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Urolithiasis in Canines: A Comprehensive Review

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Abstract

Urolithiasis is often a recurrent problem in dogs, primarily associated with lower urinary tract disease. The urolith develops as a result of crystal precipitation and the aggregation of poorly soluble mineral solutes. Due to dietary modifications and lifestyle changes, canine urolithiasis is becoming more prevalent worldwide. Struvite and calcium oxalate stones are the most commonly found calculi in dogs. For successful management, it is essential to know about the anatomical location of the urolith, the pathophysiology of urolith development, the prevalence and breed predisposition, history, clinical signs, laboratory findings, and modern diagnostic imaging. In recent years, minimally invasive techniques have replaced traditional surgical methods to remove the urolith. However, there is a chance of recurrence of stones in dogs even after successful surgical intervention. So in this review, we will discuss the mechanism behind urolith formation, some dietary modification strategies to prevent recurrence, and a brief outline of the possible predisposing factors.

Key words: *Lower urinary tract, urolithiasis, diet, minimally invasive techniques.*

Introduction

Urolithiasis is defined as the development of sediment containing one or multiple poorly soluble urinary crystalloids from the renal pelvis to the urethra (Ulrich et al., 1996). It should not be considered a single disease caused by a single factor. Instead, it results from various underlying factors interacting with each other (Osborne et al., 2009a). Some urolithiasis cases can be diagnosed and treated successfully (for example, struvite calculi development caused by UTI infection), while others can be diagnosed but are challenging to treat and manage (for example, hyperuricosuria in the Dalmatian breed of dog). In some cases of urolithiasis (for example, calcium oxalate calculi in Miniature Schnauzers), the actual aetiology and pathophysiology are unknown (Bartges et al., 1999a). The abnormalities that encourage urolith development must be recognised, eliminated, or modified to establish successful treatment strategies. Risk factors associated with the formation of uroliths include age, gender, breed, structural and functional abnormalities of the urinary tract, inborn errors of metabolism, diet, urine pH, and infection of the urinary tract. So it is critical to recognise various fundamental principles related to urolithiasis that encourage urolith development, such as urinary saturation, crystal formation modifiers, urinary tract infection and obstruction, and foreign materials such as absorbable sutures (Bartges et al., 1999b). This review aims to comprehend the mechanisms that lead to canine urolith formation, the mineral composition of different types of urolith, diagnosis, management, and prevention strategies.

Anatomical location

The location of canine urolith can be found throughout the urinary tract, ranging from the renal pelvis to the urethra. The specific location of the urolith within the urinary system carries significant implications for clinical presentation, diagnosis, and treatment options. The stones in the cranial urinary tract are much less prevalent than those in the caudal urinary tract (Hunprasit et al., 2017). The prevalence of urolithiasis is reported to be mostly in the caudal or lower urinary tract, consisting of 52% in the bladder, 21.4% in the urethra, and 24.8% in cases having the urethra and bladder simultaneously. The distribution and location of urolith in the upper urinary region are less common, and the position of stones occurs mostly in the ureter and renal pelvis, each contributing 0.6%. Whereas the occurrence of stones, both in the lower and upper urinary tract, is a rare incidence, comprising 0.6% of total canine cases. (Mendoza-López et al., 2020). These findings provide significant insights into the distribution and location of calculi in the urinary tract, enhancing our comprehension of the occurrence and potential clinical outcomes of urolithiasis.

