

Retrospective study of 353 confirmed cases of urolithiasis in dogs and cats treated at veterinary clinics in the northern region of Pará, Brazil

Estudo retrospectivo de 353 casos confirmados de urolitíase em cães e gatos atendidos em clínicas veterinárias da região norte do Pará, Brasil

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Abstract

Urolithiasis is the third most prevalent disease of the urinary tract of dogs and cats, and is characterized by presence of crystals and / or formation of stones. The present study objective was to report the confirmation rate of suspected cases of urolithiasis in dogs and cats treated at veterinary clinics in the city of Santarém, Pará. A retrospective cohort study was carried out from the database of medical records from six veterinary clinics from the years 2012 to 2023. Dogs and cats were evaluated for clinical suspicion, species, age, breed, feeding type, diagnosis, location of the urolith and type of urolith. As the data did not present a normal distribution, they were submitted to the Chi-square test and Fisher's exact test. The analyses were performed using Statistical Analysis Software (SAS), considering a 5% significance level. Of the 532 files analyzed of suspected cases, 353 were confirmed. The percentage of cases in cats (72.23%) was higher than in dogs (55.37%). The age range between 2 and 5 years was the period when it had more confirmed cases and most of the uroliths were found in the urinary vesicle, both in dogs and cats. It was concluded that there was a high index of confirmed cases of urolithiasis in dogs and cats, being superior in this last species. In addition, in both species are more affected animals between 2 and 5 years of age, being more common the location of uroliths in the bladder.

Keywords: urolithiasis, urolith, urinary vesicles.

Resumo

Urolitíase é a terceira doença mais prevalente do trato urinário de cães e gatos, e é caracterizada pela presença de cristais e/ou formação de cálculos. O objetivo do presente estudo foi relatar a taxa de confirmação de casos suspeitos de urolitíase em cães e gatos atendidos em clínicas veterinárias da cidade de Santarém, Pará. Foi realizado um estudo de coorte retrospectivo a partir do banco de dados de prontuários de seis clínicas veterinárias dos anos de 2012 a 2023. Cães e gatos foram avaliados quanto à suspeita clínica, espécie, idade, raça, tipo de alimentação, diagnóstico, localização e tipo do urólito. Como os dados não apresentaram distribuição normal, foram submetidos ao teste Qui-quadrado e teste exato de Fisher. As análises foram realizadas por meio do Statistical Analysis Software (SAS), considerando um nível de significância de 5%. Dos 532 prontuários analisados de casos suspeitos, 353 foram confirmados. O percentual de casos em gatos (72,23%) foi maior que em cães (55,37%). A faixa etária entre 2 e 5 anos foi o período em que houve mais casos confirmados e a maioria dos urólitos foi encontrada na vesícula urinária, tanto em cães quanto em gatos. Concluiu-se que houve alto índice de casos confirmados de urolitíase em cães e gatos, sendo maior nesta última espécie. Além disso, em ambas as espécies são mais acometidos animais entre 2 e 5 anos de idade, sendo mais comum a localização dos urólitos na bexiga.

Palavras-chave: urolitíase, urólito, vesículas urinárias.




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Introduction

Data coming from veterinary clinic centers on uroliths provide information on patient risk factors for uroliths, which are important for their clinical recognition and for understanding the pathophysiology (Hunpravit et al., 2019; Kopecny et al., 2021). Urolithiasis is a condition resulting from metabolic alterations that occur commonly in the medical routine of small animals, affecting 15-23% in felines (Jepson, 2023; Putschakayala & Haritha, 2024; Ximenes et al., 2023) and about 33% in canines (Naeverdal et al., 2023; Mulyani et al., 2024; Yaygingül, 2024). The clinical prevalence of urolithiasis in dogs ranges from 0.5% to 1% (Elkewahy et al., 2023). It is a condition that has high rates of recurrence (To et al., 2024).

It is considered the second most common cause of feline lower urinary tract disease (FLUTD) (with 15 to 20%), with the first being idiopathic cystitis (with 55 to 65%), followed by anatomical abnormalities and behavioral problems (with about 10%) of the reports (Gülersoy et al., 2023). It can be said that approximately 13% of the causes of urinary tract disorders in cats and 18% in dogs are represented by urolithiasis. (Mustafa et al., 2023).

This disease is defined as the formation of stones or uroliths and can be present in the kidneys, ureter, urinary vesicle, or urethra (Kim & Oh, 2023). Uroliths are polycrystalline concretions composed primarily of organic and inorganic crystalloids and smaller amounts of organic matrix, formed by aggregates of urinary solutes, precipitated and organized in a central nucleus (nest or crystal nucleus) which, in turn, is surrounded by concentric laminae and surface crystals (Monnet, 2023; Santos et al., 2023).

Uroliths are classified according to their mineral composition, location, and shape, with struvite, calcium oxalate, urate, mixed, silicate, and cystine being the main ones found in dogs and cats (Stavroulaki et al., 2024). Regarding its incidence, dogs are more predisposed to develop calcium oxalate stones, and cats to struvite stones (Bartges & Corbee, 2023).

Several factors can lead to the formation of uroliths, such as changes in urinary pH, infections, high concentration of crystalloids in urine, reduced water consumption, as well as a decrease in urinary frequency associated with supersaturation of urine with salts and combined with a high supply of minerals and proteins in the diet (Cook, 2023; Eicher et al., 2023; Geddes et al., 2023; Gomes et al., 2018). Acquired lesions, inherited anatomical alterations, such as bladder diverticulum, and genetic factors that predispose the animal to urinary infections that can lead to the formation of struvite uroliths, locality, and time can also influence the formation of uroliths (Kant et al., 2023; Xu et al., 2024).

