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Original Article

Dietary based managemental concepts for preventing urolithiasis in animals

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Introduction

The system of the urinary tract has the ability to eliminate waste materials from the body in the form of fluid, and typical urine is in a meta-stable over-saturation state, implying it does not precipitate spontaneously. As urine is a complex solution, mineral salts can remain dissolved even in instances in which saturation is too high. Whenever urolithiasis emerges, there is an unstable over-saturation which ultimately results in spontaneous precipitation and mineral precipitation. Uroliths, formerly referred to as "calculi" or simply "urinary stones", are mineral solutes that precipitate and create crystals in urine. These crystals possess the potential to expand and aggregate to a macroscopic size. The organic matrix that exists in uroliths is assumed to vary drastically among the stones and amounts approximately between 2% to 10% of the stone's chemical composition. In accordance with the variety of urolith, minerals contribute to the remaining 90% to 98% of the urolith. Stones throughout the urinary tract might be frequently referred to as 'urolithiasis' in general. Nephroliths, ureteroliths, urocystoliths, & urethroliths are acronyms for uroliths that may accumulate in the kidney, ureter, bladder, or urethra, irrespective of their sequence.

This urinary tract instability usually manifests by the formation and consolidation of insoluble mineral and salt concretions adjacent to a protein-based material nidus, predominantly in the bladder or urethra, however it can take place anywhere along the lumen of the urinary tract. Macroscopic concretions are frequently referred to as 'uroliths', in contrast to abnormal microscopic (tiny) precipitates in urine are categorized as 'crystalluria'. There must also be further favorable circumstances (such as an ideal pH) for crystallization in the instance of specific stones (i.e. struvite, cystine, and urate). Urinary tract infections, dietary habits, intestinal absorption, amount of urine produced, the duration of urination, pharmaceutical substances, and genetic factors have the potential to have a consequence on these specifications.

Assortment of Stones

The five main different kinds of stones are silica, calcium phosphate, calcium carbonate, calcium oxalate, and struvite. There might additionally be crystals of tyrosine, hippuric acid, cystine, and uric acid. The nourishment and the instant physical and chemical situations in the urine at that specific point influence whether any particular kind of crystal has been identified or not.

Prevalence / Incidence

- **Sex:** In response to the flexible nature of the urethral lumen, urolithiasis is not typically encountered in females.
- **Species**: The most frequently impacted animals are goats, subsequently followed by cattle, cats, and dogs.
- **In terms of age**: As a consequence of their abundant protein diet, ruminant animals that are under six months of age tend to be more susceptible. The most prevalent age group of canines with urolithiasis is middle-aged breeds (3–7 years).
- **Castration status:** Animals who have had their castrations are prone to vulnerability compared with those who have not.
- **Dietary habit:** According to Siener (2006), obesity and the related dietary pattern establish urolithiasis more prevalent.

- **Period:** Severe cold seasons (December–February) and severe the warmer months (March–June) are when urolithiasis in ruminants is most common. In contrast, the pattern of incidence in dogs is reversed, with the fewest instances being reported in January and February.
- **PH of the urine:** Uric acid and cystine uroliths formed when urine has an acidic pH. Similar to this, struvite, calcium carbonate, and calcium phosphate uroliths precipitate from urine with an alkaline pH. However, urine pH has absolutely no impact on the solubility of silicates as well as oxalate uroliths.