Prevalence and mineral composition of canine urolith

Prevalence studies serve as valuable tools for identifying emerging disease trends. Furthermore, the association of breed, age, and sex with urolith type assists clinicians in recognising the specific composition of the urolith and enhancing diagnostic efficacy (Lulich et al., 2013). The overall prevalence of urolithiasis in dogs varies across different continents and has been estimated to be 0.5% to 3% (Wallerstrom & Wagberg, 1992; Tion, 2012). The most prevalent urolith found in dogs is struvite, generally associated with intact females, followed by calcium oxalate and other types such as calcium phosphate, purine, silica, and cystine. The compound uroliths were less prevalent (Hunprasit et al., 2017). The struvite and calcium oxalate uroliths are the most prevalent types and account for 80.8% of the total uroliths (Houston et al., 2017; Kopecny et al., 2021). Urolithiasis can affect dogs of any age, but most diagnosed cases fall between the ages of 5 and 8 years old because, at this age, the most systemic and metabolic diseases occur, including urinary tract alternations resulting in the development of calculi (Mendoza-López et al., 2019). In terms of the sex-wise prevalence of urolithiasis, males are at greater risk for the development of urolith than females, which may be due to the longer and narrower urethra in males, which retains the urolith and makes it difficult to expel naturally, whereas the shorter and wider urethra in females expels the tiny urolith during urination (Mendoza-López et al., 2017). In terms of the specific composition of uroliths, studies have shown that non-neutered males are associated with the development of calcium oxalate and metabolic uroliths, while non-neutered females have a higher likelihood of forming struvite and mixed uroliths. The smaller breeds of dogs are more prone to calcium oxalate stones, and the larger breeds of dogs are a greater chance of struvite urolith formation. Dalmatian dog breeds are more likely to develop xanthine and urate uroliths, whereas the Scottish deer-hound dog breeds are found to have an abnormally high prevalence of cystine urolithiasis (Houston et al., 2017).

Pathophysiology of formation of Canine urolith

The mechanism and pathophysiology of urolith development in dogs are similar to those in humans (Robinson et al., 2008). The mechanism behind the calculi's development involves a complex sequence of events, including an abnormal change in urine composition (matrix nucleation theory), the supersaturation of urine resulting in crystal aggregations and growth (precipitation-crystallisation theory), and the presence of inhibitors in urine for crystal development (crystal inhibition theory). For the specific composition of calculi in canines, either a single theory or a combination of all of the theories are responsible (Defarges et al., 2020). Uroliths are formed as a result of crystallisation and nucleation processes. The initial step in calculi development begins with the precipitation of microcrystals in the urine, leading to the formation of macrocrystals, which subsequently aggregate and grow, resulting in the development of a solid stone (Lou et al., 2020). Sometimes foreign materials, especially absorbable suture materials used after cystotomy, act as nucleation sites for lithogenic substances in the urinary tract, which are excellent scaffolds for crystal precipitation and growth, resulting in the development of calculi (Hickey et al., 2020). Likewise, once the crystal precipitates and aggregates, it acts as a framework for the deposition of other different compositions of calculi, resulting in the formation of a compound urolith characterised by a shell composed of different crystals around the original nidus (Lulich et al., 2013). Various authors have shown that relative supersaturation (RSS) is a superior indicator of urine crystallisation compared to activity products. An RSS value exceeding 1 signifies supersaturation and indicates the entry of urine saturation into the metastable region. The threshold at which spontaneous crystal formation differs depending on the specific mineral, approximately reaching an RSS of 2.5 for struvite and ranging from 10 to 14 for calcium oxalate (Sturgess, 2009).

