Review Report

Management of urolithiasis in breeding bulls

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Abstract

Urolithiasis is commonly encountered and frequently a fatal disease in the ruminant species. Clinical signs of urolithiasis are related to both its severity and chronicity. After complete obstruction of 24–48 h, bladder or urethral obstruction can occur. The varying urinary environments affect the type of stone development: phosphatic stones occur when cattle consume high phosphate diets; silica calculi form when grazing native grasses in the Western US; and calcium stones form when cattle consume high amounts of lush clover grass or alfalfa hay. Medical management is rarely successful as lone treatment but is used in conjunction with a surgical procedure. For a bull to return to reproductive function, the surgical procedure chosen must leave the urethra intact. The two procedures discussed presently are the ischial urethrostomy and tube cystostomy.

Keywords: Bovine, urinary stones, ischial urethrostomy, tube cystostomy

Introduction

Urolithiasis is a condition affecting most veterinary species and is a significant economic disease in ruminants. Fatalities from urolithiasis have been reported to range from 3 to 20%.[1,2] Urolithiasis is commonly associated with small ruminants or castrated males of all ruminants, but stones form in several urinary environments and breeding bulls can develop this disease as well. This article will focus on diagnosis, pathophysiology, and treatment of urolithiasis for bulls intended to return to reproductive function.

Clinical signs

Each case of urolithiasis can present with different clinical signs based on the chronicity and severity of the obstruction (Figure 1). Hemorrhage and necrosis of the urethral mucosa are evident at the site of obstruction, but the bladder will also show signs of mucosal trauma (Figure 2). In cattle, the most common site of obstruction is the distal portion of the sigmoid flexure.[3]

Cattle can present with acute colic-type symptoms including bruxism, kicking of the abdomen, and a wide base stance. An enlarged urinary bladder may be present and upon rectal palpation urethral pulsations can be observed. Urethral pulsations can also be palpated just below the anus on midline. The chronicity of the obstruction will determine secondary effects of urolithiasis, such as urethral rupture or bladder rupture. Urethral rupture occurs at the site of the obstruction, predisposed by mucosal hemorrhage and necrosis caused by the stone. Urine subsequently accumulates in the subcutaneous tissues, commonly in the preputial region (Figure 3). In cases of bladder rupture, the abdomen can be enlarged and filled with large amounts of blood-tinged fluid, creating a fluid wave. In cases of chronic urethral obstruction, hydronephrosis, hydroureter, and bladder wall hypertrophy are often present.

Pathophysiology

Multiple factors are involved in urolith formation; however, a requirement is high concentrations of crystalloids that aggregate to form crystals.[4] Urine contains substances that act as inhibitors of crystallization (mucopolysaccharides, ions, and organic acids), but when urine becomes supersaturated with crystalloids, these inhibitors become exceeded.[4] The crystalloids are no longer soluble in the urine and form precipitates (i.e., supersaturation). These precipitates enlarge and form calculi as more minerals become insoluble. Supersaturation of the urine is not solely responsible for stone formation. All stones increase in occurrence during winter months presumptively due to decreased water consumption.[4] Dehydration, or rather water deprivation, with resultant concentration of urinary minerals, appears to be a potential contributing factor in

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Figure 1. Urethral calculi visible on preputial hairs.

Figure 2. Bladder mucosal trauma. Picture courtesy of Department of Pathobiology, Auburn University Veterinary Teaching Hospital.

Figure 3. Subcutaneous swelling due to urine accumulation in the prescrotal region.

the development of all types of uroliths.[4,5] Other less common factors that have been reported to increase urolith formation include hypovitaminosis A, hypervitaminosis D, and estrogenic intake.[2,6,7] Exact etiologies of stone formation vary with the type of urolith formed and specific predisposing factors are listed below.

Types of stones

Phosphatic calculi

Ruminants consuming diets with high levels of phosphorus (almost all grain-based diets) are prone to developing struvite (magnesium ammonium phosphate hexahydrate) or apatite (calcium phosphate) calculi. It is unknown exactly what role phosphorus plays in urolith formation, but rations where the calcium to phosphorus ratio is less than 2:1 are particularly prone to cause outbreaks of urolithiasis.[4] Struvite stones appear to be affected by magnesium and other minerals present in the diet as well. Phosphatic calculi are typically white or gray, smooth, radiopaque, and easily broken.[4]

