STRUVITE VERSUS CALCIUM OXALATE –
THE DILEMMA

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INTRODUCTION

Urolith: A urolith is an organized concretion found in the urinary tract and containing primarily organic or inorganic crystalloid and a much smaller amount of organic matrix.

There are 3 main theories why uroliths form in companion animals or in people:
1. The precipitation-crystallization theory involves a state of urine supersaturation with crystalloids as the predominant factor in the precipitation and of crystals and the eventual growth of calculi.
2. The matrix-nucleation theory claims that there has to be some abnormal substance in the urine or along the bladder wall for calculi to form.
3. The crystallization-inhibition theory implies that it is not the excess of minerals but the absence of an inhibitor of crystallization is the primary factor in the development of calculi.

It is likely that all of these factors play a role in the formation of uroliths in cats, although recent evidence has suggested that the most important mechanism in feline stone formation is likely to be precipitation-crystallization theory. The emphasis of this manuscript will be trying to identify the causes of oxalate and struvite formation in cats and how they can be prevented or, in some cases, treated medically.

Relative supersaturation takes into account: concentrations of interactive complexes between ions
- Activity coefficients of ions
- Determines activity product for each salt

Knowing the RSS of the relevant crystalloids in an individual cat’s urine would predict the likelihood of stone formation in that cat. Then, therapeutic manipulation of the conditions of the cat’s urine (concentration of crystalloids, pH etc...) ideally would allow us to lower the RSS into the undersaturated range and achieve dissolution of the forming urolith. This is not possible today in all cases for a number of reasons, the first being that although RSS can be measured on a research basis it is not currently and may never be a practical test for the clinical setting. The other is that we cannot achieve an undersaturated RSS for some stones like calcium oxalate. Of the two most common stones in cats, calcium oxalate and struvite stones, today with a combination of diet and other therapeutic manipulations in many cases we can:
1. Dissolve and prevent recurrence of struvite uroliths
2. Prevent reformation of the mineral (struvite) component of urethral plugs
3. Reduce the risk of recurrence of calcium oxalate uroliths

HOW COMMON ARE THESE TYPES OF UROLITHS

Twenty years ago struvite uroliths were by far the most common type of uroliths in cats. Recently calcium oxalate has surpassed struvite and has become the most common comprising approximately 50% of all stone submitted to different labs. Most recently a study from the Canadian Urolith Center in Guelph Ontario reported 49.8% oxalate and 43.9% struvite out of 4730 stones submitted over a 6 year period. This increase could be a true shift from struvite to calcium oxalate but is more likely also a dramatic increase in calcium oxalate urolithiasis. This is more likely when taking into account the sharp increase in stone submission during the same time period.

What caused this dramatic increase? To answer that one must examine the risk factors for calcium oxalate formation. These have recently been carefully evaluated at the University of Minnesota Urolith Center.

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**RELATIVE SUPER SATURATION (RSS)**

<table>
<thead>
<tr>
<th>UNSTABLE: OVERSATURATED</th>
</tr>
</thead>
<tbody>
<tr>
<td>- rapid growth</td>
</tr>
<tr>
<td>- aggregation of crystals</td>
</tr>
<tr>
<td>- spontaneous nucleation</td>
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</tbody>
</table>

<table>
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<tr>
<th>FORMATION PRODUCT</th>
</tr>
</thead>
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<table>
<thead>
<tr>
<th>METASTABLE: SUPERSATURATED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing concentration</td>
</tr>
<tr>
<td>of crystallizable substance in urine</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SOLUBILITY PRODUCT</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>STABLE: UNDERSATURATED</th>
</tr>
</thead>
<tbody>
<tr>
<td>- no nucleation or growth</td>
</tr>
<tr>
<td>- dissolution</td>
</tr>
</tbody>
</table>

MEDICALLY MANAGING FELINE UROLITHIASIS –
WHAT HAVE WE LEARNED FROM RSS?

1. Decreasing urine specific gravity is one of the most important things to lower RSS and dissolve (struvite) or prevent (calcium oxalate and struvite). Urine specific gravity during stone dissolution or in a cat with recurrent calcium oxalate stones should not be above 1.020-1.030. This can be achieved in a number of ways:

   a. Feed canned diets. Canned food is higher in moisture and will result in a lower RSS then dry food. This simple change may be the most important step in preventing recurrence of calcium oxalate urolithiasis.

   b. Encourage drinking – changing water bowls often, supplying running water, flavoring the water.

   c. Adding salt to the diet. Struvite dissolution diets have high salt concentrations, but historically adding salt (NaCl) was thought to be contraindicated in the prevention of calcium oxalate. This is because salt increases calciuresis and theoretically then would be detrimental. Lite salt (KCl) was recommended in these cases but unfortunately was never very successful in lowering urine specific gravity. A new study in dogs assessing RSS of calcium oxalate with different levels of NaCl\(^5\) shows, though, that even if there is increased calciuresis the dilution achieved with salt still has a marked effect in lowering RSS and can therefore be recommended. Additional studies are necessary in cats to ensure that the same is true for this species as well.

2. Dissolution diets. These diets have the appropriate mineral content to dissolve struvite uroliths i.e. low phosphorus (high calcium to phosphorus ratio) and low magnesium. There are now also commercially available diets for prevention of calcium oxalate.

3. Urine pH. One thing that is clear is that basic pH should be avoided to prevent struvite urolithiasis and acidification is required for their dissolution. There is some controversy over calcium oxalate and pH. Can we prevent calcium oxalate stones while still inducing a mildly acidic pH around 6.5? According to the recent study\(^1\) quoted above we can. If the results of that study can be duplicated in large prospective studies then we have to question whether low pH truly is bad for calcium oxalate formers. It may be that the results of the retrospective studies showing decreased pH as a risk factor were caused by diets with marked decreased pH or that something else in those diets was truly causing the calcium oxalate stones.

4. Additional additives such as citrate to inhibit calcium oxalate formation, urine acidifiers to aid in struvite dissolution are still necessary in some cases but are not used as commonly today with the improvement of commercial diets, and the ability to improve diets and other therapies by understanding and utilizing RSS.

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<table>
<thead>
<tr>
<th>Patient related factors. Important factors appear to include:</th>
<th>Calcium oxalate</th>
<th>Struvite</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Urolith</strong></td>
<td>Percentage in 1981</td>
<td>1%</td>
</tr>
<tr>
<td><em>Breeds predisposed</em></td>
<td>Percentage in 1997</td>
<td>53%</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>Older cats</td>
<td>Younger cats</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td><strong>Reproductive status</strong></td>
<td>Neutered</td>
<td>Neutered</td>
</tr>
<tr>
<td><strong>Stones in kidneys or ureters</strong></td>
<td>Rare (5%)</td>
<td>Very rare (0.6%)</td>
</tr>
</tbody>
</table>

Environmental factors including diet, amount of exercise, body condition, indoor-outdoor status have all been suggested as predisposing to uroliths in cats. A recent large study\(^2\) from the Minnesota Urolith Center the following was revealed:

1. Increased risk for calcium oxalate:
   a. Diets low in sodium and potassium
   b. Diets causing maximal urine acidification

2. Increased risk for struvite:
   a. Diets high in magnesium, phosphorus and calcium

3. Decreased risk for calcium oxalate
   a. Diets high in protein and moisture

4. Decreased risk for struvite
   a. Diets low in sodium and potassium
   b. Diets causing maximal urine acidification
   c. Diets high in fat

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\(^1\) The North American Veterinary Conference – 2005 Proceedings

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REFERENCES


