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Nutritional strategies to prevent urolithiasis in canines

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Abstract

Urolithiasis is a common problem in canines where nutrition acts as a significant predisposing factor. The nutritional factors mainly influence urinary constituents and pH, which affect stone nucleation and growth. Non-operative treatment modalities are required to prevent and reduce the risk of recurrent urolithiasis. Medical management is primarily centered on the diet. Careful monitoring throughout is needed. Nutritional management is the best preventive strategy against urolithiasis.

Keywords: Urolithiasis, Nutrition, Canine.

Introduction

The urinary system is designed to eliminate body wastes in liquid form and normal urine is in a state of metastable over saturation (*i.e*. no spontaneous precipitation). Urolithiasis presents a state of unstable over saturation where spontaneous precipitation exists and minerals precipitate, crystals do not dissolve and they add together allowing the growth of urolith (also called urinary stones or calculi). It is a condition of urinary tract in which insoluble mineral and salt concretions develop and aggregate around a nidus of proteinaceous material mainly within the bladder or urethra (Belknap and Pugh, 2002), but can occur anywhere in the urinary tract. Abnormal microscopic precipitates in urine are known as crystalluria whereas macroscopic concretions are called uroliths. Commonly formed stones are struvite, calcium oxalate, calcium phosphate, calcium carbonate and silica. Uric acid, cystine, hippuric acid and tyrosine crystals may also be found. The presence of specific type of crystal depends on the diet and transitory physical and chemical conditions that exist in urine at that time.

Nutritional Management

Struvite Uroliths (Magnesium Ammonium Phosphate)

Struvite uroliths are one of the most common uroliths in dogs. Struvite calculi, especially in dogs, are often associated with infection with urease producing organisms (*Staphylococcus, Proteus*).

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Urease is an enzyme that breaks down urea with the release of ammonium and bicarbonate ions into the urine.

Nutritional aimed at dietary management of struvite uroliths include:

- Dissolution of uroliths within the bladder.
- Preventing formation of reoccurring uroliths or crystals.
- Promotion of an acidic urinary pH.
- Increasing water intake and encouraging frequent urination.

Restricted levels of protein are required (1.47 grams protein/100 kcal ME) for the management of struvite uroliths (Osborne *et al.,* 2000), but a high biological value is needed. The urine acidifying substance in diets designed for struvite dissolution is DL-Methionine, used at a dose rate of 0.5 g/kg of diet (Osborne *et al.,* 2000). The majority of calories obtained from the diet need to be acquired from a non-protein source. Thus, proportionately the carbohydrate and fat levels of ME are increased in these diets. Feeding diets with higher fat content to dogs with hyperlipidemia, pancreatitis or even at-risk groups (such as Schnauzers and Spaniels) is contraindicated.

Decreased amounts of phosphorous (24 mg phosphorus/100 kcal ME) and magnesium (3.3 mg magnesium/100 kcal ME) are present in diets designed to aid urinary tract issues, as these are constituents of struvite urolith (Osborne *et al.,* 2000). Sodium levels are often increased in these diets, in order to increase water intake (23.3 mg sodium/100 kcal ME). The antioxidants, Vitamin E and β-carotene are often supplemented, as they help to reduce oxidative damage and help to combat urolithiasis. As an oxalate precursor, Vitamin C should not be supplemented when feeding diets designed for struvite dissolution.

Calcium Oxalate Uroliths

Calcium oxalates are the second most common uroliths in dogs and most common in cats.

Nutritional aims of dietary management include:

- Promoting an alkaline urinary pH.
- Reducing the amounts of calcium, sodium and oxalates in diet.
- Increasing water consumption and frequency of urination.

For these uroliths to form, the urine must be supersaturated with calcium. Factors that may affect supersaturation of calcium include hypercalcaemia (although serum calcium is often normal) and possibly a diet containing high protein, high calcium and low Vitamin B_6. A decrease in intestinal *Oxalobacter formigenes* bacteria, which metabolise oxalates, has been found in dogs that form oxalate-containing uroliths compared to those that do not (Gnanandarajah *et al.*, 2012). The solubility of calcium oxalate crystals is less directly influenced by urine pH within the physiologic range than struvite stones, but acidosis may increase the amount of calcium released from the bones to buffer the acid, resulting in hypercalciuria. Preventing recurrence includes treatment of any underlying cause of

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hypercalcaemia, concurrent disease (such as hyperadrenocorticism) and increasing water intake to encourage the formation of less concentrated urine. Decreased urine concentration can also be aided by adjusting the diet (and possibly with thiazide diuretics, if necessary). Diuresis (resulting in decreased urine concentration) decreases the risk of calcium oxalate urolithiasis in dogs. The levels of calcium in diet should be restricted, but not reduced, as with levels of sodium. Restricted calcium levels are approximately 0.68% DMB.

