Methods of Urolith Removal

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New, minimally invasive techniques for removing uroliths have been developed or have become more readily available in veterinary medicine. TABLE 1 summarizes the advantages and disadvantages of each method, the number and type of uroliths for which each is appropriate, and necessary equipment for each.

Uroliths can be eliminated by physical removal, and certain types can be dissolved. Indications for physical removal include obstruction of the urethra, renal pelvis, or ureters; failure of dissolution therapy; and unacceptable clinical signs associated with urolithiasis, such as recurrent urinary tract infections or pollakiuria. The benefits of physical removal of cystic calculi include rapid resolution, definitive diagnosis of urolith type (via quantitative urolith analysis), and reduced risk of urinary obstruction. In asymptomatic patients, removal of cystic calculi is not mandatory, particularly if there are relative contraindications to anesthesia or surgery. If a urolith is suspected to be composed of struvite, urate, or cystine, medical dissolution can be attempted if no indication for more immediate removal is present. There are no effective medical dissolution protocols for calcium oxalate uroliths.

The decision to remove nephroliths or ureteroliths is more complicated than the decision to remove cystic or urethral calculi. Nephroliths are commonly detected in cats with chronic kidney disease, but in most cases, they do not cause progression of renal dysfunction, and nephrotomy is generally not recommended. Nephroliths and ureteroliths should be physically removed if they are causing obstruction to urine flow, progressive deterioration in renal function, or recurrent urinary tract infection or are enlarging despite preventive measures. Surgical removal of partial or completely obstructing ureteroliths that do not pass within 24 hours may be prudent. A staged approach to surgery can be considered if uroliths are found at multiple sites in the upper urinary tract. The reversibility of renal dysfunction depends on completeness and duration of obstruction. Studies in dogs have shown variable and permanent decreases in renal function after 7 days of acute ureteral obstruction, with no improvement after 40 days of obstruction, although there are reports of improvement after 70 days in people, and we have observed improvement in cats after 70 days.

All methods of stone removal should be followed by imaging to confirm complete urolith removal. Appropriate management to prevent regrowth of uroliths is recommended.

Nonsurgical Techniques

 Voiding urohydropropulsion is used to evacuate small urocystoliths by flushing them out through the urethra (BOX 1). A general guideline is that this technique can be used to remove uroliths <5 mm in diameter from male and female dogs weighing more than 8 kg, uroliths <3 mm from female cats and small dogs, and uroliths ≤1 mm in diameter from...
### TABLE 1  Comparison of Various Methods of Urolith Removal

