Urinary calculi (also known as uroliths or stones) are common in small animal patients. Although calculi vary in composition, most cause the same clinical signs and are diagnosed similarly. Common clinical signs of calculi include dysuria, stranguria, pollakiuria, hematuria, and incontinence; however, calculi can exist without causing clinical signs.1

The urinary tract is designed to remove waste from the body in liquid form. Calculi form when certain waste products precipitate from this solution, forming crystals. As microscopic crystals clump together, they can become macroscopic calculi.2

Calculi can be described by their location, shape, size, and, most important, mineral makeup. Knowing the mineral composition of calculi is important because treatment and prevention vary among types of calculi. More than 80% of calculi in dogs and cats are either calcium oxalate or struvite (magnesium ammonium phosphate hexahydrate).3

**Diagnosis**

**Imaging Techniques**

Imaging techniques are used to determine the size, shape, number, and location of calculi.1 Most calculi are radiodense—visible on survey radiography.1 During double-contrast cystography, which is also useful for detecting calculi, the bladder is distended with air and a small amount of positive contrast medium is infused into the bladder through a urethral catheter to form a puddle. Then the patient is rotated to coat the bladder mucosa so that calculi can be visualized.4 Ultrasonography can provide information about kidney architecture and the presence, location, and number of calculi.

**Urinalysis**

In patients with suspected urinary tract disorders, urinalysis is an important part of the diagnostic evaluation. Crystalluria can be an important finding associated with urolithiasis. Crystals do not confirm the presence of calculi but do suggest crystalline oversaturation.3 Temperature change due to elapsed time between urine collection and urinalysis can cause crystals to form in urine, resulting in false-positive crystalluria. Therefore, urine samples should be collected and processed in a timely manner.1 Ideally, urine should be collected via cystocentesis and analyzed while at body temperature.

Urine specific gravity and urine pH can help assess the chemical environment in the urinary bladder. The chemical environment of the urine determines calculus formation and can suggest which type of calculus is present. A high urine specific gravity can suggest an increase in the concentration of calculi precursors.5 Calcium oxalate calculi form in neutral to acidic urine (i.e., a normal to low pH), whereas struvite calculi are more common in alkaline urine (i.e., a high pH).1 Urine culture and sensitivity testing is indicated in patients with urolithiasis because urinary tract infections are common in these patients.6

**Blood Chemistry**

When calculi are found, it is important to obtain a blood chemistry profile. Blood chemistry results can sometimes suggest the presence of underlying diseases or conditions, such as Cushing disease (hyperadrenocorticism) and hypercalcemia, that can predispose patients to calculi.7 Because calculi occasionally cause obstruction leading to renal or urinary tract damage, a patient’s renal values and electrolytes should be monitored. In addition, hepatic function should be evaluated to detect urate calculi, which are caused by liver dysfunction.

**Calculus Analysis**

Determining the composition of calculi is essential for preventing recurrence. Although many types of calculi have a characteristic appearance, guessing composition by appearance is unreliable and subject to error.8 All removed or voided calculi should undergo chemical analysis.

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**Glossary**

- **Crystalluria**—microscopic crystalline material in the urine
- **Cystoscopy**—endoscopy of the urinary bladder
- **Cystotomy**—surgical incision of the urinary bladder
- **Dissolution**—dissolving a solid substance into a solution
- **Diuresis**—increased production of urine from the kidneys
- **Dysuria**—painful or difficult urination
- **Hematuria**—blood in urine
- **Laparotomy**—surgical incision through the abdominal wall
- **Pollakiuria**—abnormally frequent urination
- **Stranguria**—straining to pass urine
- **Urinary incontinence**—involuntary leaking of urine

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to determine the mineral composition and develop a successful treatment and prevention plan. Analysis results report the chemical makeup of the different components of calculi (TABLE 1). In cases of recurrence, calculi should be resubmitted because mineral composition can change from one episode to another.²