History, clinical and laboratory findings

The diagnosis of urolithiasis can be made by considering the owner's history, clinical symptoms, and diagnostic test results. Changes in the animal's water consumption, the volume of urine production, frequency of urination, colour of urine, and behaviour etc., should be documented through anamnesis. Furthermore, past and current medications, food, appetite, variations in body weight, and previous illnesses must all be obtained (Hoxha & Rapti., 2018). Hematuria, stranguria, pollakiuria, dysuria or anuria, reduced appetite or anorexia, distended urinary bladder, dehydration, dribbling of urine, pale and congested mucous membranes, vomiting, and weight loss are all common clinical symptoms in dogs with urolithiasis (Fromsa & Saini, 2019). However, the clinical signs associated with ureter and renal stones often exhibit intermittent or asymptomatic signs. Symptoms associated with ureteral calculi typically result from renal dysfunction caused by obstructive uropathy or concurrent pyelonephritis (Kuntz et al., 2015). The laboratory findings in a urolithiasis patient, especially a complete blood count and biochemical profile, which are frequently remain within the normal range. However, distinct abnormalities may indicate the existence of a specific urolith type in some cases, such as calcium oxalate and calcium phosphate stones are associated with increased calcium concentrations in the blood. The existence of uroliths in the urinary tract, whether in the upper or lower part, can result in azotemia and leucocytosis, which can be caused by pyelonephritis but not by simple cystitis (Dvorska & Saganuwan., 2015). Urinalysis plays a vital role in the diagnostic assessment of various urinary disorders. The detection of crystal segments in urine suggests an ongoing process of urolith development. The solubility of crystals is influenced by the pH and specific gravity of the urine. Specifically, struvite uroliths are more likely to form in alkaline urine, while calcium phosphate tends to form in alkaline to neutral urine. Calcium oxalate and silica crystals are more likely to develop in neutral to acidic urine, while xanthine, urate, brushite, and cystine crystals tend to form in acidic urine. An elevated specific gravity of urine is often indicative of a higher concentration of urolith precursors (Bartges & Callens, 2015).

Diagnosis

Imaging plays a crucial role in localising and providing a definitive diagnosis of calculi. Survey and contrast abdominal radiographs, as well as ultrasonography, are the commonly employed diagnostic imaging techniques for the identification of urolith (Fromsa & Saine, 2019). The opacity of urolith can vary in a plain radiograph due to the distribution of different mineral compositions. In a plain radiograph, struvite and calcium oxalate stones appear radiopaque, whereas cysteine and urate stones are radiolucent (Marolf & Thrall, 2018). The detection of radiolucent uroliths is most challenging on a plain radiograph. The positive cystography with a concentration of 20% iopamidol (Iopamiron®) and double contrast cystography demonstrates positive outcomes in the detection of radiolucent uroliths (Faria et al., 2022). The double contrast radiography successfully identifies 100% of radiolucent stones, enabling size measurement and accurate counting of radiolucent uroliths (Crivellenti et al., 2017). However, cystosonography is gaining popularity as an advanced diagnostic alternative to radiography. For the detection of cystoliths, ultrasonography is more sensitive than contrast and survey radiography (Lulich & Osborne, 2009). Ultrasonography imaging of a urolith in the urinary bladder reveals a hyperechoic cystolith characterised by an acoustic shadow beneath the urolith (Yassein Elgazar et al., 2021). The *in vitro* measurements of cystolith size used in ultrasonography tend to give an inaccurate representation of the true size of the stones in comparison to plane cystography, double contrast cystography, and computed tomography (Byl et al., 2010). In recent years, non-enhanced computed tomography (CT) has become the imaging modality for assessing urolithiasis in dogs following urinary catheterisation and retrograde hydro-propulsion (Bruwier et al., 2022). Diagnostic imaging methods such as radiography, ultrasonography, and computed tomography can detect the location of uroliths, but they are unable to differentiate the composition of the stones. To establish effective therapeutic and preventative strategies, particularly for cases involving mixed or compound uroliths, a scanning electron microscope with X-ray dispersive spectrometry is employed. This advanced technique allows the identification of the elemental composition of the stones, including the chemical composition of the crystallization nidus (Kalinski et al., 2012).

Treatment, management and prevention of canine urolith

The management of urolithiasis involves either surgical intervention or medical management based on the mineral composition of the calculi. In many cases, medical management has proven successful in treating urolithiasis (Lulich et al., 2016). Sometimes urocystolith-induced urethral obstruction can lead to metabolic acidosis, hyperkalemia, azotemia, and dehydration. The management of this condition focuses on promptly relieving the obstruction and correcting metabolic acidosis (Bartges & Callens, 2015). In this context, a brief discussion will be provided on the medical management and prevention of different canine uroliths, as well as different surgical procedures for retrieving uroliths.

