INTRODUCTION
Uroliths in both dogs and cats can lodge in the kidney, ureters, bladder, urethra or can be present in several parts of the urinary tract simultaneously. Based on information from the Minnesota Urolith Center, since the 1980’s, there has been an increase in the number of calcium oxalate urolith submissions in both dogs and cats. Although some uroliths such as struvite will respond well to medical therapy, medical protocols that will promote dissolution of calcium oxalate uroliths are currently unavailable and, as a result, some form of intervention is often necessary. Although calcium oxalate and struvite are most commonly identified, surgical removal of urate (particularly ammonium urate in conjunction with ligation of a portosystemic shunt), calcium phosphate, xanthine, silica stones as well as dried solidified blood calculi may be necessary.

It is not clear if calculi lodged in the kidney or ureter will migrate into the bladder. Removing stones from the bladder is far more straightforward than removal from the ureter or kidney. Anecdotal evidence suggests that some stones will eventually pass into the bladder without therapy. At our facility, we have seen a few cats with calcium oxalate calculi lodged in the ureter pass into the bladder following medical management. In one report of 11 cats with calcium oxalate ureteroliths, however, imaging studies were performed over periods of 11 to 42 days and no urolith migrated in any of the cats over these time periods.

Given this uncertainty, it is not always clear how long one should wait to address either renal or ureteral uroliths. Surgery has been indicated in cases of worsening ureteral obstruction, known impairment of normal renal function, ureteral colic or pain, or the presence of a secondary infection that doesn’t respond to medical therapy. Factors that also need to be considered with regards to prognosis include the function of the contralateral kidney and the overall health of the patient. Recovery of renal function depends on the severity and duration of the obstruction and the presence of pre-existing renal disease. Unfortunately, in cases of unilateral ureteral obstruction, a diagnosis may go undetected if function in the opposite kidney is normal.

CLINICAL PRESENTATION AND INVESTIGATION
Dogs and cats with uroliths affecting the kidney and ureter can present asymptomatic or with non-specific clinical signs including lethargy, weight loss, anorexia, vomiting, fever, polydipsia and polyuria. Hematuria may or may not be present. Patients may also present with abdominal pain and splinting or renomegaly. Patients with cystic uroliths usually present with pollakiuria, stranguria, and hematuria and those with urethral calculi can present with signs typical of partial or complete urethral obstruction. It is important to perform a complete physical examination since many affected patients are older and may have concurrent disease(s). A urinalysis, complete blood count, biochemical profile, and plain abdominal radiographs are usually recommended as initial investigative steps. Uroliths are often visualized on plain radiographs, although small ureteroliths, radiolucent ureteroliths or those overlying colonic contents are occasionally missed. Further imaging studies including ultrasonography, excretory urography, antegrade pyelography and computed tomography are often helpful in identifying small ureteroliths, the presence of hydronephrosis and/or hydroureter, as well as delineating the level of an obstruction. It is important to note that ureteral dilation identified using one of these modalities, does not always extend to the level of the obstruction.
KIDNEY
There are two options for the surgical removal of nephroliths. A nephrotomy provides the greatest exposure of the renal pelvis and collecting duct system, but entails temporary interruption of the affected kidney’s blood supply. The kidney is partially dissected from its retroperitoneal location. The renal artery and vein are isolated and temporarily occluded with Rommel tourniquets. A longitudinal incision is made with a scalpel through the convex lateral surface of the kidney. Calculi are removed from the renal pelvis and the collecting duct system, both of which are flushed with sterile saline. The nephrotomy incision is closed by approximating the two “halves” of the kidney and the renal capsule is sewn with 4/0 PDS in a simple continuous pattern. The Rommel tourniquets are released and the two “halves” of the kidney are held firmly opposed for 5 minutes. Although this technique provides more optimal surgical exposure, there may be some negative consequence to long term renal function. In one report, nephrotomy in normal cats gradually decreased GFR by 20% over one year. Additionally, complications such as hemorrhage and urinary leakage can occur.

Alternatively, a pyelolithotomy may be performed if the nephrolith has created dilation of the renal pelvis. This approach does not provide as good an exposure of the pelvis as a nephrotomy, but does not necessitate occlusion of the renal vasculature. To expose the pelvis, the kidney is dissected free of its peritoneal attachments and folded medially. An incision is made over the proximal ureter and pelvis and the stones are removed. A suture (3/0 to 5/0 prolene) can be passed distally to ensure that there is no obstruction of the more distal ureter. The proximal ureter and pelvis are closed with either a continuous suture pattern or single interrupted, appositional sutures using prolene, nylon or PDS.

If the nephrolith is not causing an obstruction or changing in size, if no significant hematuria, pain or evidence of an infection is present, monitoring the patient may be a reasonable alternative. Extracorporeal shock wave lithotripsy (ESWL) may also be an alternative treatment in managing dogs with nephroliths.

URETER
Patients diagnosed with ureteroliths are often treated initially with a period of medical management, including the parenteral administration of fluids and diuretics to determine if passage will occur. The optimal time for medical management prior to pursuing surgery is unknown. In the author’s experience, if medical management does not appear to be effective within 24-48 hour and a partial or complete ureteral obstruction is present or the ureterolith is associated with an infection, surgical removal is recommended. In some patients that are severely azotemic and unstable, hemodialysis or the placement of an emergency nephrostomy tube may be beneficial in stabilizing the patient prior to surgery. Additionally, the placement of a nephrostomy tube has allowed for the preoperative assessment of renal function in the obstructed kidney.

