Surgery of Obstructive Urolithiasis in Ruminants

Jennifer M. Ewoldt, DVM, MS[a,*], Meredyth L. Jones, DVM, MS[b], Matt D. Miesner, DVM, MS[c]

KEYWORDS

- Urolithiasis • Urethral obstruction • Cystotomy
- Urethrotomy • Cystostomy • Ruminant

The predisposition to obstructive urolithiasis in male ruminants involves a combination of anatomic and dietary factors. Uroliths in male ruminants most frequently lodge in the distal sigmoid flexure, near the insertion of the retractor penis muscle, or in the vermiform appendage (urethral process) of small ruminants.[1] Both of these are areas of narrowed urethral diameter. Urethral obstruction at these sites may result in local rupture of the urethra or urinary bladder rupture.

Struvite (magnesium ammonium phosphate) and apatite (calcium phosphate) uroliths are commonly seen in animals fed high-grain diets,[2,3] whereas animals consuming legumes are predisposed to calcium carbonate uroliths.[4] Silicate stones may be observed in animals grazing silicaceous plants and soils in the western United States and Canada.[5] Calcium oxalate stones may be associated with oxalate-containing plants.[6]

A significant factor in the availability of urolith components and their binding ability is urine pH.[1,2,7] Struvite, apatite, and calcium carbonate uroliths are known to precipitate in alkaline urine.[2,8–10] Struvite crystallization occurs only at a pH range of 7.2 to 8.4, whereas apatite stones develop at a urine pH of 6.5 to 7.5.[11] Urine pH may have little or no effect on silicate or calcium oxalate uroliths.

Total body water balance plays an important role in calculogenesis by its effects on urine volume and concentration, which may be seen in winter and during times of systemic illness, when water consumption is reduced. A negative body water balance contributes to supersaturation of urine, precipitation of crystals, and formation of organic and inorganic crystalloids in urine.

[a] Scott County Animal Hospital, 115 South 16th Street, Eldridge, IA 52748, USA
[b] Department of Clinical Sciences, 111B Mosier Hall, Kansas State University, Manhattan, KS 66506, USA
[c] Department of Clinical Sciences, College of Veterinary Medicine, Kansas State University, 1800 Dennison Avenue, Manhattan, KS 66506, USA
* Corresponding author.
E-mail address: doctorewoldt@aol.com (J.M. Ewoldt).

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Medical treatment of obstructive urolithiasis in ruminants has generally been unrewarding. Some form of surgical intervention is necessary to relieve the obstruction, either by direct removal of the urolith, or by bypassing the obstruction. Some surgical methods result in loss of urinary continence, some end the ability of intact males to breed, and others have many complications, the most common of which is urethral stricture. Cost is always a factor in the treatment of ruminants, many of which are destined for slaughter.

In this article, medical management of urolithiasis is described briefly, followed by surgical management and preventative measures.

EVALUATION AND MEDICAL TREATMENT

Physical examination of animals suspected to have obstructive urolithiasis should include evaluation of the abdominal contour and the underline, which may be altered because of bladder or urethral rupture, respectively. Palpation of the preputial hairs may reveal blood clots, crystals, or small stones. In obstructed small ruminants, the urethra may pulse ventral to the anal sphincter or on digital rectal examination, and abdominal palpation may detect bladder distension or free abdominal fluid. In cattle, rectal palpation may reveal urinary bladder distension. Transabdominal ultrasound may also confirm free abdominal fluid.

The penis should be exteriorized in obstructed small ruminants, which is facilitated by use of sedatives. Acepromazine (0.05–0.1 mg/kg, intravenous or intramuscular)[12,13] and diazepam (0.1 mg/kg, slow intravenous) provide systemic and muscle relaxation. The use of xylazine should be avoided because it promotes diuraesis and may contribute to rupture if the obstruction is not relieved immediately. Alternatively, lumbosacral epidural using 2% lidocaine (1 mL/7 kg) may be used in the place of sedation in small ruminants to relieve discomfort and aid in exteriorization of the penis.

