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Research article

Factors affecting the repeated surgery of urolithiasis in dogs after surgical removal at the lower urinary tract

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Abstract

The objective of this case-control study was to identify the risk factors associated with the repeated surgery of canine urolithiasis at the lower urinary tract after surgical removal. There were 87 dogs included in this study between August 1st, 2014 and July 31st, 2016 at the Small Animal Teaching Hospital, Chiang Mai University, Thailand. Post-operative monitoring was performed until July 31st, 2017, the repeated surgical rate was 24.13% (21 of 87 dogs). The interval between the surgical episodes varied from 2 months to 36 months. Study variables included the type of primary diet, signalment, post-operative antibiotics, urinalysis, bacterial identification, uroliths analysis, post- operative diet, source of drinking water, and urination behavior. Missing variables and the information of repeated surgery from the medical record were obtained by a telephone interview of the owner. Dogs with struvite uroliths had a 16.54 times (95% CI =1.62 – 4.89 x 10^2; p-value = 0.040) greater risk of repeated surgery when compared with the non-struvite uroliths. This result strongly supports the idea that the surgical removal of struvite uroliths in the dog should not be considered as the final step of the treatment plan. Further analysis to identify the type of uroliths is warranted in order to identify dogs with a high risk of repeated surgery. Reducing the concentration of urolith precursors by using a specific diet or drinking more water, and changing the urination management, are recommend. Client education on how to reduce risk of uroliths reformation should be a high priority.

Keywords: Canine urolithiasis, Lower urinary tract, Risk factors, Repeated surgery, Struvite

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INTRODUCTION

Multiple techniques have been report as effectively methods to remove uroliths from the urinary tract of the dog (Lulich et al., 2016). Minimally invasive procedures to dissolve and removing the uroliths from the lower urinary tract are including of medical dissolution (Lulich et al., 2016), voiding urohydropropulsion, retrograde urohydropropulsion followed by dissolution or removal, catheter retrieval, cystoscopic removal, and cystoscopy-assisted laser lithotripsy and surgery (Langston, Gisselman, Palma, & McCue, 2010). Surgical removal of the uroliths from the urinary tract is one of a standard treatment of urolithiasis in dogs, especially in a case of complete obstruction of the urinary tract (Arulpragasam, Case, & Ellison, 2013; Lulich et al., 2016; Lulich & Osborne, 2009). The advantages of the surgical treatment include quick and effective treatment, immediate correction of intraluminal obstruction of the urinary tract, improved recovery potential of the kidney to return to normal function, removed uroliths can be sent for further diagnosis for the type of uroliths (via quantitative stone analysis), and the possibility to perform a biopsy on the urinary tract tissues (Bartges & Callens, 2015; Brown, Parks, & Greene, 1977; Okafor et al., 2014; Okafor et al., 2013). To confirm completely removal of all stone, immediately post-operative imaging e.g. radiography or ultrasonography must be performed in all case (Grant, Harper, & Werre, 2010; Koehler, Osborne, Buettner, Lulich, & Behnke, 2009; Langston, Gisselman, Palma, & McCue, 2008; Lulich et al., 2016; Lulich & Osborne, 2009). The success rate of surgical removal is high, but a repeat formation of the uroliths after the surgery is also possible (Brown et al., 1977; Okafor et al., 2014; Okafor et al., 2013; Puttick & Sereda, 2012; Tion, Dvorska, & Saganuwan, 2015). The surgical procedure is painful to the animal and requires several days for post-surgical care (Arulpragasam et al., 2013; Lulich et al., 2016).

