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Implication of Nutrition in Urolithiasis in Companion Animals

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Introduction

Uroliths are commonly occurring diseases in companion animals affecting the urinary system. The urinary system excretes body waste as urine having normally no spontaneous precipitation (stable saturation). When urine is over-saturated and urinary environment favor precipitation of calculogenic minerals, they do not dissolve and as a result, spontaneous precipitation occurs forming urolith or urinary stone or calculi. Salt concentration and insoluble minerals in the urinary tract aggregate and lead to form nidus (inner part of urolith which is formed first. Macroscopic solidification in urine are known as uroliths whereas abnormal microscopic solidification are crystalluria which further may form uroliths but not is all cases, and uroliths can be present without crystalluria. Nutritional management is designed to target the nidus, dissolve urinary stones (struvite, urate, cystine) and/or reduce the risk of recurrence.

Incidence

Ruminants are affected more, especially small ruminants (majorly goats), followed by cats and dogs. Incidence is seen more in younger ruminants below 6 months of age due to feeding of a high protein diet. In canines, the middle age group (3-7 years) has the highest incidence. In the case of sex, females are lesser affected due to flexible urethral lumen. pH of urine is a factor, and acidic pH leads to precipitation of urate and cysteine crystals in the lumen, whereas alkaline pH of the urine leads to precipitation of struvite, calcium carbonate, and calcium phosphate uroliths. However, the solubility of silicate and oxalate uroliths does not depend on the pH of the urine. Sometimes, castrated animals are more susceptible than non-castrated animals. However, in canines, the incidence is opposite and urinary calculi are least seen in the months of January and February. And finally considering the dietary habits, obesity and the related dietary pattern is related to the incidence of urolithiasis.

Type of Stone and Its Implications:

There are five types of uroliths-

1. Purine uroliths

Urates:

According to reports, ammonium urate, made up of uric acid and the monobasic ammonium salt of uric acid is the third most prevalent urolith in cats. In normal cats and dogs, uric acid is one of several biodegradable products of purine nucleotide metabolism. In presence of hepatic uricase, uric acid is metabolized to allantoin (excreted by the kidneys) which is soluble in the urinary environment. In cats it is also reported occurrence of urolithiasis may be due to urinary tract infections, or feeding purine in large quantities (such as liver or other organ meats), with metabolic acidosis and highly acidic urine. Together these factors result in increased renal excretion of ammonia and urate, with increased risk of subsequent urate urolith formation. Uroliths containing urate can occur in several different forms. In urine when pH reaches <5.5 Uric acid crystals tend to form, and in the case of humans when urine pH is normal this mineral exists as a combination of free urate and undissociated ion.

2. Struvite uroliths

The most common component in canine uroliths is struvite and composed of magnesium aluminum phosphate ($NH_4MgPO_4.6H2O$). It mainly occurs either due to the presence of urease producing bacteria in the urinary tract (infection-induced struvite) or without infection in the urinary tract (sterile struvite). Manipulation of urine pH 5.5–6.0 is suitable for the prevention and dissolution of uroliths.

Infection induced struvite uroliths most commonly occur due to Staphylococcus spp. The occurrence of cases is observed more in canine sp than feline spp (occasionally). When urine is alkaline (pH>6.5) and oversaturated with struvite crystalline substances (magnesium, ammonium, and phosphorus) by metabolizing urea to ammonia, alkaluria is produced and ionization state of phosphorous is changed as a result struvite uroliths is formed.

Sterile struvite uroliths occur mostly in felines of 1 to 10 years old age group, rarely observed in dogs. It depends on the diet if the diet contains magnesium @0.15-1.0% on dry matter basis, or a diet containing phosphorus, calcium, chloride and fibre, moderate protein, and low-fat content. Depends on the urine pH, ions, water intake and urine volume. Consumption of more water may reduce the concentration of calculogenic substances results decreasing the incidence of uroliths formation. Cats should be fed calorically dense diet 0.058% magnesium (dry matter basis) or high moisture canned feed and increases NaCl @0.79% to induce urinary pH 6.0.