Clinical features depend on the number, type, and location of uroliths in the urinary tract. The most observed clinical signs are frequency, dysuria, stranguria, hematuria, urinary incontinence and uremia, ischuria and in cases of complications, they may present progression to urethral and/or bladder obstruction, hydronephrosis and hydroureter, bladder or urethral rupture, pyelonephritis, urethritis and bladder dilation. Systemic signs such as diarrhea, anorexia, vomiting, and lethargy may occur, in addition to the presence of palpable urinary gallstones (Ardebili & Razavi, 2023; Gloor et al., 2024; Ozcan et al., 2023).

The diagnosis of urolithiasis involves the patient's history, physical examination, laboratory findings, and imaging tests such as ultrasound and radiography (Ji et al., 2023; Malhi et al., 2023; Montatore et al., 2023). In view of the high incidence of cases of urolithiasis among urinary tract disorders in the clinical medical routine of small animals, the aim of this study was to report the confirmation rate of suspected cases of urolithiasis in dogs and cats treated at private veterinary clinics in the municipality of Santarém, Pará.

Material and methods

Study population

A retrospective cohort study was carried out based on the analysis of the database of six randomly chosen veterinary clinics, located in the municipality of Santarém (02° 26' 35" S and 54° 42' 30" W), mesoregion of Baixo Amazonas, northern region of Pará. Medical records were evaluated between January 1, 2012 and December 31, 2023, separating patients specifically with urinary tract disorders (lower and upper), with suspected urolithiasis.

Medical record data extracted

A total of six veterinary clinics (A-E) were consulted, the clinics were in different neighborhoods, with a total of 532 suspected cases from all the clinics, broken down by establishment (clinics A - 102 cases, B - 112 cases, C - 113 cases, D - 108 cases, E - 97 cases). Information was collected such as: year of presentation of the urolith, species (canine or feline), age (between 6 months and 1 year (puppies), 1 to 2, 2 (youngsters) to 3, 3 to 5 and over 5 years (adults)), breed (all breeds recorded in the medical records), type of food provided (kibble and kibble with homemade food), as well as clinical suspicion, diagnostic confirmation by radiography or ultrasound (total number of suspects) and location of the urolith. The type of urolith that affected both dogs and cats was also observed. The medical records showed no comorbidities in the animals studied.

During the anamnesis, most of the medical records described that the main complaints of the owners of canines and felines with suspected urolithiasis were difficulty in urinating (dysuria), increased urination but in small quantities (polyuria), the presence of blood (hematuria), excessive licking of the genital area, apathy, inappetence, straining to urinate and abdominal pain.

Statistical analysis

For the statistical analysis, the data were submitted to the Shapiro-Wilk test to verify the normality and homoscedasticity of the data. As the data did not present a normal distribution, they were submitted to the Chi-square test and Fisher's exact test. The analyses were performed using Statistical Analysis Software (SAS), considering a 5% significance level.

Results

Of the 532 suspected cases analyzed, 353 were confirmed, making a confirmation rate of 66.35%. Analyzing the clinical suspicions, it was identified that 351 (65.97%) presented bleeding through the urethral canal as one of the most common clinical signs of urinary tract disorders, and the remaining 181 (34.03%) suspected cases already had a history of urinary tract infection. Of the confirmed cases, the presence of stones was detected by ultrasonography in 351 animals (Figure 1) and only two with radiography.

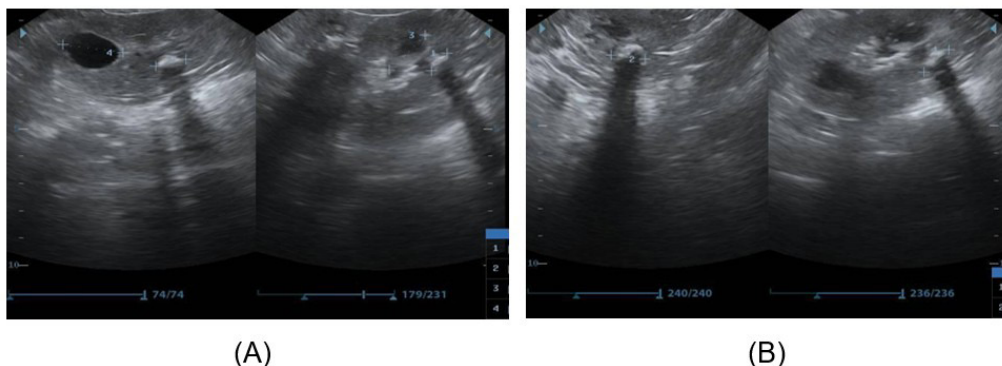


Figure 1. Ultrasound image of a kidney containing uroliths diagnosed in dogs and cats in veterinary clinics in the northern region of Pará. In (a) left kidney. In (b) right kidney

It was observed that the total number of confirmed cases among the species, most were cats with 255 (71.83%) ($p < 0.05$), however, it should be considered that the number of cats with suspected 355 cases is higher than that of suspected cases in dogs (177). In dogs, the percentage of confirmed cases in each year did not differ ($p < 0.05$), with the exception of 2016 and 2017, where a low confirmation rate was observed. In cats, the percentage of occurrence was lower in the years 2014 and 2018, however, there was no statistical difference from the years 2012, 2013, 2015, 2016 and 2017 ($p > 0.05$). However, of the confirmed cases among the different species in the same year, a higher percentage of confirmation was observed in cats from 2016 to 2023 when compared to dogs ($p < 0.05$).

