Epidemiologic evaluation of canine urolithiasis in Thailand from 2009 to 2015

Vachira Hunprasit²,³, Carl A. Osborne⁴, Pamela J. Schreiner⁵, Jeff B. Bender⁶, Jody P. Lulich⁴

¹ Department of Veterinary Clinical Science, College of Veterinary Medicine, University of Minnesota, MN, USA
² Faculty of Veterinary Science, Chulalongkorn University, Bangkok, Thailand
³ Division of Epidemiology and Community Health, University of Minnesota, Minneapolis, USA
⁴ Department of Veterinary Population Medicine, University of Minnesota, MN, USA

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ABSTRACT

The cross-sectional study described the epidemiology of 8560 canine urolith submissions from Thailand to the Minnesota Urolith Center between January 2009 and December 2015. The frequency of urolith types, the relationships between urolith type and breed, sex, and neutered status, and change of annual submission proportion over the study period were analyzed. Struvite was the most common canine urolith (44%), and was commonly found in intact females with a mean age of 6.3 ± 3.1 years. Calcium oxalate was the second most common (27%), more frequently found in intact males with a mean age of 8.8 ± 3.3 years. Compound, purine, cystine, calcium phosphate, and silica urolith were less common. During the study period, the proportion of struvite urolith significantly decreased from 48% in 2009 to 39% in 2015 (p < 0.001). The proportion of CaOx increased from 21% in 2009 to 32% in 2015 (p < 0.001). The results of this study can help veterinarians predict urolith composition to select diagnostic tests and to initiate therapy prior to urolith removal.

1. Introduction

Urolithiasis is a common and recurrent problem in dogs, estimated to occur in 0.4–2.0% of dogs receiving medical care (Bovee and McGuire, 1984). The type of urolith may vary depending on age, breed, and sex of the dog, the type of food consumed, and geographic location of where the dog resides (Franti et al., 1999; Ling et al., 1998a; Ling et al., 1998b).

Selecting safe and effective urolith-removal procedures depends on reliable identification of urolith composition. Although radiographic appearance aids prediction of composition, some urolith types are radiographically indistinguishable (Weichselbaum et al., 1999; Weichselbaum et al., 2001). Likewise, in some urolith-forming dogs, crystalluria is absent or incongruent with the type of urolith residing in the patient (Fromsa et al., 2011). Knowing the prevalence of the different types of uroliths, and the likelihood at which they occur in particular breeds, sexes and ages of dogs, can help veterinarians more accurately predict their mineral composition.

Unfortunately, epidemiologic information is not available for dogs in Thailand. The results of similar studies conducted in different geographic areas may not be applicable because of differences in geography, diet and breed popularity. The purpose of this study is to evaluate epidemiological data from urolith-forming dogs in Thailand to assist veterinarians in this region to more effectively administer medical care.

2. Materials and methods

2.1. Sample population

Canine urolith submissions from Thailand to the Minnesota Urolith Center between January 2009 and December 2015 were reviewed. The information evaluated from each record included quantitative mineral composition of the urolith, year of submission, breed, sex, neutered status, age, and location of urolith within the urinary tract of the dog.

2.2. Urolith analyses

Mineral composition of uroliths was determined by polarization microscopy and infrared spectroscopy. A urolith without a nidus or shell that contained ≥ 70% of a single mineral was identified by that mineral. A urolith without a nidus or shell that contained < 70% of any single mineral was referred to as a mixed urolith. Compound uroliths were defined as having a central core or outer layer containing ≥ 70%
of a single mineral with an opposing outer layer or central core of a different mineral.

2.3. Statistical analyses

Descriptive statistics of categorical variables, including mineral composition, breed, sex, neutered status, and anatomic location were presented in percentages, and age as mean ± SD. Age between male and female for each urolith type was compared by Student's t-test. The relationship between urolith type and breed, sex, and neutered status were examined by χ² test. The change of the annual submission percentage of each urolith type was evaluated by Cochran-Armitage trend test (Armitage, 1955). Statistical analyses were performed using SAS/STAT™ software (SAS Institute Inc., Cary, NC, USA). The level of statistical significance was set at 0.05.