Urolithiasis is a formation of stony concretions called uroliths along the urinary tract (Bartges & Callens, 2015; Koehler et al., 2009; Langston et al., 2008). In small animals, urolithiasis is one of the most commonly diagnosed diseases in clinical practices worldwide (Bende, Kovacs, Solymosi, & Nemeth, 2015; Brandenberger-Schenk, Rothenanger, Reusch, & Gerber, 2015; Calabro et al., 2011; Del Angel-Caraza, Diez-Prieto, Perez-Garcia, & Garcia-Rodriguez, 2010; Vrabelova et al., 2011a). Uroliths could be found in every part of the urinary tract from inside the kidneys to the urethra. Specific terminologies are assigned to designate the location of the urolith formation including nephrolithiasis, pyelolithiasis, ureterolithiasis, cystolithiasis, and urethrolithiasis for uroliths occurring in the kidney, renal pelvis, ureter, urinary bladder, and urethra, respectively (Bartges & Callens, 2015). Uroliths damage and irritate the uroepithelium, which leads to inflammation of the urinary tract (Bartges & Callens, 2015). This makes the urinary tract venerable to the secondary bacterial infection. Frequent noticeable clinical signs of urinary tract inflammation and infection include hematuria, pollakiuria, stranguria, and/or dysuria (Calabro et al., 2011; Koehler et al., 2009; Langston et al., 2008). Uroliths in the urinary tract may increase in their size and may also migrate along the urinary tract, which can cause a complete obstruction of the urinary tract. At this stage the affected animals are no longer able to urinate (Bartges & Callens, 2015; Kaiser et al., 2012).

Previous clinical studies suggested that among all of the sick animals that came to the veterinary hospital about 2.03% were affected by urolithiasis (Low, Uhl, Kass, Ruby, & Westropp, 2010; Mircean, Giurgiu, Mircean, & Katsaros, 2008). In Sweden, during 1956 and 1982, approximately 0.3% of licensed dogs were diagnosed with urolithiasis (Wallerström & Wågberg, 1992). In Norway, during 1956 and 1970, 0.05% of registered dogs were diagnosed with urolithiasis (Wallerström & Wågberg, 1992). In Germany, the reported incidences ranged from 0.5% to 1.0% (Hesse, 1990). In Romania, the reported incidence was 2.06% in 2006 (Mircean et al., 2008). In the United States, 18% of dogs that came to a veterinary hospital with a chief complaint on the lower urinary tract had uroliths (Lulich et al., 2016; Nelson & Couto, 2014).

The vast majorities of uroliths were commonly found in the lower urinary tract, including in the urinary bladder and urethra (Bartges & Callens, 2015). Only 5% of all uroliths were found in the kidney and ureter (Chew, DiBartola, & Schenck, 2011; Nelson & Couto, 2014; Tion, Dvorska, & Saganuwan, 2015). The reported prevalence of cystolithiasis in female and male dogs were 93.1% and 79.0%, respectively (Elliott, Grauer, Westropp, 2017). Four percent of female and 2% of male dogs had stones in the upper urinary tract (Ling, Franti, Ruby, Johnson, & Thurmond, 1998). The formation of the uroliths in dogs depends on several conjoint factors and may include the breed, sex, age, diet, water, urinary tract infection, environment, and drugs (Elliott et al., 2017; Okafor et al., 2014; Okafor et al., 2013; Wisener, Pearl, Houston, Reid-Smith, & Moore, 2010). The incidence of canine uroliths had been report in the dog population worldwide. In Benelux, 51% of canine uroliths were composed of struvite, and 33% of calcium oxalate were found in1994. In 2003, 40% had struvite uroliths, and 46% had calcium oxalate uroliths (Picavet et al., 2007). There was a report in Mexico city in 2010, the composition and distribution of the uroliths were struvite 38.1%, calcium oxalate 26.7%, silica 13.3%, urate 7.6%, mixed 11.4%, compounds 1.9%, and cystine 1% (Del Angel-Caraza J, 2010). In Spain and Portugal between January 2004 and December 2006, the most frequent calculus was calcium oxalate (38.1%) followed by struvite (32.9%) (Vrabelova et al., 2011). In Thailand, Struvite was the most common canine urolith (44%) and calcium oxalate was the second most common (27%). 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 ($p<0.001$) (Hunprasit, Osborne, Schreiner, Bender, & Lulich, 2017).