**Calcium Oxalate Urolithiasis**

One of the two most common types of calculus in dogs and cats is calcium oxalate. Calcium oxalate calculi are often white and hard with a jagged surface.³ The predisposing factors for calcium oxalate formation include breed, age, sex, obesity, and disease.²

Canine breeds such as the miniature schnauzer, Lhasa apso, Yorkshire terrier, shih tzu, and bichon frise have an increased risk for calcium oxalate formation.³ Exotic feline breeds, such as the Himalayan, Persian, and Burmese, have a higher risk than other feline breeds.⁹ In dogs, males are more prone than females to develop calcium oxalate calculi; in cats, males and females have an equal risk. Older, more obese, neutered animals have a higher incidence of these calculi than younger, leaner, intact animals.⁷

Cushing disease and primary hyperparathyroidism may predispose dogs to calcium oxalate calculus formation.³ In cats, hypercalcemia has been linked to calcium oxalate formation.¹³ Managing the underlying problem is necessary for preventing recurrence of calculi.

No medical therapy or dietary change can dissolve calcium oxalate calculi; therefore, physical removal is the only option for eliminating this type of calculi.⁷

Once calcium oxalate calculi are removed, options are available for prevention. It has been shown that the recurrence rate increases over time; therefore, preventive measures should be implemented immediately to help avoid calculus formation.³ The incidence of calcium oxalate formation may be decreased by feeding a veterinary-formulated diet that is nonacidifying and lower in calcium, oxalate, and protein.¹⁰ This type of diet helps induce a neutral to alkaline urine pH, creating a less ideal environment for the formation of calcium oxalate crystals and calculi. In addition, increased fluid intake increases urine volume and diuresis, flushing calcium and oxalic acid from the urinary tract.² Fluid intake can be encouraged by adding water to food, providing water fountains designed for pets, and offering palatably flavored ice cubes as treats (i.e., tuna or low-sodium bouillon)¹⁰ to induce a urine pH of >7.0 and a urine specific gravity of <1.020.⁸

**Struvite Urolithiasis**

Another common calculus is magnesium ammonium phosphate hexahydrate, commonly known as struvite.¹¹ Struvite calculi are often light tan and oval to pyramidal.⁸ In dogs, most struvite calculi are caused by urinary tract infection (i.e., infection induced).¹² In contrast, 95% of struvite calculi in cats are present without infection (i.e., sterile struvite).¹³ These calculi can be eradicated by physical removal or by medical and/or dietary dissolution.

**Infection-Induced Struvite Urolithiasis**

Infection-induced struvite calculi are more common in dogs than in cats.¹² After infection, struvite crystals can form within a few days or weeks.⁸ In dogs, this type of calculus is due to the activity of urease-producing bacteria during a urinary tract infection. Urease metabolizes urea in the urine, leading to calcui formation.¹² These calculi are usually associated with *Staphylococcus* spp.¹²

These calculi can be dissolved with a struvite dissolution diet when provided with an appropriate antimicrobial, which should be determined by bacteriologic culture and sensitivity testing.¹⁸ The antibiotic must be given throughout dissolution because bacteria may become trapped in the matrix of calculi. As the calculi dissolve, trapped bacteria are released into the urine, possibly causing reinfection and preventing dissolution of calculi.¹¹

Diets for infection-induced struvite dissolution are formulated to:

- Induce diuresis to flush the urinary tract
- Decrease concentrations of magnesium, ammonium, and phosphate in urine

These diets are low in protein, magnesium, and phosphorus.¹² As with any dissolvable calculi, the number and size of struvite calculi do not dictate the likelihood of dissolution but do contribute to the dissolution rate.⁸ The average time for dissolution is 3 months.¹⁰

Because struvite calculi are caused by infection in dogs, a veterinary diet will not prevent the development of these calculi. Prevention entails treating infections with an appropriate antimicrobial as determined by culture and sensitivity testing. In addition, a urine sample should be checked after completion of antibiotic treatment to ensure that the infection has resolved. Other causes of recurrent urinary tract infections should be determined and corrected. Possible causes include underlying disease or an anatomic abnormality such as a recessed vulva.