Etiology

Its cause is multifaceted and complicated. whereas several predisposing etiologic factors for urolithiasis are acknowledged, the precise mechanism underlying stone growth and development still unexplained. The production of urinary calculi is typically detrimental of a collaboration of physiological, dietary, and managerial components. It could happen as a result of an exaggerated or inadequate mineral intake in dairy farms since fattening cattle are fed diets heavy in cereal grains and oil meals. Such feedstuffs are rich in magnesium and phosphorus but relatively low in calcium and potassium, which makes them more prone to ailments. Phosphate calculi are primarily brought about by excessive urinary phosphate excretion, which is the outcome of a calcium-phosphorus imbalance. Many different factors have also been implicated as contributing to the formation of phosphate calculi, which in turn causes obstructive urolithiasis in cattle. These consist of high protein rations, low or restricted water consumption, heavy concentrate-low roughage diets, dehydration, urine alkalinity, mineralized artesian water, alkaline water sources, an excess of sodium bicarbonate in the diet, and vitamin imbalances such as hypo and hypervitaminosis. Uroliths formed from silica, carbonates, or oxalate are less prevalent. These kinds of calculi are frequently observed in cattle grazing on pastures with high concentrations of oxalates, estrogen, or silica. Diethylstil-bestrol implants have reportedly been linked to urolithiasis in castrated beef cattle. For range cattle in semi-arid environments, seasonal and geographic factors are significant. Due to the passage's possible narrowness and convoluted path, the male ruminant urinary tract's anatomy also plays a part in its development. Uroliths frequently lodge in the sigmoid flexure in all ruminant species. On unusual instances, uroliths may also be detected at the ischial arch. The urethral process is a highly frequent location for uroliths to lodge in small ruminants.

Clinical manifestations

The degree of obstruction to urine flow influences the signs and symptoms that are clinically indicative of urolithiasis, degree to which the surrounding tissue is reacting. The primary manifestations that are associated with the initial phase of urolithiasis include diminished water intake, prolonged rumination, and anorexia. subsequently protracted, painful initiatives to urinate, animals with partial obstruction dribble blood-tinged urine. As the disease progresses, additional manifestations might involve abdominal bilateral distention, tenesmus, colic, shifting of weight, teeth grinding, urethral pulsation, and a tendency heading towards rectal prolapse.

Animals can kick at their abdominal area, tread their feet, wag their tails, or adopt an arching stance. In male ruminants experiencing colic manifestations, urolithiasis should always be considered as the main contributory factor, especially in sheep and goats. There may also be mineral deposits on the urethral hairs, uremic breath odor, urinary bladder distention, stranguria, anuria, oliguria, hematuria, and pelvic urethral pulsations. Tachycardia, tachypnea, rectal prolapse, and rumen stasis constitute fewer specific manifestations.

Uroliths cause significant destruction of the bladder and urethral mucosa, eventually resulting in haematuria, oligouria, and dysuria. As metabolic wastes are retained in the terminal phases and are reabsorbed, the temperature begins to decrease, and this leads to toxaemia. Complete occlusion of the urethra induces uraemia ultimately mortality.

Treatment

The preliminary line of management is surgical treatment to relieve bladder pressure, which is subsequently followed by medications aimed at restoring the animal to a state of equilibrium. For the management of urolithiasis, an abundance medicinal and surgical therapeutic approaches have been developed in practically every species of animal. If obstructive urolithiasis in ruminants gets recognized initially in the clinical course, it can be satisfactorily controlled. Animals with minor stones can be treated with litholytic medications such as cystone, tranquilizers, and antispasmodics. Diuresis shouldn't be employed prior to calculi removal, and it's frequently not recommended to administer them thereafter.

Although hyperkalemia, hyponatremia, and hypocalcaemia have been detected, stabilizing these disorders of metabolism often involves giving intravenous fluids for an extended period of hours while periodically monitoring serum electrolyte concentrations, hydration, as well as acid-base balance. Occasionally these procedures raise concerns regarding whether bladder distention in animals with an intact bladder may exacerbate. Peritoneal dialysis is a successful strategy for animals with elevated BUN and creatinine concentrations.Surgery is the most prevalent therapy for obstructive urolithiasis. Surgical modification of obstructive urolithiasis is unsuccessful as a result of recurrent urolithiasis, calculi at numerous locations, extensively compromised urethra, atonic bladder, or severe cystitis. For the removal of the blockage, urethrotomy—either post-scrotal or post-ischial—at the exact spot of calculi lodgement is frequently suggested and performed. Nevertheless, the urethra and subcutaneous tissues deteriorate necrotic as the outcome of surgical urine disintegrating from the blockage site.

Along with that, recurrent urolithiasis and postoperative urethral constriction may contribute to the serious complications afterwards urethrotomy. Alternative procedures for surgery encompass peile amputation, intra-pelvic cystic catheterization, bladder fistulation, penile catheterization, tube cystotomy. The tube cystotomy approach involves inserting a tube in the bladder that enables urine to pass through normally. This procedure is followed by the excellent results obtained from chemically dissolving calculi. When invasive surgical procedures are not achievable, a realistic solution for urine diversion is provided by cystostomy tubes. Cystotomy tubes can be employed as an alternative to urethral catheterization or to gain access around urine outflow blockages.