Regarding the location of the urolith in the urinary tract, it was found in dogs that most of them were in the bladder, followed by the kidneys with 22% and in only 5% of the cases in the

urethra (Figure 2). In cats, a higher number of uroliths was observed in the urinary vesicle and equal percentages in the kidneys and urethra (Figure 2).

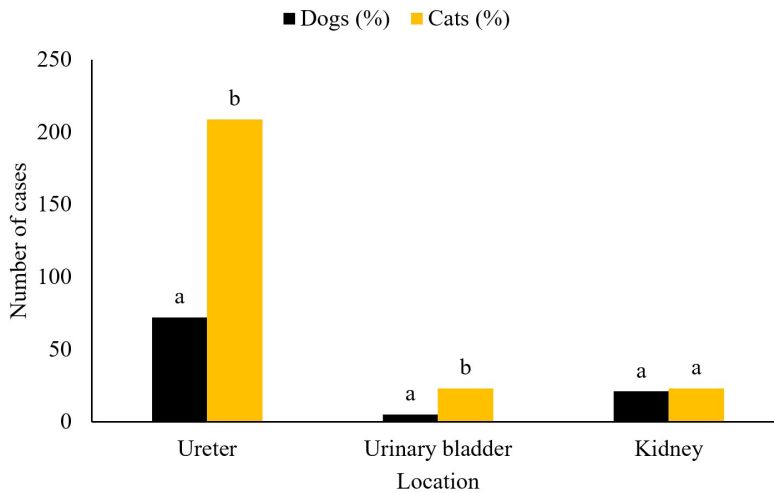


Figure 2. Location of uroliths diagnosed in dogs and cats in veterinary clinics in the northern region of Pará. Note: a, b: indicates statistical difference between lines; *differs statistically between species of the same age.

It was found that most of the animals had urolithiasis in adulthood, corresponding to between 3 and 5 years ($p < 0.05$), with 43.05% of the cases. Regarding the age of the affected animals, a high rate of confirmed cases was found in both dogs and cats in the 2 to 3 years and 3 to 5 year groups ($p < 0.05$), being significantly higher than in the other age groups (Figure 3).

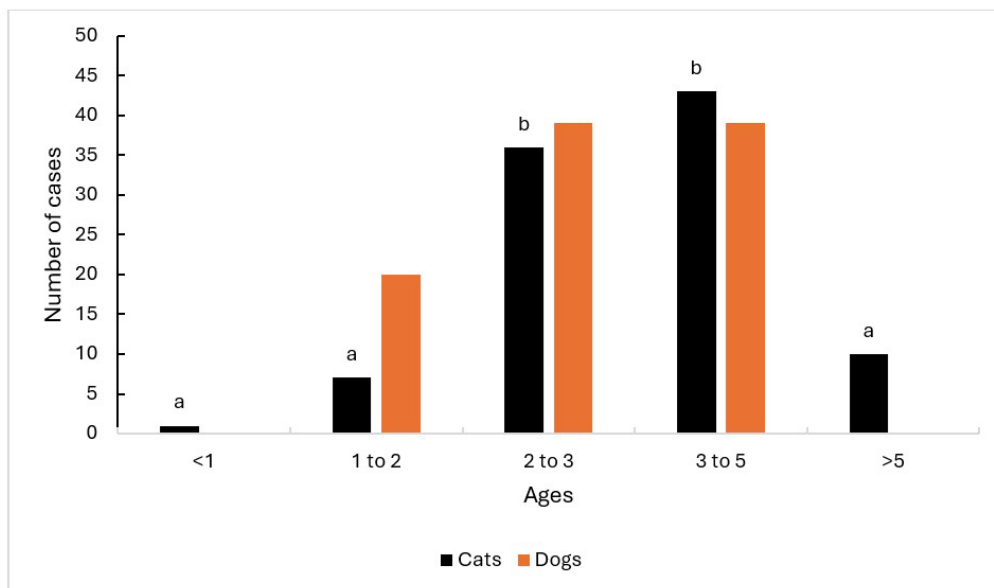


Figure 3. Distribution of confirmed cases of uroliths in dogs and cats according to age group. Note: a, b or ab: indicates statistical difference between lines; *differs statistically between species of the same age

Of the total number of animals that presented urolithiasis in this study, the mixed breed animals were the ones that stood out the most, however, it should be noted that the number of mixed breed animals was much higher than those with defined breeds, such as Labradors, Golden, Chow-

chows, Shitzu, German Spitz (SPTZ), German Shepherds and Bulldogs (Figure 4a, b). There was no difference between dogs and cats fed only with kibble or kibble plus homemade food ($p>0.05$).

Of the total of 353 confirmed cases, urolith types were diagnosed in 60.20% of cases in dogs and 90.58% in cats. Of these, the highest numbers of struvite-type calculi were observed, followed by calcium oxalate and urate ($p<0.05$) (Figure 5).