3. Result

From 2009 to 2015, 8560 canine urolith submissions were received from 139 veterinary hospitals in Thailand. Of 8560 submissions, 239 (2.8%) were from the upper urinary tract and 8321 (97.2%) were from the lower urinary tract (Table 1). Fifty-one percent (4288) were from male dogs: 3294 were intact and 994 were neutered. Forty-seven percent (4002) were from female dogs: 3008 intact and 994 were spayed. Sex was not reported in 270 submissions. The average age of dogs at the time of urolith removal was 7.2 ± 3.4 years. Seventy-three percent of uroliths were from 7 breeds: Shih Tzu (2464; 28.8%), mixed breed (1449; 16.9%), Yorkshire Terrier (156; 17.5%), Pug (394; 4.6%), Yorkshire Terrier (319; 3.7%), and Chihuahua (310; 3.6%).

3.1. Struvite urolith

Forty-four percent (3750) was struvite. Struvite uroliths were more common in females (68.9%) than males (31.1%) (p < 0.001) and more common in intact than neutered dogs (p < 0.001). The average age of dogs with struvite uroliths was 6.3 ± 3.1. Age was not different between males and females (6.3 ± 3.2 years vs. 6.2 ± 3.0 years, p > 0.05). Struvite uroliths were identified in 57 pure breeds. Common breeds included Shih Tzu (1284; 34.2%), Miniature Poodle (508; 13.5%), Pomeranian (192; 5.1%), Pug (154; 4.1%), Chihuahua (110; 2.9%), Golden Retriever (81; 2.2%), and Yorkshire Terrier (80; 2.1%). The annual proportion of struvite submissions decreased from 47.8% in 2009 to 39.4% in 2015 (p < 0.001).

3.2. Calcium oxalate urolith

Twenty-seven percent (2328) of uroliths were CaOx. Calcium oxalate uroliths were submitted more often from males (83.7%) than females (16.3%) (p < 0.001) and more common in intact animals than neutered (p < 0.001). The average age of dogs with CaOx urolith was 8.8 ± 3.3 years: average age of males and females did not differ (8.7 ± 3.3 years vs. 9.1 ± 3.1 years, p-value > 0.05). Calcium oxalate uroliths were reported in 48 pure breeds. Common breeds included Shih Tzu (523; 22.5%), Pomeranian (341; 14.6%), Miniature Poodle (257; 11.0%), Yorkshire Terrier (156; 6.7%) and Chihuahua (125; 5.4%). There was a significant increase in the annual proportion of CaOx urolith submissions from 21.2% in 2009 to 32.4% in 2015 (p < 0.0001).

3.3. Compound urolith

Fourteen percent (1203) of uroliths were compound. Compound uroliths were more common in females (59.6%) than in males (40.4%) (p < 0.001). The average age of dogs with compound uroliths was 7.5 ± 3.4 years which average age of males and females did not differ (7.7 ± 3.6 years vs. 7.4 ± 3.2 years, p > 0.05). Compound uroliths were identified in 41 pure breeds. Common breeds included Shih Tzu (366; 30.4%), Miniature Poodle (179; 14.8%), and Pomeranian (105; 8.7%). A uniform central core was present in all compound uroliths. Of these, 401 (33.3%) had a central core of struvite of which 62.3% had an outer layer of Calcium phosphate (CaP). Three hundred and thirty-seven (28%) had a central core of CaOx of which 71% had an outer layer of struvite. Thirty-six uroliths had a nidus which was not composed of elements filtered by the kidneys. Of these 36 foreign items, 26 were filamentous material consistent with suture, two were composed of plant material and one was rubber material. The outer layer of these foreign body-associated compound uroliths was predominantly struvite (Table 2).

3.4. Purine urolith

Five percent (415) of uroliths were purine. Purine uroliths were overrepresented in males compared to females (86.8% vs. 13.2%; p-value < 0.001). The average age of dogs with purine urolith was 6.5 ± 3.6 years. Female dogs (5.8 ± 2.8 years) with purine urolith were of similar age as male dogs (6.7 ± 3.7 years) (p > 0.05). Purine urolith was identified in 25 pure breeds. Common breeds included Dalmatian (120; 28.9%), Shih Tzu (74; 17.8%), Pug (44; 10.6%), Miniature Poodle (20; 4.8%), Yorkshire Terrier (14; 3.4%), and Pit Bull Terrier (14; 3.4%). There was a significantly decrease annual proportion of purine uroliths over time from 7.7% in 2009 to 3.4% in 2015 (p-value < 0.001).

