

Canine Uroliths: Frequently Asked Questions and Their Answers

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KEYWORDS

• Urolith • Calculi • Question • Crystalluria • Urine pH

This article is devoted to answering frequently asked questions from veterinarians, veterinary technicians, and pet owners about urolithiasis. The authors do not stop with determining the mineral composition of uroliths; but also respond to questions related to the detection, treatment, and prevention of various types of uroliths from the urinary tract.

Originally it was suggested that this article be divided into veterinary and owner-related questions, but with the wealth of information available on the Internet, many owners have become quite curious and knowledgeable about uroliths affecting their pets, especially as it relates to nutrition. They frequently have many of the same questions asked by veterinarians and veterinary technicians.

The information has been divided into the following topics: urolith analysis, urolith types, diagnosis, treatment and prevention, urolith recurrence, urinalysis, diet, water, and miscellaneous.

UROLITH ANALYSIS

1. *What Are Uroliths?*

Answer: Uroliths are aggregates of crystalline and occasionally noncrystalline solid substances that form in one or more locations within the urinary tract. The urinary tract is designed to eliminate wastes in liquid form. When urine becomes oversaturated with lithogenic substances, uroliths may form and can interfere with the complete and frequent voiding of urine.

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Uroliths typically are composed of one or more mineral types (**Table 1**).¹ These minerals may be pure, deposited in layers, or they may be mixed throughout the urolith. In addition some drugs may precipitate as crystals within the urinary tract and be incorporated into the urolith.

If foreign substances, such as suture material, hair, or plant material are present within the lumen of the urinary tract, they can become the nidus for urolith formation.

2. Why Should Uroliths Be Analyzed?

Answer: While guessing the mineral composition of uroliths by their appearance is sometimes possible, this method is subject to considerable error. Erroneous guesses of the mineral composition in turn often leads to formulation of erroneous therapy. Detection of the composition of the interior core of uroliths and/or microscopic surface crystals may also escape detection. To develop an effective treatment plan, knowledge of the composition and structure of the entire urolith is essential.

3. What Methods of Analysis Are Recommended?

Answer: Two general methods of urolith analysis are available: qualitative analysis and quantitative analysis.

Qualitative analysis is a colorimetric test designed to identify the chemical components of a substance or mixture. Drops of test reagents are added to an aliquot of pulverized urolith; the appearance of different colors indicates various anions or cations

Table 1 Crystalline substances that may be detected in uroliths		
Chemical Name	Crystal Name	Formula
Oxalates		
Calcium oxalate monohydrate	Whewellite	CaC ₂ O ₄ ● H ₂ O
Calcium oxalate dihydrate	Weddellite	CaC ₂ O ₄ ● 2H ₂ O
Phosphates		
β-tricalcium phosphate (calcium orthophosphate)	Whitlockite	β-Ca ₃ (PO ₄) ₂
Carbonate apatite	Carbonate apatite	Ca ₁₀ (PO ₄ ● CO ₃ ● OH) ₆ (OH) ₂
Calcium hydrogen phosphate dihydrate	Brushite	CaHPO ₄ ● 2H ₂ O
Calcium phosphate	Hydroxyapatite	Ca ₁₀ (PO ₄) ₆ (OH) ₂
Magnesium ammonium phosphate hexahydrate	Struvite	MgNH ₄ PO ₄ ● 6 H ₂ O
Magnesium hydrogen phosphate trihydrate	Newberyite	MgHPO ₄ ● 3H ₂ O
Uric acid and urates		
Anhydrous uric acid	Same	C ₅ H ₄ N ₄ O ₃
Uric acid dihydrate	Same	C ₅ H ₄ N ₄ O ₃ ● 2H ₂ O
Ammonium acid urate	Same	C ₅ H ₃ N ₄ O ₃ ● NH ₄
Sodium acid urate monohydrate	Same	C ₅ H ₃ N ₄ O ₃ Na ● H ₂ O
Cystine	Same	(SCH ₂ CHNH ₂ COOH) ₂
Amorphous silica	Same	SiO ₂
Xanthine	Same	C ₅ H ₄ N ₄ O ₂

that are present. Because this method requires pulverizing the sample into a sand of powdery consistency, the layers of different minerals frequently identified by quantitative methods of analysis typically cannot be identified by qualitative methods. Also, this method is not designed to determine the approximate percentages of different minerals that are present. Likewise, these tests are not designed to identify some biogenic components of uroliths such as silica or xanthine. In addition, crystalline drug metabolites are missed. One study comparing a qualitative chemical test to quantitative physical tests revealed false positive and false negative results. Test results were in agreement in only 92 of 223 cases.²

Quantitative methods of analysis are designed to determine the composition of a urolith, and the amounts or proportions of the components of a urolith. Several physical methods of quantitative urolith analysis may be used to determine and quantify the mineral composition of the sample. At the Minnesota Urolith Center, we most frequently use optical crystallography (polarized light microscopy) and infrared spectroscopy. On occasion, we use energy dispersive spectroscopy and x-ray diffraction techniques. Some laboratories include high-performance liquid chromatography to identify different forms of purines.³

4. What Is Optical Crystallography?

Answer: Optical crystallography encompasses the use of a polarizing light microscope to identify crystalline and/or noncrystalline components of uroliths by matching them to known refractive index oils. Representative sections of the urolith selected for microscopic examination are identified with the aid of a dissecting light stereomicroscope.

5. What Are Basic Principles of Infrared Spectroscopy?

Answer: Infrared spectroscopy is based on unique wave patterns generated when infrared waves encounter a sample. Some waves are absorbed by the sample (absorbance) and some waves pass through the sample (transmittance). The resulting spectrum is a molecular fingerprint of the sample. Because no two unique molecular structures produce the same infrared spectra, results can be compared with known reference spectra for identification. This procedure is useful in characterizing urolith components that cannot be identified with the polarizing light microscope, in determining the quality and consistency of samples, and for quantifying the amounts of different substances within the sample.

6. How Should the Results of Urolith Analysis Be Interpreted?

Answer: At the Minnesota Urolith Center, the following anatomic classification is used to describe different portions of the uroliths (**Fig. 1**).

