located just caudal to the os penis, or, less commonly at the ischial arch. While the stone is held between the forefinger and thumb in one hand, a 2 to 3 cm skin incision is made directly over the calculus. The retractor penis muscle is identified and dissected off of the underlying urethra. An incision is made into the urethra which is identified by its purple-blue color. The incision is made directly over the obstructing calculus. Hemorrhage is controlled with digital pressure and suction used to aid visualization. The calculus is removed from the urethra and a catheter is placed from the urethrotomy site into the bladder. The urethral incision can be left open to heal by second intention. Blood may drip from the incision for a few days until the incision heals. To limit hemorrhage, the urethrotomy incision can be closed with small (4-0 or 5-0) absorbable suture, but care should be taken to identify the mucosa and suture it separately from the subcutaneous tissue and skin. For a calculus lodged at the ischial arch, a perineal urethrotomy would be required. This is more difficult than a prescrotal urethrotomy due to the deeper location of the urethra and greater cavernous tissue in this area. Also, if a stricture were to occur in this region after urethrotomy, an antepubic urethrostomy would be required.

Tube cystostomy

Percutaneous cystostomy tube placement can be used to bypass a site of obstruction or to bypass a laceration resulting from traumatic urethral catheterization. The patient is sedated and local anesthesia is used if the patient is severely compromised. A skin incision is made on midline midway between the umbilicus and the pubis. The linea alba is penetrated and the bladder is exteriorized through the incision. A 10 to 14 french foley catheter (or Pezzer tube) is pulled into the abdomen through a skin incision just lateral to the midline incision. A pursestring suture (3-0 or 4-0 absorbable) is placed in the ventral surface of the bladder near the trigone and a stab incision is made into the bladder in the middle of the pursestring suture. The catheter is advanced into the bladder and the pursestring suture is tightened. The bulb of the foley is inflated. The bladder is secured to the body wall around the site where the catheter enters the abdomen with interrupted sutures (3-0 monofilament absorbable.) The catheter is secured to the skin with a finger-trap suture and the midline abdominal incision is closed routinely. The bladder can be evacuated by attaching the catheter to a sterile collection bag and allowing continuous drainage, or by syringe aspiration 4 to 6 times daily. The stoma should be evaluated daily and covered by a clean bandage. When it is time for the tube to be removed, the stoma will heal by second intention within a few days.

CYSTOTOMY

A cystotomy can be performed once the calculi have been retropulsed into the bladder. In male dogs, the prepuce is flushed with dilute nolvasan or betadine so that it can be left in the sterile field during surgery and the surgeon can access the penis for catheterization. If it was very difficult to retropulse the stones into the bladder, consider leaving a sterile catheter in the urethra that is cut where it exits the penis. In male cats, the urethral catheter is left in place until

the surgeon has opened the bladder. Preoperative radiographs should be available during surgery so that stones can be counted.

A ventral midline or paraprepucial incision is made from the umbilicus to the pubis. The bladder is exteriorized and a stay suture is placed at the apex. A scalpel blade is used to enter the lumen of the bladder on the ventral aspect. The incision is extended with metzenbaum scissors with care taken to stay on the ventral midline to avoid lacerating a ureter. A bladder spoon is helpful to remove calculi. When no more calculi are retrieved with the bladder spoon, digital palpation of the bladder neck and proximal urethra is performed to locate any calculi that may have been missed. Once all calculi have been removed from the bladder, the urethral catheter that was placed before surgery is removed (in cats this is done by a non-sterile assistant, while sterile saline is flushed into the catheter.) In male dogs, a large, sterile urinary catheter is then passed from the penile urethra into the bladder and the catheter is flushed several times with saline. The bladder is again checked for stones. Flushing is repeated while the catheter is withdrawn. The catheter is passed back and forth several times until no more stones are seen entering the bladder. The catheter is then passed from the bladder out the urethra and flushed as before. Prior to bladder closure, a piece of bladder mucosa is excised and submitted for culture and sensitivity along with a stone. Any bladder masses are removed for biopsy as necessary and if a urachael diverticulum is found, it should be excised. The bladder wall is closed with 4-0 or 3-0 absorbable monofilament suture material. Suture materials that are appropriate for use in the bladder and urethra (regardless of whether or not there is infection present) include PDS, Maxon and Monocryl. An attempt should be made to avoid penetrating the mucosa when suturing the bladder. A single layer simple interrupted or simple continuous pattern is used for small, thick bladders. A two layer closure can be used if the bladder is not too thick (i.e. simple continuous pattern with a cushing oversew.) If multiple calculi were present, a postoperative radiograph is indicated to insure adequate removal of all stones. In one study, one of every seven dogs and one of every five cats were found to have uroliths remaining after cystotomy.