Recommended dietary modifications include lower protein diet with levels of 1.6-2.2 g/100 kcal ME have been suggested (Senior, 1989) with adequate, but not excessive, phosphorus, magnesium and potassium. Some researchers have found an increase in dietary sodium, resulting in diuresis, decreases the relative supersaturation of calcium, even though it increases the total excretion. Sodium increases calcium excretion into the urine and a dietary level of 0.1-0.2% sodium DMB or 45-55 mg sodium/100 kcal ME is recommended (Senior, 1989).

Uric Acid/ Urate Uroliths

Urate calculi are formed due to increased excretion of urates or uric acid in urine. Dalmatian dogs and bulldogs have a higher frequency of urate stone formation than other breeds. In normal animals, purines convert to hypoxanthine, which converts to xanthine, then into uric acid, which then converts to allantoin - a soluble end product excreted in urine. In Dalmatians, uric acid is not converted to allantoin, resulting urine that is oversaturated with uric acid and therefore contains higher levels of urates than other breeds (Sorenson and Ling, 1993). Dalmatians also have a lower percentage of renal tubular reabsorption than other breeds, resulting in increased urate excretion. Other risk factors include increased renal excretion of ammonium, low urinary pH and urinary tract infections with urease-producing bacteria - for example, *Staphylococcus*, *Proteus*, *Escherichia coli* and *Mycoplasma*, which may increase ammonium ions.

Nutritional aims of dietary management of urate urolithiasis include:

- Restricting protein level.
- Increasing the source of non-protein calories.
- Promoting an alkaline urinary pH.

The diet designed to aid in the management of urate urolithiasis can have overall restricted levels of proteins (1.6-2.2 g protein/100 kcal ME) (Senior, 1989), especially those proteins that contain larger amounts of nucleic acids, as they contain purines, e.g. protein from muscle or organ tissues. Milk proteins (casein) and eggs provide a suitable source, as they contain a lower amount of purines, but also have a high biological value, which is required when a restriction on protein levels is required in the diet.

Allopurinol is a xanthine oxidase inhibitor, which reduces the rate of urate excretion into the urine. It decreases the production of uric acid by inhibiting the conversion of hypoxanthine to xanthine and

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xanthine to uric acid. Allopurinol needs to be added to the diet when dissolution of urate uroliths is required, although checking the dietary manufacturer's guidelines is recommended. A dose rate of 15 mg/kg *per os* (PO) twice daily (BID) should be utilised, although dose rate is dependent on the individual (Osborne *et al.*, 2000).

Cystine Urolithiasis

Cystine uroliths are uncommon in both cats and dogs, but arise due to a metabolic defect where the reabsorption of filtered cystine in the proximal tube is impaired (Bovee, 1984). Once in the urine cystine is very insoluble, especially in acidic urine.

Nutritional aims in the management of cystine uroliths include:

- Promoting an alkaline urinary pH.
- Reducing the amount of cystine produced by body.
- Increasing water consumption and frequency of urination.

A low protein diet is required (9-11% protein DM), as this will aid in the reduction of total daily excretion of cystine. Low sodium levels are also required as sodium excretion can enhance cystine excretion. Low sodium in combination with low protein levels tends to increase the urine volume, which further decreases the urinary concentration of cystine (Lulich *et al.*, 2016). In order to create an alkaline urine pH, supplementation with Potassium citrate (50-100 mg/kg b. wt. PO BID) is required.

Silicate Uroliths

Silicate uroliths are more commonly seen in male dogs (96%) than females (4%) (Osborne *et al.*, 2000), most likely due to females being able to pass smaller uroliths before they can induce clinical signs. Foods that contain large amounts of plant-derived materials are thought to be a predisposing factor for silicate uroliths, another factor being the consumption of soil, as silica in the soil passes through to the plants and is readily absorbed via the intestines.

Dietary management of dogs suffering from silicate uroliths is through prevention. Change of diet to one that does not contain large amounts of plant derived materials and increases the volume of urine produced are the main factors.

Conclusion

Dogs that have suffered from any form of urolithiasis need to have regular urinalysis while on the diet, including pH and having microscopy performed. Client education can be key in prevention in at-risk breeds and those that are over their ideal body condition score. This includes increasing water intake as much as possible in all groups and the frequency of urination.

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