Despite advances in the prevention and management of urinary calculi, calculus removal remains a common need in small animal practice. In fact, changes in calculus management have increased the percentage of calculi that are difficult to manage medically. Endoscopic techniques that reduce the need for calculus removal by traditional laparotomy and cystotomy have been developed. In my experience, most cystic and urethral calculi can be removed by transurethral or laparoscopic-assisted cystoscopy. These techniques decrease trauma to and urine contamination of the abdomen. Endoscopy also improves the ability to examine the urinary system for disease and the presence of more calculi.

**Patient and Technique Selection**

Nearly all calculi in female dogs and cats can be removed by either transurethral cystoscopy or laparoscopic-assisted cystoscopy, in my experience. Most male dogs can be treated with laparoscopic-assisted cystoscopy. Transurethral cystoscopy is preferred for female cats and dogs because it is less invasive than laparoscopic-assisted techniques; however, calculi must be small enough to be pulled through the urethra if transurethral cystoscopy is to be successful. Size criteria are continually being modified, but I have found that in female cats and dogs, calculi can be removed that are twice the diameter of the largest cystoscope appropriate for the patient. For example, a 7-kg female dog can usually accommodate a 2.7-mm cystoscope with a 14.5-Fr sheath. These dimensions should allow a calculus 6 to 7 mm in diameter to be removed through the urethra. In male dogs, transurethral removal is limited to much smaller calculi because the stones must traverse the os penis region of the urethra. Calculi in male cats can be removed by laparoscopic-assisted cystoscopy, but the urethra is too small for current transurethral cystoscopy techniques. The ability to endoscopically remove cystic and urethral calculi has largely replaced the need for hydropulsion in female dogs.

Transurethral cystoscopic calculus removal in female dogs has been enhanced in some specialty hospitals by cystoscopic lithotripsy. As with basket removal of calculi from the lower urinary tract, lithotripsy can be more widely used in female dogs than male dogs. Cystic lithotripsy is indicated for calculi that are too large to be removed cystoscopically with baskets. The current contraindications to lithotripsy are large calculi and high numbers of calculi in relation to the operator’s expertise. Trauma and time required to fragment and remove large or multiple calculi can be excessive during inappropriate lithotripsy.

Laparoscopic-assisted cystoscopy through one or two small abdominal incisions has proven to be an effective and relatively simple way to remove calculi from female and male dogs and cats. The primary contraindication is the presence of stones several centi-
meters in diameter that require removal through a long abdominal incision. Although cystoscopy can still be used to examine the urinary system after removal of larger calculi, the longer incision might as well be for a traditional laparotomy and cystotomy. The presence of a very large number of smaller calculi can discourage some endoscopists, but the use of lavage and suction permits removal of larger numbers of stones during laparoscopic-assisted cystoscopy.

In the hospitals in which I practice, traditional laparotomy and cystotomy are usually reserved for patients with very large calculi or those requiring other complex abdominal procedures, such as nephrectomy. However, some additional procedures are better performed during laparoscopy than by laparotomy. An example would be a liver biopsy, for which laparoscopy is minimally invasive and can be used to obtain multiple tissue samples from selected sites as well as a bile sample for culture.

Some subspecialists successfully remove calculi from the ureters and bladder using advanced endourologic techniques. These techniques are widely performed in people; in the veterinary setting, they have been most commonly applied in larger female dogs. Lithotripsy and endoscopic removal of calculi from the kidneys and ureters are typically referral procedures, in contrast to the endoscopic techniques for transurethral and laparoscopic-assisted cystoscopic procedures, which have been performed by general practitioners trained in endoscopy.

**Preoperative Patient Management**

Patient evaluation is directed toward determining renal function, the presence of urinary tract infection, systemic organ function, and the number, size, and distribution of calculi. Tests include a complete blood count, serum chemistry profile, urinalysis, and urine culture. Abdominal radiography is indicated to determine the size, number, and distribution of radiopaque calculi. Radiopaque calculi are composed of struvite, silica, and calcium oxalate; more radiolucent calculi contain urate, uric acid, and cystine. Abdominal ultrasonography is preferred to radiography for detecting radiolucent calculi and helps obtain more information about renal structure and function. Both imaging techniques are commonly used, but urinary contrast procedures seem to be less frequently employed. Ultrasonography by an experienced ultrasonographer is particularly useful for monitoring dogs with recurrent calculi, especially when the calculi are small.