<table>
<thead>
<tr>
<th>Technique</th>
<th>Urolith Location</th>
<th>Urolith Size/Number</th>
<th>Urolith Type</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Anesthesia</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upper Urinary Tract</strong></td>
<td></td>
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<tr>
<td>Extracorporeal shock wave lithotripsy</td>
<td>Kidney, ureter</td>
<td>Small to moderate size</td>
<td>All</td>
<td>No surgery</td>
<td>Limited availability</td>
<td>Yes</td>
<td>Extracorporeal shock wave lithotripter</td>
</tr>
<tr>
<td>Percutaneous nephrolithotomy</td>
<td>Kidney, proximal ureter</td>
<td>Moderate size to large</td>
<td>All</td>
<td>Less invasive than open surgery</td>
<td>Limited availability</td>
<td>Yes</td>
<td>Lithotripter; rigid cystoscope</td>
</tr>
<tr>
<td>Pyelotomy</td>
<td>Kidney</td>
<td>Any</td>
<td>All</td>
<td>Less renal damage than nephropotomy</td>
<td>Renal pelvis must be distended</td>
<td>Yes</td>
<td>Surgical</td>
</tr>
<tr>
<td>Ureterotomy</td>
<td>Ureter</td>
<td>Any size, small number</td>
<td>All</td>
<td>Rapid resolution of obstruction</td>
<td>Risk of urine leakage; postoperative swelling or stricture may cause obstruction; multiple uroliths increase risks</td>
<td>Yes</td>
<td>Surgical; magnifying loupes or operating microscope in cats</td>
</tr>
<tr>
<td>Nephrotomy</td>
<td>Kidney</td>
<td>Any</td>
<td>All</td>
<td>No special equipment</td>
<td>Temporary decrease in renal function</td>
<td>Yes</td>
<td>Surgical</td>
</tr>
<tr>
<td>Ureteral stent</td>
<td>Ureter</td>
<td>Large number</td>
<td>All</td>
<td>May be only option</td>
<td>Stents not readily available, difficult to place</td>
<td>Yes</td>
<td>Surgical; intraoperative fluoroscopy</td>
</tr>
<tr>
<td><strong>Lower Urinary Tract</strong></td>
<td></td>
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<tr>
<td>Voiding urohydropropulsion</td>
<td>Bladder, urethra</td>
<td>Small size, any number</td>
<td>All</td>
<td>No surgery</td>
<td>Risk of obstruction with larger uroliths</td>
<td>Sedation or anesthesia</td>
<td>Catheter</td>
</tr>
<tr>
<td>Retrograde hydropropulsion</td>
<td>Urethra</td>
<td>Small size</td>
<td>All</td>
<td>Avoids urethrotomy</td>
<td>Does not remove uroliths</td>
<td>Sedation or anesthesia</td>
<td>Catheter</td>
</tr>
<tr>
<td>Cystoscopic evacuation</td>
<td>Bladder</td>
<td>Small size, any number</td>
<td>All</td>
<td>No surgery</td>
<td>Only small uroliths removed</td>
<td>Yes</td>
<td>Rigid cystoscope</td>
</tr>
<tr>
<td>Laser lithotripsy</td>
<td>Bladder, urethra</td>
<td>Medium size; small to moderate number</td>
<td>All</td>
<td>No surgery</td>
<td>Limited availability; may take longer than cystotomy if large urolith burden</td>
<td>Yes</td>
<td>Rigid or flexible cystoscope; laser lithotripter</td>
</tr>
<tr>
<td>Laparoscopic-assisted cystotomy</td>
<td>Bladder</td>
<td>Any</td>
<td>All</td>
<td>Less invasive than standard cystotomy</td>
<td>Same procedure duration as standard cystotomy with skilled operator</td>
<td>Yes</td>
<td>Rigid cystoscope</td>
</tr>
<tr>
<td>Cystotomy</td>
<td>Bladder</td>
<td>Any</td>
<td>All</td>
<td>Rapid, readily available</td>
<td>Bigger incision than laparoscopic-assisted cystotomy</td>
<td>Yes</td>
<td>Surgical</td>
</tr>
<tr>
<td>Urethrotomy</td>
<td>Urethra</td>
<td>Any</td>
<td>All</td>
<td>Removes uroliths resistant to other techniques</td>
<td>Risk of stricture</td>
<td>Yes</td>
<td>Surgical</td>
</tr>
<tr>
<td>Urethroscopy</td>
<td>Urethra</td>
<td>Any</td>
<td>All</td>
<td>Decreases risk of future obstruction in dogs with recurrent urolith formation</td>
<td>Increased long-term risk of infection</td>
<td>Yes</td>
<td>Surgical</td>
</tr>
<tr>
<td><strong>Upper and Lower Urinary Tract</strong></td>
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<tr>
<td>Dissolution</td>
<td>Bladder, kidney</td>
<td>Any</td>
<td>Struvite, urate, cystine</td>
<td>No anesthesia or surgery</td>
<td>Not applicable to all urolith types; takes weeks to months for resolution</td>
<td>No</td>
<td>None</td>
</tr>
</tbody>
</table>
Methods of Urolith Removal

Female cats. Larger uroliths have been removed with this technique in some situations; removal is more likely to be successful for uroliths with smooth contours than for uroliths with irregular contours. Voiding urohydropropulsion should not be used in patients with a urethral obstruction and is not ideal for patients that have recently undergone bladder surgery. Anesthesia is not needed in all animals but facilitates performing the procedure. Agents that provide analgesia and muscle relaxation are recommended.

Antibiotics should be used for 3 to 5 days after the procedure is performed to prevent iatrogenic urinary tract infection.

Retrograde urohydropropulsion (BOX 2) does not remove uroliths from the urinary tract; rather, it relocates them from the urethra to the bladder, where they can be dissolved by medical therapy or removed via cystotomy or laser lithotripsy techniques.

