Use of urohydropropulsion, cystoscopy and lithotripsy to manage feline urolithiasis

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Determining the need for urolith removal and effective therapies depends on the effects of the urolith on the patient (asymptomatic, recurrent infection, dysuria, or urinary obstruction), the physical characteristics of the urolith (mineral composition, size, contour, and location), and the familiarity of procedures and availability of equipment to the veterinarian. For example, with additional training and newer technologies (cystoscopy, basket retrieval, and lithotripsy), surgical removal of uroliths is becoming less desirable for both the patient and client (Table 1).

Table1 Methods for urolith removal

	Method	Suitable application	Considerations
Least invasive	**Medical dissolution**	Sterile struvite and infection-induced struvite uroliths are quickly dissolved with special foods and medication at a fraction of the cost of surgery. For more information visit us urolithcenter.org (activate the recommendations tab on the left for a list of therapeutic recommendations based on urolith type)	Sterile struvite uroliths dissolve within weeks. Infection-induced struvite uroliths may take 1–2 months to dissolve. Nephroliths require longer dissolution times than urocystoliths. Urethral obstruction is uncommon during dissolution
	Voiding urohydro-propulsion	To evacuate small to moderate size (≤4 mm) urocystoliths of any composition in female cats. Uroliths with an irregular contour may need to be smaller	Not suitable for male cats, including males with a perineal urethrostomy. Not suitable in cats with an active urinary tract infection. Not suitable for cats with urethral obstruction If the cat has many (> 5) irregular larger (> 3 mm) uroliths, consider basket retrieval. Not suitable for cats that have recently undergone urinary bladder surgery
Most invasive	**Urolith basket retrieval**	To evacuate small to moderate size (≤ 4 mm) urocystoliths of any composition in female cats. Uroliths with an irregular contour may need to be smaller	Performed during cystoscopy. Not suitable for male cats, including males with a perineal urethrostomy. Not suitable for cats with a urethral obstruction

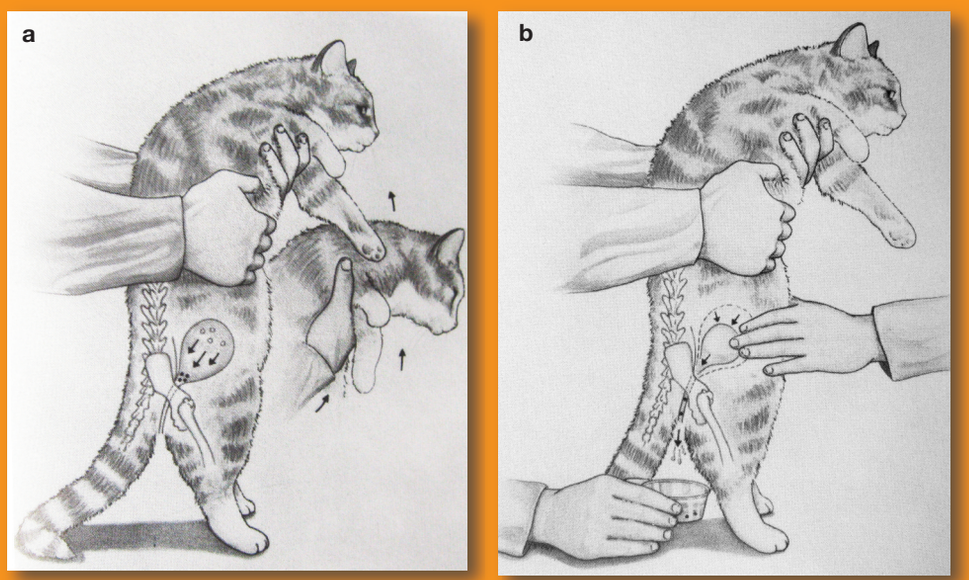


FIGURE 1 (a) To remove urocystoliths by voiding urohydropropulsion the patient is positioned so that the longitudinal axis of the vertebral column is approximately vertical. As a result uroliths move from the ventral portion of the urinary bladder to the urinary bladder neck. (b) To expel urocystoliths, voiding is induced by applying steady digital pressure to the urinary bladder

Voiding urohydropropulsion

Twenty years ago at the University of Minnesota, we developed an innovative technique to remove urocystoliths, called voiding urohydropropulsion (Table 2).[1] By taking advantage of the effect of gravity on urolith position in the urinary bladder and dilation of the urethral lumen during the voiding phase of micturition, this simple technique allowed uroliths to be rapidly flushed out of the urinary bladder (Figures 1 and 2). This procedure is ideal for eliminating recurrent uroliths in patients that are routinely monitored. Detecting recurrent uroliths early, prior to them causing clinical signs, usually indicates that they are small enough to easily void and that the bladder wall is sufficiently healthy to easily accommodate forceful manual expression. Below is a list of important considerations to ensure successful urolith removal:

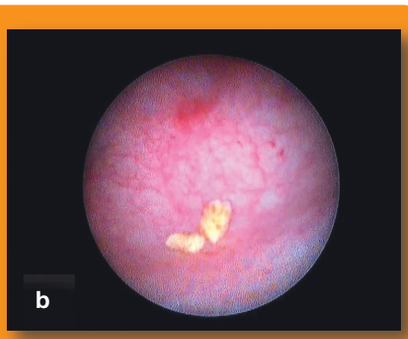
- Choose the right patient. Voiding urohydropropulsion works well in female cats with small urocystoliths (< 4 mm).[1] The urethra in male cats is too narrow to accommodate passage of the uroliths once the diagnosis is made.
- Don't assume that a light plane of anesthesia is sufficient to relax the urethra; full anesthesia beyond the depth necessary to perform an abdominal celiotomy should be utilized.
- This procedure is not suitable for managing uroliths in the urethra. Therefore, using only ultrasound to diagnose uroliths is inadequate to avoid performing voiding urohydropropulsion in cats with urethroliths.[2]
- This procedure is not suitable for managing patients with urethral obstruction or recent urinary bladder surgery; the integrity of the urinary bladder wall has been compromised and may not accommodate safe bladder expression.
- Select cats based on urolith size and your level skill. If you have never performed voiding urohydropropulsion, select cats with smaller (≤3 mm), smooth uroliths, and prepare for cystotomy in case of an adverse event. You should not be concerned about uroliths becoming lodged in the urethra during urinary bladder expression because they are easily flushed back into the urinary bladder for surgical removal.[3]

FIGURE 2 To facilitate repositioning of uroliths into the trigone and urinary bladder access for manual expression, the anesthetized cat is supported under the forelegs and positioned such that the patient's back rests against the chest of the holder. Alternatively, the cat can be placed in a V trough, the cat is held secure as the head of the V trough is tilted upward

Basket removal of urocystoliths

Specially-designed baskets are used to remove urocystoliths during cystoscopic evaluation of the urinary bladder (Figure 3). These very slim baskets are inserted through the biopsy channel in the cystoscope. After the urolith is visualized, an opened basket is placed around the urolith and once it is captured, the basket is closed. The urolith is positioned close to the end of the cystoscope, and the urolith and cystoscope are slowly pulled through the urethra as water is flushed to maintain urethra dilation. The process is repeated until all the uroliths have been removed. Urolith diameter and contour are important factors permitting passage of uroliths through the urethra. Below is a list of important considerations to ensure successful urolith removal.

- Choose the right patient. Basket removal of uroliths works well in female cats with smaller uroliths (Table 1). However, the urethral lumen in male cats is too narrow to accommodate



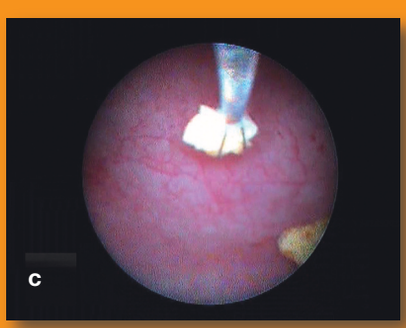


Figure 3 (a) Right lateral radiographic image of the caudal aspect of the abdomen of a 7-year-old female Bengal cat with dysuria obtained during initial examination. Two radio-opaque structures in the urinary bladder measuring 3.7 mm and 2.5 mm in diameter are consistent with a diagnosis of urocystolithiasis. A third structure (2.7 mm) of similar density in the right kidney was consistent with a diagnosis of nephrolithiasis. (b) Cystoscopy performed following general anesthesia of the cat confirmed two urocystoliths in the urinary bladder. (c) A urolith removal basket inserted through the working channel of the cystoscope retrieved the uroliths, permitting their removal through the lumen of the urethra. (d) Retrieved urocystoliths were composed of 100% calcium oxalate

passage of suitable cystoscopes to retrieve uroliths.

- Don't assume that a light plane of anesthesia is sufficient to relax the urethra; full anesthesia beyond the level necessary to perform an abdominal celiotomy is desired.[4,5] This is especially important because the feline urinary bladder is easily traumatized, possibly causing moderate hematuria that minimizes cystoscopic visibility.
- This procedure is not ideal for managing patients with urethral uroliths or urethral obstruction. Uroliths lodged in the urethra are likely too large to be pulled through the narrower portions of the distal urethra.
- Small uroliths inadvertently left during a recent cystotomy are easily removed by basket retrieval; integrity of the urinary bladder wall is sufficient to accommodate cystoscopy but concurrent hemorrhage may minimize cystoscopic visualization.