If present, prerenal and postrenal azotemia or uremia should be addressed before calculus removal in all but the most urgent cases of obstruction. Confirmed renal dysfunction may require modification of the plan for calculus removal. In patients with a preexisting urinary tract infection, surgical drainage may be necessary. Urine cultures are performed to identify causative organisms and appropriate antimicrobial therapy.
tract infection, culture and antibiotic administration should be attempted before emergency relief of urinary obstruction. In patients with recurrent urinary tract infections, collection of a bladder mucosal sample for culture should be considered during calculus removal. Regardless of the protocol used to control urine contamination of the abdomen, the risk of contamination dictates the use of antibiotics during cystoscopy and laparoscopic-assisted cystoscopy.

Transurethral Cystoscopy
Calculus removal using a stone basket is less invasive than and preferred to cystotomy during laparotomy or laparoscopic-assisted cystoscopy if the calculi are small enough for removal via the urethra. The clinician must be a competent and experienced cystoscopist to attempt calculus removal using a basket retrieval instrument. In general, basket removal can be attempted for calculi <3 mm in diameter in female cats and male dogs. In female dogs, calculi removed using this method should be no more than twice the diameter of the largest cystoscope that can be placed in the urethra. Commonly used cystoscope sizes are 1.9 mm for female cats and dogs weighing <5 kg, 2.7 mm for female dogs between 5 and 15 kg, and 3.5 or 4.0 mm for larger female dogs (FIGURE 1). The two smaller cystoscope sizes can be used to retrieve calculi in nearly all female dogs. A 1.9-mm cystoscope and a basket retrieval instrument have been used to remove calculi during cystoscopic examination of the urethra and bladder of male cats after perineal urethrostomy.

It is not uncommon during transurethral cystoscopic calculus removal to find lesions that may be related to recurrent urinary tract infections. These include strictures, transitional cell carcinoma, inflammatory polyps, and persisting cystotomy closure sutures.

Basket retrieval devices with three or four wires are preferred (FIGURE 1). They should easily fit through the operating channel of the cystoscope. After diagnostic cystoscopy is used to examine the lower urinary tract and flush the bladder, the basket is passed through the

**FIGURE 2**
Transurethral cystoscopy in a 6-year-old spayed schnauzer. The patient had a 3-week history of repeated straining to void and inappropriate voiding inside the house. The dog had previously had a cystotomy to remove calcium oxalate calculi.

Radiograph showing a urethral calculus (circle). Urine culture results at the time of radiography had no bacterial growth. Using radiography and ultrasonography, the dimensions of the calculi were measured to determine whether transurethral cystoscopy could be used to remove them. The dog weighed 10 kg, and the largest calculus appeared to be 5 mm in diameter.

Endoscopic view of the larger calculus at the outflow tract, just before being snared with the basket retrieval device.

The removed calculi were 6 mm in diameter. Despite attempts to medically prevent recurrence, clinical signs developed, and more calculi were diagnosed using ultrasonography and removed by cystoscopy.
operating channel (FIGURE 2). Individual techniques vary, but I prefer to have the bladder only mildly distended and to keep the lavage flow rate low. This practice concentrates the calculi and reduces the swirling effect that can be produced by higher flow rates. Having the patient in dorsal recumbency and tilted with the head up can also move the calculi toward the outflow tract. External abdominal manipulation of the bladder can be helpful.

The basket is opened in the area of the calculi and gradually closed during cystoscopic examination. Some clinicians prefer to tighten the wires very securely around the stones. I often use less force to cradle the calculi during extraction. The basket distention helps to gradually dilate the urethra during extraction and reduces the likelihood of calculus fragmentation due to basket compression. This procedure is repeated until all the calculi are removed. Vigorous flushing may be used to remove the smallest calculi. Leaving the cystoscope sheath in the urethra with the cranial end in the outflow tract while squeezing on the bladder can provide a conduit for small calculi to be flushed from the bladder.

Laser lithotripsy uses a holmium:YAG laser as well as a cystoscope. Some urologists routinely perform laser lithotripsy of calculi in the bladder, ureters, and kidneys. Patient selection is critical because the time for fracture and extraction can be excessive for large or multiple calculi. Candidates for laser lithotripsy are patients that do not meet the criteria for other forms of endoscopic calculi removal. In general, laser lithotripsy appears to require a longer time for removal of calculi while resulting in a similar percentage of retained calculi as traditional cystotomy. Clinical studies of minilaparotomy cystotomy have fewer patients, but this technique appears to ensure a very favorable percentage of calculi removal.