Nidus—central area of obvious initiation of urolith growth, which is not necessarily the geometric center of the sample.

Stone—the major body of the urolith.

Shell—a complete, outer, concentric lamination of the urolith.

Surface crystals—an incomplete, outer lamination of the urolith.

Although all portions of the sample are analyzed, if all areas are composed of the same mineral composition, it is listed only under the “stone” area. Occasionally layers are encountered within the urolith or between the main layers that are listed as bands or incomplete bands on the report. Tiny focal deposits within the urolith may also be

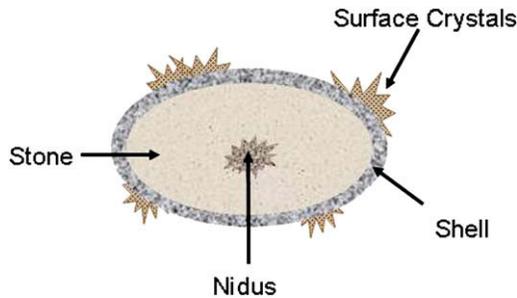


Fig. 1. Schematic cross section of a urolith illustrating separate areas that may be present. All layers are not present in all stones.

observed. These areas are included in the report if they are composed of a different composition than the other layers of the urolith.

7. Do I Need to Send All of the Uroliths Removed?

Answer: It is best to send a representative sample of all uroliths removed. Sometimes the larger urolith may contain a nidus layer that is not present in the smaller uroliths. Also, uroliths removed from different areas of the urinary tract may differ in composition. (See **Fig. 5** in “Changing Paradigms in the Frequency and Management of Compound Uroliths” elsewhere in this issue.)

8. If Only One Urolith Is Retrieved, Do I Need to Send the Entire Urolith for Analysis?

Answer: Submitting the entire urolith ensures that all layers of the urolith will be available for the most accurate analysis. Even if a sample visually appears to be homogenous, when examined microscopically, layers of different mineral composition may be present. (**Fig. 2**).

9. How Small Can the Sample Be to Be Suitable for Quantitative Analysis?

Answer: Because each lab is different, we recommend that you contact the laboratory providing the analysis to determine the minimum sample size. At the Minnesota Urolith Center, we generally indicate that if the urolith can be seen with the unaided eye (ie, the size of a poppy seed), we should be able to analyze it. Exceptions may include drug

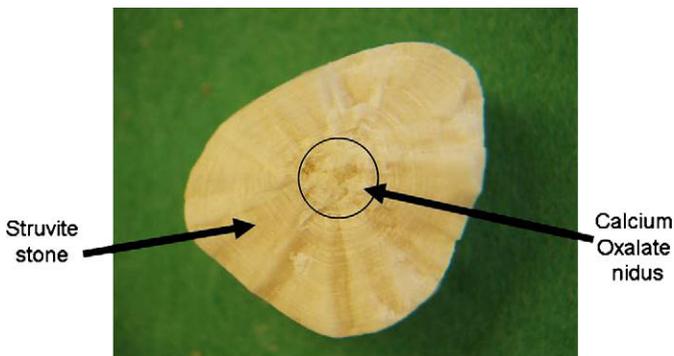


Fig. 2. The urolith above appears to be homogenous. However, the stone layer is composed of struvite and has a calcium oxalate nidus.

metabolites. Please note on the submission form alerting the lab of the small sample size (eg, Tiny sample enclosed).

10. What Should We Do If the Sample Has Been Fixed in Formalin Before Analysis?

Answer: Because formalin may alter or dissolve crystalline components, please send uroliths for mineral analysis dry. If a sample has been placed in formalin or other fixatives, and has not dissolved, remove the sample from the solution and allow it to dry. Please indicate that this sample has placed in formalin or another type of fixative on the urolith submission form.

11. The Patient Had Uroliths That Were Analyzed Previously. Should I Submit Uroliths Retrieved During the Most Recent Episode?

Answer: Yes. Recurrent uroliths may or may not be similar in composition to those retrieved in the initial episode. For example, development of a staphylococcal urinary tract infection in a dog that previously has a calcium oxalate urolith could lead to the formation of infection-induced struvite uroliths. In addition, dogs and cats are at risk for different mineral types at different stages of their lives. Therefore, we highly recommend that uroliths retrieved from each episode be analyzed.

UROLITH TYPES

Specific recommendations for each mineral type can be found at the Web site www.cvm.umn.edu, under *Departments and Centers*, then follow the prompts to find Minnesota Urolith Center.

12. What Is the Significance of Struvite and Calcium Phosphate in the Same Urolith?

Answer: Infection-induced uroliths also commonly contain small quantities of calcium phosphate. In most cases, therapy designed specifically for calcium phosphate is not required. In a few patients, the occurrence of calcium in struvite uroliths may be related to concomitant hypercalciuria. If therapy for struvite uroliths includes diets designed to promote acidic urine, the patient should be monitored closely for development of calcium oxalate crystalluria. Detection of persistent calcium oxalate crystalluria should prompt reevaluation of the strategy recommended for therapy.

13. What Is the Significance of Small Amounts of Ammonium Urate in Struvite Uroliths?

Answer: Infection-induced uroliths commonly contain small quantities of ammonium urate. In general, we recommend that therapeutic strategies designed to manage struvite uroliths be followed when considering management of these minerals. Therapy designed specifically for ammonium urate is not typically required.

14. What Microbes Are Commonly Associated with Formation of Struvite Uroliths?

Answer: Urease-producing *Staphylococcus intermedius* has most commonly been associated with the formation of canine struvite uroliths. Less frequently, urease-producing *Proteus spp* and ureaplasmas (*Ureaplasma urolyticum*) have been associated with infection-induced struvite uroliths. Because *Escherichia coli* and other commonly isolated bacterial urinary tract pathogens do not produce urease, they are typically not a cause of infection-induced struvite uroliths.⁴

15. What Is the Value of Determining If a Urolith Is Composed of Calcium Oxalate Dihydrate or Calcium Oxalate Monohydrate?