Once the penis is exteriorized, the urethral process of small ruminants may be amputated (see section on surgical treatment). This narrowing of the urethra is a common site of obstruction in these species and may provide temporary relief of the obstruction. The urethral diverticulum at the level of the ischial arch prevents retrograde passage of a urinary catheter into the urinary bladder (**Figs. 1** and **2**).[14–16] Therefore, retrograde catheterization or retropulsion of uroliths is not recommended to avoid further trauma or puncture of the urethra at the level of the diverticulum. Attempts at retropulsion of uroliths may result in overdistention of the urinary bladder as the stone is diverted into the diverticulum, allowing fluid to pass into the bladder, followed by the urolith falling back into the urethra and preventing the bladder from emptying.

Once the obstruction is relieved, treatments to acidify the urine should be initiated in an effort to solubilize additional stones and sediment. Initially, ammonium chloride is administered at a dosage of 200 mg/kg orally, with the dosage adjusted to attain a urine pH of 6.0 to 6.5. Care should be taken in dosing so that systemic overacidification does not occur.

Fluid therapy should be instituted as indicated by the clinical findings and economics of the case. Intravenous fluid therapy will also help stabilize critical patients before surgical treatment, and reduces the risk for anesthetic death due to hyperkalemia-induced arrhythmia. After relief of the obstruction, diuresis is important to replace dehydration, reduce azotemia, and flush the urinary tract. A good choice for intravenous fluid therapy is 0.9% NaCl, although additional electrolyte and acid-base abnormalities should be considered.

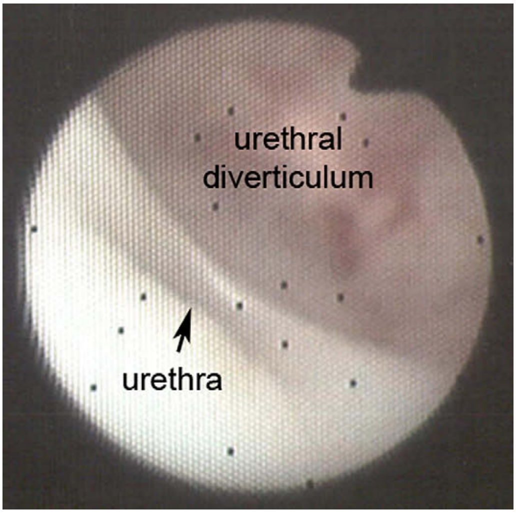

Fig. 1. Endoscopic view of the urethra at the level of the ischial arch. The large cavity to the upper right of the image is the blind pouch of the urethral diverticulum; the narrow opening to the left is the urethra.

Nonsteroidal anti-inflammatory drugs should be administered to decrease inflammation and aid in the prevention of urethral stricture formation, but they should be used with caution until adequate renal perfusion is attained. Broad-spectrum antibiotic therapy should be instituted to prevent or treat infection resulting from devitalized or inflamed urinary tissues, and cavitational accumulation of urine. Beta-lactams (penicillins and cephalosporins) may be chosen because they have a good spectrum of activity and are excreted in the urine.

The goals of medical therapy should include the provision of analgesia, correction of fluid and electrolyte imbalances, treatment or prevention of inflammation or infection, and dissolution of remaining uroliths once the acute obstruction is relieved. Most cases of urethral obstruction will require surgical intervention during the course of case management.

Fig. 2. Contrast urethrogram revealing the urethral diverticulum located at the ischial arch (*arrow*).

SURGICAL TREATMENT

Surgical treatment of urolithiasis in ruminants was traditionally limited to short-term salvage procedures in feedlot animals destined for early slaughter. Success rates varied and depended on the duration of obstruction before surgery, the condition of the animal and the urethral tissue at the time of treatment, concurrent urethral rupture, and the location of the urolith itself. An increase in the number of small ruminants kept as pets has led to the development of new techniques for surgical treatment of urolithiasis. The intent is to develop a corrective procedure that does not stricture rapidly, and does not end the breeding ability of intact males. Research has also led to ways to replace ruptured urethral tissue to salvage animals that would otherwise be doomed to slaughter or euthanasia. The perceived value of these animals as pets also provides the opportunity to perform procedures that would not be cost effective in feedlot animals.