3.5. Calcium phosphate urolith

Two percent (147) of urolith were CaP. Calcium phosphate were more common in males (62.2%) than females (37.8%) (p = 0.0112). The average age was 7.5 ± 3.6 years. Male dogs with CaP uroliths were younger than female dogs (7.0 ± 3.8 years vs. 8.3 ± 3.4 years

Table 1

<table>
<thead>
<tr>
<th>Urolith type</th>
<th>n</th>
<th>Sex</th>
<th>Male</th>
<th>Female</th>
<th>no report</th>
<th>Age (y)</th>
<th>Location of urolith</th>
<th>Upper urinary tract</th>
<th>Lower urinary tract</th>
</tr>
</thead>
<tbody>
<tr>
<td>Struvite</td>
<td>3750</td>
<td>1127 (929/198)</td>
<td>2501 (1924/577)</td>
<td>122</td>
<td>6.3 ± 3.1</td>
<td>91 (38.1%)</td>
<td>3659 (44.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CaOx</td>
<td>2328</td>
<td>1899 (1403/496)</td>
<td>371 (341/130)</td>
<td>58</td>
<td>8.8 ± 3.3</td>
<td>63 (26.4%)</td>
<td>2265 (27.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compound</td>
<td>1203</td>
<td>469 (346/123)</td>
<td>691 (527/164)</td>
<td>43</td>
<td>7.5 ± 3.4</td>
<td>35 (14.6%)</td>
<td>1168 (14.0%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purine</td>
<td>415</td>
<td>349 (257/92)</td>
<td>53 (43/10)</td>
<td>13</td>
<td>6.5 ± 3.6</td>
<td>15 (6.3%)</td>
<td>400 (4.8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CaP</td>
<td>147</td>
<td>89 (65/24)</td>
<td>54 (35/19)</td>
<td>4</td>
<td>7.5 ± 3.6</td>
<td>10 (4.2%)</td>
<td>137 (1.7%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cystine</td>
<td>134</td>
<td>126 (117/9)</td>
<td>2 (2/0)</td>
<td>6</td>
<td>4.8 ± 2.4</td>
<td>3 (1.3%)</td>
<td>131 (1.6%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silica</td>
<td>18</td>
<td>15 (15/0)</td>
<td>3 (3/0)</td>
<td>0</td>
<td>7.6 ± 2.4</td>
<td>1 (0.4%)</td>
<td>17 (0.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>565</td>
<td>214 (162/52)</td>
<td>327 (233/94)</td>
<td>24</td>
<td>6.9 ± 2.9</td>
<td>21 (8.8%)</td>
<td>544 (6.5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8560</td>
<td>4288 (3294/994)</td>
<td>4002 (3008/994)</td>
<td>270</td>
<td>7.2 ± 3.4</td>
<td>239</td>
<td>8321</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a Reported as number of intact/number of neutered.
studies in dogs. Similar changes in urolith prevalence were observed in other geographic areas (Bende et al., 2015; Houston and Moore, 2009; Low et al., 2010; Vrabelova et al., 2011). Unlike some other geographic regions in the world, the most common urolith identifi ed in dogs in Thailand was struvite (Bende et al., 2015; Stevenson et al., 2003). Feeding diets designed to prevent struvite uroliths promote acidic urine and hypercalciuria which are risk factors for CaOx formation (Lekcharoensuk et al., 2001). In many geographical locations, the prevalence of CaOx has already surpassed struvite. Based on the rate of change in the prevalence of struvite and CaOx in our study, we expect that in 2018, CaOx submissions will surpass struvite in dogs residing in Thailand.

The proportion of compound uroliths in the study was higher than in other studies (Ulrich et al., 2009; Vrabelova et al., 2011). In those studies, most compound uroliths had a central core of struvite and outer layer of CaP, as was found in our results. Struvite and CaP carbonate share a common risk factor of reduced solubility in alkaline urine associated with urinary tract infection (Kruger et al., 1999). For compound uroliths with a central core of CaOx surrounded by an outer layer of struvite, it is plausible that the CaOx nidus predisposed to urinary tract infections. Compound uroliths with a central core composed of a foreign body were uncommon. Several types of foreign body-induced urolithiasis have been reported (Del Angel-Caraza et al., 2011; Houston and Eaglesome, 1999). Suture material is a common (Ulrich et al., 2009) accounting for 76% of urolith submissions with a foreign body nidus. The most common mineral surrounding the foreign body was struvite, which was similar to another report (Ulrich et al., 2009). The presence of foreign body in the urinary tract can initiate urolith formation and significantly reduce the time to urolith recurrence in dogs (Appel et al., 2008). To minimize foreign body-associated urolith recurrence, nonsurgical methods (e.g. dissolution, voiding urohydropropulsion) for urolith removal should be considered.