Answer: Although different combinations of calcium oxalate salts have been identified in canine uroliths, the predominant form encountered has been calcium oxalate monohydrate (whewellite). Pure calcium oxalate monohydrate has been observed in dogs more frequently than pure calcium oxalate dihydrate (weddellite). A similar observation has been made in cats and people with calcium oxalate uroliths. When calcium oxalate salts occur in combination, the dihydrate salt is usually found surrounding a nucleus of the monohydrate salt.⁵ The significance of this observation has not yet been confirmed, although it has been suggested that calcium oxalate dihydrate may form initially and then be converted to calcium oxalate monohydrate.⁶⁻⁹ In humans, detection of calcium oxalate dihydrate on the outside of a urolith may indicate recent formation, whereas detection of external layers of calcium oxalate monohydrate indicates lack of recent urolith formation.¹⁰ If valid in dogs, this hypothesis would be of clinical significance because it would help to determine if the disorders underlying calcium oxalate urolithiasis were persistent. This in turn would provide evidence of the need for continuous therapy to minimize urolith recurrence. In one study, human patients with calcium oxalate dihydrate uroliths had more recurrences of uroliths than did patients with calcium oxalate monohydrate uroliths.⁶

Calcium oxalate monohydrate and dihydrate uroliths are typically dense and brittle; they have relatively small quantities (~3%) of matrix. Pure calcium oxalate monohydrate and calcium oxalate dihydrate have different colors and shapes. In humans, uroliths composed of calcium oxalate monohydrate frequently assume the shape of mulberries or jackstones.⁷ To date, only a few canine calcium oxalate jackstones have been observed at the Minnesota Urolith Center (**Fig. 3**). Calcium oxalate dihydrate most commonly forms rosette-shaped uroliths.

16. What Is the Frequency of Occurrence of Uroliths Other Than Purines in Dalmatian Dogs?

Answer: Between 1981 and 2002, the Minnesota Urolith Center received 9,541 uroliths from Dalmatian dogs. Of those uroliths 96% were composed of urates, 2%



Fig. 3. Calcium oxalate urolith with “jackstone” appearance.

were of mixed composition, 2% were compound uroliths. Struvite, calcium oxalate, silica, cystine and calcium phosphate uroliths each made up less than 1% of the uroliths. Of these 9,541 samples: 93% were from male or castrated male dogs, 4% were from female or spayed female dogs, and 3% were gender unknown. Although urate uroliths are common in Dalmatians, other mineral types may also occur. Therefore, uroliths from all Dalmatians should be submitted for analysis.

17. What Is the Significance of Ammonium Urate Uroliths in Breeds Other Than Dalmatians?

Answer: The observation of uroliths composed predominantly of ammonium urate in non-Dalmatian dogs, should arouse suspicion that portal vascular anomalies or liver disease are the underlying problem. Provocative bile acids tests are recommended to rule in or rule out an underlying hepatic disorder. If liver disease is confirmed, dietary changes to reduce the urine concentration of uric acid and ammonium are recommended.

18. What Are the Similarities and Differences Between Xanthine Uroliths in Dogs and Cats?

Answer: Formation of xanthine uroliths can occur spontaneously or can be induced with the administration of the drug allopurinol. Acquired xanthine uroliths in dogs are usually an iatrogenic complication associated with treatment of urate uroliths with allopurinol. Similarly, xanthine uroliths can occur as a result of treatment of canine leishmaniasis with allopurinol. Naturally occurring xanthine uroliths have been found more commonly in cats than in dogs.¹¹ Cavalier King Charles Spaniels have been observed to have naturally occurring xanthine uroliths.¹²

19. What Are Some of the Contraindications of Allopurinol Therapy?

Answer: The use of allopurinol therapy in dogs can lead to the iatrogenic formation of xanthine crystalluria and uroliths. Unfortunately xanthine and urate crystals cannot be easily differentiated from each other by polarizing microscopy. If large quantities of crystals are present in the urine, infrared spectroscopy can be performed to differentiate the crystal type. In a study of healthy beagles, urinary excretion of xanthine was measured in dogs fed a low-protein, casein-based diet versus a high-protein, meat-based diet. When consuming the high-protein diet and allopurinol, urinary xanthine excretion was significantly higher. Therefore, if dietary compliance with a low-protein diet is not followed, and treats or an inappropriately high purine diet is fed, the possibility of xanthine formation increases.¹³

20. What Are the Similarities and Differences Between Cystine Uroliths in Dogs and Cats?

Answer: Cystinuria is an inborn error of metabolism causing impaired renal tubular re-absorption of the relatively insoluble nonessential dibasic sulfur containing amino acid cystine. Renal excretion of other dibasic amino acids may also be altered. Cystinuria predisposes affected dogs and cats to formation of highly recurrent cystine uroliths. Dietary management and drug therapy have been used to dissolve cystine uroliths in dogs. However, studies to determine the safety and efficacy of drug therapy in cats is still pending. Canine cystine uroliths are encountered most commonly in males.¹⁴ The Minnesota Urolith Center analyzed 1,928 canine cystine uroliths submitted between 2000 and 2006. Over 90 breeds were affected; the breeds most commonly affected were: English Bulldogs (18%), mixed breed dogs (6%), Dachshunds (6%), Staffordshire Bull Terriers (6%), Mastiffs (6%), and Chihuahuas (5%).

21. What About Prevention of Uroliths Composed of Two Different Mineral Types that Have Opposite Risk Factors?

Answer: A variety of mineral combinations can occur in compound uroliths. For information related to dissolution and prevention, please see the article entitled, “Changing Paradigms in the Frequency and Management of Compound Uroliths” elsewhere in this issue.

22. The Urolith Results Indicated that a Hollow Cylindrical Central Area Was Present. Why Did This Hollow Area Form?

Answer: Please refer to the article entitled, “Changing Paradigms in the Frequency and Management of Compound Uroliths” elsewhere in this issue for information about this phenomenon.

23. What About Foreign Material (Bodies) Found Inside the Urolith?

Answer: Please refer to the article entitled, “Changing Paradigms in the Frequency and Management of Compound Uroliths” elsewhere in this issue for details about foreign objects found in uroliths.