Medical management of canine urolith

Urolith dissolution should always be tried when the stone is non-obstructive, and responsive, considering the possibility of urolith recurrence in many cases in which prophylactic action should be implemented whenever possible. The nature and variety of urolith can be accurately predicted by assessing history, radiographic morphology, urine microbiological analysis, pH of urine, urine quantitative and qualitative crystallographic analysis. These predictions assist in determining the best treatment protocol for the patient (Milligan & Berent., 2019).

a. Struvite Dissolution and Prevention

Struvites are made up of magnesium ammonium phosphate hexahydrate and are more likely to form when the minerals in urine are oversaturated. Struvite uroliths in dogs are usually associated with a urinary tract infection caused by urease-producing bacteria like *Staphylococcus spp., Klebsiella spp., or Proteus spp*. Urease-producing bacteria convert urea to ammonia, causing urine to become more alkalinised (Queau, 2019). This elevation in urine pH causes calcium and magnesium phosphates to precipitate, resulting in aggregation and stone formation. Due to the increased risk of ascending urinary tract infections in female dogs, they are more likely to develop struvite stones than male dogs (Ling et al., 1998; Ross et al., 1999). This is most probably due to their shorter and wider urethras and the vulva's close association with the anus. The treatment of struvite urolithiasis should include removing any obstructions to outflow, removing any existing calculi, eradicating or controlling a urinary tract infection, and preventing recurrence if necessary. The recurrence of struvite uroliths can be avoided with different combinations of antibiotic treatment, urease inhibitor therapy, urine acidification, and diuresis induction (Wingert et al., 2021). Sterile or infection-induced struvite urolithiasis is treated with either surgery to remove the calculi or medicinal treatment. Infection-induced struvite urolith is usually treated with a struvilolytic diet (such as Hill's Prescription Diet urinary care) and suitable antibacterial medication for four weeks following noticeable urolith dissolution (Osborne et al., 1999a; Seaman & Bartges, 2001; Dear et al., 2019). A standard calculolytic diet lowers the pH of the urine, thereby increasing the solubility of struvite urolith, reducing the substrate for bacterial urease, and lowering phosphorus and magnesium levels. Diuresis is assisted by adding NaCl and lower protein contents to the diet. Protein-limited diets lead to decreased serum urea nitrogen levels. As a result, dilute urine is produced (Palma et al., 2013). However, it should be noted that adding NaCl (sodium chloride) to diets may not be recommended for dogs with cardiac and hypertensive conditions, as it can exacerbate the disease and lead to volume overload. Additionally, restricting protein intake associated with increased fat content can potentially result in complications such as hypercholesterolemia and pancreatitis (Seaman & Bartges, 2001; Palma et al., 2013). However, the dissolution of sterile struvite uroliths in dogs can be medically managed by solely using a struvilolytic diet without requiring the administration of antibiotics. The supplementation of acetohydroxamic acid in canines with struvite uroliths caused by experimentally induced urease-positive staphylococcal infection resulted in a dose-related reduction in urolith growth and dissolution (Krawiec et al., 1984).

b. Calcium oxalate dissolution and prevention:

Calcium oxalate is the most prevalent type of calculus found in dogs in the United States (Low et al., 2010; Osborne, 1999b). It occurs when urine is oversaturated with oxalate and calcium (Bartges et al., 1999a). Calcium oxalate stones are more common in particular breeds, including the Standard and Miniature Schnauzer, Toy and Miniature Poodle, Yorkshire Terrier, Lhasa Apso, Shih Tzu, and Bichon Frise (Lekcharoensuk et al., 2000). Overweight or obese dogs with hyperlipidemia are also at higher risk of developing calcium oxalate uroliths (Lekcharoensuk et al., 2000; Paulin et al., 2022). The hypercalcemia and hypercalciuria associated with primary hyperparathyroidism increase the risk of calcium oxalate urolith development (Lulich et al., 2010). Hypercalciuria can be reduced by the administration of bicarbonate ions. The prevention strategy to dissolve the oxalate urolith includes increasing urine volume by using diuretics, reducing urine acidity, promoting dilute urine, using urine alkalising agents, and improving inhibitors like citrate, pyrophosphate, nephrocalcin, and magnesium concentration (Bartges and Callens, 2015). Canned foods with increased levels of fat, protein, calcium, phosphorus, potassium, sodium, chloride, and magnesium have a lower possibility of calcium oxalate urolith development as compared to other diets. On the other hand, the highest carbohydrate content in canned foods is associated with a higher risk of calcium oxalate urolith formation (Lekcharoensuk et al., 2002). The addition of sodium chloride (salt) to the diet increases voluntary water intake, which reduces the calculogenic minerals in urine. Precaution should be taken when using dietary sodium chloride addition in the diet to prevent urolith development, especially in dogs with impaired kidney function, a cardiac ailment, or increased blood pressure. Administration of hydrochlorothiazide (HCTZ) notably decreases the calcium concentration in urine and the chance of calcium oxalate urolith development (Lulich et al., 2001). Magnesium is another essential nutrient to consider in the dietary modification of calcium-oxalate urolithiasis. Magnesium in urine is considered an inhibitor of calcium oxalate urolith development like urinary citrates and phosphates and should not be limited in the diet. The phosphorus levels in the diet should not be restricted excessively since low serum phosphorus levels may result in enhanced conversion of cholecalciferol to calcitriol in the kidney via the 1-hydroxylase enzyme under the influence of parathyroid hormone, resulting in increased absorption of intestinal calcium (Capuano et al., 2005; Zhang et al., 2002). The development of calcium oxalate uroliths may be prevented by providing a moderate to slightly higher protein diet. Recent studies suggest that a protein-rich diet may have potential health benefits. This is because more protein can increase urine volume and decrease urine pH, leading to raised calcium levels through bone remodelling and decreased renal tubular calcium absorption (Lekcharoensuk et al., 2001; Butterweck and Khan, 2009). Excess Vitamin C helps in urolith development through the alteration of ascorbic acid into oxalate, so it should be avoided (Butterweck and Khan, 2009). The enteric bacteria known as *Oxalobacter formigenes*t break down the oxalic acid in the gastrointestinal tract and prevent the development of oxalate calculi. So a recent study revealed that dogs with lower colonisation of these enteric bacteria in the intestines have a higher likelihood of developing oxalate stones compared to those with higher colonisation (Gnanandarajah et al., 2012). The addition of potassium citrate in the diet raises the pH of urine to become more alkaline, and in urine, citric acid combines with calcium to form a more soluble complex, which inhibits the nucleation of calcium oxalate crystallisation (Butterweck and Khan, 2009).

c. Urates dissolution and prevention

In dogs, urate calculi are the third most prevalent urolith. These uroliths are formed when urine becomes excessively saturated with urate and, typically, ammonium. These uroliths occur as a result of hepatic illness, usually a portosystemic vascular shunt (G. Caporali et al., 2015; Bartges et al., 1999b), or an inherited metabolic disorder in English Bulldogs and Dalmatians breed of dogs causing hyperuricosuria. In most dogs, allantoin is the chief metabolic end product of purine catabolism, except for the Dalmatian breed, which produces uric acid at the time of purine degradation that leads to hyperuricosuria and hyperuricemia, resulting in inefficient exchange and transport of uric acid in both the hepatic and renal proximal tubules (Bannasch et al., 2008). The Dalmatian, Black Russian Terrier, and English Bulldog have a mutated SLCA29 gene sequence that affects the transport of uric acid to the liver. This mutation causes a failure to convert uric acid into allantoin, increasing the chance of urate stone development (Bannasch et al., 2008; Safra et al., 2005). So the dissolution of urate calculi is very challenging in dogs with uncorrected hepatic disease. When urate calculi cannot be dissolved symptomatically, surgical removal, including laser lithotripsy or voiding urohydropropulsion, remains the treatment of choice (Bartges, 2015). In dogs, urate uroliths are dissolved by providing a low or restricted purine diet, a diuretic diet, alkalinising the urine, and oral administration of allopurinol-a xanthine oxidase inhibitor, at a dose rate of 15 mg/kg every 12 hours (Bartges et al., 1999b). Renal failure diets are also used to control the urate calculi due to their low protein content, which leads to a lower purine content.