Tube cystostomy for urinary diversion in ruminants was initially described in 1965 as a treatment of ruptured bladders in steers.[17] Since then, it has become popular as a treatment of obstructive urolithiasis in many species of animals, but especially in small ruminants. Rakestraw and colleagues[18] described a case series of 15 small ruminants treated with tube cystostomy, 12 of which were successfully relieved of urinary obstruction. Fortier and colleagues[19] described a group of 25 goats treated with tube cystostomy. A more recent review of 63 small ruminants undergoing tube cystostomy indicated excellent results both short and long term following surgery.[20]

Tube cystostomy provides an alternative surgical treatment to the perineal urethrotomy and urethrostomy techniques previously used to manage urinary obstructions. Long-term outcome of urethrostomy and urethrotomy are reported to be poor.[21,22] Outcome is poor because of stricture formation at the urethrotomy/urethrostomy site, which leads to repeat urethral obstruction.

Urinary diversion techniques, such as antepubic urethrostomy and perineal urethrostomy, are unsuitable for breeding animals because of loss of urethral patency.[21,23] Urinary bladder marsupialization has been described but has been associated with extensive urine scalding problems, stoma stricture, and bladder prolapse through the fistula site.[24,25] Laser lithotripsy, although sometimes used in equine urolithiasis,[26,27] has been described in only a few case reports in ruminants, with some success.[28,29]

The most successful surgical method of treating obstructive urolithiasis in cattle and small ruminants is surgical tube cystostomy.[17,18,20] In this technique, the patient is anesthetized in dorsal recumbency, and the bladder is approached by way of a paramedian incision. A cystotomy is performed to remove any uroliths present, and a Foley catheter (12 to 24 F) is then passed through a stab incision in the body wall of the inguinal region, placed into the bladder through a stab incision, and sutured into place with the cuff inflated (**Fig. 3**). Following closure of the celiotomy incision, an extra catheter is secured with sutures or bandages to the abdominal wall (**Fig. 4**). The catheter is allowed to drain freely for several days, after which it is periodically occluded with a clamp to test for normograde urine flow through the urethra. Once normograde flow is established, the catheter cuff is deflated and the catheter is removed. In two separate reports, urine flow was re-established in a mean of 11.5 and 11 days.[18,20] The success rate of this procedure was 76% to 90% in the short term, and 86% in the long term.[18,20] Success rates have been shown to depend on several factors.[19,20] The major drawback of surgical tube cystostomy is the cost associated with the procedure, because animals must be hospitalized during the waiting period before catheter occlusion. Tube cystostomy has been used to restore breeding function in intact male animals, avoiding the loss of breeding function, as previously described.[30] One of the

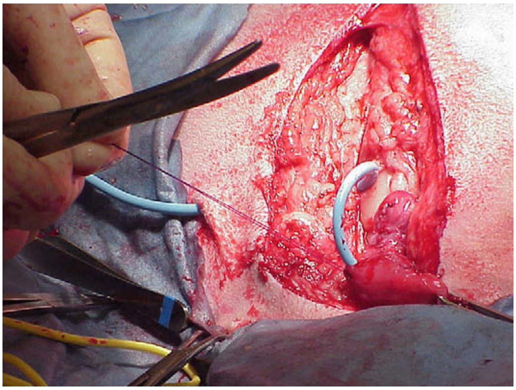

Fig. 3. Intraoperative view of placement of tube cystostomy catheter. The catheter enters the abdomen through the body wall to the left, and is sutured in place in the bladder at the bottom of the image. The sutured cystotomy incision for removal of uroliths can be seen to the right of the catheter.

authors (JME) has experience with this technique in llamas, alpacas, whitetail deer, and a camel, and has anecdotal evidence of its use in potbellied pigs. Success rates vary widely in these alternative species, but the technique is the same.

