Winning strategies against urolithiasis

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Urolithiasis is a multifactorial disease of male ruminants causing significant economic loss and compromise of animal welfare. Known risk factors include anatomic factors, urine pH, water intake, dietary composition and genetic factors. Clinical cases of obstructive urolithiasis may be treated using a variety of medical and surgical interventions, including tube cystostomy, perineal urethrostomy, urinary bladder marsupialization and modifications of these procedures designed to optimize patient outcome. Preventative measures aimed at the known risk factors include addressing body water balance, mineral composition of the diet and anatomical factors.

Medical management

Medical management of urolithiasis includes therapies to relax the urethra, relieve pain, acidify the urine, support systemic circulation, and address other abnormalities as indicated.

Medications used with the intent to relax the urethra include acepromazine (0.05 mg/kg, subcutaneously, q 4 hours) and midazolam (0.2 mg/kg, subcutaneously, q 4 hours) or diazepam (0.1 mg/kg, slow intravenously, q 4 hours). Morphine (0.05-0.1 mg/kg, subcutaneously, q 4-6 hours) and flunixin meglumine (1 mg/kg, intravenously) or meloxicam (2 mg/kg, orally, initial dose) may be considered for pain management.

NSAIDs should be used with great caution in animals with urinary obstruction, so one may choose to delay until the obstruction is relieved and fluid therapy is initiated. Ammonium chloride (100-200 mg/kg, orally, initial dose) is administered for urine acidification. If clients are reticent to pursue surgery, animals under this protocol may be placed in a dry stall without bedding and observed for urination from the urethra for a few hours to overnight. For animals to be left overnight with a distended urinary bladder, needle decompression is indicated to reduce the risk of rupture.

When medical management, vermiform amputation and time have failed, a noninvasive intervention is the Walpole's cystocentesis.[1] In this procedure, under ultrasound guidance, urine is withdrawn from the urinary bladder and replaced with 50mL Walpole's solution. After 2 minutes, urine is withdrawn and the pH tested. This procedure is repeated until the urine pH reaches 4-5. The initial report of this procedure showed 80% (20/25 animals) short term success. A subsequent data set obtained by the author (MJC) at the same institution indicated a 38% success rate, or 7/19 animals (Jones et al., unpublished, 2016). Walpole's cystocentesis should only be considered in cases for which surgery is not an option for the owner and euthanasia is the only other option. Leakage of Walpole's solution into the abdomen at surgery or via a bladder perforation may be fatal and leakage from an undetected urethral rupture results in massive tissue damage and pain.

Surgical management

Surgical intervention for urolithiasis is indicated in most cases for resolution. Several procedures have been described over time and continue to be modified by surgeons working to decrease common side effects, reduce treatment costs and optimize outcomes.

Tube cystostomy and modifications

The objective of tube cystostomy is to divert urine away from the urethra out through the body wall in order to allow the urethra to heal and the obstructing uroliths to be expelled or dissolved. The traditional tube cystostomy is an open-abdomen procedure. The abdomen is entered via an 8 cm parapreputial incision midway between the preputial orifice and scrotum. The urinary bladder is identified and stay sutures placed and a cystotomy performed for removal of uroliths and attempted normograde flushing of the urethra. A Foley catheter is placed through an additional incision in the body wall and into the urinary bladder. The cuff is inflated using saline and secured in place with a pursestring suture in the urinary bladder. In cases of urinary bladder rupture, the defect is repaired, then the catheter placed.[2] The urinary bladder is pulled to the body wall by the balloon and a Chinese finger trap suture pattern is used in the skin to secure the external portion of the tube to the body wall. A Heimlich valve or closed urinary system is used to prevent aspiration of air and contaminants into the urinary bladder. Medical management is instituted during hospitalization. The urine is diverted for at least 4-5 days, at which time a hemostat is used to occlude the tube and the patient is observed for urination from the urethra. This is repeated daily until urination occurs, which occurs in a mean of 11.5 days.[2] Once a strong urine stream from the urethra is achieved for at least a day, the holding suture is removed, the balloon deflated, and the tube pulled.