The majority of uroliths are composed of struvite or calcium oxalate; however, other minerals such as urate and cystine could be found (Bartges & Callens, 2015). Uroliths may be saturated from more than one mineral in the urine and caused mixed uroliths. Some uroliths could be manage by medical dissolution (eg, struvite, urate, and cystine) while others (eg, calcium oxalate) are not possible (Lulich et al., 2016). Medical management involves decreasing minerals concentration that could be a cause of uroliths in the urinary tract (Bartges & Callens, 2015; Osborne, Lulich, Forrester, & Albasan, 2009). Struvite uroliths formation is more likely to occur in young or female dogs, while calcium oxalate uroliths are more likely to occur in male or mature dogs (Elliott et al., 2017). Certain breeds, such as Shih Tzu and Miniature Schnauzer, are predisposed to develop urolithiasis (Koehler et. al., 2009; Allen, Swecker, Becvarova, Weeth, & Werre, 2015). Consumption of food and water containing high levels of magnesium, ammonium, and calcium may increase mineral crystals in the urinary system (Okafor et al., 2013). Excessive mineral crystals may aggregate and form as stones in the urinary tract, especially when animals drink less water (Okafor et al., 2014; Okafor et al., 2013). Dogs suffering from urolithiasis with a complete obstruction of the urinary tract that require emergency surgical removal also possess a high anesthetic risk due partly to a compromise in renal functions (Arulpragasam et al., 2013; Langston et al., 2010). The repeated surgery is caused several disadvantages e.g. economical loss, increased anesthetic risk, increased more scar tissue on the urinary tract, and pain (Bartges & Callens, 2015; Koehler et al., 2009; Lulich et al., 2016; Okafor et al., 2014). Therefore, the objective of this case-control study was to identify the risk factors contributing to the repeated surgery of canine urolithiasis after surgical removal from the lower urinary tract.

MATERIALS and METHODS

Study samples

This study was a case-control study. The samples in this study were retrieved from all dogs having been diagnosed with urolithiasis at the lower urinary tract and treated with surgical removal at the Small Animal Teaching Hospital, Faculty of Veterinary Medicine, Chiang Mai University (SATH, FVM, CMU) during a period from August 1st, 2014 to July 31st, 2017. At least 12 months post-operative monitoring (until July 31st, 2017) was recorded. The dog that had the stone more than one location (not only at the lower urinary tract but also other location such as kidney or ureter) was rule-out from the study.

Methodological approach for research specific aims

Case and control selection

In this study, dogs with urolithiasis at the lower urinary tract were separated into two groups; case and control groups. Dogs in the control group were those that received surgery to remove the stone from the lower urinary tract and had only one time surgery during the period of study. Dogs in the case group were those that received surgery to remove the stone from the lower urinary tract more than 1 time during the period of study. The duration of post-operative monitoring for the repeated surgery ranged from 12 to 36 months.

Medical records review

Variables selected from the medical record included signalment, the type of primary diets or treats, post-operative antibiotics, results of urinalysis, bacterial identification, analysis result of uroliths, post-operative diets or treats, sources of drinking water, and urination behavior. The sources of drinking water were classified into tap water, mineral water, commercial bottled water for human consumption, table water, water from a pond, and others. The urination behaviors were classified into two categories, limited voiding and free voiding. Variables missing from the medical record were obtained by a telephone interview of the owner.

The details of interest concerning signalment included breed, sex, and neuter status. Breeds were classified followed by American Kennel Club (AKC) into 5 groups as xsmall (e.g. Chihuahua, Miniature Pinscher, Pomeranian, Yorkshire terrier, and Toy Poodle), small (e.g., Beagle, Shih Tzu, Miniature Schnauzer, and Pug), medium (e.g. Thai Bang-Keaw), large (e.g. Labrador retriever, Golden retriever, and German shepherd), and xlarge (e.g. Great Dane). The pre- and post-operative diets were classified into three groups, including homemade food, dry commercial food, and moist commercial food.

