In cats, signs of lower urinary tract diseases (LUTD) may occur due to infection, neoplasia, urolithiasis, anatomical defects or inflammation of the urinary tract. Regardless of the etiology of LUTD, clinical signs are similar and can include hematuria, frequent urination, apparently painful urination, inability to urinate or urinating outside the litter box. Several studies conducted during the 1970s and 1980s demonstrated that less than 1% of the total cat population would be newly diagnosed with LUTD each year.1,2

The Role of Dietary Calcium in Calcium Oxalate Urolithiasis

With the apparent increase in prevalence of calcium oxalate urolithiasis in veterinary patients, interest has shifted to minimizing risk factors for this stone type. It may seem logical to reduce dietary calcium intake as a means of reducing urinary calcium and calcium oxalate calculi. This practice has been recommended for many years in both human and veterinary medicine. However, in recent years, several studies have generated evidence suggesting this may not be an appropriate course of action.2,4

While reducing dietary calcium does reduce urinary calcium, it also causes an increase in urinary oxalate excretion and calcium oxalate relative supersaturation.5 Relative supersaturation is a calculated index based on the solubility of various complexes in the urine. An increase in relative supersaturation is associated with an increased risk of stone formation.

Restriction of dietary calcium enhances urinary oxalate excretion, while increased dietary calcium reduces urinary oxalate.3,5 This effect is thought to be due to the ability of calcium to bind oxalate in the gastrointestinal tract and decrease its absorption.3 When dietary calcium is reduced, absorption at the gut level becomes more efficient such that a greater percentage of the ingested calcium is absorbed. The increased efficiency of absorption on calcium-restricted diets was positively correlated with increased urinary oxalate and calcium oxalate supersaturation in stone forming patients.5

In addition to the calcium effects, several of these studies evaluated the effect of oxalate intake on urinary oxalate or stone formation. Intake of high oxalate foods was not found to be a risk factor for calcium...
Update on the Role of Diet in Feline Urolithiasis

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While data are not available to allow direct comparisons, it appears that the total prevalence of urinary tract diseases in cats has not changed dramatically over time. In the first half of this century, these conditions were described as “common.” Of cats presented to the Royal Veterinary College in Copenhagen from 1934 - 1949, 3.4% were diagnosed with LUTD.

Of these, 28.5% had detectable uroliths. This report is comparable to the 24% occurrence of uroliths in cats with LUTD presented to the University of Minnesota veterinary teaching hospital during the late 1980s. If crystals or uroliths are present, these crystalline components are influenced by various characteristics of the urine which may vary by stone type. The concentration of minerals as well as proteins and other compounds that act as promoters or inhibitors of stone formation, the urine pH and urine volume all influence whether or not stones will form. Some of these characteristics can be influenced by dietary alterations, accounting for the link between diet and these diseases. However, it is also recognized by most scientists that stones and urethral plugs are manifestations of disease, and dietary manipulation does not eliminate the underlying pathophysiology. It has been recognized for over 60 years that acidification of urine through diet manipulation may be used for the treatment and prevention of struvite urolithiasis.

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acidification of urine through diet manipulation may be used for the treatment and prevention of struvite urolithiasis. In the early part of this century, it was recognized that addition of phosphoric acid to the diet would result in acidic urine which dissolved struvite crystals. Conversely, the addition of magnesium salts or potassium citrate to the diet was recommended in the management of calcium oxalate stones in veterinary patients. The importance of knowing what type of stone one was dealing with was also recognized.

Several studies during the 1970s evaluated dietary magnesium as a contributing factor for stone formation. The addition of magnesium oxide to various base diets appeared to show that high dietary magnesium did induce stone formation. However, the amount of magnesium required to induce stones was 5 to 7 times that found in commercial cat foods of the time. Magnesium oxide (MgO) salt also served as an alkalinizing agent. Therefore, the results of the studies were confounded by the influence of the magnesium salt on urinary pH. Despite these limitations, these studies were used to support the contention that low magnesium diets were necessary to treat or prevent LUTD.

In the mid 1980s, Buffington’s and Tartellin’s groups demonstrated that the influence of urinary pH was more important than the effect of magnesium. When cats

Urethral Obstruction in Cats

Little notice appears to have been taken in earlier literature of this very common condition in cats. ... It mostly occurs in adult males, among whom the neutered variety appears most susceptible, as evidence by the greater numbers treated. ... The condition is not by any means infrequently encountered in entire cats, and animals may be attacked at any time between about two and 10 years of age. Why it is that Persian cats are more often victims than short-haired cats is difficult to explain, but such is the fact. It may be seen in successive cats, and appears as if hereditary. ... By far the commonest cause is obstruction of the urethra with a sabulous material or, rarely, by the presence of cystic or urethral calculi. ...