24. Is Calcium Carbonate a Common Primary Mineral Type in Dogs?

Answer: No. At the Minnesota Urolith Center we have only found 6 of 350,803 canine uroliths submitted from 1981 to 2007 to be composed primarily of calcium carbonate. We occasionally find calcium carbonate as a minor component of canine and feline uroliths, but are unsure of its significance. In contrast, calcium carbonate is a common primary mineral type in horses, rabbits, guinea pigs, and goats.

25. What About Stones Formed in Other Locations, Such As Cholecystoliths, Pancreatoliths, and Sialoliths?

Answer: Stones do occur in these locations in animals. In most cases, the mineral composition of these stones can be analyzed by the same quantitative techniques used to analyze urocystoliths. Please contact the Minnesota Urolith Center if you have specific questions.

DIAGNOSIS

26. Do Uroliths Have a Characteristic Appearance?

Answer: Most uroliths have typical appearances or “habits.” For example, struvite uroliths often are light tan and have a pyramidal or oval shape. Another noticeable example is silica uroliths having a jackstone appearance. However, we commonly receive samples that do not have the typical appearance characteristics. (Figs. 4 and 5).

In addition, the inner composition of a urolith cannot reliably be predicted by evaluating the appearance of its outer surface. In our series of canine uroliths analyzed from 1981 to 2007, 9% of uroliths were classified as compound.

27. How can the Mineral Composition of Uroliths be Determined if All of the Uroliths are Still in the Patient?

Answer: Urolith composition can often be “guesstimated” by looking at relevant clinical findings including results of radiography, urinalysis, urine culture and the patients breed, age, and gender (see Table 2). For additional information about interpreting radiographic findings, the article “Changing Paradigms in the Frequency and Management of Compound Uroliths” elsewhere in this issue.



Fig. 4. Characteristic shapes of various urolith types.

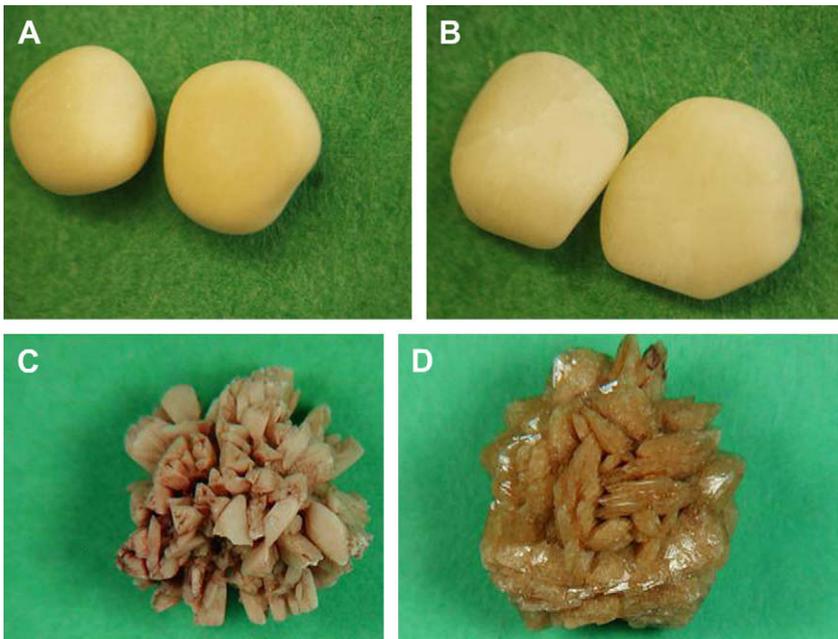


Fig. 5. Photos above demonstrate how uroliths of different composition can have similar appearances. (A) Cystine. (B) Magnesium ammonium phosphate. (C) Magnesium ammonium phosphate. (D) Calcium oxalate.

Table 2
Checklist of factors that suggest the probable mineral composition of canine uroliths

Mineral Type	Urine pH	Radiographic Density	Breed Predisposition	Gender Predisposition	Common Age (y)
Magnesium ammonium phosphate	Neutral to alkaline	+ to +++++	Miniature Schnauzer, Shih Tzu, Yorkshire Terrier, Pug, Labrador, Dachshund	Female (>85%)	2–9
Calcium oxalate	Acid to neutral	++ to +++++	Bichon Frise, Lhasa Apso, Miniature Schnauzer, Pomeranian, Shih Tzu, Yorkshire Terrier	Male (>70%)	5–11
Purine, including urate	Acid to neutral	0 to ++	Dalmatian, English Bulldog, Miniature Schnauzer, Shih Tzu, Yorkshire Terrier	Male (>85%)	1–4
Calcium phosphate	Alkaline to neutral (brushite forms in acid urine)	++ to +++++	Bichon Frise, Miniature Poodle, Pomeranian, Pug, Shih Tzu, Yorkshire Terrier	Male (>53%)	<1; 6–10
Cystine	Acid to neutral	+ to ++	English Bulldog, Staffordshire Bull Terrier, Mastiff, Dachshund, Chihuahua, Newfoundland	Males (>94%)	1–7
Silica	Acid to neutral	++ to +++	German Shepherd, Labrador, Shih Tzu, Yorkshire Terrier, Rottweiler, Boxer, Bichon Frise	Male (>92%)	3–10

28. How Is it Possible for the Patient to Have Uroliths Without Crystalluria?

Answer: The absence of crystalluria in patients with confirmed uroliths indicates that at the time urine was collected, it was not oversaturated with substances required for the formation of crystals. Detection of crystalluria is not synonymous with the presence of uroliths.¹⁵ However, the fact that crystals were not observed is often a positive observation because it should be possible to induce the same environment and at least minimize further stone growth. For further information, refer to question 48 about one cause of in vitro crystalluria.

29. A Neutered Male Schnauzer Has Bladder Stones. Can I Dissolve Them?

Answer: Refer to **Table 2**. Consideration of the dog's age, urinalysis or culture results, and radiographic findings will help guesstimate what type of urolith the patient has and if it can be dissolved. Miniature Schnauzers are at risk for forming a variety of different urolith types. Miniature Schnauzers comprised 9% of struvite uroliths, 4% of urate uroliths, and 18% of calcium oxalate uroliths submitted to the Minnesota Urolith Center between 2000 and 2006.