A technique that has been described recently for cystotomy is the laparoscopic assisted cystotomy. A small incision is made for the laparoscope and the bladder is located and exteriorized through a second small incision. A stab incision is made into the bladder and stones are retrieved normally. The scope can then be placed into the cystotomy incision to allow visualization of the entire bladder and urethra, in addition to providing a means for lavage.

URETHROSTOMY

Urethrostomy is indicated in patients that are likely to be recurrent stone formers. Urethrostomy can also be performed caudal to an area that has been damaged by catheterization, caudal to a stricture, or caudal to calculi that cannot be retropulsed into the bladder. In the dog, a scrotal urethrostomy is preferred over the prescrotal or perineal sites because the urethra in this area is larger, more distensible and more superficial, and it is surrounded by less cavernous tissue. In cats, the perineal site is used. The owner must understand that creation of a urethrostomy will not cure the underlying problem and that stones and signs of lower urinary tract disease may recur. In addition, an animal with a urethrostomy is at increased risk for developing urinary tract infection.

NEPHROLITHIASIS

Calcium oxalate and struvite are the most common types of nephroliths found in dogs. Calcium oxalate nephroliths are much more common than struvite nephroliths in cats. Detection of nephroliths is not, in itself, an indication for surgery. Sterile, non-obstructive nephroliths may persist for years without substantial change in urinary tract function. Medical dissolution may be possible for struvite and urate nephroliths in dogs. There is currently no way to dissolve calcium oxalate stones, but medical treatment may slow their growth.

Surgery is indicated if renal calculi are associated with recurrent infection or if there is evidence of obstruction (hydronephrosis.) Ultrasonography and intravenous pyelography are useful for identifying obstruction, but do not give a good indication of renal function. Scintigraphy is superior for quantifying renal function. Surgical procedures that may be considered for removal of nephroliths include nephrotomy, pyelolithotomy and nephrectomy. Nephrotomy results in a decrease in renal function, so if the renal pelvis is dilated, pyelolithotomy is preferred for removal of calculi. If there are bilateral calculi, staged procedures are often performed. Nephrectomy should only be performed if the affected kidney contributes < 33% of the total GFR.

Extracorporeal shock wave lithotripsy is a non-invasive treatment for nephrolithiasis in dogs. Although not readily available in veterinary medicine, it is the treatment of choice for renal calculi in humans. Currently, lithotripsy is being performed at Purdue University and at the University of Tennessee.

URETEROLITHIASIS

Calcium oxalate calculi are the most common type of uroliths found in the ureters of cats. Potential risk factors for the formation of these stones include hypercalcemia, feeding a urine-acidifying diet or a single brand of cat food, an indoor only environment, and being of the Persian breed. Struvite and calcium oxalate calculi most frequently cause ureteral obstruction in dogs. If ureteral calculi are diagnosed by plain radiography and are not associated with significant obstruction, serial radiographs should be taken to monitor calculi movement. Medical dissolution of ureteroliths is unlikely to be successful because calculi in the ureter are not continually bathed in urine and calcium oxalate calculi are not amenable to dissolution. Intravenous fluid diuresis, with or without diuretics, may encourage movement of calculi to the bladder. Failure of calculi to progress down the ureter on subsequent radiographs is an indication for surgical intervention. There is currently no recommendation for the appropriate amount of time to monitor patients for passage of ureteroliths. Because even partial obstruction of the ureter results in decreased renal blood flow, decreased renal function and potentially irreversible renal damage, early surgical intervention is indicated if there is evidence of obstruction.