Foleys catheters, mushroom tip catheters, percutaneous catheters, and low profile gastrostomy tubes are currently being adapted to be utilized as cystotomy tubes, among other several tube types which are readily accessible. Prior to being removed, cystotomy tubes should be allowed in place for a minimum of fourteen days in order in order to permit for proper adhesions between the bladder and the body wall and minimize the likelihood of urine leakage or peritonitis. There are a number of complications associated with tube cystotomy, which involves the urine leakage, wound infection or dehiscence, discomfort at the stoma site, obstruction or unintentionally caused dislodgment, and challenges connected with ascending infection as a consequence of the tube.

Constraints on Therapeutic Assistance

Surgical intervention has an abundance of challenges, particularly struggling to determine the cause of urolithiasis at the initial stage, substantial expenses, frequent recurrences, years of meticulous follow-up, hazards to long-term fertility, prospective adverse reactions, & no assurance of success. (Van Metre and Fubini, 2006)

Prevention strategies for ruminant animals

When acquiring appropriate urolithiasis prophylactic strategies, the constituents of uroliths as well as environmental and nutritional variables should be carefully taken into account. Significant measures to avoid complications should be carefully considered, for instance offering a 2:1 calcium to phosphorous ratio throughout the entire ration, boosting the salt content to 4% of the diet to encourage water intake and enhance the quantity of urine, and sustaining sufficient and plentiful accessibility to water. Dietary alterations that cause urine to become more acidic may assist to avoid the formation of struvite crystals. It would be beneficial to improve the ration through the removal of alfa-alfa nourishment, minimizing or removing grain feeding, shifting to grass hay as the main source of pasture, promoting grazing, & reinforcing with ammonium chloride.

By discontinuing alfa-alfa and grain feeding, respectively, these adjustments attempt at minimizing the urinary load of calculogenic substances such as calcium and phosphorus. In addition to possibly influencing the diet's mineral composition, unrestricted utilization of grazing may boost daily water intake, which might reduce the production of calculo-genesis by diluting urine. The dietary balance of strong cations and anions may be shifted in favor of a higher concentration of strong anions by alternating from legume to grass hay along with supplying ammonium chloride.

Reinforcing the dried paddy grass is recommended in order to decrease the oxalate content of the grass in regions upon which sheep are solely fed on paddy grasses during the colder seasons as a result of the shortage of pastures. Urolithiasis could be effectively managed through delivering clean water at multiple locations, intentionally salting moistened grass hay, triggering diuresis, and continuing to produce diluted urine. It is a prerequisite to thoroughly examine the animals in order to categorize them as stone formers or non-stone formers in advance of the disorder exhibiting clinical manifestations.

Main Prophylactic Approaches

- The recommended ratio of Ca to P is in the range of 1:1 and 2:1 to safeguard against the accumulation of surplus phosphorus in the urine.
- Unlimited consumption of freshwater. [Calves are more susceptible to urolithiasis when their water intake reduces below 3.5 units per unit of dry matter intake from feed.]
- Promote the consumption of high quality forage - In order to keep a healthy rumen, ruminants necessitate a minimum of 1.5% of their body weight in forage (Schoenian, 2006).
- Judicious utilization of concentrate feeds.

- ❖ Ad libitum nourishing to prevent noticeable variations in the chemical makeup of urine.
- ❖ Offering a greater amount of sodium chloride (3.5 percent of daily DM intake) to encourage drinking more water throughout the day.
- ❖ Oxalate-containing plants, cottonseed meal, sorghum, bengal gram, clovers, triticale, and feed additives which includes diethylstilbestrol, stilbestrol, lime stone, and sugarcane bagasse are deliberately supplemented.
- ❖ Grazing management strategies involve the following :
- ✓ Preventing the number of females that can graze on high-risk pastures.
- ✓ Allowing steers & wethers restricted access to pasture rich in oxalate.