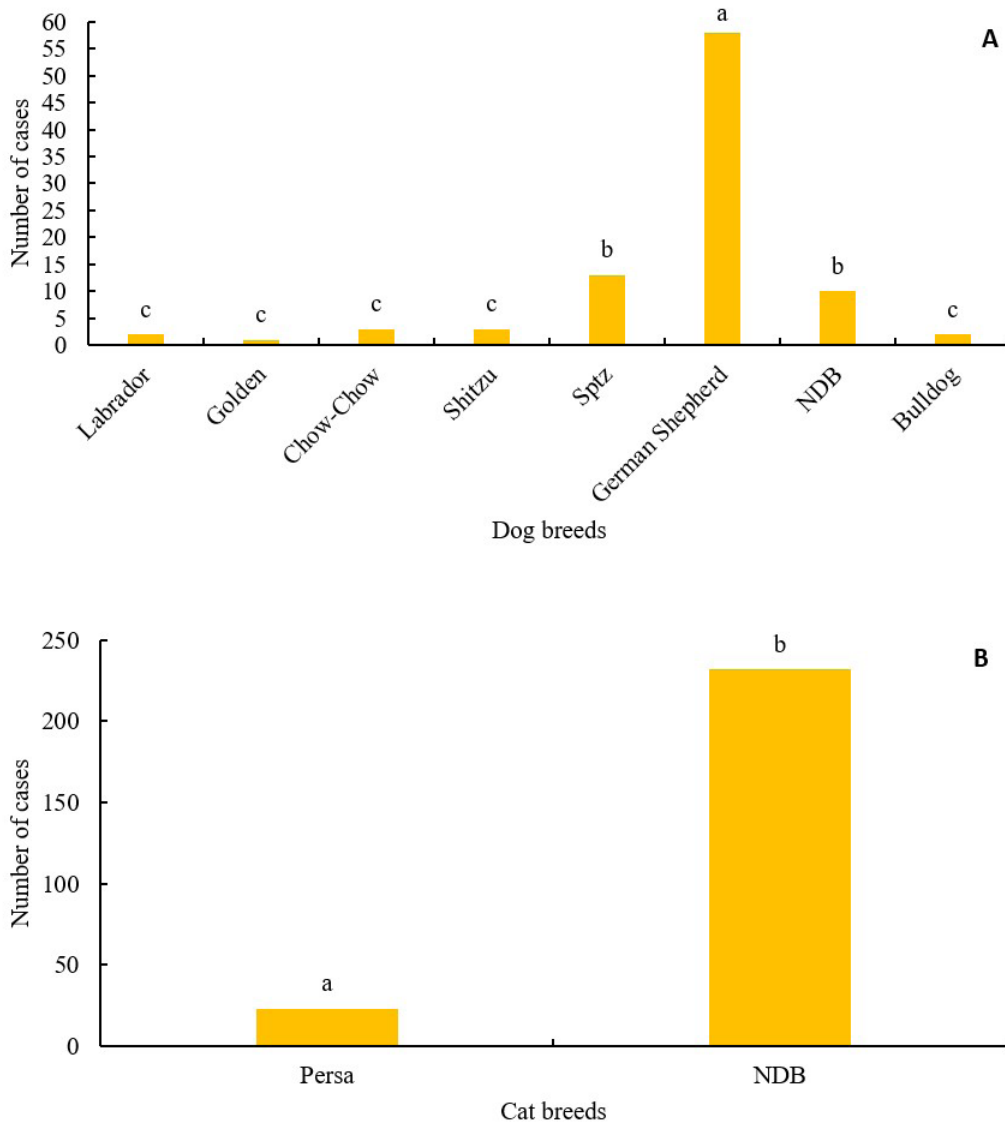


Figure 4. Number of cases of dogs (A) and cats (B) with confirmed cases of urolithiasis in veterinary clinics in the northern region of Pará. Note: NDB = no defined breed. Note: a, b indicates statistical difference between lines.

Discussion

The number of suspected cases of urolithiasis in cats increased over the years 2012 to 2023, this can be attributed to the possible increase in the demand for veterinary medical service by owners (Joubran et al., 2024). In addition, a higher number of confirmed cases was found in cats than in dogs ($p<0.05$). This result may be related to the strong concentration of cat urine, which, because they originate from desert regions, have adapted to consume little liquid, and consequently produce little urine volume, making them more susceptible to the development of urolithiasis (Defarges et al., 2020; Hall et al., 2021; Queau et al., 2020).

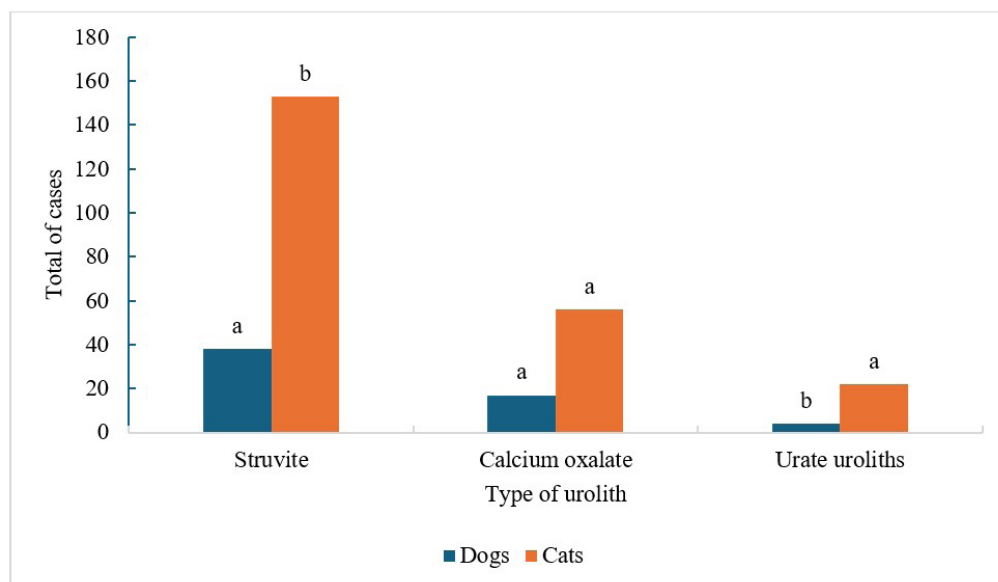


Figure 5. Types of uroliths diagnosed in dogs and cats. Note: a, b indicates statistical difference between lines