Pre-operative urinalysis was obtained 30 days or less prior to the surgical treatment. The urine samples were collected via cystocentesis or catheterization. All urine samples were analyzed by the Clinical Laboratory of the SATH within 12 hours after collection. The urine color and turbidity were evaluated with the naked eye. Specific gravity and the protein in urine samples were evaluated by using a refractometer. The leukocytes, nitrite, protein concentration, bilirubin, RBCs, hemoglobin, and WBCs were evaluated using commercial urine dipsticks (URI TEX VET vet-10; Best equipment center Co., Ltd. (Thailand)). Presence of crystal, epithelium, squamous epithelium, transitional epithelium, bacteria, and an estimate of the level of bacteriuria (mild, moderate, severe) were evaluated in urine sediment via microscopic examination.

Bacterial identifications were based on samples obtained from a direct swab of the intraluminal of the urinary bladder during the operation. After the uroliths had been removed, they were cleaned, dried, and kept in a container. All uroliths samples were submitted to the Minnesota Uroliths Center (College of Veterinary Medicine, University of Minnesota, St Paul, MN, USA) (Hunprasit et al., 2017).

Statistical analysis

Associations between variables obtained from medical records or telephone interviews and the repeated surgery for urolithiasis in dogs were analyzed using logistic regression analyses using R statistical software version 3.5.0. All variables were initially screened by univariable logistic regression analyses. Variables with p-value ≤ 0.2 were primarily chosen. Evaluation of multicollinearity among selected variables was performed using chi-squared test for categorical variables (p-value < 0.05) and Pearson correlation coefficient for continuous variables (cor ≥ 0.5). When multicollinearity was detected (i.e., $p < 0.05$ or $r \geq 0.5$) among some variables, one variable with the most biological plausibility was selected for multivariable logistic regression analyses.

Multivariable logistic regression was used to test the associations between the factors and the repeated surgery to treat urolithiasis. Factors from the univariate analysis with p-value ≤ 0.2 and without marked multicollinearity were included in the full multivariate logistic regression for model selection. A stepwise procedure for model selection was performed based on the Akaike Information Criterion (AIC) using the bestglm package (Zhang, 2016). The model with the lowest AIC value was chosen as the final logistic regression model. The goodness-of-fit of the final logistic regression model was evaluated using the Hosmer–Lemeshow statistic in the ResourceSelection package (Lele et al., 2017). The predictive ability of the final logistic regression model was analyzed using a Receiver Operating Characteristic (ROC) and area under the curve (AUC) in the ROCR package (Sing et al., 2015). The good predictive model was defined as the model with AUC value greater than 0.8.

RESULTS

Descriptive data of enrolled animals

From August 1st, 2014 to July 31st, 2016, a total of 87 dogs matched the study inclusion criteria and were included in this study. Sixty-six of 87 dogs with no repeated surgery were assigned to the control group, and 21 of 87 dogs with repeated surgery after surgical removal of the stone from the lower urinary tract were assigned to the case group. Post-operative monitoring was performed until July 31st, 2017, the repeated surgery rate of canine urolithiasis at the lower urinary tract was 24.13% (21/87 dogs). The surgical episode interval in these dogs ranged from 2 months to 36 months. Mean and SD of the surgical episode interval were 14.1± 11.4 months.

The breeds of dogs in this study were Shih Tzu, 29% (25/87); mixed breeds, 29% (25/87); Poodle, 13% (11/87); and others, 29% (26/87). In the control group, there were 55% (36/66) male and 45% (30/66) female dogs. In case group, there were 67% (14/21) male and 33% (7/21) females.