d. Xanthine dissolution and prevention

In dogs, xanthine urolithiasis is uncommon, with few studies indicating a prevalence of 0.07 to 0.46% (Houston and Moore, 2009; Low et al., 2010; Osborne et al., 2009a). Hereditary xanthinuria is a rare autosomal recessive condition caused by mutations in the xanthine dehydrogenase (XDH) or molybdenum cofactor sulfurase (MOCOS) genes. Breeds predisposed to xanthinuria include King Charles Spaniels, Manchester Terrier Cavaliers, Dachshunds, English Cocker Spaniels, and mixed-breed dogs (Tate et al., 2021). The average age of dogs susceptible to xanthine urolith is five years, with exception of the Cavalier King Charles Spaniel breed of dog, in which, naturally occurring xanthine uroliths are seen even at an age of less than one year (Van Zuilen et al., 1997). The majority of xanthine uroliths in dogs develop as a result of secondary allopurinol medication. Allopurinol rapidly binds to xanthine oxidase and inhibits its activity, decreasing the conversion of hypoxanthine to xanthine and xanthine to uric acid. The consequence is a decrease in uric acid levels and an increase in xanthine levels in the blood and urine. Large doses of allopurinol, combined with a high-purine diet, lead to the production of xanthine uroliths (Ling et al., 1997; Bartges et al., 2000). Several factors influence the management of allopurinol-induced xanthinuria, including allopurinol dosage, the number of precursors of purine in the feed intake, the amount of endogenous purine precursor formation, and the status of liver function (Osborne et al., 2009b). To reduce the risk of developing xanthine urolith, concurrent intake of high-purine diets and treatment of affected patients with allopurinol should be restricted. Feeding canned diets with high moisture, alkalinising, and diuretic content is highly recommended to reduce urine xanthine concentration and pH (Bartges & Callens, 2015; Osborne et al., 2009b).

e. Cystine dissolution and prevention

Cystinuria is an inherited metabolic condition characterized by irregular transport of amino acids in the intestine and kidneys, involving cystine and other dibasic amino acids such as lysine, ornithine, and arginine. (Kovarikova et al., 2021; Milliner, 1990; Osborne et al., 1999c). The breeds predisposed to cystinuria included English Bulldogs, Dachshunds, Mastiffs, and Newfoundlands (Osborne et al., 1999c). The guidelines for cystine urolith dissolution include lowering the cystine content in the urine and increasing cystine solubility through various combinations of dietary modification, high fluid intake, diuresis, administration of thiol-containing drugs, particularly D-penicillamine or mercaptopropionylglycine, urine alkalinisation, and reduced dietary protein intake (Bovee, 1986; Osborne et al., 1999c; Milliner, 1990). Recent studies have also revealed that castration is a method to prevent cystine urolithiasis in dogs (Florey et al., 2017; Kovarikova et al., 2021).

f. Mixed and compound uroliths dissolution and prevention

The compound urolith comprises 14% of total urolith and is more frequent in females than males; common breeds predisposed are Shih Tzu, Miniature Poodle, and Pomeranian (Hunprasit et al., 2017). A compound urolith comprises various minerals that are divided into discrete layers, and the core area of the urinary calculi comprises more than 70% single mineral composition and is encircled by dissimilar mineral composition (Ulrich et al., 2009). The majority of compound urolith comprises a central core of struvite urolith, which is encircled by an external layer of calcium phosphate (CaP), followed by a central core of calcium oxalate, which is encircled by struvite urolith (Hunprasit et al., 2017). The prevention protocols are intended to reduce the formation of minerals in the central core area of compound uroliths than in the external area, according to the theory of heterogeneous nucleation (Ulrich et al., 2009).