Catheter-assisted retrieval of uroliths through a urinary catheter (BOX 3) is mainly used to collect small cystic calculi for diagnostic purposes (mineral analysis). Anesthesia may not be needed, depending on the patient. Cystoscopic retrieval has been described for small uroliths or urolith fragments after lithotripsy; the latter may be aspirated through the rigid cystoscope sheath after the telescope has been removed. This technique allows retrieval of larger uroliths than does catheter assistance but is limited by the inner diameter of the cystoscope sheath. An Ellik evacuator (Bard Urologic Division, Covington, GA) aids...
Lithotripsy has the goal of fragmenting uroliths into pieces small enough for urolith removal. During cystoscopy, a urolith basket can be used to snare uroliths smaller than the diameter of the distended urethra (FIGURE 1). The cystoscope and basket with urolith are then slowly withdrawn while visualizing the urethra to ensure that the urolith does not become lodged in the urethra. Transurethral rigid cystoscopy is generally limited to female patients or male patients with a perineal urethrostomy.

Laparoscopic-Assisted Cystotomy

Calciulli too large to be removed via voiding urohydropropulsion can be removed with laparoscopic-assisted cystotomy, also called percutaneous cystolithotomy. An incision just large enough for urolith removal is made in the abdominal wall, and with the assistance of a laparoscope, the bladder is positioned in the abdominal wall incision and incised. The uroliths are then removed with graspers or a urolith basket (FIGURE 2). After cystoscopy or radiography to ensure complete urolith removal, the bladder is closed outside the body, and then the abdominal incision is closed.

Lithotripsy

Lithotripsy has the goal of fragmenting uroliths into pieces small enough to pass out of the body spontaneously or be removed by noninvasive methods. Intracorporeal therapies involve direct contact of the lithotripter with the urolith, either in the bladder via cystoscopy or in the kidney via a percutaneous nephrolithotomy. Laser lithotripsy has generally replaced electrohydraulic lithotripsy for intracorporeal techniques. Extracorporeal techniques are applied externally to fragment nephroliths and ureteroliths.

Laser Lithotripsy

Laser lithotripsy involves using cystoscopy to place a laser in direct contact with uroliths for fragmentation (FIGURE 3). Holmium:yttrium-aluminum-garnet (YAG) laser energy is absorbed in minimal volumes of fluid with limited risk of damage to the urothelium. After lithotripsy, cystoscopic evacuation or voiding urohydropropulsion is performed to remove fragments. Urolith composition does not influence the efficacy of laser fragmentation. In one report of treatment of cystic and urethral calculi, all female dogs and cats and approximately 80% of male dogs were rendered urolith free by holmium:YAG laser lithotripsy. Some male dogs were too small for the procedure, and some dogs had to have follow-up cystotomy to remove larger uroliths. Laser lithotripsy is limited by procedural time. With large uroliths or large urolith burdens, the time required for this procedure may be lengthy, and cystotomy may be a better approach.

Extracorporeal lithotripsy can be applied to nephroliths and proximal ureteroliths via percutaneous nephrolithotomy. Under fluoroscopic guidance, a guidewire is passed percutaneously into the dilated renal pelvis, followed by placement of a sheath that allows introduction of the endoscope and lithotripsy probe (ultrasonic, electrohydraulic, or laser). After the urolith is fragmented, the fragments are removed through the sheath using a basket. When the fragments have been removed, a temporary stent (nephroureteral stent or double pigtail ureteral stent) is usually placed, extending into the renal pelvis, down the ureter, and into the bladder. The stent remains in place for 2 to 4 weeks and can be removed cystoscopically. Because urolith fragments do not pass through the ureter for removal, this technique may be superior to extracorporeal shock wave lithotripsy (ESWL) for large nephroliths.

Extracorporeal Shock Wave Lithotripsy

Two types of lithotripters are used for ESWL: wet and dry. A wet lithotripter requires partial submersion of the patient in a water bath. A dry lithotripter couples the shock waves to the patient through a water-filled cushion. Dry lithotripters are less efficacious than wet lithotripters, but they also cause less damage to surrounding tissue.