3. Calcium oxalate

Medical dissolution cannot easily control CaOx uroliths. To reduce the risk of recurrence of CaOx uroliths dietary management is quite necessary. It is noticeable that urinary calcium excretion is increased with high-sodium diets. However, urine calcium concentration is either constant or decreased because of concurrent urine dilution. The concentrations of solutes in urine such as oxalate can decrease, thus decreasing CaOx.

The urinary excretion affected by dietary oxalate (such as potatoes, beans, beets, and leafy vegetables) is variable. Intestinal oxalate-degrading bacteria and dietary calcium also affect oxalate absorption. Also, endogenous production via the metabolism of some sugars (glucose, fructose), amino acids (eg, hydroxyproline, glycine, serine), or vitamin C influence the urinary oxalate excretion. Deficiency in vitamin B6 (pyridoxine) increases endogenous production and excretion of oxalate in a rare case and oxaluria In humans cannot be decreased by supplementation, The risk factor for CaOx are diets high in animal protein that are associated with metabolic acidosis and hypercalciuria. In contrast, in the case of cats and dogs, the high dietary protein intake seems protective against CaOx and leads to an increase in urine volumes. In cats, one study found slightly higher CaOx RSS with increasing dietary protein (35%–57% dry matter) in dry diets but not in wet diets. Besides, the increasing protein was not associated with a consistent increase in calcium excretion or a decrease in urinary pH in either study.

4. Cystine

For cystine stones, dietary treatment should be designed to dissolve them and prevent a recurrence. Again, promoting urine dilution is of paramount importance. Urine cystine excretion can be modulated by dietary protein intake, and more specifically methionine and cysteine. Most plant protein sources have smaller amounts of sulfur amino acids than animal proteins. The solubility of cystine is highly dependent on pH, with higher solubility for pH>7.2. A low protein alkalinizing diet and/or medical treatment with 2-mercaptopropionylglycine (2- MPG) (15–20 mg/kg by mouth every 12 hours) has been successfully used in Dogs.

5. Silica

Silica uroliths are uncommon in dogs and cats, and medical dissolution has never been reported. For prevention, emphasis should be put on urine dilution. Preventing pica, avoiding diets rich in high-silica plant ingredients (eg, brown rice or soybean hulls), and offering bottled water in areas with soils high in silica are recommended. Canned diets, aside from promoting diuresis, are typically lower in vegetable ingredients. The effect of urine pH on silica solubility is unknown.

Preventive measures in companion animals

In companion animals, struvite urolithiasis is most common followed by urate, cystine, and calcium oxalate. General preventive strategies include a low level of high-quality protein to reduce excretion of urea, low calcium, phosphorus and magnesium to reduce the concentration of calculi constituents and higher sodium intake to induce water flow causing reduced concentration of urine. In dogs, the diet typically should contain 8% protein, 0.3% calcium, 0.12% phosphorus, 0.02% magnesium and 1.2% sodium in DM, 1-2 mg/kg/day K, 1-2 mg/kg/day Zn and 100-200 mg/d Vit. B12. Dry and canned veterinary commercial diets with controlled amounts of precursors, and acidifying and/or diuretic properties, successfully dissolve naturally occurring struvite uroliths in cats.

Specific preventive strategies are also being followed such as for struvite uroliths, diets must contain lower levels of magnesium and phosphorus. Urine pH should be lowered and output increased by feeding low protein, high sodium diet. Water consumption of pets can be increased by switching pets from dry food (<12% water) to wet food (75% water). When feeding of wet food is not possible, dry food is supplemented with urinary acidifiers like NH4Cl salt (0.5-1% of DMI) or 1-2g D, L-methionine. NH4Cl is unpalatable, so, table sugar can be added to the diet. Molasses should be avoided as a flavoring additive because its high potassium content may reduce the acidifying effect of NH4Cl. For urate uroliths, treatment is by feeding diets containing around 10% protein and 70% moisture in dogs. In the case of cystine uroliths, feeding low protein and low sodium diets. All prevention recommendations should be periodically monitored to meet individual patient's needs. This typically includes follow-up urinalysis, serum chemistry profiles and radiography. Early detection of small urocystoliths that recur despite appropriate medical therapy facilitates non-surgical removal by voiding urohydro-propulsion.

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