Laser lithotripsy

The term lithotripsy is derived from the Greek words 'lith' meaning stone, and 'tripsis' meaning to crush. A lithotriptor is a device for crushing or disintegrating uroliths. Extracorporeal shock wave lithotripsy is commonly utilized to fragment uroliths in the upper urinary tract, whereas intracorporeal lithotripsy is commonly used to fragment uroliths in the lower urinary tract via urethrocystoscopy. Although several forms of energy (ultrasonic, ballistic, electrohydraulic, and laser) can fragment uroliths, not all energy forms are suitable for use in companion animals. For example, the probes for ultrasonic lithotripsy are too large to pass through the operating channel of cystoscopes commonly used for cats. When treating humans, the safety and efficacy of electrohydraulic lithotripsy was inferior to Holmium:YAG laser lithotripsy.[6] Because of the versatility and safety of the Holmium:YAG laser, it has become the author's treatment modality of choice for intracorporeal fragmentation of urocystoliths. The Holmium:YAG laser is a thermal device that delivers light energy to the urolith through a special flexible glass (quartz) fiber that is less than a millimeter in diameter. The laser creates a super-heated bubble at the fiber tip. To accurately aim the laser, the quartz fiber is inserted through the biopsy channel of the cystoscope. The tip of the fiber is touching the urolith when the laser is activated. As the laser energy is absorbed by the water in the urolith; the water rapidly expands fragmenting the urolith. This photo-thermal effect is confined to a small space of approximately 1–2 mm in diameter, and therefore does not damage the urinary bladder wall.

Table 2 Steps for performing voiding urohydropropulsion

1 **Anesthetize the patient**	The type of anesthesia selected may vary based on patient considerations. A common mistake is assuming that only a minimal depth of anesthesia is needed. In our experience, the depth of anesthesia needed to perform voiding urohydropropulsion is greater than that needed for routine surgery. Consider the addition of short-acting anesthetics (eg, Propofol, 0.5–1 mg/kg IV) 30 seconds prior to urinary bladder expression, or lumbar epidural anesthesia (0.1–0.2 ml/kg of 2% lidocaine without epinephrine) to facilitate urethral relaxation. Avoid anesthetic drugs likely to increase urethral tone (eg, dexmedetomidine and other adrenergic receptor agonists)
2 **Attach a 3-way stopcock to the end of an 8 Fr urinary catheter and insert catheter into urethra**	The three-way stopcock facilitates control of the volume of fluid entering the urinary bladder and containment of fluid once the urinary bladder is full
3 **Fill the urinary bladder**	Sterile physiologic solutions (lactated Ringer's solution, normal saline) are injected through a transurethral catheter to distend the urinary bladder. If fluid is expelled prematurely around the catheter prior to adequate urinary bladder filling, the vulva and/or urethra can be gently occluded using your thumb and first finger. Placement of additional fluid may not be needed
4 **Position the patient such that the spine is approximately vertical**	Repositioning the patient allows uroliths to accumulate at the neck of the urinary bladder facilitating their expulsion. Anatomically, the urethra does not become vertical until the caudal spine is 20 to 25 degrees anterior of vertical, but this may not be clinically important
5 **Agitate the bladder**	Gently agitating the urinary bladder left and right is performed to dislodge uroliths that may be loosely adhered to the urinary bladder mucosa
6 **Remove the urinary catheter**	
7 **Express the urinary bladder**	Apply steady digital pressure to the urinary bladder to induce urination. Once voiding begins, the urinary bladder is more vigorously compressed. Compress the urinary bladder dorsally and cranially (toward the back and head of the patient). Movement of the urinary bladder caudally toward the pelvis may cause the urethra to kink preventing maximal urethral dilation
8 **Repeat steps 2 through 7**	The urinary bladder is flushed repeatedly until no uroliths are expelled
9 **Medical imaging**	Imaging provides an appropriate method of assessing successful expulsion of uroliths. To enhance detection of remaining small uroliths consider a double-contrast cystography (only the lateral view is needed)

Not all cats are suitable candidates for laser lithotripsy. Below is a list of important considerations to insure successful urolith removal.

- Choose the right patient. This procedure works well in female cats (Table 2). The urethra of male cats is too narrow to accommodate passage of suitable cystoscopes to fragment uroliths using laser lithotripsy.
- Don't assume that a light plane of anesthesia is sufficient to relax the urethra; full anesthesia beyond the level necessary to perform an abdominal celiotomy is desired.
- This procedure is ideal for managing female cats with urethral uroliths or urethral obstruction. Uroliths lodged in the urethra are held in place which facilitates rapid laser targeting and fragmentation.
- Laser lithotripsy is well suited for managing uroliths inadvertently left in the urinary bladder following a cystotomy and therefore, avoids additional surgical incisions.
- Patients with very large uroliths or a large number of uroliths may require longer anesthetic periods to complete removal; therefore, cats with this clinical picture may be better managed with standard surgical urolith removal.

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