Silica calculi

These uroliths are primarily a problem of ruminants grazing native rangeland in western North America.[6] Unpolymerized silicic acid is dissolved in ruminal fluid of the grazing animal, absorbed, and excreted in urine. Cattle on rangeland typically have intermittent access to water, resulting in periods of water deprivation, leading to formation of highly concentrated urine at times. [4] Calculi develop as silicic acid concentrates and polymerizes to polysilicic acid.[4] Urine pH does not alter silica urolith formation. Silica uroliths are hard, smooth, white to brown, and radiopaque.[4]

Calcium-based calculi

The two primary types of calcium-based calculi observed are calcium carbonate and calcium oxalate. Calcium carbonate uroliths form in small ruminants grazing lush, clover pastures or fed high amounts of alfalfa hay. These stones are round, smooth, and copper colored.[4] Calcium oxalate crystals are often present in normal urine, but form in low calcium diets and in periods of decreased water intake. Oxalate stones are dense, hard, white to yellow, and smooth or jagged.[4] Calcium based calculi are less commonly observed in cattle compared to small ruminants.[1,7]

Stone analysis

The type of urolith is presumptively identified based on outward physical characters such as shape and color, as described above.[7] Since there is overlap in the gross appearance of a urolith, and most stones are of mixed composition, it is helpful for chemical analysis to be performed on collected stones. Determination of the composition of uroliths collected at time of surgery is used for herd management and prevention of future cases.[4] Uroliths may be submitted to a number of diagnostic labs for analysis (Minnesota Urolith Center, University of Minnesota College of Veterinary Medicine or G.V. Ling Urinary Stone Analysis Laboratory, UC Davis School of Veterinary Medicine).

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Treatment

Most cases of urethral obstruction will need to be corrected by surgical intervention.[5] Patients often develop dehydration and severe electrolyte abnormalities, especially if bladder rupture has occurred, indicating the need for medical therapy no matter the treatment option chosen.[7,8] A combination of surgical and medical management is often needed to ensure a good prognosis and return to breeding capacity.[5]

Medical management

Very few cases of urethral obstruction can be corrected by medical management alone. Medical management is aimed at relief of the obstruction and correction of electrolyte abnormalities. Certain phenothiazine tranquilizers can have antispasmodic effects on the tunica albuginea and straightening of the sigmoid flexure aiding in passage of urethral stones.[3,9] Acepromazine (Acepromazine injection, VetOne, MWI, Boise, ID, 0.05–0.1 milligram/kilogram (mg/kg) intravenous (IV) or intramuscular (IM)) has been used for this purpose, but its efficacy has not been proven.[10,11] Alpha-2 adrenergic agonists (Anased® 20, Xylazine Injection, Akorn Animal Health, Lake Forest, IL) should not be used due to their diuretic effect.[12] Non-steroidal anti-inflammatories are beneficial for patient recovery and irritated urinary tract mucosa.[11]

Patients with uroperitoneum often require preoperative stabilization of hypovolemia and correction of electrolyte abnormalities. Initial boluses of hypertonic saline followed by physiologic saline can be used to correct volume deficits and hyponatremia. Obstructed patients should not be supplemented with potassium since many patients are already suffering from hyperkalemia.[11] Hyperkalemia can induce bradycardia and fatal cardiac arrthymias.[4] Severe elevations of potassium can be corrected by administration of dextrose 50% (Dextrose 50% Injection, VetOne, MWI, Boise, ID).[4] Slow drainage of fluid from the abdomen reduces pressure on the diaphragm and slows progression of metabolic derangements caused by uroperitoneum. Acute renal failure is an occasional sequela to urethral obstruction and should be taken into consideration during physical exam and bloodwork evaluation.

Depending on the composition of the urinary stone present, acidification of the urine can result in breakdown of the stones. Phosphatic calculi form in alkaline urine and may be broken down by acidifying the urine. Silica and calcium-based calculi form in a range of urine pH levels and will not be broken down by acidification of the urine.[4] Ammonium chloride (Ammonium chloride AF animal feed grade, BASF, Ludwigahafan, Germany) at an initial dose of 200 mg/kg orally once daily will acidify the urine, increasing by 50 mg/kg to keep the urine pH between 6 and 6.5.[5]

Surgical correction

The method of surgical correction chosen is highly dependent on the proposed outcome of the animal. For castrated animals that are intended for human consumption, economic considerations may be the most important deciding factor. In the circumstance of breeding bulls, the most important factor is preserving their breeding capacity by maintaining a patent urethra.