The urethral canal is the commonest location of stone in cats, although, in comparison with other animals, even this is but seldom affected. Some authorities consider that the particles of grit or gravel so familiarly encountered in male urethrae should be regarded as minute calculi; and if this view were accepted, calculus would indeed be common in the cat ... 

were fed a diet containing 0.50% magnesium as magnesium chloride, an acidifying salt, no struvite crystals were noted. The feeding of 0.50% Mg from MgO, an alkalinizing salt, resulted in alkaline urine and struvite crystalluria in all cats, and urinary tract obstruction in one cat. This data, consistent with publications from the 1930s and 1940s, confirmed that urinary acidification can minimize the risk of struvite formation and that Mg is of lesser importance. Based on his research, Buffington published a recommendation that cats be fed diets which do not "cause struvite urolithiasis." While emphasizing that the vast majority (>99%) of cats require no special diet, it was further recommended that normal cats be fed diets "formulated and tested to avoid promotion of struvite formation (urine pH between approximately 6.0 and 6.8) and avoid metabolic acidosis (serum bicarbonate or total CO2 [at least] 18)." [Note: Based on normal CO2 values of 17-24 mmol/L.]

Beginning in the mid 1980s, the stone diagnostic laboratories at the University of Minnesota and University of California noted a change in the composition of stones submitted for analysis. By the early 1990s, a recognizable change had occurred in LUTD – fewer struvite stones were being analyzed but many more calcium oxalate stones were being submitted. According to both laboratories, the increase in calcium oxalate was disproportionate to the reduction in struvite, suggesting a true increase in calcium oxalate urolithiasis and leading to the hypothesis that "struvite-preventative" diets were contributing to the formation of calcium oxalate stones. An epidemiologic study published in 1995 evaluated dietary and other factors among cats with calcium oxalate urolithiasis. The diets were grouped according to the average urine pH produced by the diet, as identified by the diets’ manufacturers. The results suggested that consuming urine acidifying diets (average urine pH of 5.8 to 6.3) was associated with an increased risk of developing calcium oxalate uroliths compared with “non-acidifying” (average urine pH > 6.3) diets. Cats with calcium oxalate uroliths were more than three times as likely as other cats seen at the veterinary hospital to have been fed diets that were classified as urine acidifying. Unfortunately, this study did not report the actual urinary pH values of the affected cats, but based the urine pH on diet history and information supplied by individual pet food manufacturers. Thus, the urine acidification scores reflect the average urinary pH value of apparently healthy cats fed the diet of interest. As the underlying pathophysiology of urolithiasis is unclear, it is uncertain if the affected cats reacted differently to their diets.

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**SELECTED REFERENCES**

than normal, healthy cats. Despite these limitations, this study suggests that routine use of some acidifying diets may have adverse effects.

Dietary characteristics thought important to minimize struvite formation that may enhance the formation of calcium oxalate uroliths include both acidification and magnesium restriction.

To date, evidence is lacking to show any diets effective at dissolving or preventing calcium oxalate formation in susceptible cats.

While calcium oxalate solubility does not change appreciably at varying urinary hydrogen ion concentrations, it can be influenced by the concentrations of free urinary calcium and oxalate, as well as inhibitors and promoters of calcium oxalate uroliths. Acidifying diets have been shown to increase urinary calcium excretion, and may inhibit proteinaceous inhibitors (e.g., Tamm-Horsfall mucoprotein, nephrocalcin). Other inhibitors of calcium oxalate include urinary magnesium, citrate and pyrophosphate.

The table lists those breeds for which one of these two stone types compromised at least 65% of the stones analyzed for the males of that breed.

<table>
<thead>
<tr>
<th>Breed</th>
<th>Number of Dogs</th>
<th>Struvite (%)</th>
<th>Calcium Oxalate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miniature Schnauzer</td>
<td>562</td>
<td>31.6</td>
<td>67.1</td>
</tr>
<tr>
<td>Yorkshire Terrier</td>
<td>279</td>
<td>18.9</td>
<td>71.8</td>
</tr>
<tr>
<td>Lhasa Apso</td>
<td>283</td>
<td>23.1</td>
<td>76.3</td>
</tr>
<tr>
<td>Cocker Spaniel</td>
<td>147</td>
<td>83.3</td>
<td>14.7</td>
</tr>
<tr>
<td>Labrador Retriever</td>
<td>115</td>
<td>71.2</td>
<td>28.8</td>
</tr>
<tr>
<td>Bichon Frise</td>
<td>84</td>
<td>19.1</td>
<td>78.7</td>
</tr>
<tr>
<td>Pomeranian</td>
<td>72</td>
<td>12.5</td>
<td>87.5</td>
</tr>
<tr>
<td>Springer Spaniel</td>
<td>62</td>
<td>69.8</td>
<td>14.3</td>
</tr>
<tr>
<td>Maltese Terrier</td>
<td>48</td>
<td>22.4</td>
<td>77.6</td>
</tr>
<tr>
<td>Welsh Corgi</td>
<td>41</td>
<td>69.8</td>
<td>30.2</td>
</tr>
<tr>
<td>Samoyed</td>
<td>32</td>
<td>25.0</td>
<td>75.0</td>
</tr>
<tr>
<td>Cairn Terrier</td>
<td>29</td>
<td>13.8</td>
<td>86.2</td>
</tr>
<tr>
<td>Scottish Terrier</td>
<td>26</td>
<td>69.2</td>
<td>23.1</td>
</tr>
</tbody>
</table>

* Many specimens contained two or more compounds.