Specialized preventative initiatives

- ➢ **Calcic uroliths (Calcium oxalate and Calcium carbonate):**
- ❖ Low oxalate, low calcium, and high levels of moisture.
- ❖ Prohibit animal protein, sodium chloride, and vitamin C, avoid restricting magnesium as well as phosphorus.
- ❖ For the prevention of recurrent calcium oxalate stones, implement supplements of vitamin B6 and potassium citrate (100–150 mg/kg/day).
- ❖ Diminished concentrations of arachidonic acid (Naya et al., 2002).
- ❖ Minimize the amount of alfalfa fed in modest quantities in order to decrease the likelihood of calcium carbonate stones.
- ❖ Enhanced citrate diminishes the absorption of calcium; zinc and/or phytic acid could additionally be effective in intervention.
- ➢ **Phosphatic uroliths (calcium phosphate, struvite)**
- ❖ Phosphatic urolithiasis can be eliminated via maintaining a total ration Ca: P of 2:1 and a dietary magnesium amount ranging from 0.2-0.3% (DM basis).
- ❖ Dietary protein contributes to the majority of the ammonium and phosphate that exist in urine. Thus, low-protein foodstuff should be offered them.
- ❖ Acidifiers such as 4% NaCl, 10% acetic acid, D, L methionine, ascorbic acid, 0.5-1% NH_4Cl (or 45g/day for steers and 10g/day for sheep) as well as phosphoric acid are all capable of being utilized in order to effectively dissolve uroliths.
- ➢ **Siliceous uroliths**
- ❖ supplements that contain either 1-2% NH_4Cl or 3-5% NaCl.
- ❖ Caution careful of rich plant proteins (corn gluten, soybean hulls, etc.).
- ❖ Over 200 g/kg b.w./day of water consumption.
- ❖ phosphorus replenishing.
- ➢ **Cystine uroliths -** Utilizaton of lactate, $CaCO_3$, sodium bicarbonate, and potassium citrate.

Prevention strategies for pets

The most prevalent urolithasis in dogs and cats is struvite, which is followed by urate, cystine, and calcium oxalate. The position and chemical constituents of the urolith, as well as patient-specific attributes, influence the most effective therapeutic strategy, even though general care comprises both surgical removal and medicinal management. As nephrolithiasis is typically indistinguishable from to a more rapid rate of renal injury progression, surgical management of nephrolithiasis in animals is suggested in the majority of situations.

Main Prophylactic Approaches

- ❖ Minimal quantities of excellent protein helps minimize urea excretion.
- ❖ High sodium levels produce considerable quantities of urine with minimal concentration.
- ❖ For dogs experiencing urolithiasis, a typical diet should include 8% protein, 0.3% calcium, 0.12% phosphorus, 0.02% magnesium, and 1.2% salt in the diet. Additionally, 1-2 mg/kg/day of K and Zn and 100-200 mg/d of vitamin B_{12} should be supplied.
- ❖ Low concentrations of calcium, phosphorus, and magnesium are responsible for decreasing the components of calculi's concentration.

Specialized preventative initiatives

- ➢ **Struvite uroliths**

Struvite is the most prevalent component encountered in dog urine stones. The prevalent mineral composition is struvite ($MgNH_4PO_4·6H_2O$), whereas ammonium urate and carbonate-apatite frequently occur in trace proportions. These uroliths typically develop in conjunction with urinary tract infections triggered by urease-producing Staphylococcus or Proteus species. Sterile struvite uroliths are peculiar in dogs, despite being prevalent in cats. A family of English Cocker Spaniels has been reported to have them, indicating a potential genetic predisposition. Diets ought to be modest in phosphorus and magnesium. A diet rich in sodium and low in protein should be fed for decreasing urine pH as well as improve production. Pets can consume more water if they are fed wet food (75% water) as opposed to dry food (<12% water). In scenarios in which it is not feasible to feed wet food, urinary acidifiers such as NH_4Cl salt (0.5-1% of DMI) or 1-2g D, L-methionine can be introduced to dry food. NH_4Cl has an undesirable preference. Table sugar therefore can be incorporated in a diet. Since molasses has a high potassium level, it should not be employed as a flavoring addition as it could minimize the acidifying action of NH_4Cl.