To reduce the costs associated with the tube cystostomy procedure, a percutaneous tube cystostomy technique has been developed for placement of the cystostomy tube.[31] This technique was successful in the initial description, but subsequent reports indicated that it is 5.6 times more likely to require a second procedure to replace the tube following premature tube loss.[19] If successful, percutaneous tube cystostomy is managed similarly to the surgically placed tubes, in that the tube is periodically occluded after a waiting period of approximately 7 days, and is removed once urination is re-established.

Urinary bladder marsupialization has been moderately successful in restoring urination in goats.[24,25] It does eliminate urinary continence and may, as a result, be

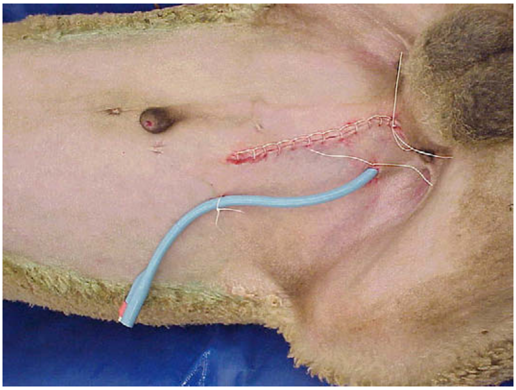

Fig. 4. Completed tube cystostomy procedure, showing the location of abdominal incision and placement of Foley catheter through the abdominal wall. The remaining catheter is sutured to the abdominal wall to keep it elevated and protected.

unacceptable to some pet owners. In this technique, the apex of the bladder is marsupialized to the ventral body wall at midline during a midline celiotomy, creating a stoma that allows for free drainage of urine from the bladder (**Fig. 5**). Major complications include bladder mucosal prolapse through the stoma, urine scald on the ventrum of the animal, and ascending urinary tract infections through the marsupialization site.[24,25] The marsupialization stoma strictured in 3 of 25 goats.[24,25] Success rates were 66% and 94% in two separate studies.[24,25] Hospitalization was significantly shorter than tube cystostomy (mean of 4 days vs. 14 days), which may reduce the cost associated with the procedure.

Prepubic urethrostomy has been described in a sheep and a goat for relief of obstructive urolithiasis.[23] In the report described, prepubic urethrostomy was used for relief of urinary obstruction following perineal urethrostomy stricture formation. The technique used is similar to that performed in dogs and cats. Both animals described were able to void normally after the procedure, but recurrent cystitis and further stricture formation were complications. Because of the proximal location of the surgery in the urethra and the difficulty of the procedure, this technique should be reserved for revision of failed urethroplasties.

Several researchers have recently investigated laser lithotripsy for dissolution of uroliths in ruminants.[28,29] A chromium-thulium-holmium:yttrium-aluminum-garnet (Ho:YAG) laser was used successfully to rupture a urethral calculus when placed through an ischial urethrotomy in a steer, and fractured uroliths in three goats and two potbellied pigs.[28,29] The use of lithotripsy depends on the presence of a urethra sufficiently large for passage of the laser in an endoscope, and positioning of the uroliths in the distal urethra. Lithotripsy, however, presents a viable option for removal of uroliths in the future, and further investigation is warranted. Advantages include reduced cost and rapid discharge from the hospital.

Buccal mucosal grafting has recently been described for the reversal of a perineal urethrostomy in a goat.[32] In this case, the urethra was reconstructed using a strip of tissue from the buccal mucosa following unsuccessful revision of the urethrostomy site. Buccal mucosa proved to be an excellent tissue for this procedure, and healing was excellent, with good long-term survival.

Vesicular irrigation with hemiacidrin was used in conjunction with percutaneous tube cystostomy to restore urinary function in a goat.[31] The investigators concluded that irrigation resulted in rapid dissolution of calcium phosphate uroliths without the

Fig. 5. Completed urinary bladder marsupialization. The stoma is visible at the top of the photo, with the abdominal incision at the bottom of the photo. (*Courtesy of* Kimberly A. May, DVM, MS.)

need for celiotomy and cystotomy. Vesicular irrigation could be combined with surgical or percutaneous tube cystostomy, and perhaps also with other techniques, to dissolve uroliths in situ. The efficacy of this technique on different types of uroliths is not known.