TREATMENT AND PREVENTION

30. What Are the Most Important Steps to Consider when Minimizing Recurrence of Uroliths?

Answer

- Be certain that you have an accurate diagnosis.
- Correct any underlying conditions, such as urinary tract infections or hypercalcemia.
- Promote less concentrated urine, aiming for a specific gravity <1.020.
- Monitor the patient at appropriate intervals to identify potential recurrences early.

31. How Important Is the Recommendation to Periodically Monitor the Patient for Recurrence?

Answer: All prevention recommendations should be periodically monitored and adjusted to meet each individual patient's needs. This typically includes follow-up urinalyses, serum chemistry profiles, and radiography. Early detection of small urocytoliths that recur despite appropriate medical therapy facilitates nonsurgical removal by voiding urohydropropulsion.¹⁶

See question 42 for information about recurrence rates of different mineral types.

32. How Do I Decide to Try Dissolution Versus Other Methods of Urolith Removal?

Answer: If the uroliths are small enough, voiding or catheter retrieval may be possible. The advantage of these techniques is that retrieved uroliths can then be analyzed to determine appropriate dissolution or prevention protocols. Before attempting dissolution, perform diagnostic studies (urinalysis, urine culture, radiography, analysis of voided uroliths, etc.) to evaluate urolith size and location, as well as confirmation of urolith composition. Urethroliths and ureteroliths cannot be dissolved by medical protocols (See question 34). Discuss the cost of diet and antibiotic therapy with the owner. Also inform them of the estimated cost and the desirability of recheck appointments, when providing them with the option of medical dissolution. Some owners avoid surgical procedures for their pets and will elect to try the option of dissolution first. Other clients may feel that their pet is uncomfortable and will elect to have the uroliths surgically removed. When formulating medical dissolution protocols, be sure to discuss the need for compliance with your recommendations with the owner.

If a reduction in urolith size or numbers is not seen by medical imaging techniques after 4 to 6 weeks, reassess the patient and consider other options. Regardless of the management selected, the owner should be advised of the need for periodic monitoring. See question 31.

33. *What Sizes or Number of Uroliths Makes the Candidate a Poor Candidate for Medical Dissolution?*

Answer: The size and number of uroliths do not dictate the likelihood of response to therapy. We have had success in dissolving uroliths that are small and large, single and multiple. However, the rate of dissolution is related to size and surface area of the urolith exposed to urine. Just as one large ice cube dissolves in water more slowly than an equal volume of crushed ice, one large urolith will dissolve more slowly in urine than an equal volume of many smaller uroliths. The rate of dissolution is influenced by surface area of the urolith exposed to undersaturated urine.¹⁶

34. *Can Struvite Uroliths Located in the Urethra or Ureters Be Dissolved Medically?*

Answer: Urolith dissolution requires sustained contact of uroliths with urine that has been modified so that it is undersaturated with lithogenic minerals. Struvite, urate, or cystine uroliths located in the ureters or urethra cannot be dissolved by medical protocols because they are only intermittently in contact with urine. If urethroliths are returned to the urinary bladder by retrograde urohydropulsion, they may be subsequently managed by medical dissolution, lithotripsy, or surgery.¹⁶

35. *The Patient Voided a Few Small Uroliths that Were Composed of Struvite, with a Shell of Calcium Phosphate Carbonate. What Is the Likelihood that Uroliths of Similar Composition Remaining in the Bladder Can Be Dissolved?*

Answer: Please refer to the article entitled, "Changing Paradigms in Compound Uroliths" in this edition of Veterinary Clinics of North America for specific information about compound uroliths.

36. *The Nidus and Stone Layers of the Urolith Have Very Different Mineral Components. Recommendations to Dissolve the Uroliths and to Minimize Their Recurrence Are Not Compatible with Each Other. How Should We Approach Prevention of Future Uroliths?*

Answer: Please refer to the article entitled, "Changing Paradigms in Compound Uroliths" in this edition of Veterinary Clinics of North America for information about this problem.

37. *What Urolith Types Are Most Commonly Found in Young Dogs?*

Answer: Between 1981 and 2002, 2102 uroliths from dogs less than 1 year of age were analyzed at the Minnesota Urolith Center. 56% were struvite, 22% were purine, 5% were calcium oxalate, 2% were calcium phosphate, and 2% were cystine. Infection-induced struvite is the most common cause of uroliths in immature dogs. Urate stones associated with portovascular shunts are also common. Reference #1, Osborne, Lulich, Polzin et al. Analysis of 77000 urolith. VCNA.

38. *The Dog Previously Had Struvite Uroliths and Now Has Calcium Oxalate Crystals or Uroliths. How Is This Possible?*

Answer: Sometimes calcium oxalate uroliths form following successful management preventing struvite uroliths and vice versa. Sometime uroliths contain both struvite and calcium oxalate. The dilemma is how to manage both of these mineral types. We

recommend that emphasis be placed on minimizing the recurrence of calcium oxalate uroliths since they cannot be dissolved medically.¹⁷

39. How Often Are Uroliths Overlooked in the Urinary Tract During Surgery?

Answer: In a retrospective study, urocystoliths were detected in the lower urinary tract of 15% to 20% of dogs and cats immediately following cystotomy.¹⁸ If the number of uroliths present in the urinary tract can be accurately determined by survey or contrast radiography, it is usually unnecessary to obtain immediate postsurgical films to ensure that they have all been removed since they can be accurately counted. However, if the numbers of uroliths detected by radiography are too numerous to count, postsurgical radiographs are indicated to detect uroliths that have been inadvertently allowed to remain in the urinary tract.¹⁵ Results of quantitative analysis on the retrieved uroliths will determine the best management protocol for any stones remaining in the urinary tract.

40. Radiographic Evaluation of a Dog's Coxofemoral Joints for Evidence of Arthritis Reveals Two Small Uroliths in the Bladder. Should They Be Removed?