Shock wave lithotripsy is better suited for immobile uroliths (nephroliths and ureteroliths) than cystic calculi, which tend to shift out of the focus of the shock wave path. Urolith composition does affect shock wave fragmentation; struvite is the easiest to fragment, followed by calcium oxalate, urate, and cystine, in order of increasing resistance. Feline cal-

in removal and collection of small uroliths for analysis. During cystoscopy, a urolith basket can be used to snare urocystoliths smaller than the diameter of the distended urethra (FIGURE 1). The cystoscope and basket with urolith are then slowly withdrawn while visualizing the urethra to ensure that the urolith does not become lodged in the urethra. Transurethral rigid cystoscopy is generally limited to female patients or male patients with a perineal urethrostomy.
Cystoliths are more difficult to fragment than canine calcium oxalate urinary calculi.\(^{21}\)

Using a wet lithotripter, successful fragmentation of nephroliths was achieved in 90% of dogs after one or two treatments in one study.\(^{20}\) Retreatment was necessary in about 30% of these patients, compared with a retreatment rate of about 50% after lithotripsy using a dry lithotripter.\(^{14,20}\) Fragments begin to move out of the renal pelvis within 24 hours but may take several weeks to months to clear the upper urinary tract.\(^{14}\) The amount of renal damage induced in cats by wet lithotripters causes an unacceptable decline in renal function, but successful resolution of ureteroliths in cats has been accomplished with dry lithotripters.\(^{20,22,23}\)

Transient hematuria is common after ESWL.\(^{22}\) Transient increases in creatinine occurred in half of dogs treated with ESWL but remained within the normal range in one report.\(^{14}\)

**FIGURE 1**

Percutaneous cystolithotomy.

The bladder is pulled up to a small incision in the abdominal wall using a stay suture. The cystoscope sheath is placed into the bladder, and a basket forceps is placed through the working channel of the scope to grasp and remove the stones.

The cystoscope sheath being placed into the bladder through the small abdominal incision. (Courtesy of Dr. Allyson Berent, Animal Medical Center, New York City. Used with permission of the *Journal of the American Veterinary Association* [JAVMA])

View of bladder via cystoscope with stone basket in view. (Used with permission of JAVMA)
Urolith fragments can obstruct the ureter; this situation may spontaneously resolve or require additional lithotripsy treatment.\(^2\)\(^5\)\(^2\)\(^2\) Other complications include abdominal pain, renal or perirenal hemorrhage, diarrhea, and pancreatitis.\(^4\)\(^4\)\(^2\)\(^2\)

Shock wave therapy has been used for cystic calculi, albeit less successfully than for fixed uroliths. One study reported a success rate of 80% for urethral passage.\(^4\) Repeat procedures may be necessary in some patients. This procedure can be used to complement voiding urohydropropulsion in patients that are too small for transurethral procedures.

**Cystotomy/Urethrotomy**

Cystotomy is commonly used to retrieve uroliths from the bladder. Complications with cystotomy are rare; however, urine leakage is possible. Two studies reported that uroliths were left behind in 20% of dogs after cystotomy was performed; therefore, postoperative imaging is recommended.\(^2\)\(^4\)\(^2\)\(^5\)

If urethroliths cannot be retropulsed into the bladder or removed via voiding urohydropropulsion, a temporary urethrotomy may be required. In male dogs with frequent obstruction from small uroliths despite medical management (i.e., Dalmatians with urate urolithiasis), a permanent urethrostomy may be performed. The main complication of urethrotomy is hemorrhage, which may persist up to 7 days postoperatively. Urethral stricture is uncommon.\(^2\)\(^6\)

**Nephrotomy/Pyelotomy/Ureterotomy**

Although nephroscopy can be used to remove nephroliths, concerns exist about the long-term effects on renal function from this procedure. In healthy dogs, single-kidney glomerular filtration rate (GFR) has been shown to remain stable 4 to 7 weeks after nephroscopy.\(^2\)\(^7\)\(^2\)\(^6\) One report on the effect of nephroscopy in healthy cats showed no change in single-kidney GFR after 12 weeks,\(^2\)\(^9\) while another report found a 10% to 20% decrease in single-kidney GFR after 52 weeks.\(^3\)\(^0\) The authors of both studies caution that effects on a kidney with preexisting damage may be different.