Surgical Management

The treatment of calculi in the urinary tract may not always require surgical intervention. Indications of calculi removal include urinary outflow obstruction, increased number and size of uroliths, exaggerated clinical symptoms and signs, and failure to respond to medical therapy. Voiding urohydropropulsion is a non-surgical technique for removing tiny uroliths via urethral flushing. However, even larger uroliths can be removed by these techniques with smooth contours (Langston et al., 2010). Common surgical interventions, including urethrotomy and cystotomy are available options for the management of canine urolithiasis (Bartges & Callens, 2015). Urethrotomy is indicated in dogs when conservative measures have failed to resolve obstructions in the penile portion of the urethra. This technique employs a novel surgical approach directly over the caudal portion of the *os penis*, with minimal blood loss and rapid healing of surgical incisions by second intention. However, urethrotomy performed directly over the *os penis* is straight forward with few complications to remove the calculi (Cinti et al., 2015). Laparoscopic-assisted cystotomy facilitates a shorter postoperative hospitalization in canines compared to open cystotomy, but has certain disadvantages, including increased cost and technical difficulty, which may lengthen operative time compared to open surgery (Scharf & Runge, 2022). Over the past few years, minimally invasive techniques have emerged as the preferred method for removing upper and lower urinary tract calculi in dogs, replacing the older traditional surgical techniques. Achieving better surgical outcomes in these cases requires thorough patient evaluation, careful case selection, special machinery and tools, and the expertise of trained professionals (Cleroux, 2018). In the management of uronephrolith in dogs, minimally invasive surgical techniques such as endoscopic nephrolithotomy, percutaneous endoscopic nephrolithotomy, and extracorporeal shock wave lithotripsy (ESWL) should be given preference over traditional surgery such as nephrotomy and pyelotomy to minimise the functional loss of the renal pelvis during stone retrieval (Milligan & Berent, 2019; Lulich et al., 2016). In emergency cases of obstructive ureterolith in dogs, subcutaneous ureteral bypass devices and ureteral stent placement are employed as treatment options (Cleroux, 2018). To remove stones from the urinary bladder and urethra, minimally invasive techniques include cystoscopic-guided laser lithotripsy, cystoscopy-guided basket retrieval, percutaneous cystolithotomy (PCCL), and voiding urohydropropulsion. However, the choice of different techniques depends on factors such as the size and location of the stone, as well as the individual patient's condition and the surgeon's expertise (Berent & Adams, 2015).

Conclusion

The incidence and prevalence of canine urolithiasis are gaining importance globally. The formation of calculi in the urinary tract is complex, involving multiple mechanisms and several predisposing factors. Although early diagnosis and analysis of stone type are not possible on the day of presentation, treatment can be initiated based on a presumptive diagnosis, considering the history, clinical symptoms, and breed predisposition. In recent years, advancements in diagnostics and therapeutic techniques have greatly contributed to stone identification, localisation, and removal. However, even after successful removal, there is a risk of stone recurrence. In that case, medical dissolution in the form of dietary modifications such as controlling protein and mineral intake, adjusting urine pH, and promoting water consumption plays a significant role in achieving the goal of non-recurrence. Regular follow-up visits and monitoring of urinary parameters (urinalysis and imaging) are essential to detect any recurrence or complications. Continued future research is needed to understand the mechanism of calculus development and to develop effective diagnostic and treatment approaches that improve the overall outcomes and quality of life for dogs affected by urolithiasis.

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