Dalmatian dogs had the highest prevalence for developing purine uroliths, which is similar to other observational studies (Bende et al., 2015; Low et al., 2010; Lulich et al., 2013). In Dalmatians hyperuricosuria and hyperuricosomia are controlled by a simple autosomal recessive trait for which all Dalmatians are homozygous (Bannasch and Henthorn, 2009). A defective SLC2A9 transporter has been identifi ed as the cause (Bannasch et al., 2008).

Another pathogenesis for purine uroliths is hepatic portosystemic shunts, which divert blood purines away from hepatic uricase, an enzyme that degrades urate into allantoin. Portosystemic shunts are common in Yorkshire Terriers (Tobias and Rohrbach, 2003); however, Yorkshire Terriers were uncommon in our study. The Shih Tzu was the second most common breed in Thailand with purine uroliths. Although urolith submission records are not suffi cient to accurately identify the underlying cause, Shih Tzu has been identifi ed as a common breed with extrahepatic portosystemic shunts (Caporali et al., 2015).

Over the study period, the annual proportion of purine submission decreased. A similar fl nding has been reported in other studies (Bende et al., 2015; Ling et al., 2003; Low et al., 2010; Picavet et al., 2007; Sosnar et al., 2005). It has been hypothesized that fewer struvite submissions result from medical dissolution of uroliths and better control of urinary tract infections (Low et al., 2010). It also has been hypothesized that CaOx increased because dogs are living longer (Stevenson et al., 2003).

### Table 2

<table>
<thead>
<tr>
<th>Core minerals</th>
<th>Struvite</th>
<th>CaOx</th>
<th>Purine</th>
<th>CaP</th>
<th>Brushite</th>
<th>Silica</th>
<th>Cystine</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Struvite</td>
<td>NA</td>
<td>39</td>
<td>22</td>
<td>250</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>87</td>
</tr>
<tr>
<td>CaOx</td>
<td>239</td>
<td>NA</td>
<td>13</td>
<td>32</td>
<td>14</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>34</td>
</tr>
<tr>
<td>Purine</td>
<td>51</td>
<td>28</td>
<td>NA</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>CaP</td>
<td>56</td>
<td>42</td>
<td>0</td>
<td>NA</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>115</td>
</tr>
<tr>
<td>Brushite</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>NA</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Silica</td>
<td>13</td>
<td>24</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>NA</td>
<td>0</td>
<td>0</td>
<td>42</td>
</tr>
<tr>
<td>Cystine</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>NA</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Foreign body</td>
<td>30</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>34</td>
</tr>
<tr>
<td>Other</td>
<td>112</td>
<td>11</td>
<td>15</td>
<td>17</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>163</td>
</tr>
</tbody>
</table>

* The outer layer means the adjacent layer to the central core.

p-value = 0.064). Calcium phosphate uroliths were reported in 18 pure breeds. Common breeds included Shih Tzu (35; 23.8%), Pomeranian (19; 12.9%), Pug (15; 10.2%), and Miniature Poodle (14; 9.5%).
Therefore, the data may not be representative of dogs residing in less urbanized areas of Thailand. For convenience of the submission, some owners and veterinarians may have missclassified known breeds as mixed breed. This might explain why the number of mixed breed dogs was high. This study did not take into account the recurrent urolith formers where uroliths may be submitted from the same dogs more than once.

Prevalence data in this study can help veterinarians predict urolith composition to select appropriate therapy. For example, in Thailand a radiopaque stone in a female has a high probability of being composed of struvite. This information is especially helpful when managing radiopaque nephroliths because surgical nephrolith removal can cause kidney damage. Kidney damage can be minimized by considering medical dissolution first. Radiopaque uroliths in middle-age, male dogs are likely to be calcium oxalate, especially in small breeds. For these cases, medical therapy is not effective, permitting a decision of urolith removal early after the diagnostic process. Because a large percent of urinary stones in Thai dogs are compound, once removed, uroliths should be submitted for quantitative analysis to detect all minerals in stones to more thoroughly propose effective prevention strategies. The results of this study can help veterinarians predict urolith composition in different breeds, ages and sexes to initiate early and appropriate therapy.

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**Conflict of interest**

The authors declare they have no conflict of interest.

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