Success rates for surgical tube cystostomy in small ruminants have been reported to be 48%,[3] 52%,[4] 76%,[5] and 83-86%.[2,6,7] The most common complication rates reported in these studies include displacement of the tube and recurrence of the obstruction. This procedure requires general anesthesia, a long surgical time, and a long hospitalization making it financially prohibitive for some owners. For this reason, efforts to modify this procedure were undertaken to make it more economical. These include ultrasound guided percutaneous methods of placing the tube into the urinary bladder using a variety of suprapubic catheters.[3,8,9] These have been described for use for preoperative stabilization or as an adjunct to medical management without full tube cystostomy. In one study of goats using a straight suprapubic catheter, 10/10 failed due to tube displacement, persistent obstruction, reoccurrence and urethral rupture.[3] Use of a percutaneous catheter with a memory curve to facilitate retention has been described.[9]

While obstruction or migration of the catheter and accidental gastrointestinal puncture may occur, these complications are relatively rare (12/43 goats), making this a good option to use in conjunction with medical management or until surgery is performed.[9]

Perineal urethrostomy and modifications

Perineal urethrostomy also diverts urine away from the obstructed portion of the urethra, but permanently compromises the urethra and is therefore not suitable for breeding animals. In most situations, perineal urethrostomy is considered a short-term solution to obstruction due to the high rate of stricture that can occur postoperatively, resulting in reobstruction.[10]

To address the complication of strictures, a modified proximal perineal urethrostomy (MPPU) technique has been described for use in goats with persistent or recurrent obstruction. This approach involves extensive dissection around the proximal penile body such that the ventral 180˚ of the penile body is completely free of its pelvic attachments. Further, careful mucocutaneous apposition is created for the urethral stoma. The goal is reduced tension on the stoma, which may play a role in stricture formation.[11] The most common complications were hemorrhage (1/11 goats required blood transfusion), errant urine stream, and recurrent urolithiasis, but urethrostomy sites remained patent in 9/11 goats for over a year postoperatively.[11]

In a retrospective including both traditional and MMPU, hemorrhage was the most complication of MPPU while the most common complications of traditional perineal urethrostomy were related to reobstruction (stricture, stone) and urine scald.[10]

Urinary bladder marsupialization

Urinary bladder marsupialization is a method of urine diversion where a stoma is created between the urinary bladder and body wall. A parapreputial celiotomy incision is created lateral to the prepuce and a cystotomy performed to remove debris. A second, smaller (approximately 4 cm) parapreputial incision is created on the contralateral side lateral to the prepuce where the urinary bladder is repositioned and tacked at 4 points. The seromuscular layer of the urinary bladder is sutured circumferentially to the abdominal fascia with interrupting sutures. The cystotomy margins are then sutured circumferentially to the skin with simple interrupted sutures. Absorbable, 2-0 or 3-0 suture material is used for these 2 layers and the contralateral celiotomy is closed in routine fashion.[12] Complications of urinary bladder marsupialization include urinary bladder mucosal prolapse, incontinence, partial dehiscence, occluding serum formation, cystitis, urine scald and stricture of the marsupialization site.[3,12,13] It is reported that goats may urinate normally through the urethra after stoma stricture[12] and some animals are able to develop urinary continence.[13]

Other described surgical approaches to small ruminant urolithiasis include vesicopreputial anastomosis,[14] minimally invasive surgical tube cystostomy,[15] and laser lithotripsy.[16]

Preventive management

Planning for prevention of urolithiasis should be a topic included in any herd health or nutritional consultation where male small ruminants are involved. Due to the cost, prognoses and potential complications associated with each of the treatment modalities listed, a proactive, multifaceted approach to prevention is necessary. This is not a simple disease with a simple solution.

The risk factors outlined earlier in this chapter serve as a guide to address specific risks on a given farm. What type of animals are in the group? What is their expected use? What is their current or planned diet? Understanding the goals and expectations of the client can facilitate the construction of a plan that helps clients attain their goals while minimizing disease. Further, this information can help predict the stone type most likely to appear in this herd or flock so that strategies specific to that stone type can be employed.

There are some general recommendations that we can make that can be expected to limit stone formation, regardless of stone type. Delaying castration past 4-6 months can result in an increase in urethral diameter, increasing the capacity to pass formed stones.[17-19] Delayed castration must be carefully considered especially in miniature breeds as they are precocious breeders who may breed their female peers at an early age. Sex separation is recommended. Amputation of the vermiform appendage is challenging in prepubescent animals, but removes the most common site of urolith obstruction due to its small diameter at the terminal urethra. The effect of this on fertility of breeding animals has not been evaluated[20,21] and the procedure is not commonly performed as a preventive measure.