Pyelotomy, an incision into the renal pelvis, may be performed if the renal pelvis and proximal ureter are sufficiently dilated. This procedure avoids trauma to the renal parenchyma associated with nephroscopy.\(^3\)\(^0\)

Ureterotomy may be considered for ureteroliths in the proximal ureter. Distal ureteroliths may be flushed into the bladder and retrieved through a cystotomy. The distal ureter may also be excised and reimplemented into the bladder. Major complications associated with ureterotomy include strictures at the surgical site and surgical dehiscence with subsequent urinary leakage. A recent study evaluating 16 cases in dogs noted that ureterotomy was associated with a low risk of postoperative complications and was tolerated well.\(^3\)\(^1\) In a study of cats with ureteral calculi, 31% had postoperative complications, and 18% died. However, in the cats surviving more than 1 month, 88% were still alive 2 years after surgery.\(^3\)\(^3\) If the ureter is not dilated enough to make ureterotomy technically feasible, if multiple ureteroliths are present and would require multiple ureterotomy sites, or if a cat is prone to recurrent ureterolithiasis, a ureteral stent extending from the renal pelvis to the bladder can be placed surgically or, in some cases, via cystoscopy.

**Conclusion**

Urolithiasis is a common disease in dogs and cats, and the lower urinary tract is affected more commonly than the upper urinary tract. A variety of removal methods exist, varying in their invasiveness, availability, and suitability for individual patients.

**References**

Key Points

- Medical dissolution can be used for struvite, urate, and cystine uroliths.
- Voiding urohydropropulsion can be used to remove small stones.
- Retrograde urohydropropulsion can move uroliths lodged in the urethra back to the bladder for surgical removal or dissolution.
- Cystoscopy-assisted laser lithotripsy is ideal for nonsurgical removal of a small stone burden in female dogs.
- Extracorporeal shock wave lithotripsy is best for immobile uroliths (nephroliths and ureteroliths).
- Surgical ureterotomy may be the most expedient method of removing an obstructing ureterolith.
- Ureteral stent placement may be the only option for multiple obstructing ureteroliths.
1. Effective medical dissolution protocols do not exist for ____ uroliths.
   a. struvite
   b. calcium oxalate
   c. urate
   d. cystine

2. Removal of cystic calculi is not recommended when
   a. a patient has clinical signs associated with cystic calculi.
   b. a patient has urinary tract infection.
   c. a definitive diagnosis of urolith composition is desired.
   d. cystic calculi are noted incidentally in an asymptomatic patient.

3. Voiding urohydropropulsion is ideal for removing
   a. a large cystic calculus.
   b. multiple small cystic calculi.
   c. a large number of moderate-sized to large calculi.
   d. a urolith lodged in the urethra.

4. Retrograde urohydropropulsion is ideal for
   a. a large cystic calculus.
   b. multiple small cystic calculi.
   c. a large number of small to moderate-sized calculi.
   d. a small urolith lodged in the urethra.

5. The least invasive way to remove a single, large calcium oxalate cystic calculus involves
   a. voiding urohydropropulsion.
   b. retrograde urohydropropulsion.
   c. cystoscopy-assisted laser lithotripsy.
   d. surgical cystotomy.

6. Surgical cystotomy may be more rapid than cystoscopy with laser lithotripsy for removing
   a. a single large cystic calculus.
   b. multiple small cystic calculi.
   c. a large number of moderate to large-sized calculi.
   d. a urolith lodged in the urethra.

7. Which method of urolith removal would be most appropriate for a dog with a high anesthetic risk?
   a. voiding urohydropropulsion
   b. laser lithotripsy
   c. ESWL
   d. laparoscopic cystotomy

8. In two studies, after standard surgical cystotomy, calculi were inadvertently left behind in ____ of dogs.
   a. 0%
   b. 20%
   c. 50%
   d. 80%

9. In one study, a year after nephrotoomy in healthy cats, single-kidney GFR was decreased by
   a. 0%.
   b. 10% to 20%.
   c. 50%.
   d. 80%.

10. Based on studies in dogs, complete return of renal function becomes less probable if an obstructing ureterolith is not removed within ____ day(s).
    a. 1
    b. 7
    c. 30
    d. 90