Laparoscopic-Assisted Cystoscopy

Cystoscopy via minilaparotomy was initially reported as laparoscopic-assisted cystoscopy. Laparoscopic assistance requires a laparoscope and two trocars, in contrast to the more recently reported technique of percutaneous cystolithotomy, also called keyhole transvesicular cystourethroscopy. Both laparoscopic-assisted and transvesicular cystoscopy require the use of a rigid cystoscope to examine the bladder and urethra and to remove calculi. A 2.7-mm cystoscope is generally used, except in cats and small dogs, for which a 1.9-mm cystoscope is preferred. After calculi are removed from the bladder and outflow tract, the urethra is examined with a rigid cystoscope (female dogs) or a 2.5/2.8-mm flexible fiberoptic urethroscope (male dogs; FIGURE 3). Urethral calculi in male dogs are removed by either retrograde flushing or a basket retrieval device passed beside the urethroscope during laparoscopic-assisted cystoscopy. Urethrostomy is rarely required to remove calculi obstructing the urethra just caudal to the os penis. Laparoscopic-assisted cystoscopy has been combined with other laparoscopic procedures such as liver biopsy or laparoscopic-assisted gastrointestinal foreign body removal.

In laparoscopic-assisted cystoscopy, the laparoscope trocar is placed on the midline just caudal to the umbilicus to enable identification of the apex of the moderately distended urinary bladder. A second trocar, through which a 5-mm Babcock forceps can be passed to grasp the apex of the bladder, is then placed (FIGURE 4). The second trocar site is on the midline for female dogs, cats, and some male dogs, depending on the position of the prepuce in relationship to the

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apex of the bladder. In most male dogs, the second trocar site is placed laterally (e.g., on the left side for a right-handed surgeon). The apex of the bladder is grasped with the forceps and lifted to the trocar site, which is extended as a minilaparotomy (FIGURE 4). If any bladder lumen is cranial to the trocar site, inspection and removal of calculi from the cranial pouch of the bladder becomes difficult. The bladder is not exteriorized, with the minilaparotomy being just sufficient to secure it to the abdominal wall. A variety of techniques can be used to keep the bladder firmly secured to the abdominal wall and prevent urine contamination of the peritoneal cavity. In the most common technique, four quadrant attachments with interrupted cruciate sutures are placed, and their long tags are secured to drapes. Some surgeons prefer to place a temporary continuous suture between the bladder and skin.
Once the bladder is securely sealed to the abdominal wall, a small cystotomy is performed and a rigid cystoscope (1.9 mm for cats and small dogs and 2.7 mm for larger dogs; **FIGURE 4**) is placed into the bladder. The bladder is lavaged in a fashion similar to that for transurethral cystoscopy. Some clinicians prefer to have a urethral catheter as an additional infusion source. The bladder and entire urethra of female dogs and the prostatic urethra of males are examined with the rigid cystoscope. Calculi can be removed with a variety of instruments, depending on the size and number of stones. Alligator forceps, 5-mm Babcock forceps, and arthroscopic grasping forceps are passed parallel to the cystoscope to grasp and retrieve calculi (**FIGURE 4**). Another removal technique is to use a wire basket retrieval instrument passed through the operating channel of the cystoscope. The entire assembly of cystoscope and forceps or basket retrieval device is removed with each stone and replaced into the bladder to retrieve the next.

Once the larger calculi are removed, some smaller ones can be flushed from the bladder using urethral catheter flushing and surgical suction. The cystoscope is then advanced through the urethra in female dogs and cats. A 2.5- to 2.8-mm flexible urethroscope can be passed from the bladder to the os penis in most male dogs and through the os penis in male dogs larger than 12 to 15 kg. Only the cranial portion of the urethra is examined in male cats. It is common to watch a urethral catheter pass around irregularly shaped calculi without feeling resistance to the catheter’s passage. In my experience, urethral strictures just proximal to the os penis from prior calculi obstruction and trauma are common in dogs. Knowledge of such strictures can justify a scrotal urethrostomy. After calculus removal and flushing, the cystotomy is closed in a single layer, using an appositional suture pattern, avoiding the mucosa. Greater omentum is sutured to the bladder closure.