It should be noted that stones can form in any region of the urinary tract of animals (Hoelmer et al., 2022), and the dog has a higher incidence in the bladder (Kopečný et al., 2021). Grauer (2010) and Inkelmann et al. (2012) agree that about 95% of uroliths in dogs are found in the urinary gallbladder.

Neta and Munhoz (2008) mention that only 5% to 10% of uroliths are located in the kidneys or ureters, and even though the kidney is one of the least common sites, it showed relevance in terms of percentage (22%), and even compared to the percentage in cats (9%). Kaufmann et al. (2011) mentions that in felines, uroliths are found more in the urinary vesicle or urethra, with the ureters and kidneys being the least common sites, corroborating the results obtained in this study.

Uroliths in the upper urinary tract are not commonly reported in dogs and cats. This is because there is a hypothesis that there may be a correlation between the positioning of the kidney and urinary vesicle in relation to gravity in quadrupeds and biped. In quadrupedal animals, the horizontal positioning of the kidneys and bladder are aligned parallel to the ground, causing gravity to influence their anatomy and physiology, allowing urine to flow through the ureters, reducing the occurrence of urinary stasis and the formation of stones in the upper urinary tract. On the other hand, in bipedal animals that remain upright, gravity has an impact on the accumulation of sediment and the formation of stones in the kidneys and ureters, since they are located above the bladder. This anatomical and consequently physiological difference explains the lower incidence of uroliths in the upper urinary tract in quadrupeds when compared to bipeds (Kovářiková et al., 2021).

In view of the above, according to Neta and Munhoz (2008), Breshears and Confer (2017) and Silva et al. (2022), uroliths that do not obstruct can persist for years without causing lesions or being clinically noticed. Kaufmann et al. (2011) cite that in the canine species, small uroliths can remain asymptotically in the urinary tract for months to years.

In a study in the United Kingdom, cases were observed for the average ages of 7.0 years in dogs and 7.4 years in cats (Stavroulaki et al., 2024), however, in a study in Mexico City, it was shown that the age of the animals ranged from 4 months to 14 years, with an average of 5 years (Mendoza-López et al., 2019). Inkelmann et al. (2012) at the Department of Pathology of the Federal University of Santa Maria (LPV-UFSM), performed an analysis among 76 dogs with urolithiasis, and found that most were adults, with an average age of 5 years, corroborating the results of this study that demonstrated that age (between 3 and 5 years) is the period in which there were more cases of urolithiasis.

According to a study carried out by Oyafuso et al. (2010) by quantitative evaluation of the composition of 156 dog uroliths at the Veterinary Hospital of the Faculty of Veterinary Medicine

and Animal Science of USP - São Paulo, mixed breeds were more affected, corroborating the results of this work, however, in a study carried out with 76 dogs by Inkelmann et al. (2012) at the Department of Pathology of the Federal University of Santa Maria (LPV-UFSM), Most of the dogs with defined breed (56.6%) had urolithiasis.

The total number of Shitzu dogs that had urolithiasis, which according to Stavroulaki et al. (2024) represents one of the main breeds affected by the presence of uroliths, as well as the Miniature Schnauzer, Lhasa apso, Yorkshire terrier, Bichon frisé and Poodle. Regarding the cats, although of reduced number, all of the Persian breed had the suspicion of urolithiasis confirmed. This breed of cat, according to Neves et al. (2011) is one of the most predisposed to this condition, as well as the Russian Blue and Himalayan breed.

It should be considered that diet may not influence the formation of uroliths, as the development of urolithiasis is related to dietary and non-dietary factors (Kachkoul et al., 2023), as well as factors linked to obesity, castration status, sex, age, and race (Burggraaf et al., 2021).

The data shows that the majority of confirmed cases of urolithiasis in dogs and cats are more often struvite-type stones, which are frequently associated with urinary infections, with diet being the main factor due to the change in pH making it more alkaline (Parmar et al., 2021; Yaygingül, 2024). In cats, urinary infections occur less frequently, but a diet rich in magnesium and reduced water intake contribute to stone formation (Gomes et al., 2018). The prevalence of this type of stone suggests that the main cause is related to dietary factors and bacterial infections of the urinary tract, thus favoring the diagnosis, management and prevention of urolithiasis, especially in canines, which are often more affected.

In addition, calcium oxalate stones are the second most frequently observed type, reflecting the need to establish a balance between the metabolism of minerals such as calcium and oxalate levels, influenced by the concentration present in diets and also by genetic conditions (Bartges, 2016; Grauer, 2015). Furthermore, urate stones were also one of the most common occurrences during the study, especially in canines of predisposed breeds such as Dalmatians or hepatopathic animals. There is therefore a need to develop more species-specific preventive and therapeutic approaches, taking into account various factors such as diet, metabolism, genetics and infection.