- **Urate uroliths**

Dogs with congenital portosystemic vascular shunts and Dalmatians are more likely to acquire ammonium urate stones. Urine ammonium and urate concentrations, along with other unknown variables, are accountable for the formation of ammonium urate calculi. Dalmatians excrete a significant amount of nucleic acid metabolites as partially insoluble urate due to the fact they do not convert the almost all of their metabolic urate to allantoin. To lower the concentration of all dissolved solutes in urine, urine volume should be raised as well. Canines are provided with diets with approximately ten percent protein and seventy percent moisture in order to nourish it.

- **Cystine uroliths**

In dogs with cystinuria, a renal tubular amino acid reabsorption deficiency, practically all of the stones are cystine-based. Affected dogs excrete a significant percentage of the filtered cystine load and may even show net cystine secretion, compared to healthy dogs, which show a fractional reabsorption of cystine of 97%.Food and water can be combined to enhance the volume of urine. Since increased excretion of sodium might lead to increased excretion of cystine, salt should not be added to the diet. The majority of cystinuric dogs will pass urine that is just slightly supersaturated or undersaturated for cystine as long as urine volume is sufficient and urine pH is kept above 7.5. To attain 24-hour undersaturation in such conditions, just small dosages of penicillamine could be sufficient. The diets limited in sodium and protein are implemented to treat it. Both Waltham Centre for Pet Nutrition, U.K. (Kirk et al., 2001) and Hill's Pet Nutrition, U.K. (Meyer, 2004) recommended commercialized calculo-lytic dietary regimens for nearly all kinds of uroliths.

Image Credit : https://todaysveterinarypractice.com/urology-renal-medicine/managing-urolithiasis-in-dogs/

Present Trends in Nutritional Research on Urolithiasis

- **Herbal Dietary supplements**

- Raphanus sativus, Musa paradisiaca, Homonia riparia, Petroselinum sativum, Ammania baccifera, Costus spiralis, Coleus aromaticus, and Trigonella foenum-graceum are advantageous towards calcium oxalate uroliths.
- Tribulus terrestris, Bergenia ligulata, Dolichos biflorus, M. paradisiaca and A. baccifera provide protection towards calcium phosphate uroliths.
- H. riparia and A. baccifera are implemented against struvite uroliths (Prasad et al., 2007).
- The herbal preparations today being commercialized are marketed as Trinapanchamool, Calculi (Charak Pharmaceuticals, Bombay, India), Chandraprabha bati (Baidyanath, India) and also

Cystone (Himalaya Drug Company, India) have been extensively employed in clinical practice to dissolve kidney and urinary bladder calculi.

- **An antioxidant medications**

Free radical production brought on by oxalate triggers renal epithelial cells to accumulate peroxidative damage (Thamilselvan et al., 2005). Consequently, vitamins that include as C, E, and A are responsible as chain-breaking antioxidants. They have the potential to be employed as anti-stone forming nutrients due to the fact that they are capable of preventing further oxidation and intercept the chain reaction initiated by free radicals (Kato et al., 2007). Rats have been utilized for investigating the significance of free radical scavengers in suppressing calcium oxalate uroliths in the kidney. In hyperoxaluric rats, there was an upsurge throughout both superoxide and H_2O_2-generating enzymes that consist of glycolic acid oxidase and xanthine oxidase. The cellular oxidation system was restored to normal by antioxidant therapy with vitamin E, selenium, methionine, lipoic acid, fish oil, phytic acid, ascorbic acid, potassium citrate, sodium citrate, magnesium oxide, phycocyanin, and mannitol.

The aforementioned was accomplished via minimizing the levels of lipid peroxidases and the activities of oxalate synthesizing enzymes like glycolic acid oxidases, lactate dehydrogenase, xanthine oxidase and boosting the production of enzymatic antioxidants involving superoxide desmutase and catalase, resulting in hindered Ca-oxalate uroliths.

Conclusion

The most efficient approach to safeguard against urolithiasis is by practicing dietary control. Therefore, while it might not be a substitute for surgical operations, it could undoubtedly contribute in diminishing the likelihood that uroliths will develop again. The subsequent research should concentrate on investigating the metabolic effects of dietary modifications on urolithiasis in strengthen animals by experimental validation. Researchers should also investigate the potential anti-urolithiatic properties of antioxidants and herbal plants.

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