Urolith removal by cystotomy combined with normograde and retrograde urethral flushing was successful in restoring urinary function in seven of eight small ruminants with obstructive urolithiasis.[21] The investigators concluded that this technique was more successful than perineal urethrostomy in restoring urinary function. However, at the time of that study, further techniques such as tube cystostomy, urinary bladder marsupialization, and laser lithotripsy had not been described.

Perineal urethrostomy has long been the mainstay of urolithiasis treatment in ruminants. It is considered a salvage technique in most cases, although some animals have survived for long periods of time after surgery. With this technique, a permanent opening is made in the urethra through which the animal voids urine. Perineal urethrostomy does not guarantee urethral patency because an animal can still obstruct proximal to the stoma. As a result, the urethrostomy stoma should be placed as distal as possible to allow for repeat surgery more proximally if needed. However, the stoma must be located in such a location that it will be proximal to the obstructing urolith. Numerous descriptions of the surgery are available in large animal surgery texts. The technique is usually described as a ‘‘high’’ perineal urethrostomy, located near the ischium, or a ‘‘low’’ perineal urethrostomy, located closer to the scrotum. The most common complication of urethrostomy is stricture of the stoma, which may occur rapidly (weeks to months) after surgery.[33]

Penile amputation (penectomy) is similar to the technique escribed for perineal urethrostomy; however, the penis is transected and may be completely removed rather than creating a stoma in the penis (**Fig. 6**). This procedure is simpler than perineal urethrostomy, but has the disadvantage of increased stricture rate and speed. It is strictly a salvage procedure. Again, the procedure may be performed at a ‘‘high’’ or ‘‘low’’ location, as described in food animal surgery texts.

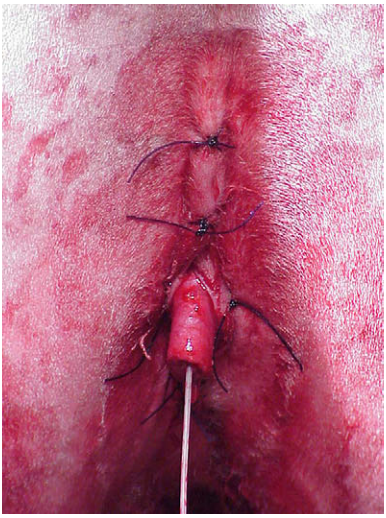

Fig. 6. Perineal urethrostomy with penile transection in a steer. The stay sutures fixating the transected penis are visible, as is a urinary catheter placed in the urethra.

If the urolith is in a location that can be palpated or reached by catheter, a simple urethrotomy can be performed over the urolith itself, or adjacent to the urolith in healthier tissue. Following incision at the urolith, it is removed with forceps or is crushed to allow the pieces to pass. An alternative technique involves retropulsion of a urolith from the distal urethra to an ischial urethrotomy where it can be removed. Urethral stricture formation is a common side effect of urethrotomy, but the simplicity of the procedure makes it popular in breeding animals where the penis must remain intact.[33] The urethrotomy incision may be allowed to heal without suturing because suturing may increase the likelihood of stricture formation. Some surgeons, however, recommend suture closure of the urethrotomy as soon as possible to prevent stricture formation.

PREVENTION

Because of the poor prognosis and expense associated with clinical cases of obstructive urolithiasis and the herd or flock implications of the disease, considerable focus should be placed on prevention. Risk factors to address in preventative strategies include high dietary phosphorus/calcium ratio, high dietary magnesium, low fiber content of rations, low urine output, and an alkaline urine pH. Additional factors, including selective grazing and castration timing, may also be addressed.

Mineral components of uroliths come primarily from the diet, making control of the mineral content of rations particularly important in prevention. In general, phosphorus should never comprise greater than 0.6% of the total ration,[2] and the calcium/phosphorus ratio should be maintained at 2.5:1 or 2:1, achieved by the use of calcium salts, if necessary.[1,3,7,34] High phosphorus levels are present in grains, particularly sorghum, wheat, corn, milo, and oats.[1,10,34] Phosphorus excretion into the urine may be decreased by the feeding of more roughage and the avoidance of pelleted rations, to encourage salivary excretion of phosphorus.[1,2,35] Magnesium control is important even in prevention of uroliths, which do not contain magnesium in their primary structure. It is recommended that magnesium never comprise greater than 0.6% of the total ration[2] and, because the magnesium in roughage diets is less available than that from concentrates,[2] roughage-based diets are preferable.