Conclusion

There was a high rate of confirmed cases of urolithiasis in both dogs and cats, being higher in the latter species. Both species are most affected in animals between 2 and 5 years of age, and the location of uroliths in the urinary gallbladder is more common. In addition, the results obtained in this study help veterinary professionals on the epidemiology of urolithiasis in dogs and cats.

Ethics statement

All procediments were consented by the animal owner (for case reports)

Financial support

Not applicable.

Conflict of interests

No conflict of interest.

Authors' contributions

WCS, BCAR, SVC, TSB, CELS, FJDS, RNCCJ and all the authors helped with the writing and preparation of the the clinical case.

Availability of complementary results

Not applicable.

The study was carried out at Departamento de Medicina Veterinária, Centro Universitária da Amazônia (UNAMA), Santarém, PA, Brazil.

References

- Ardebili, A. A., & Razavi, S. A. (2023). Successful treatment of urolith in a neutered persian cat: A case report. *Small Animal Advances*, 2(1), 1-4. <http://doi.org/10.58803/SAA.2023.2.1.01>.
- Bartges, J. W. (2016). Feline calcium oxalate urolithiasis: Risk factors and rational treatment approaches. *Journal of Feline Medicine and Surgery*, 18(9), 712-722. <http://doi.org/10.1177/1098612X166660442>. PMID:27562981.
- Bartges, J., & Corbee, R. J. (2023). Applied veterinary clinical nutrition. In A. J. Fascetti, S. J. Delaney, J. A. Larsen, & C. Villaverde (Eds.), *Nutritional Management of Lower Urinary Tract Disease* (2nd ed., Vol. 16, pp. 412-440). Wiley Online Library.
- Breshears, M. A., & Confer, A. W. (2017). The urinary system. In J. F. Zachary (Ed.), *Pathologic Basis of Veterinary Disease* (2nd ed., Vol. 11, pp. 617-681.e1). Elsevier. <https://doi.org/10.1016/B978-0-323-35775-3.00011-4>.
- Burggraaf, N. D., Westgeest, D. B., & Corbee, R. J. (2021). Analysis of 7866 feline and canine uroliths submitted between 2014 and 2020 in the Netherlands. *Research in Veterinary Science*, 137(1), 86-93. <http://doi.org/10.1016/j.rvsc.2021.04.026>. PMID:33940351.
- Cook, M. J. (2023). Urinary calculi of small ruminants. *Veterinary Clinics: Food Animal Practice*, 39(2), 355-370. PMID:37032300.
- Defarges, A., Evason, M., Dunn, M., & Berent, A. (2020). Urolithiasis in small animals. In D. Bruyette (Ed.), *Small Animal Internal Medicine* (pp. 1123-1156). Wiley-Blackwell. <http://doi.org/10.1002/9781119501237>.
- Eicher, L., Zablotski, Y., Knubben-Schweizer, G., & Voigt, K. (2023). Composition of ovine and caprine uroliths, and short-and long-term treatment success following obstructive urolithiasis—a retrospective analysis of clinical records of a Southern German veterinary hospital. *Berliner und Münchener Tierärztliche Wochenschrift*, 136(1), 1-12.
- Elkewahy, A. I., El-Maghraby, H., Badway, A., & Farghaly, S. (2023). Ultrasonography of the urinary tract in dogs and cats: Clinical investigations & prevalence. *Benha Veterinary Medical Journal*, 45(1), 54-59. <http://doi.org/10.21608/bvmj.2023.227644.1698>.
- Geddes, R. F., Davison, L. J., Elliott, J., Syme, H. M., & O'Neill, D. G. (2023). Risk factors for upper urinary tract uroliths and ureteral obstruction in cats under referral veterinary care in the United Kingdom. *Journal of Veterinary Internal Medicine*, 37(2), 567-577. <http://doi.org/10.1111/jvim.16659>. PMID:36860138.
- Gloor, C., Schweighauser, A., Rytz, U., & Francey, T. (2024). Placement of a subcutaneous ureteral bypass in a Miniature Pinscher with presumed xanthine urolithiasis as a result of allopurinol treatment. *Schweizer Archiv für Tierheilkunde*, 166(4), 207-215. <http://doi.org/10.17236/sat00422>. PMID:38572822.
- Gomes, V. D. R., Ariza, P. C., Borges, N. C., Schulz Junior, F. J., & Fioravanti, M. C. S. (2018). Risk factors associated with feline urolithiasis. *Veterinary Research Communications*, 42(1), 87-94. <http://doi.org/10.1007/s11259-018-9710-8>. PMID:29340849.
- Grauer, G. F. (2010). Urolithiasis canina. In R. W. Nelson & C. G. Couto (Eds.), *Medicina Interna de Pequenos Animais* (pp. 670-679). Elsevier.
- Grauer, G. F. (2015). Feline struvite & calcium oxalate urolithiasis. *Today's Veterinary Practice*, 5(5), 14-20.
- Gülersoy, E., Maden, M., Parlak, T. M., & Sayin, Z. (2023). Diagnostic effectiveness of stress biomarkers in cats with feline interstitial and bacterial cystitis. *Veterinary Clinical Pathology*, 52(1), 88-96. <http://doi.org/10.1111/vcp.13173>. PMID:36436835.
- Hall, J. A., Vanchina, M. A., Ogleby, B., & Jewell, D. E. (2021). Increased water viscosity enhances water intake and reduces risk of calcium oxalate stone formation in cats. *Animals (Basel)*, 11(7), 2110. <http://doi.org/10.3390/ani11072110>. PMID:34359236.
- Hoelmer, A. M., Lulich, J. P., Rendahl, A. K., & Furrow, E. (2022). Prevalence and predictors of radiographically apparent upper urinary tract urolithiasis in eight dog breeds predisposed to calcium oxalate urolithiasis and mixed breed dogs. *Veterinary Sciences*, 9(6), 283. <http://doi.org/10.3390/vetsci9060283>. PMID:35737335.
- Hunprasad, V., Schreiner, P. J., Bender, J. B., & Lulich, J. P. (2019). Epidemiologic evaluation of calcium oxalate urolithiasis in dogs in the United States: 2010-2015. *Journal of Veterinary Internal Medicine*, 33(5), 2090-2095. <http://doi.org/10.1111/jvim.15613>. PMID:31471926.
- Inkelmann, M. A., Kommers, G. D., Trost, M. E., Barros, C. S., Figuera, R. A., Irigoyen, L. F., & Siveira, I. P. (2012). Urolithiasis in 76 dogs. *Pesquisa Veterinária Brasileira*, 32(3), 247-253. <http://doi.org/10.1590/S0100-736X2012000300012>.
- Jepson, R. E. (2023). Clinical presentation of feline urolithiasis and associated diagnostic testing. *Companion Animal*, 28(10), 2-8. <http://doi.org/10.12968/coan.2023.0020>.
- Ji, Y., Hwang, G., Lee, S. J., Lee, K., & Yoon, H. (2023). A deep learning model for automated kidney calculi detection on non-contrast computed tomography scans in dogs. *Frontiers in Veterinary Science*, 10(1), 1236579. <http://doi.org/10.3389/fvets.2023.1236579>. PMID:37799401.
- Joubran, P., Roux, F. A., Serino, M., & Deschamps, J. Y. (2024). Gut and urinary microbiota in cats with kidney stones. *Microorganisms*, 12(6), 1098. <http://doi.org/10.3390/microorganisms12061098>. PMID:38930480.
- Kachkoul, R., Touimi, G. B., El Mouhri, G., El Habbani, R., Mohim, M., & Lahrichi, A. (2023). Urolithiasis: History, epidemiology, aetiologic factors and management. *The Malaysian Journal of Pathology*, 45(3), 333-352. PMID:38155376.