Bacterial culture results were available for 66 dogs. The results included 49 dogs in the control group, and 17 dogs for the case group. Among the 66 dogs, 50 (76%) showed positive results on bacterial identification, and 16 (24%) dogs showed negative results on bacterial identification. In the control (no repeated surgery) group, 73% (36/49) had positive results on bacterial identification, and 27% (13/49) had negative results on bacterial identification. In the case (with repeated surgery) group, 82% (14/17) had positive results on bacterial identification, and 18% (3/17) had negative results on bacterial identification.

The history of antimicrobial dispense was classified into two groups based on the period of prescription: less than 30 days and greater than 30 days. In control group, 79% (52/66) possessed a history of antimicrobial dispense of less than 30 days, and 21% (14/66) possessed a history of antimicrobial dispense longer than 30 days. In the case group, 76% (16/ 21) possessed a history of antimicrobial dispense of less than 30 days, and 24% (5/21) had a history of antimicrobial dispense of more than 30 days.

Results of uroliths analysis were available for 64 dogs (Figure 1). There were 64% (41/64), 17% (11/64), 10% (6/64), and 9% (5/64) of the dogs with struvite, calcium oxalate (CaOx), compound uroliths (CaOx and struvite), and other type of uroliths, respectively. The percentage of urolith types in each group (case and control) are shown in Figure 2 and Figure 3.

Results of uroliths analysis were available in 15 of 21 dogs from case group. Types of uroliths for these 15 dogs were struvite 87% (13/15) and mixed uroliths 13% (2/15). Results of urolith analysis were available in 49 of 66 dogs from control group. Types of uroliths for these 49 dogs were struvite 57.14% (28/49), CaOx 22.44% (11/49), compound uroliths (CaOx and struvite) 10.20% (5/49), and other types of uroliths (mixed, compound, and cysteine) 10.20% (5/49 dogs).

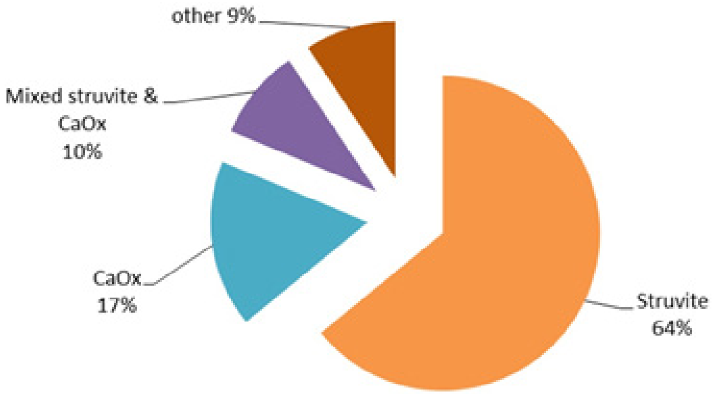

Figure 1 The uroliths analysis result in total 64 dog-records in this study.

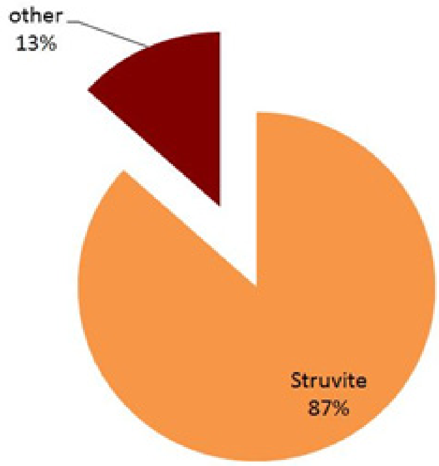

Figure 2 The uroliths analysis results in 15 dogs in case group; the dogs that had repeated surgery of urolithiasis at the lower urinary tract was performed during the 36 months period of study.