Answer: Not always. If uroliths are detected in the bladder and the patient is asymptomatic without significant bacteriuria, the option to monitor the urolith activity is an alternative to surgery. However, the owner should be informed that the patient may be at increased risk for urinary tract infection or urethral obstruction, and instructed to monitor the patient accordingly.¹⁹ Depending on the mineral type, medical dissolution may also be an option.

41. What Is the Best Method to Manage Nephroliths?

Answer: Because of the risk of surgical damage to functional kidney tissue during surgery, if the nephroliths are presumed to be calcium oxalate and not associated with obstruction of urine flow, uncontrollable infection, or deterioration of renal function, monitoring kidney stone activity and selecting protocols to minimize urolith growth may be the best course of action. Monitor the status of the patient's nephrolith activity by radiography or ultrasonography every two to six months, unless clinical signs mandate more frequent evaluation.¹⁷

UROLITH RECURRENCE

42. How Quickly Can the Uroliths Reform? Will They Recur?

Answer: Urolith formation is a process that typically takes several weeks (eg, infection-induced struvite) to months (eg, calcium oxalate) rather than days. A retrospective study looking at 438 dogs, with a variety of urolith types, found a recurrence rate of 25%.²⁰

Struvite: Infection-induced uroliths can form within a few days to a few weeks following infection of the urinary tract with urease-producing microbes. Struvite uroliths associated with urinary tract infections (UTI) caused by *Staphylococci* or *Proteus spp* have been detected in puppies as young as five weeks of age.²¹

Calcium oxalate: Thirty-three calcium oxalate-forming dogs were evaluated for recurrent uroliths by postsurgical radiography following surgical removal of uroliths. Radiographs evaluated immediately following surgery confirmed that all uroliths were removed. After one year, uroliths were detected by radiography or urolith retrieval in 36% of the dogs. After 2 years, the recurrence rate was 42%, and after 3 years it was 48%. The diet and therapy these patients were receiving, if any, was not specified.²²

Purine: Purine uroliths appear to have a high recurrence rate. A retrospective study of 438 dogs revealed a minimum recurrence rate of 33%.²⁰

Cystine: Because cystinuria is an inherited metabolic defect, uroliths frequently recur within 2 to 12 months.²³

43. Uroliths Were Detected in the Urinary Tract by Postsurgical Radiography. How Should I Proceed?

Answer: If small uroliths are detected on postoperative films, they may be removed nonsurgically either by catheter retrieval or voiding urohydropropulsion after healing of the bladder occurs.²⁴ If the analysis results indicate that the uroliths removed are cystine, struvite, or urate, it may be possible to dissolve the remaining uroliths with diet and medical therapy.

44. The Uroliths Have Recurred. Is Surgery the Only Option for Removal?

Answer: If the recurrent uroliths are small enough, they may be removed by minimally invasive techniques (ie, catheter retrieval or voiding urohydropropulsion).²⁴ If it is suspected that the uroliths are struvite, urate, or cystine; dietary and medication therapy can be used in an effort to dissolve the uroliths. If the patient is asymptomatic one option to consider is initiating therapy to minimize urolith growth. Intracorporeal lithotripsy may be considered for urethroliths. Surgery is an option for urolith removal if the recurrent uroliths become problematic.

45. Postsurgical Films Did Not Indicate Any Uroliths, But Radiographs of the Entire Urinary Tract Obtained 4 Weeks Postsurgery Revealed Several Small Uroliths in the Bladder Lumen. How Is This Possible?

Answer: Uroliths on postsurgical radiographs can be missed due to a variety of reasons including:

- Overexposure of radiographs.
- Error in patient positioning.
- Portions of the urinary tract obscured by the pelvis.
- Air in bladder lumen or abdominal cavity following surgery.

In some patients, infection-induced struvite urolith can recur during this short period of time. Other urolith types generally take longer to recur and are so small at 4 weeks that they are not detectable by routine radiographs.²⁵

URINALYSIS

46. What Is a Normal Urine pH for a Dog Or for a Cat?

Answer: Urine pH for dogs and cats typically falls within a range of 5.5 to 7.5 pH units, but on occasion may be slightly higher or lower.²⁶

47. What Is the Best Time To Collect a Urine Sample: Fasted Or Postprandial?

Answer: Both. For routine screening, samples may be collected at any time. There are advantages for collecting urine during specific periods of the day. Early morning samples are preferred to evaluate normal dogs and cats, since these samples are more likely to be concentrated and more likely to be acidic. Acidity tends to prevent dissolution of proteinaceous structures, such as cells and casts.²⁷ Postprandial urine samples collected 3 to 6 hours after eating may be used to evaluate the effect of diet on urine pH, specific gravity and crystalluria.²⁷

48. Is Refrigeration the Best Way to Preserve Urine Following Collection?

Answer: Refrigeration is a method of preservation for urine samples that cannot be analyzed within 30 to 60 minutes following collection. It is often preferred over other methods of chemical preservation that may interfere with reagent strip tests. Unfortunately, the change in temperature associated with refrigeration is a common cause of in vitro crystalluria.²⁸ Therefore, detection of crystals in refrigerated samples should be validated by reevaluation of fresh urine. If a sample has been refrigerated, ideally it should be allowed to return to room temperature before analysis.

49. How Useful Are pH Meters in Evaluation of Urine?

Answer: Because accurate and consistent urine pH values are important in monitoring patients with uroliths, we recommend monitoring the patient's urine with a portable pH meter. Urine pH values obtained by reagent strips (colorimetric dyes) may vary by as much as 0.5 units on either side of the observed value. A recent study comparing portable (handheld) pH meters, reagent test strips, and pH indicator paper strips indicated that inexpensive portable pH meters correlated well with values obtained with expensive benchtop pH meter models.²⁹

50. How Often Should I Monitor Urinalysis?

Answer: Monitor the urine frequently during initial stages of evaluation. How frequently is somewhat dependent on the type of urolith the patient had and how quickly the uroliths can form. By monitoring the urine you can determine if changes in the diet or medical treatment are warranted. In patients with rapidly recurring uroliths, such as struvite, cystine, and urate, urine should be monitored weekly to determine if therapy is effective. Once efficacy is established, urine may be evaluated every 2 to 4 weeks depending on the needs of the patient. For slower recurring uroliths such as calcium oxalate and silica, monitor every 4 weeks, then intervals between follow-up examinations may be approximately every 3 months. Remember early detection of recurrence may allow use of nonsurgical techniques for removal such as voiding urohydropulsion or catheter retrieval.²⁴

51. The Patient's Owner Has Been Feeding the Recommended Diet; However, Persistent Crystalluria Has Been Occurring. Why Is This Happening?