- Kant, S., Singh, K. D., Verma, A. K., Verma, M. K., & Jaiswal, S. (2023). Dietary based managerial concepts for preventing urolithiasis in animals. *Indian Farmer*, 10(11), 6.
- Kaufmann, C., Neves, R. C., & Habermann, J. C. A. (2011). Doença do trato urinário inferior dos felinos. *Anuário da Produção Científica dos Cursos de Pós-Graduação*, 4(4), 193-214.
- Kim, H. J., & Oh, S. H. (2023). Comprehensive prediction of urolithiasis based on clinical factors, blood chemistry and urinalysis: UROLITHIASIS score. *Scientific Reports*, 13(1), 14885. <http://doi.org/10.1038/s41598-023-42208-9>. PMID:37689768.
- Kopecný, L., Palm, C. A., Segev, G., & Westropp, J. L. (2021). Urolithiasis in dogs: Evaluation of trends in urolith composition and risk factors (2006-2018). *Journal of Veterinary Internal Medicine*, 35(3), 1406-1415. <http://doi.org/10.1111/jvim.16114>. PMID:33960543.
- Kovaříková, S., Maršálek, P., & Vrbová, K. (2021). Cystinuria in dogs and cats: What do we know after almost 200 years? *Animals (Basel)*, 11(8), 2437. <http://doi.org/10.3390/ani11082437>. PMID:34438894.
- Malhi, M., Hanumanthrao, P., & Kumari, P. R. (2023). A update on current diagnostic modalities and treatment of urolithiasis review. *Journal of Survey in Fisheries Sciences*, 10(2), 710-717.
- Mendoza-López, C. I., Del-Angel-Caraza, J., Aké-Chiñas, M. A., Quijano-Hernández, I. A., & Barbosa-Mireles, M. A. (2019). Epidemiology of feline urolithiasis in Mexico (2006-2017). *Journal of Feline Medicine and Surgery Open Reports*, 5(2), 2055116919885699. <http://doi.org/10.1177/2055116919885699>. PMID:31803489.
- Monnet, E. (2023). Urolithiasis of the lower urinary tract. *Small Animal Soft Tissue Surgery*, 2(1), 523-532. <http://doi.org/10.1002/9781119693741.ch44>.
- Montatore, M., Muscatella, G., Eusebi, L., Masino, F., Gifuni, R., Giannubilo, W., Sortino, G., & Guglielmi, G. (2023). Current status on new technique and protocol in urinary stone disease. *Current Radiology Reports*, 11(12), 161-176. <http://doi.org/10.1007/s40134-023-00420-5>.
- Mulyani, G. T., Pramono, A. B., & Pangestiniingsih, T. W. (2024). Diagnosis and treatment of urolithiasis in a Toy Poodle dog. *Open Veterinary Journal*, 14(3), 937-940. <http://doi.org/10.5455/OVJ.2024.v14.i3.23>. PMID:38682149.
- Mustafa, B., Shehta, A., Gouda, H., & Shety, T. (2023). Monitoring the inflammatory process of feline lower urinary tract disease. *Slovenian Veterinary Research*, 60(Suppl 25), 173-183. <https://doi.org/10.26873/SVR-1577-2022>.
- Naeverdald, T. V., Midtgård, J. E., Llaraena, A. K., & Ziener, M. L. (2023). A retrospective study on epidemiology and management of canine cystine uroliths in one part of Norway from 2015 to 2020. *Acta Veterinaria Scandinavica*, 65(1), 47. <http://doi.org/10.1186/s13028-023-00711-z>. PMID:37964384.
- Neta, E. S. M., & Munhoz, A. D. (2008). Urolitíase em cães e gatos: Uma revisão. *MEDVEP*, 6(17), 24-34.
- Neves, L., Wanderley, M. C., & Pazzini, J. (2011). Doença do trato urinário em gatos (*Felis catus domesticus*, LINNAEUS, 1758) atendidos em clínicas veterinárias da região de Ribeirão Preto-SP. *Nucleus Animalium*, 3(1), 115-136. <http://doi.org/10.3738/na.v3i1.571>.