**Sterile Struvite Urolithiasis**

Sterile struvite calculi are most common in cats.¹² In sterile struvite cases, urine pH is the most important factor affecting calculi

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**Key Points**

- Determining the mineral composition of urinary calculi is crucial for preventing recurrence.
- New, minimally invasive approaches have been developed for urinary calculus removal.
- Understanding of treatment and prevention of urinary calculi is necessary for effective client education.

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**Table 1. Components of Calculus**

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nidus</td>
<td>Area of initiation of calculus growth</td>
</tr>
<tr>
<td>Stone</td>
<td>Major component of calculus</td>
</tr>
<tr>
<td>Shell</td>
<td>Complete outer area of calculus</td>
</tr>
<tr>
<td>Surface crystals</td>
<td>Incomplete outer area of calculus</td>
</tr>
</tbody>
</table>

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formation and dissolution. Dissolution diets are formulated to achieve a urine pH of 6.0 to 6.5, and calculus dissolution usually takes 2 to 4 weeks. These diets are low in magnesium, phosphorus, and protein. The selected dissolution diet should be the only one that is fed. In addition, increasing water intake to increase urine volume is useful. Radiography should be performed every 3 to 4 weeks to monitor the number and size of calculi.

Sterile struvite calculi can be prevented by maintaining a urine pH <6.5. Water consumption should be encouraged because it dilutes the urine. Feeding canned food is the easiest way to encourage water consumption, although some cats are reluctant to consume canned diets. Transitioning to a canned diet slowly and warming the food may encourage acceptance. Water intake may also be increased by providing filtered drinking fountains designed for pets, offering palatably flavored water and ice cubes, and adding water to a dry diet.

**Treatment**

**Dietary and Medical Dissolution**

Dietary and medical dissolution are effective for several types of calculi. The primary goals of dissolution are to:

- Reduce calculogenic substances in the urine; a specifically formulated diet can help to restrict intake of these dietary components
- Increase the solubility of calculogenic components in the urine; this can be accomplished by administering medications or diets that change the urine pH
- Increase the volume of urine by adding water to the diet; this can be accomplished by feeding canned food, providing filtered drinking fountains designed for pets, offering flavored water and ice cubes, and adding water to a dry diet

Owner compliance is necessary when a dissolution diet is prescribed. Communicating to the client the importance of exclusive feeding of prescribed food and medications is paramount to successful treatment.

**Surgical and Nonsurgical Removal**

Detection of calculi does not necessarily warrant surgical intervention. However, obstruction of urine outflow, an increase in the size and/or number of calculi, persistent clinical signs, and a lack of response to therapy are indications for calculus removal. Surgery is required in patients with nondissolvable calculi and clinical signs. While traditional cystotomy is the most common method of calculus removal, calculi can be removed using less invasive, nonsurgical options, including catheter-assisted retrieval, urohydropropulsion, and cystoscopic removal.

In catheter-assisted retrieval or urohydropropulsion of calculi, both of which are minimally invasive, the patient is sedated and a catheter is passed into the urinary bladder, which is filled with saline. In cats, a 3- or 5-French catheter is used; in dogs, a 5- or 8-French catheter is usually appropriate, depending on patient size. During catheter retrieval, the contents of the bladder are aspirated while the bladder is agitated by palpatating and manipulating it or rotating the patient’s body. In urohydropropulsion, the patient is held vertically while the distended bladder is manually expressed. These methods can be used to eliminate small calculi or to collect them for analysis to plan further treatment.

Cystoscopy (endoscopy of the urinary bladder) produces magnified images of the fluid-distended urinary tract, allowing identification of abnormalities such as strictures, masses, and calculi. Cystoscopic techniques are more efficient than surgical procedures, decreasing the risk of trauma and abdominal contamination.