Answer: The detection of crystals in urine indicates that the sample is oversaturated with crystalline substances. This may occur as a result of in vitro or in vivo events. Fresh urine samples should be analyzed as soon after collection as possible to verify that in vivo crystalluria is significant. Monitoring the patient's urine pH, specific gravity, and serum urea nitrogen values should be considered to evaluate owner and patient compliance and the effectiveness and safety of therapy. If the patient's lab values are not in the expected range, the probability that she or he is eating something in addition to, or instead of, the recommended diet should be discussed, preferably with the person responsible for the care of the animal. For example, dogs eating a low-protein canned diet such as Hill's u/d should have a urine specific gravity of <1.020 and a serum urea nitrogen of <1.7 nmol/L.³⁰

52. Why Is the Urine pH Higher or Lower than Expected?

Answer: If the urine pH is not what is expected, ask the owner if they are feeding the recommended diet or if they are adding additional food treats. Patients eating a diet high in fruits, legumes, and vegetables tend to have more alkaline urine; and those eating diets high in protein tend to form more acidic urine. If the patient has a urinary tract infection with urease producing bacteria, prolonged time between collection and

analysis of unpreserved samples allow the bacteria to alter the urine and make it more alkaline. Often lack of owner compliance is a key reason why the urine pH or specific gravity are not what you expect.

53. We Rechecked the Dog's Urine and Found that It Has Calcium Oxalate and Struvite Crystals in the Same Urine Sediment Sample. Is There a Plausible Explanation for This Observation?

Answer: Additional information is required to provide a meaningful answer:

How was the sample collected? Cystocentesis is the ideal method to collect urine for analysis, especially when monitoring a patient for recurrent infections.

How much time lapsed between collection and analysis? This information may be helpful in determining if the crystals are in vitro artifacts.

Was there a significant number of bacteria in the urine? In properly collected and preserved urine samples, struvite crystals are often significant when they are observed in association with bacteria and white cells.

Was the urine sample refrigerated? Refrigeration of urine could promote in vitro calcium oxalate crystalluria in a urine sample with in vivo struvite crystalluria.²⁸

54. Why Do We Need to Perform Urinalyses In-House?

Answer: When performing routine urinalyses, it is acceptable to send urine samples to a reputable clinical pathology laboratory. But when monitoring a patient with a history of urolithiasis, perform the urinalysis in-house as soon after collection as possible to minimize in vitro changes in the sample.

DIETS

55. What Diet Should I Feed While I Wait for the Results of Urolith Analysis?

Answer: Feed a diet unlikely to enhance urolith formation that avoids mineral excesses or deficits. The diet should also promote a neutral urine pH. If possible, feed a canned diet to reduce urine concentration. Once the results of the urolith analysis are received, follow the appropriate recommendation protocols to promote dissolution or minimize recurrence. Specific recommendations for each mineral type can be found at the Center's Web site.

56. I Have Received the Results of Urolith Analysis, Which Diet Should I Consider?

Answer: Uroliths form when urine is oversaturated with one or more lithogenic components. The goal of management is to correct as many risk factors as possible (eg, urinary tract infections caused by urease producing microbes; reduce hyperammonemia and hyperuricemia, etc). Several dietary risk factors may contribute to oversaturation; therefore, reducing urine concentration by feeding a canned diet is a common recommendation for prevention of all mineral types of stones. Due to the increasing variety of manufacturers that make therapeutic diets to prevent urolith recurrence, we recommend that you contact diet manufacturers directly to determine the quality of evidence available to support their recommendations, and to determine if any of their manufactured diets meets your patient's needs.

57. How Strict Does Dietary Compliance Have to Be?

Answer: Veterinarians and their staff frequently overestimate the degree to which clients comply with management recommendations. To enhance compliance, clients should be included in the planning so that the prevention protocol includes what they can do, and excludes what they cannot or will not do. Educating clients about

the expected benefits associated with therapy, and the expected adverse outcomes if therapy is not implemented enhances compliance. Therapy requiring changes in lifestyle (eg, meal feeding versus ad libitum feeding), confusion about instructions, too many medications, and difficult tasks (eg, frequent oral administration of pills to cats) are likely to reduce compliance. However, an expectation of full compliance is often unrealistic. In general, less than full compliance is acceptable as long as the desired therapeutic benefit can safely be achieved.¹⁶

58. Should I Feed a Canned or Dry Food?

Answer: One of our goals in urolith prevention is to promote a less concentrated urine (urine specific gravity <1.020). We recommend feeding canned diets, which are approximately 70% to 80% moisture, to dogs and cats with a history of urolithiasis.

59. My Dog or Cat Does Not Like Eating Canned Diets. What Are Your Recommendations?

Answer: While we all think pets should love eating a canned diet after years of eating dry food, we are often surprised to see them turn up their noses at canned food. Try warming the food slightly (be sure that it is not too hot) to enhance palatability of the food. If necessary, instruct the owner to make the change from the patient's current diet to the recommended food very slowly. Sometimes pets are very resistant to change, and by making the change over several days (7–14 days) they may accept the new diet. Try adding flavor-enhanced water to the canned food or add water to the dry food. Monitor the patient's urine frequently and aim for a urine with a specific gravity of 1.020 or less. Remember, if a patient is currently sick, it is best not to change the food until they are feeling better, to avoid a negative food association (food aversion).

60. Are There Any Resources That I Can Rely Upon to Evaluate the Safety and Efficacy of Homemade Diets?

Answer: Several text books and Web sites provide recommendations for homemade diets designed to promote urolith dissolution and to minimize recurrence of various types of uroliths. Since urolith-formers may have other conditions such as food allergies, diabetes, etc. that are best managed by dietary changes contrary to those recommended to minimize urolith recurrence, it may not be possible to find a manufactured diet that will optimally meet your patient's needs. Veterinary nutritionists are available to formulate a diet that best meets the patient's needs. Many veterinary colleges or veterinary specialty centers have a veterinary nutritionist on staff. Access to veterinary nutritionists also may be obtained from various websites.