Ischial urethrostomy

Sometimes referred to as a "high perineal urethrostomy," the approach for an ischial urethrostomy is 5 centimeter (cm) below the rectum within the ischial arch (Figure 3).[13] The patient is restrained in a standing position and a caudal epidural is performed. An alternative local block is the pudendal nerve block. The surgical site is clipped and surgically prepped. An incision is made beginning 5 cm below the rectum and continued for 10 cm, deep enough to incise through the dense layer of fascia overlying the retractor penis muscles. Blunt dissection is used between the retractor penis muscles to visualize the bulbospongiosus muscle (Figure 5). Care should be

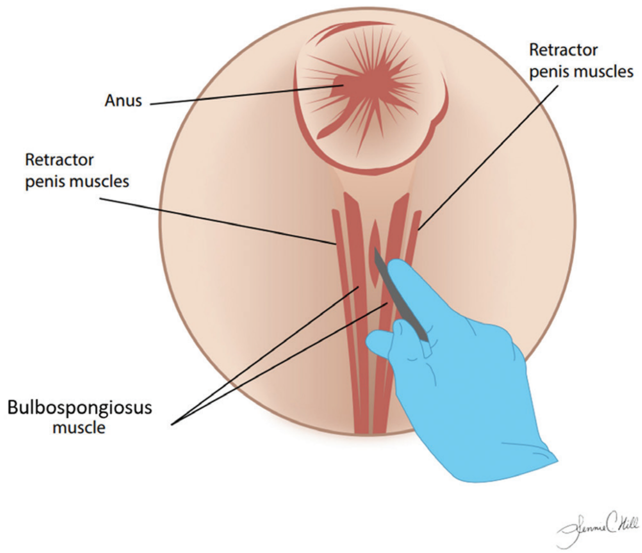

Figure 4. Ischial urethrostomy incision site.

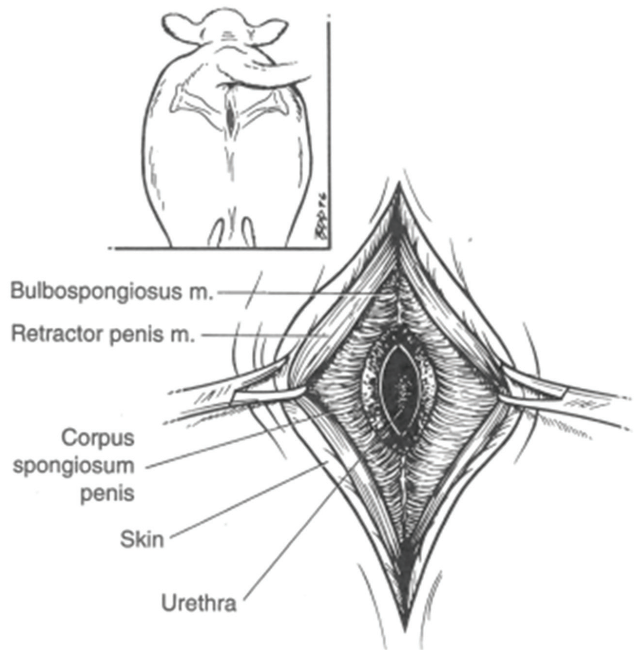

Figure 5. Ischial urethrostomy incision anatomy.[13]

taken to incise directly on midline through the bulbospongiosus muscle into the urethra (Figure 6). Hemorrhage from the bulbospongiosus muscle is common and a fair amount of hemorrhage from the corpus spongiosum may occur (Figure 7). Inexperienced surgeons can have difficulty reaching the urethra due to the depth of the bulbospongiosus muscle and urethra.

Once the urethra is opened, a catheter can be passed into the bladder. A 20–28 French Foley catheter with a balloon can be used to maintain urine evacuation from the bladder (Silicone Foley Catheters 23–34 inches long. Agtech Inc, Manhattan, KS) (Figure 8).[5] Normograde flushing of the distal urethra can be attempted by passing a catheter distally from the incision site. The authors have infused a mixture containing 5 milliliters (mLs) lidocaine (Lidocaine HCl 2% Injection), 5 mL dexamethasone (Dexamethasone Injection 2 mg/mL) and 10–20 mL saline into the distal urethra to provide the potential benefit of decreasing urethral inflammation as well as decreasing discomfort from urethral spasm.

The advantage of an ischial urethrostomy instead of a perineal urethrostomy is that the breeding potential of the bull can be salvaged. The urethra at the site of an ischial urethrostomy has a larger diameter, resulting in less concern of stricture formation.

Tube cystostomy

Originally described in 1965 for steers, a tube cystostomy is the procedure of choice when urinary bladder or urethral rupture has occurred.[14] The authors believe a tube cystostomy is the best option, even when the bladder is intact, for a bull in which future use as a breeder is desired. Tube cystostomy provides diversion of urine from the bladder for relief of urethral spasm or swelling and allows for stone passage.