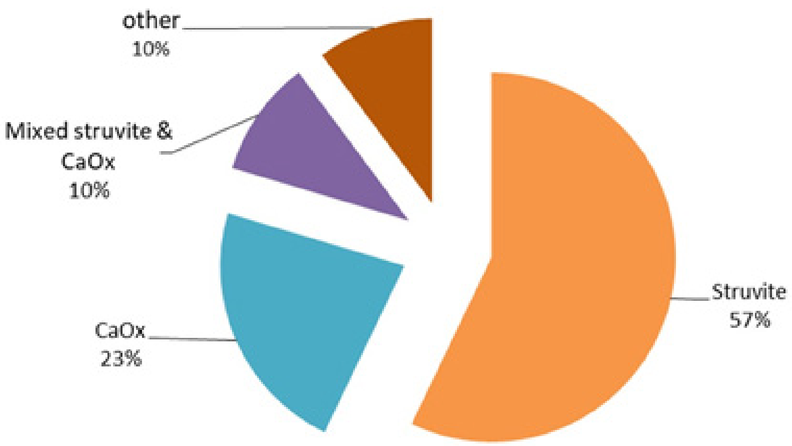

Figure 3 The uroliths analysis results in 49 dogs in controls group; the dogs that had no-repeated surgery of urolithiasis at the lower urinary tract was performed during the 36 months period of study.

Univariable logistic regression analysis

Univariable logistic regression analysis to determine the association of variables and the repeated surgery of urolithiasis was performed with each categorical and continuous variables. There were 14 variables with p-value ≤0.2. After performing tests for multicollinearity among these variables, only 7 variables, including neutered status, use of doxycycline after surgery, urine color, struvite calculi, duration of diet before calculi, body weight, and number of neutrophils were selected as shown in Table 1 and Table 2. All 7 variables were introduced to the multivariable logistic regression analysis.

Table 1 Categorical variables with p-value ≤0.2 from univariable logistic regression analysis for their associations with the repeated surgery of urolithiasis

Variables	Category	No. of case dogs	No. of control dogs	OR (95% CI)	P value
Neuter status	No & Yes	20	65	4.07 (1.43 – 12.00)	0.008 *
Using doxycycline after surgery	No & Yes	21	66	0.20 (0.01 – 1.12)	0.137
Urine color	Yellow & Brown	18	35	5.48×10^{-1} (0.31-1.17)	0.368
	Yellow & Black	14	25	1.05×10^{-7} (NA–3.51×10^{8})	0.992
	Yellow & Red	15	31	2.05 (0.01 – 1.30)	0.155
Calculi result Struvite	Negative & Positive	15	49	4.87 (1.18 – 33.36)	0.051
Duration of diet before calculi (month)	< 6 & 6 – 12	4	4	0.11 (0.002 – 2.09)	0.178
	<6 & >12	19	62	0.087 (0.004-0.733)	0.040

Table 2 Continuous variables with p-value ≤0.2 from univariable logistic regression analysis for their associations with the repeated surgery of urolithiasis

Variables	No. of case dogs	No. of control dogs	OR (95% CI)	P value
Body weight	20	66	-0.06 (-0.17 – 0.01)	0.187
Neutrophils	19	63	-1.15×10^{-4} (-2.37×10^{-4} - -2.33×10^{-5})	0.032

Multivariable logistic regression analysis

Variables remained in the final multivariable logistic regression model for the repeated surgery of urolithiasis in dogs included neutered status, use of doxycycline after surgery, number of neutrophils, urine color and struvite calculi as shown in Table 3. The primary factor associated with the repeated surgery of urolithiasis in dogs was presenting struvite calculi (OR = 16.54; 95% CI =1.62 – 4.89×10^{2}; p-value = 0.040; Table 3). The final model fitted the analyzed data when tested using the Hosmer–Lemeshow goodness-of- fit (p-value > 0.05). The calculated area under the ROC curve (AUC) for the final multivariate model was 0.89 (95% CI: 0.7–0.8); therefore, the final model had high predictive capability.