[Source: Ling GV, Franti CE, Ruby AL, Johnson DL. AJVR 1998; 59:630-642]
Effects of Sample Handling and Storage on Serum Ionized Magnesium and Calcium Concentrations and pH

Objective - We hypothesized that variations in serum tube filling volume would alter serum ionized magnesium (iMg) and calcium (iCa) concentrations due to alterations in serum pH. We hypothesized that anaerobically stored serum samples would be acceptable for analysis of iMg and iCa concentrations, and pH, for at least three days.

Methods - Blood was collected from the jugular vein of normal dogs into 3- or 12-ml serum tubes. Tubes of each size were filled to 1/3 capacity, full, and “overfull.” Samples were kept anaerobic and serum was analyzed for iMg and iCa concentrations as well as serum pH. One-way ANOVA was performed within the 3-ml tubes and within the 12-ml tubes. Student’s t-test was used to compare results between 3- and 12-ml tube studies. Significance was set at p <0.1.

Results - For the tube filling experiment, there were no significant differences in iMg concentration at any fill volume for either the 3- or 12-ml tubes. iCa concentrations were different for fill volume in the 12-ml tubes (p = 0.08) but not the 3-ml tubes. No differences were found between 3-ml and 12-ml iMg and iCa concentrations when tubes were filled. Serum pH was significantly different within both 3-ml (p <0.01) and 12-ml (p <0.01) filling studies. For the storage experiment, there were no differences in serum iMg and iCa concentrations and pH (p =0.76) following up to three days of storage.

Conclusions - Serum tubes should be filled completely for accurate measurement of canine iMg, iCa, and pH. Feline serum that has been maintained under anaerobic conditions under refrigeration is useful for the measurement of iMg and iCa concentrations for at least three days.

Andrew J. Summers, Dennis J. Chew, CA Tony Buffington, The Ohio State University College of Veterinary Medicine, Proceedings of the 1998 Purina Nutrition Forum.

Hyperventilation Syndrome in Cats With Interstitial Cystitis

Hyperventilation syndrome results from respiratory alkalosis induced by stress. Because we have observed dysphoria associated with management procedures in some cats with interstitial cystitis (IC) in our colony, we compared effects of these procedures on behavior, clinical signs of IC, urine pH and bicarbonate concentrations in cats with IC to their effects on normal cats. Eight adult male cats (four normal, four affected) were studied in two experiments. First, cats were stressed by placing them into clean cages (mild stress). Pooled urine specimens were collected at 24-hour intervals until parameters returned to baseline. One month later, pre-stress behavioral observations were made, after which cats were subjected to phlebotomy and cystocentesis (moderate stress) prior to re-caging them. After mild stress, cats with IC had hematuria, stranguria, and pollakiuria. None of the normal cats showed any signs of ill health. Urine and blood pH, and bicarbonate concentration and excretion, were increased in all cats after either stress, and were significant in affected cats. After moderate stress, cats with IC exhibited significantly more behaviors related to stress, including hyperventilation, hiding, hissing, and restlessness. They also showed a significant decrease in sociable and greeting behaviors. Cats with IC were more acutely affected by stress, with an onset of clinical signs, an increase in stress related markers of blood, urine and behavior, and slower recovery from stress than seen in normal cats.

H. A. Johnson, J. L. Blaisdell, C. A. Buffington. College of Veterinary Medicine, The Ohio State University, Columbus, OH, Proceedings of the 1996 Purina Nutrition Forum.
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oxalate stone formers, as their intake of these foods did not differ from non-stone formers. The majority of urinary oxalate is of endogenous origin, rather than dietary. Only a limited number of oxalate rich foods caused an increase in urinary oxalate in normal volunteers. These included beets, nuts, chocolate, wheat bran, strawberries, rhubarb, spinach and tea. Altering oxalate intake had less effect on urinary oxalate than altering calcium intake.

There appear to be differences between stone formers and non-stone formers in calcium and oxalate intake and metabolism. Calcium intake was significantly lower and urinary calcium and oxalate output were higher in stone-forming subjects compared to healthy controls. Stone formers also had a greater output of urinary urea compared to normal, suggesting a positive correlation between protein intake and calcium oxalate risk in predisposed individuals. On the other hand, high protein intake was associated with a reduced risk of calcium oxalate urolithiasis in dogs. A family history of stones was found to be a significant risk factor for stone formation in humans. These findings, along with other data, suggest a genetic link to stone formation. Such links have already been documented for cystinuria.

**Bottom line**
The use of calcium restricted diets appears to be contraindicated in the management of patients with a history of calcium oxalate urolithiasis.

**REFERENCES**