Keyhole transvesicular cystourethroscopy is performed in a similar fashion except that laparoscopy is not used and the apex of the
bladder is grasped with surgical instruments passed through a small laparotomy. Again, it is critical that the cranial portion of the bladder be selected to avoid having bladder cranial to the cystotomy site. The remainder of the procedure is similar. Both laparoscopic-assisted and transvesicular cystoscopy techniques have been reported as being effective in the hands of the technique developers. Both allow the same excellent examination of the lower urinary tract, limit bladder trauma, limit urine contamination of the abdomen, and should increase the likelihood of complete removal of calculi.

Intraoperative Nephroscopy and Cystoscopy

Rigid endoscopy during an open laparotomy causes minimal insult to the urinary system from the renal pelvis to the urethra, improves lighting, and increases magnification much more effectively than magnifying loupes and diode head lights. The optical space within the lumen of the renal pelvis and ureters is obtained as for cystoscopy, using saline infusion. The most frequent intraoperative use of endoscopy is to examine the renal pelvis and recesses when removing renoliths. The approach is similar to arthroscopy, with a scope being placed through a puncture in the greater curvature (lateral margin) of the kidney. Penetration of the pelvis is easy when the pelvis is dilated. Calculi have been removed by using an alligator forceps placed beside a 30° scope or through a separate puncture to achieve triangulation or by using a basket retrieval device placed through the operating channel of the cystoscope (FIGURES 5 AND 6). Unlike nephrotomy, this minimally invasive retrieval of renal calculi using a scope placed through the renal pelvis does not require transient occlusion of renal vessels. The scope can also be passed through the proximal part of the ureter. When removing calculi endoscopically, the renal recesses must be thoroughly examined to ensure complete stone removal. The kidney perforations are closed by firmly apposing their sides or by placing small sutures in the capsule across the perforation. The scope can be used to differentiate between intraluminal calculi and mural calcification. I have also used an arthroscope to examine dilated ureters when removing ureteral calculi or performing a neocystostomy or ureterotomy.

Cystoscopes and ureteroscopes have also been used to examine the lumen of the bladder and urethra during traditional laparotomy. Calculus removal via laparotomy in these cases usually involves major procedures such as nephrectomy or removal of stones from the kidney or ureter, which are not amenable to less invasive techniques. The cystoscope can be passed through a minicystotomy before a

QuickNotes

Urinary calculi often recur.

FIGURE 6

Removal of renal calculi from a 12-year-old castrated Maltese.
cystotomy is performed, for example, to determine the precise area before resection of an inflammatory polyp.14

Other Minimally Invasive Techniques
Calculation removal treatments for dogs and cats are gradually being adapted from those used for people. Laser and electrohydraulic lithotripsy are already being used for cystic calculi in dogs and cats.3–11 Laser lithotripsy and ureteral stenting during ureteroscopy are routinely used for ureteral calculi in people; however, size is a limiting factor in small animals, especially cats and small dogs. In people, renal calculi are removed by percutaneous nephrolithotomy, ureterolithotomy, and cystolithotomy, typically involving lithotripsy, basketing, and flushing. Finally, extracorporeal shock wave lithotripsy is an alternative to reduce calculus size so that urine flow can flush the fragments.33,35

Postoperative Patient Management
Case management must be directed to the patient’s needs. At least one lateral radiograph should be taken after calculus removal while the patient is anesthetized to ensure that residual radiopaque calculi are not present. Appropriate fluid management helps maintain renal function and flush residual blood and calculi fragments. Although laparoscopic procedures are less invasive than traditional surgery, pain medication is routinely used. Typical protocols include administering opioids during the initial recovery period and either NSAIDs or opioids for the first few days after calculus removal. Bupivacaine can be infused into the urethra for additional transient analgesia. Dietary management to reduce calculus formation is usually delayed until the patient is fully recovered and the final calculus analysis obtained. Nutritional therapy soon after surgery should focus on supporting early healing.

Urinary calculi often recur. Patients with a history of calculus removal must be closely monitored by the owner and veterinarian. Those with a history of urinary tract infection must have regular urinalysis and, if indicated, urine cultures. When feasible, dietary management should be considered. Dogs and cats in which calculi recur despite good medical management are candidates for ultrasonography studies every 4 to 6 months. Radiography can also be considered for radiopaque calculi. C

References