Table 3 Final multivariable logistic regression model for factors associated with repeated surgery of urolithiasis in dogs.

Variables	Categories	OR	95% CI	P value
Neuter status (X5)	Intact & Neutered	1.85	0.25 – 1.46	0.538
Use doxycycline after surgery	No & Yes	5.3 x 10^{-9}	NA – 9.29 x 10^{90}	0.995
Neutrophils (X16)	NA	0.1	0.99915 - 0.99997	0.147
Urine color (X32)	Yellow & Brown	1.58	0.17 – 16.54	0.687
	Yellow & Black	1 x 10^{-7}	NA – Inf	0.998
	Yellow & Red	0.39	0.01 – 9.06	0.563
Struvite stone (x50.1)	Negative & Positive	16.54	1.62 – 4.89 x 10^{2}	0.040

DISCUSSION

The objective of this study was to investigate risk factors associated with the repeated surgery of urolithiasis after surgical removal from the lower urinary tract in dogs. Knowing the important risk factors for this disease is necessary for effective prevention of the repeated surgery (Okafor et al., 2014; Okafor et al., 2013). Seventy-four variables were included in univariable analysis to determine the association between variables and the repeated surgery. In the final multiple logistic regression model, only the presence of struvite uroliths was statistically significantly associated with the repeated surgery of canine urolithiasis.

In this study, the dogs with struvite uroliths were 16.54 times more likely to develop recurrent urolithiasis and needed repeated surgery to removal the stone from the lower urinary tract when compared with the non-struvite uroliths dogs. Based on the results of our study, a proper post-surgical management needs to be prioritized, especially on dogs with a history of struvite uroliths. This can be accomplished by client education on how to avoid possible risk factors that may contribute to struvite uroliths formation after surgical treatment (Bartges & Callens, 2015). According to Okafor (2013), the important risk factors increasing development of struvite urolithiasis in dogs include 7 factors; toy or small breeds, neutered female, urine with protein (> 30 mg/dL), alkalinity urine (pH > 7.5), urine with RBCs, urine with WBCs, and urine with ketone (≥ 5 mg/dL) (Okafor et al., 2013). Further clinical studies also suggested that dogs suffering from urinary tract infection originating from urease-producing bacteria, which cause alkaline urine and high magnesium excretion, possessed a greater risk of developing struvite (magnesium ammonium phosphate) urolithiasis (Calabro et al., 2011; Okafor et al., 2013).

The diagnosis of urolithiasis in the lower urinary tract of all 87 dogs in the study was accomplished via radiography. The repeated surgical rate of canine urolithiasis in this study was 24.1% (21 of 87 dogs). The percentage of recurrent rate and repeated surgery in our study corresponds to the previous clinical study on canine urolithiasis in canine populations in New York in 1977 (Brown et al., 1977), which indicated that the recurrence rate was 25% (111/438 dogs). The correspondence of the repeated surgery rate in canine urolithiasis patients in our study was too high as same as to the recurrence rate of canine urolithiasis that was reported 43 years ago (Brown et al., 1977). This might be indicated that our current preventive strategies for the recurrence of canine urolithiasis at the SATH, CMU needs to be revised or needs further investigation.

Previous research suggested that the recurrence of canine urolithisis commonly occurred within 12 months after surgery (Brown et al., 1977; Koehler et al., 2009). The results of the above-mentioned research support our finding. Among 21 dogs in our study with the history of recurrent urolithiasis, 8 dogs developed recurrent urolithiasis and must be treated with repeated surgery within 12 months after the first surgery. The mean interval of the surgical episode in these dogs was 6.25 months and ranged from 2 to 12 months. In the other hand, based on all 21 dogs in case group, the mean intervals between the episodes of surgery was 14.06 months and ranged from 2 to 36 months. Our study also showed that the recurrence of canine uroliths which needed to repeat surgery was commonly detected within the first year following surgery. This finding corresponds to the results of the previous studies (Brown et al., 1977; Calabro et al., 2011; Chew et al., 2011; Koehler et al., 2009; Ling et al., 1998).