Increasing water intake and urine volume is an important preventive measure for urolithiasis. Sources recommend the provision of adequate palatable water at desirable temperatures according to the ambient environment[1,2,10,34] and ruminants demonstrate a reduction in water intake for grain feeding over roughage feeding.[2] Water intake is not perfectly tied to urolithiasis because in one study, a decrease of water intake of 20% below normal voluntary intake did not alter the incidence of urolithiasis.[36]

The role of urine pH in urolithiasis is well documented and various sources recommend urine pH goals of 5.5 to 6.5, based on the solubilities of the common stone compositions. Because of an ability to alter acid-base balance and body water balance, salts have been widely used and recommended for the prevention of urolithiasis. Anionic salts containing primarily chlorides have been popular and used extensively because they reduce urine pH, increase urine output, and, ultimately, prevent urolithiasis.[1,2,7,10] Sodium chloride (1%–4%), calcium chloride (1%–2%) and ammonium chloride (0.5%–2%) have been traditionally added to as percentages of rations to increase water intake and produce acidic urine, with inconsistent results.[37–40]

The addition of these salts as a simple percentage of the diet without consideration for the components of the total ration may lead to inconsistent and unsuccessful maintenance of low urinary pH. The concept of dietary cation-anion difference (DCAD) states that with increased cations in the diet, alkalotic tendencies will occur.

Conversely, increased anions in the diet have acidifying potential. Different commercial diets are commonly formulated using various commodities and these commodities are interchanged regularly in feed preparation based on availability. If a feedstuff or a particular batch of feed is higher in cations, or anionic salts are fed in conjunction with high-potassium forage, the DCAD of the diet will be raised and urinary acidification may not occur, despite the addition of the standard dose of anions. This one-dose-fits-all method may be the major cause of sporadic urolith formation in animals being fed anionic salts. The use of DCAD balancing for ruminant urolithiasis is mentioned as a recommendation in some sources,[1,10,41,42] and it is recommended that high cation–containing feedstuffs such alfalfa and molasses be avoided.[10] Few controlled studies for target DCAD levels currently exist, but a DCAD of 0 mEq/kg appears to achieve a urine pH of intact and castrated goats of less than 6.5.[41,42] To assess accurately the efficacy of salts in the diet, whether DCAD balanced or not, owners should be encouraged to assess urine pH periodically at home.

Grazing of female animals on pastures that have high silica content of soil and plants is preferred to the grazing of male animals on these pastures. If male animals are to be grazed in these locations, water intake should be encouraged by maintaining desirable and accessible water sources and supplementation of the anionic salts, ammonium chloride,[43] or sodium chloride,[44] and reduction in the dietary calcium/phosphorus ratio.[44,45]

Early castration is commonly thought to reduce the positive influence of testosterone on urethral diameter and to diminish normal prepucial to penile attachments that are present in the neonate. In calves and in goats, intact animals have shown to have the largest urethral diameters, followed by delayed and partial castrates, with early castrates having the smallest urethral diameters.[46,47] Delaying castration, where production parameters allow, may serve to increase urethral diameter and reduce obstructive rates.

Urolithiasis is multifactorial, making it difficult to design consistently reliable preventative programs. With adherence to the above goals, primarily focusing on dietary modification, significant reductions in clinical cases may be achieved.

SUMMARY

Most cases of obstructive urolithiasis will require surgical intervention at some point during the treatment process. Fluid, anti-inflammatory, antibiotic, and acidifying therapies should be used in support of surgical intervention.

Surgical technique may be chosen based on the characteristics of the individual case, including site of obstruction, location of the rupture, and value of the animal. Prevention remains the mainstay of urolithiasis management. Identification of a case of obstructive urolithiasis should trigger action for the affected individual and the entire herd or flock of origin.

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