Options for surgical treatment of ureteroliths include ureterotomy, retrograde flushing of calculi into the renal pelvis followed by pyelolithotomy, resection of the affected portion of the ureter followed by primary anastomosis or reimplantation into the bladder, and ureteronephrectomy. Complications occur in approximately 30% of patients and include urine leakage, dehiscence, persistent obstruction, stricture formation and persistent azotemia. Perioperative mortality rates have been reported to be 18%; however, twelve months after surgery, 91% of cats were still alive. This compares favorably to the 66% survival after 12 months of medical management. Death is most commonly attributed to ureterolith recurrence and worsening of chronic renal failure.

TABLE 1

TYPE	BREED/SEX	URINE pH	RADIOGRAPHS	LABORATORY RESULTS
Struvite	Schnauzer, Dachshund, Poodle, Scottie, Beagle, Pekinese, Corgi, Bichon, Cocker Female dogs	Alkaline or neutral	Opaque, round or faceted, may assume shape of renal pelvis, ureter, bladder or urethra	Bacteria on urinalysis/ positive culture in dogs; cats usually sterile urine
Calcium oxalate	Schnauzer, Lhasa, Yorkie, Poodle, Shih Tzu, Bichon, Persian, Himalayan Male dogs and cats	Acidic or neutral	Opaque, round to oval (occasionally jackstone)	Hypercalcemia (rare); increased alkaline phosphatase or tests supporting a diagnosis of Cushing's
Urate	**Dalmatian, English bulldog**, Breeds at risk for portosystemic shunt (Schnauzer, Yorkie) Male dogs w/out PSS	Acidic or neutral	Radiolucent, round or oval, microhepatica if PSS	Low BUN, albumin, cholesterol, glucose +/- high liver enzymes if PSS
Cystine	Dachshund, Bassett, English bulldog, Mastiff, Newfoundland, DSH, Siamese Male dogs	Acidic or neutral	Radiolucent to slightly opaque, usually small, round to oval	No abnormalities
Silica	**German shepherd**, Golden, Labrador, Schnauzer Male dogs	Acidic or neutral	Opaque, jackstone	No abnormalities

MEDICAL TREATMENT RECOMMENDATIONS

Struvite

Risk factors: Urinary tract infection by urease producing bacteria (*Staphylococcus, Proteus)* and factors that precipitate infection development (i.e. urethrostomy.) Diet important for sterile struvite formation in cats.
Dissolution: Calculolytic diet with no other supplements or treats in patients with sterile struvite stones; eradicate infection with appropriate antibiotics in those associated with infection.
Prevention: Feed acidifying, magnesium-restricted diet for sterile struvite stones and monitor for acidic urine pH and low urine specific gravity (discontinue if persistent calcium oxalate crystalluria occurs because feeding an acidifying diet may promote formation of calcium oxalate stones); urine culture after antibiotic therapy to determine that infection is cleared.

Calcium oxalate

Risk factors: Diet high in calcium, protein, sodium and vitamin D; ascorbic acid supplements, exogenous or endogenous exposure to high concentrations of steroids; furosemide; dry diets and water restriction; hypercalcemia.
Dissolution: No effective drugs available for dissolving.
Prevention: Correct causes of hypercalcemia; avoid vitamin C, D and calcium supplements; avoid furosemide and steroids; feed canned diets and allow free access to water; add potassium citrate to diet (75 mg/kg BID); consider prescription diets; monitor for alkaline urine, low urine specific gravity and calcium oxalate crystals.

Urate

Risk factors: Genetic factors for dogs that are predisposed; presence of a portovascular anomaly.
Dissolution: Low purine calculolytic diet; allopurinol (15 mg/kg BID); add potassium citrate if urine not alkaline.
Prevention: Low purine calculolytic diet; allopurinol only if crystalluria persists because prolonged administration often results in formation of xanthine uroliths; consider urethrostomy in Dalmations if urethral obstruction occurs; correct PSS (allopurinol not effective in preventing urolith recurrence in dogs with portovascular anomalies.)