One of the possible types of recurrence of uroliths after the surgical removal is suture –nidus uroliths and was reported in 9.4 % of the recurrence uroliths removed from the urinary bladder (Appel et al., 2008). Because the suture material used may serve as a nidus of the urolith formation, the veterinary surgeons at the SATH, CMU had recognized this problem and used biologically friendly suture materials and avoided a penetration of suture materials through the bladder mucosal layer. Therefore, suture-nidus uroliths were not found in the dogs with recurrence uroliths in this study. This finding was not in agreement with the results of Appel S.L. study (Appel et al., 2008).

Surgical removal is an effective treatment to remove uroliths, but the cost of treatment is beyond the financial means of some dog owners (Bartges & Callens, 2015; Koehler et al., 2009; Lulich et al., 2016; Okafor et al., 2014). The surgical procedure is painful to the animal and requires several days for post-surgical care. Dogs suffering from urolithiasis with a complete obstruction of the urinary tract that require emergency surgical removal also possess a high anesthetic risk due partly to a compromise in renal functions (Arulpragasam et al., 2013; Langston et al., 2010). The high recurrent rates and repeated surgery of the uroliths associated with the struvite uroliths in this study suggested that specific long-term case management strategies should be implemented in these dogs after successful surgical removal. This is in order to prevent a reformation of the uroliths and to avoid the possibility that the dogs may be subjected to a second surgery. Uroliths frequently occur when the environment in the urinary tract, including high urine concentration, is suitable for the stone formation (Okafor et al., 2014; Okafor et al., 2013). The composition of minerals in struvite uroliths are magnesium, ammonium and phosphate, and those minerals are likely to form sediment in alkaline urine (pH > 7.5). A high-protein diet is more likely to have high ammonium and phosphate in the urine; thus, the diets designed to prevent or even dissolve struvite stones have limited protein. However, low protein diets cause high pH urine, which favors the struvite formation. To modify this effect, urine acidifiers such as the amino acid methionine or vitamin C are commonly added in to those diets. Changing the management factors, such as setting a toilet schedule (at least 3 times per day), encouraging greater water consumption by serving clean water all day, and providing a moist diet, are also important keys to reducing uroliths recurrence (Nelson & Couto, 2014; Bartges & Callens, 2015). Besides the above-mentioned client education, frequent radiographic or ultrasonographic follow-ups and urinalysis surveys for the possibility of urolith reformation are highly recommended (Lulich et al., 2016). If a small urolith is detected, an immediate medical management can be implemented to promote dissolution of the urolith (Lulich et al., 2016).

CONCLUSION

Presence of struvite urolith was the only statistically significant factor found to contribute to the repeated surgery of urolithiasis after surgical removal of the stone at the lower urinary tract. Dogs with struvite uroliths had a 16.54 times (95% CI =1.62 – 4.89 x 10^2; p-value = 0.040) greater risk of repeated surgery when compared with the non-struvite uroliths. This result strongly supports the idea that the surgical removal of struvite uroliths in the dog should not be considered as the final step of the treatment plan. After the uroliths are removed by surgery, further analysis to identify the type of uroliths is warranted in order to identify dogs with a high risk of recurrence. After the identification, a specific preventive strategy should be recommended to the owner in order to avoid formation of the same type of uroliths, which can be a health problem that requires repeated surgical correction. Reducing the concentration of urolith precursors by using a specific diet or drinking more water, and changing the urination management, are recommend. Client education on how to reduce risk of uroliths reformation should be a high priority. A regular post-surgical imaging diagnostic survey of the urinary tract should be scheduled in these dogs for a possible early identification of the recurrence of uroliths.

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