Dilution of urine and frequent urination helps rid the urinary bladder of both organic and inorganic components of uroliths, regardless of stone type. Making sure that clean, palatable, temperature-appropriate water sources are readily available at all times in all seasons can facilitate this dilution and regular urination. Water balance is also influenced by feed type. Foraging and grazing requires additional water for mastication and digestion, while meal feeding grains and pelleted feeds shunt water to the rumen. This results in the release of antidiuretic hormone, reducing urine output and dilution. For these and other reasons, limiting grains and pellets and increasing forage and grazing time are good practices towards preventing urolithiasis.[22,23]

The organic nidus may include cellular, protein, sugar and other components. Providing protein at a level necessary for the stage of life and production, but not in excess, helps limit excess protein in the urine. Palatable trace minerals that include adequate Vitamin A prevent metaplasia and cellular sloughing of the uroepithelium that can serve as a nidus.[24]

We can take our recommendations beyond the general to the specific by identifying the specific stone types associated with certain groups of animals. A basic generalization is that younger, grain-fed animals tend to develop phosphatic type stones, while young adults, miniature breeds and those consuming alfalfa or other legumes tend to develop calcium carbonate stones.[25] Other stone types, such as silicate, form in animals in sandy western soils in the U.S. and Canada, but we know very little about preventing these other than to limit the access of males to these grazing areas.

For animals with anticipated risk for phosphatic urolithiasis, urine pH and mineral balance are important factors to address. A goal for controlling phosphatic urolithiasis is to, at least periodically, reduce the urine pH below 6.5, the target pH for dissolution.[26,27] This can be done in a variety of ways, including reducing the DCAD of the total diet to 0 mg/kg using chloride salts.[28,29] D, L methionine at a dosage of 200mg/kg orally daily has been shown to effectively reduce urine pH.[30] A strategy that addresses concerns about individual susceptibility to urinary acidifiers and renal adaptation to acidification is to titrate an ammonium chloride dose in the individual animal to a urine pH of < 6.5 and then pulse dose 3 days on, 4 days off.[31] It is clear that DCAD balancing is a more appropriate approach to herd-level control, while titration and pulse dosing are more appropriate for individual animals, although pulse dosing can be used with DCAD balanced diets. Regardless of the acidification method used, urine pH should be regularly monitored in meal-fed animals 5-7 hours after receiving an acidifier to confirm that the target pH is being achieved.[29] Balancing magnesium, phosphorus and calcium is important in the control of struvite and other phosphatic stones. In general, the goal is to keep magnesium and phosphorus low, while using calcium to offset absorption of phosphorus. We know that magnesium and phosphorus are highly available when obtained through grains,[32] while forages increase salivary excretion of phosphorus, resulting in our consistent recommendation of reducing grains and increasing forage intake. Calcium competes for absorption with phosphorus, leading to the recommendation that the Ca:P ratio of diets to prevent phosphatic stones be 2-3:1.[33,34] This ratio must be closely monitored and not exceeded as it may predispose to calcium-containing uroliths.

For animals at risk for calcium carbonate urolithiasis, the dietary Ca:P ratio should be limited to 2:1 in order to keep phosphorus absorption at bay while not allowing calcium to be available in excess. Exclusion of legumes, particularly alfalfa, is generally recommended for these at-risk animals.[35] Although calcium carbonate forms in alkaline urine, it is not readily dissolved by urine pH reduction. Acidifying urine pH may be limited to helping to prevent formation, but may be a two-edged sword due to the effect of acidification on renal calcium excretion. Calcium availability in the urine is increased with metabolic acidosis, as is induced by the chloride salts. For this reason, the use of chloride salts should be limited to the dose which reduces urine pH to 6.5 without over acidification. This highlights the need to be specific regarding target stone type when addressing preventive measures. The use of acidifying measures to prevent phosphatic stones may actually increase the formation of calcium-containing stones.

Although it has not been confirmed in large, controlled studies, it has been strongly suggested that there is individual susceptibility to urolithiasis ("stone formers") and there are instances where urolithiasis of the same stone type has been repeated in families.[35-37]

Prevention of urolithiasis will likely never be able to be distilled to a simple, formulaic plan, however, the preventive measures addressed here can significantly reduce the incidence of the disease. Decades of research and data generated regarding urolithiasis can leave us frustrated when breakthrough cases occur. However, in most cases of obstructive urolithiasis, at least one breach of these recommendations can be readily identified. We must be vigilant in educating livestock producers about proper nutrition, husbandry, and other risk factors, as well as help them understand the physiologic basis for these recommendations to encourage a commitment to multimodal prevention over the long term.

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