Ureteroliths are removed when they are causing a partial or complete obstruction or are associated with a urinary tract infection. Depending on the size of the patient, ureteral surgery often requires substantial magnification. At the Veterinary Hospital of the University of Pennsylvania, an operating microscope is used to provide appropriate magnification. Calculi in the proximal ureter are removed by ureterotomy. The ureter is closed with single interrupted sutures of 8/0 nylon or Vicryl. Calculi lodged in the distal ureter may be removed by ureterotomy or the affected area of the ureter may be removed in toto and the distal ureter re-implanted into the urinary bladder. To allow for re-implantation of the mid-portion of the ureter,
the kidney can be mobilized from its retroperitoneal space and moved caudally towards the bladder. The most common complications following ureteral surgery include urinary leakage and stricture. It is the author’s opinion that these complications can be minimized with appropriate magnification and experience.

Many patients present with both nephrolithiasis and ureterolithiasis. If the nephroliths are not addressed at the time of surgery, it is important that the patient be monitored periodically since these uroliths have the ability to migrate into the ureter and cause subsequent obstructions. Finally, patients with large numbers of ureteroliths located unilaterally or bilaterally represent a management challenge. The placement of ureteral stents or a subcutaneous ureteral bypass to relieve the obstruction has been effective in many of these cases. Complications that have been reported with the use of implants include lower urinary tract signs, urine extravasation, increased incidence of urinary tract infection, implant migration and implant occlusion.

BLADDER

Dogs and cats with cystic calculi usually present with pollakiuria, stranguria, and hematuria. Similar to renal and ureteral calculi, the initial evaluation should include a complete physical examination and diagnostics including a urinalysis, complete blood count, biochemical profile, plain abdominal radiographs and in some cases an abdominal ultrasound.

The surgical technique of choice to remove cystic calculi is a ventral cystotomy. The calculi are removed and the bladder is flushed. The urethra is catheterized and flushed retrograde to ensure that no stones remain. The bladder is closed with single interrupted appositional sutures of 3-0 to 4/0 PDS. Although uncommon, urinary leakage from the surgical site can occur. In some patients, voiding urohydropulsion may also be effective in retrieving uroliths smaller than the narrowest part of the urethra.

Using a rigid or flexible cystoscope, laser lithotripsy is also an option for the intracorporeal fragmentation of uroliths. A holmium:YAG laser is used to fragment the stone until the pieces are small enough to be removed normograde through the urethral orifice with the assistance of a stone basket or via voiding urohydropropulsion.

URETHRA

Historically, the majority of male cats presented for urethral obstruction had struvite plugs obstructing the urethra. In these cases, the cat was stabilized, unblocked, the bladder flushed, and medical management instituted. With the increasing incidence of calcium oxalate urolithiasis, it is important to rule out urethral and cystic urolithiasis in male cats with urethral obstruction. This necessitates at least abdominal radiographs in cats with urethral obstruction. If this investigation is not performed, it is likely that any urethral calcium oxalate urolith pushed back into the bladder will migrate and re-obstruct the cat when the urinary catheter is removed. Radiographs are also carefully scrutinized for evidence of renoliths or ureteroliths. In both male and female cats, calcium oxalate cystoliths can be removed via a ventral cystotomy. In many female cats, cystoscopy in conjunction with laser lithotripsy and removal of fragments with a basket device can also be performed.

Repeated episodes of urethral obstruction is the primary indication for perineal urethrostomy in cats. To perform a perineal urethrostomy, the patient is placed on a rectal stand and a purse string suture placed in the anus. An elliptical incision is made from just dorsal to the scrotum to ventral to the prepuce. The penis is mobilized using blunt and sharp dissection. The
ischiocavernosus and ischiourethralis muscles are cut and the ventral ligamentous attachments severed. The retractor penis muscle is excised from the dorsal surface of the penis to the level of the bulbourethral glands. A tom cat catheter is placed and the urethra incised to just cranial to the bulbourethral glands. The urethral mucosa is then sutured to the skin using 4-0 or 5-0 prolene. In some cases that have sustained substantial injury to the distal urethra, a transpelic urethroplasty or a prepubic urethroplasty should be considered. In some cases that are extremely unstable, the placement of a temporary cystostomy tube may be necessary.

In male dogs, urethral calculi most often lodge at the ischial arch or just caudal to the os penis. Initial treatment for a urethral obstruction includes urethral catheterization, bladder decompression and IV fluid therapy. In females, massaging a urethral urolith toward the vagina may dislodge it. In males and females, urohydropropulsion may also be beneficial in flushing the calculi into the bladder. If successful in flushing calculi into the bladder, a cystotomy can be performed. In male dogs, if the obstruction can’t be relieved, a urethrotomy or urethroplasty may be necessary.

A urethrotomy is most often performed for obstructions at the base of the os penis, but occasionally can be performed in the perineal location. A urethrotomy should not be performed over the os penis since this frequently results in stricture formation. In the prescrotal location, the retractor penis muscle is retracted laterally and an incision is made on midline through the urethra directly over the calculus. The incision can be allowed to heal by second intention, however significant hemorrhage is often observed. Alternatively, the incision can be closed primarily with 4-0 or 5-0 synthetic absorbable suture.

A urethroplasty is indicated for patients with calculi lodged within the os penis, chronic stone formers or those with permanent damage to the distal urethra. In male dogs, the urethroplasty can be performed in a prescrotal, scrotal, perineal or prepubic location. The scrotal location is preferred because at this location, the urethra is large and distensible and more superficial, resulting in less hemorrhage. To perform the technique, a catheter should first be placed in the urethra and, if not already performed, the dog should be neutered. The retractor penis muscle is retracted laterally and the corpus spongiosum and urethra are incised along midline for approximately 4cm. The urethral mucosa is sutured to the surrounding skin edge with 4-0 or 5-0 monofilament nonabsorbable suture material in a simple interrupted or continuous pattern. Hemorrhage can occur following the procedure, but is usually self limiting.