61. Can I Use Over-The-Counter Dog Foods to Manage the Urinary Issues?

Answer: With the exception of infection-induced canine struvite, we do not have experience using over-the-counter-diets to minimize urolith recurrence. Infection-induced canine struvite can be prevented by eradicating and controlling bacterial infections of the urinary tract. Although a therapeutic diet in combination with an antimicrobial is required to dissolve infection-induced struvite uroliths, infection-induced struvite will not recur unless there is a UTI caused by urease producing microbes. Provided that the infection is eradicated or controlled, a complete and balanced canned over-the-counter grocery brand diet that meets NRC recommendations should be satisfactory to prevent recurrence in infection-induced struvite patients. The patient should be monitored for recurrent UTI and struvite uroliths at appropriate intervals.

62. How Do I Convince the Pet Owner to Feed the Recommended Product?

Answer: Sometimes due to financial reasons pet owners cannot afford to feed a therapeutic diet. Others prefer a homemade diet or are resistant to change. The veterinarian and owner in partnership need to work toward finding the best diet or medical therapy to help reduce the risk of recurrence within the owner's desires and financial limitations.

63. Can I Mix Other Foods with a Urolith-Management Food to Treat Multiple Problems?

Answer: It is difficult to answer the question without knowing what problems you are attempting to treat. If an alkalinizing diet is being fed and mixed with an acidifying diet the combination would likely eliminate the desired effect of both diets. In most situations it would be best to find a diet that is designed to manage the problem of greatest significance.

64. What Treats Can I Feed While Trying to Prevent Struvite, Calcium Oxalate, Cystine, Urate Uroliths?

Answer: In patients with a history of struvite uroliths, control and prevention of urinary tract infections is the primary means of preventing further urolith recurrence. Feeding small quantities of treats should not contribute to the recurrence of this urolith type.

For other urolith types, the decision to give treats should be based on the ingredients, and the mineral type of the urolith retrieved from the dog. Evidence derived from retrospective case-control studies of risk factors associated with calcium oxalate urolithiasis in dogs revealed that dogs fed substantial quantities of manufactured dietary treats were up to 5 times more likely to develop calcium oxalate uroliths than dogs not fed treats (Lekcharoensuk C, unpublished data, 2001). Many owners give their dogs human foods as treats. A list of human foods that are acceptable, and foods to avoid, when attempting to minimize formation or recurrence of calcium oxalate and urate uroliths has been extrapolated from reports about urolithiasis in humans.^{31,32} Evidence derived from a retrospective case-control study evaluating environmental risk factors associated with calcium oxalate urolithiasis in dogs revealed when the daily allowance of human food fed a dogs was $\geq 1/8$ of the total, the risk of calcium oxalate urolith formation was 14% greater compared with dogs whose diets contain less than one-eighth of human food (Lekcharoensuk C, unpublished data, 2001). Since it is recommended that the owner feed a canned diet for prevention, small amounts of the dry formula can be used as treats.

WATER

65. How Do I Get the Patient to Drink More Water?

Answer: There are several options to encourage a patient to consume more water:

- Use a pet water fountain to provide continuous filtered fresh running water.
- Provide the pet with fresh water in water dishes located in multiple sites.
- Add a small amount of flavoring agent to drinking water such as tuna juice or low-sodium bouillon.
- Add additional water to dry or wet food.
- Offer the dog or cat ice cubes as additional fluid and as a treat.

66. Why Is the Recommendation to Drink Adequate Amounts of Fluid Important?

Answer: An excessive concentration of minerals or crystals in the urine is a prerequisite for urolith formation. Therefore, increased water intake has at least two beneficial

outcomes. First, it leads to the dilution of crystalline material in the urine, and second, it reduces the risk of recurrence because the formation of large volumes of urine increases the frequency of micturition and the frequency that crystals will be voided.³³

67. How Can One Assess Whether Or Not the Patient Is Drinking Adequate Quantities of Fluid?

Answer: The easiest way to monitor the amount of fluid that a patient is drinking is to measure the specific gravity of the urine. The goal is to try and maintain a urine specific gravity of less than 1.020.

68. Is Hard Water a Risk Factor For Urolithiasis? Should I Give Distilled Water?

Answer: In general, increasing water intake with the goal of decreasing urine concentration and increasing urine volume should be considered as a key component of medical management for all types of uroliths. A retrospective case-control study designed to evaluate risk factors associated with calcium oxalate urolithiasis in dogs revealed that when well water was the primary source of drinking water, the risk for calcium oxalate was reduced by 41%. However, these results may be confounded by other factors indicating that a reduced risk of calcium oxalate had also been observed in dogs living in a rural environment (Lekcharoensuk C, unpublished data, 2001). A study of cats did not reveal that the source of water was associated with calcium oxalate urolith formation.³⁴ It is unlikely that water hardness plays a significant role in the formation of uroliths. The quantity of water consumed is much more important. Use of distilled water is of questionable value unless its flavor enhances water consumption.

MISCELLANEOUS

69. Can We Give Rawhide Chews?

Answer: We have not studied the effect of this type of treat as it relates to the dissolution and or prevention of uroliths. However, since rawhide chews are made of approximately 60%–80% low-quality protein, we do not recommend feeding them to patients when eating a high protein diet is contraindicated.

70. Are Glucosamine Supplements Beneficial?

Answer: The use of glucosamine supplements in urolith patients is probably not harmful. Some investigators indicate that glucosamine use may be helpful in inhibiting calcium oxalate crystal adherence to the bladder wall. However, we have not studied the effects of glucosamine as it relates to the dissolution and or prevention of uroliths.

71. What About Toothpaste or Toothbrushing?

Answer: We have no studies to evaluate the effects of toothpaste and urolith recurrence. Given the small quantity of toothpaste likely to be consumed, we hypothesize that it would have no effect on the status of urolithiasis.

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