In transurethral cystoscopy, a cystoscope is inserted into the urethra and passed into the urinary bladder. This procedure is preferred for use in female cats and dogs because it is less invasive than other diagnostic and treatment methods. If calculi are small enough, they can be removed using baskets and graspers.
larger calculi, cystic lithotripsy is indicated. In lithotripsy, a laser fiber is passed through the operating channel on the cystoscope (Figure 2). The fiber emits light at an infrared wavelength to fragment calculi (VIDEO). The resulting particles are removed transurethrally. A flexible urethroscope is necessary for transurethral cystoscopy in male dogs. Calculi can be identified, but removal is limited because of the male urethral anatomy. Most scopes are too big to be used transurethrally in male cats. In male dogs and male cats, calculi can be removed by mini-cystotomy, a minimally invasive procedure in which a cystoscope is passed into the bladder through a small body wall incision and a smaller bladder incision (Figure 3). Calculi are removed and the bladder and urethra examined (Figure 4). Magnification allows complete removal of calculi. Bladder wall biopsies may be obtained for histopathology and culture and sensitivity testing.

**Conclusion**

Veterinary patients often have clinical signs associated with the lower urinary tract. The possible presence of urinary calculi should be investigated in these cases, for which noninvasive dissolution methods, minimally invasive procedures, and surgical procedures are available.

Technicians can play a crucial role in managing urinary calculus cases. Technicians may be responsible for setup, operation, cleaning, and storage of endoscopic and surgical equipment. Client communication skills are imperative because recognition of clinical signs as well as client compliance are key to successful diagnosis, treatment, and prevention of calculi.

**References**

1. Which treatment is the best for eliminating calcium oxalate calculi?
   a. dissolution diet therapy
   b. increased water intake
   c. transurethral cystoscopy
   d. administration of an antibiotic

2. Which disease/disorder can be associated with calcium oxalate calculus formation?
   a. hyperadrenocorticism
   b. hypothyroidism
   c. portosystemic shunting
   d. diabetes mellitus

3. Which of the following is not minimally invasive for removing calculi from the bladder?
   a. catheter retrieval
   b. cystotomy
   c. transurethral cystoscopy
   d. urohydropropulsion

4. Which of the following patients is most predisposed to calcium oxalate calculus formation?
   a. an intact female miniature schnauzer
   b. a young female miniature schnauzer
   c. an overweight neutered male miniature schnauzer
   d. a lean male miniature schnauzer

5. Struvite is also known as
   a. magnesium ammonium phosphate hexahydrate.
   b. potassium magnesium phosphate.
   c. calcium phosphate apatite.
   d. magnesium hydrogen phosphate trihydrate.

6. Which urine pH range is best for dissolving sterile struvite stones?
   a. 5.5 to 6.0
   b. 6.0 to 6.5
   c. 7.0 to 7.5
   d. 8.0 to 8.5

7. Prevention of infection-induced struvite calculi includes the use of
   a. urine-alkalinizing agents.
   b. fluid restriction.
   c. a high-protein diet.
   d. monitoring and appropriate antibiotic treatment of urinary tract infections.

8. Which statement regarding diagnostics is incorrect?
   a. Radiodense calculi can be seen on survey radiographs.
   b. When crystalluria is present, urinary calculi are always present.
   c. All calculi should be analyzed to determine their composition.
   d. Renal damage caused by urinary calculi can sometimes be noted by changes in blood work results.

9. Which statement regarding transurethral cystoscopy is true?
   a. To remove urinary calculi, an incision is made in the bladder.
   b. It produces magnified images of the entire lower urinary tract.
   c. It is ideal for male cats.
   d. Laser lithotripsy cannot be used with this procedure.

10. Which of the following does not affect the time necessary for calculus dissolution?
   a. the size of calculi
   b. the presence of a urinary tract infection
   c. the number of calculi
   d. the patient’s breed