- Oyafuso, M. K., Kogika, M. M., Waki, M. F., Prosser, C. S., Cavalcante, C. Z., & Wirthl, V. A. B. F. (2010). Urolitíase em cães: Avaliação quantitativa da composição mineral de 156 urólitos. *Ciência Rural*, 40(1), 102-108. <http://doi.org/10.1590/S0103-84782010000100017>.
- Ozcan, U., Iscan, G. S., Kulluk, E., Sayilkan, B. U., Esin, C., Colak, Z. N., Meral, Y., & Dalgın, D. (2023). First report on the anti-urolithiatic activity of viburnum opulus on urolithiasis/crystalluria in dogs and cats. *JAPS: Journal of Animal & Plant Sciences*, 33(4), 786-793. <http://doi.org/10.36899/JAPS.2023.4.0672>.
- Parmar, J. J., Parikh, P. V., Panchal, M. T., Ghodasara, D. J., & Bhandari, B. B. (2021). Clinico-diagnosis and surgical-therapeutic management of lower urinary tract disorders in dogs. *Indian Journal of Animal Research*, 55(11), 1315-1322.
- Putchakayala, R., & Haritha, G. S. (2024). Urinary system diseases of dogs and cats. In T. Rana (Ed.), *Introduction to Diseases, Diagnosis, and Management of Dogs and Cats* (pp. 147-161). Academic Press. <http://doi.org/10.1016/B978-0-443-18548-9.00010-X>.
- Queau, Y., Bijsmans, E. S., Feugier, A., & Biourge, V. C. (2020). Increasing dietary sodium chloride promotes urine dilution and decreases struvite and calcium oxalate relative supersaturation in healthy dogs and cats. *Journal of Animal Physiology and Animal Nutrition*, 104(5), 1524-1530. <http://doi.org/10.1111/jpn.13329>. PMID:32157751.
- Santos, M. O. D. F., da Silva, J. A. B., Leite, J. L., Bruno Filho, R., & de Oliveira, I. M. (2023). Urolitíases: Uma revisão de Literatura. *Seven Editora*, 1(4), 6.
- Silva, L. R. D., Rutcoski, V. M., Bavaresco, K. C., Vaccarin, C. V., Festugatto, R., Lusa, T., & Wurfel, S. D. F. R. (2022). Uretrostomia em cão: Relato de caso. *Annales de Medecine Veterinaire*, 2(1), 98-100.
- Stavroulaki, E. M., Ortega, C., Lawlor, A., Lulich, J., & Cuq, B. (2024). Trends in urolith composition and factors associated with different urolith types in dogs from the Republic of Ireland and Northern Ireland between 2010 and 2020. *The Journal of Small Animal Practice*, 65(1), 30-38. <http://doi.org/10.1111/jsap.13676>. PMID:37800280.
- To, I., Berent, A. C., Weisse, C. W., An, A., Harling, B., Sack, D., Ciardullo, R., Slade, D. J., Palma, D. A., Jesus, A. A. D., & Fischetti, A. J. (2024). Preoperative parameters (signalment, digital radiography, urinalysis, urine microbiological culture) and novel algorithm improve prediction of canine urocystolith composition. *Journal of the American Veterinary Medical Association*, 262(8), 1039-1046. <http://doi.org/10.2460/javma.23.12.0686>. PMID: 38579782.
- Ximenes, Z., Widyastuti, S. K., & Suartha, I. N. (2023). Urolithiasis in domestic male cat. *Veterinary Science and Medicine Journal*, 1(1), 381-391. <http://doi.org/10.24843/vsmj.2023.v5.i11.p07>.

- Xu, C., Yang, Y., Shao, Z., Ren, R., Zhang, Y., Jin, Y., & Shi, H. (2024). Candidate urinary biomarkers show promise for distinguishing between calcium oxalate versus struvite urolithiasis in dogs. *American Journal of Veterinary Research*, 1-12. Ahead of print. <http://doi.org/10.2460/ajvr.23.09.0214>. PMID: 38301355.
- Yayingül, R. (2024). Clinical, laboratory, radiography and ultrasonography findings and surgical treatment the lower urinary system urolithiasis in cats and dogs. *Animal Health Production and Hygiene*, 13(1), 23-30. <http://doi.org/10.53913/aduveterinary.1375487>.