A tube cystostomy procedure can be performed standing or via a ventral midline incision. For a standing procedure a left flank approach is preferred. The bull is administered caudal

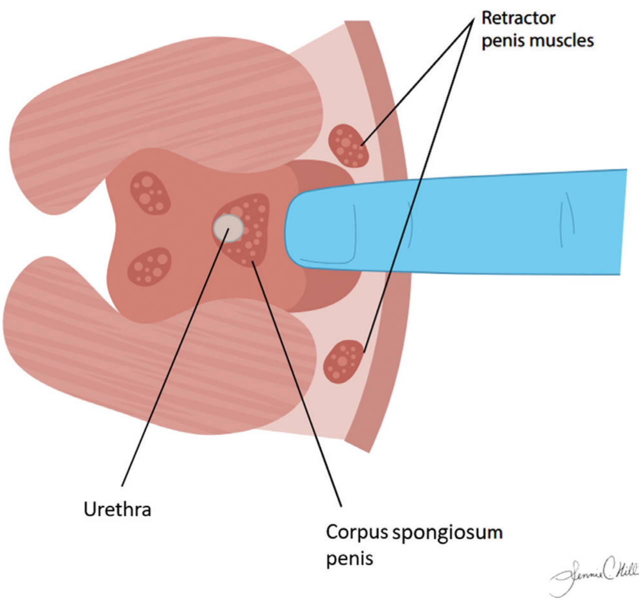

Figure 6. Midline palpation of the urethra at the ischial urethrostomy incision site.

Figure 7. Ischial urethrostomy incision.

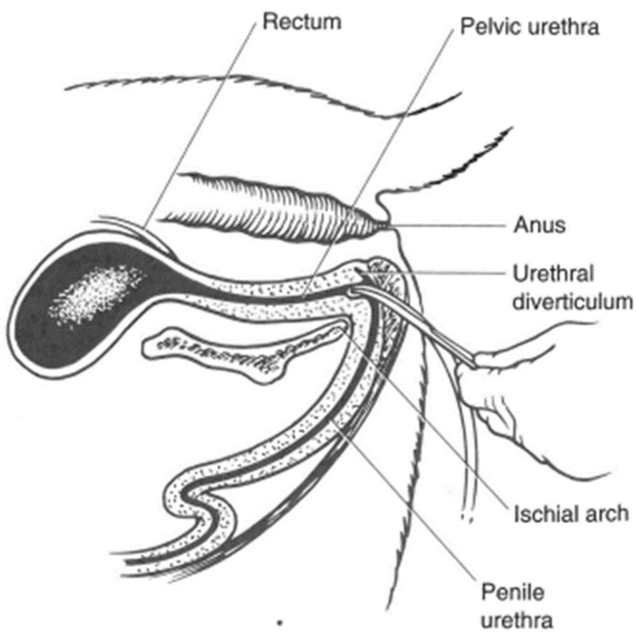

Figure 8. Using hemostats to direct a catheter into the urethra during an ischial urethrostomy procedure.[13]

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epidural anesthesia and the left flank is clipped and surgically prepped. Paralumbar anesthesia is achieved by surgeon's preference, commonly via an inverted L block. The urinary bladder is visualized and exteriorized as much as possible. Infusion of lidocaine into the bladder via an extension set and small gauge needle can be helpful for bladder relaxation. A stab incision through the abdominal wall is made 8–10 cm caudo-lateral from the surgical approach incision for insertion of a 20–30 French Foley.[5] If a ventral midline incision is performed, the stab incision for insertion of the Foley is made lateral to the initial incision at least 3 cm from the prepuce.[5] For both approaches, the Foley catheter is passed into the abdomen by aid of a stylet to insert the Foley into the cranioventral aspect of the bladder near the apex. The balloon is distended, and a purse-string suture is placed in the seromuscular layer of the bladder around the Foley with care taken to not crimp the catheter. Tension is placed on the catheter to move the bladder close to the abdominal wall. A Chinese finger trap suture is placed around the exterior portion of the Foley to the exterior abdominal wall (Figure 9). A one-way valve is placed on the end of the Foley using the finger of an exam glove and the initial abdominal incision is closed in a routine three layer closure (Figure 10).

Administration of ammonium chloride acidifies the urine causing breakdown of the stone(s).[4,5] Urine pH is monitored to ensure adequate doses are given as described above. The Foley catheter is left in place for a minimum of 7 days or until urine flow through the urethra has been re-established.[5] The catheter is occluded and observation of normograde voiding of urine indicates that the offending urinary calculi have passed. The Foley is typically kept in place for 2–3 days past observation of normal urination to ensure re-obstruction has not occurred.

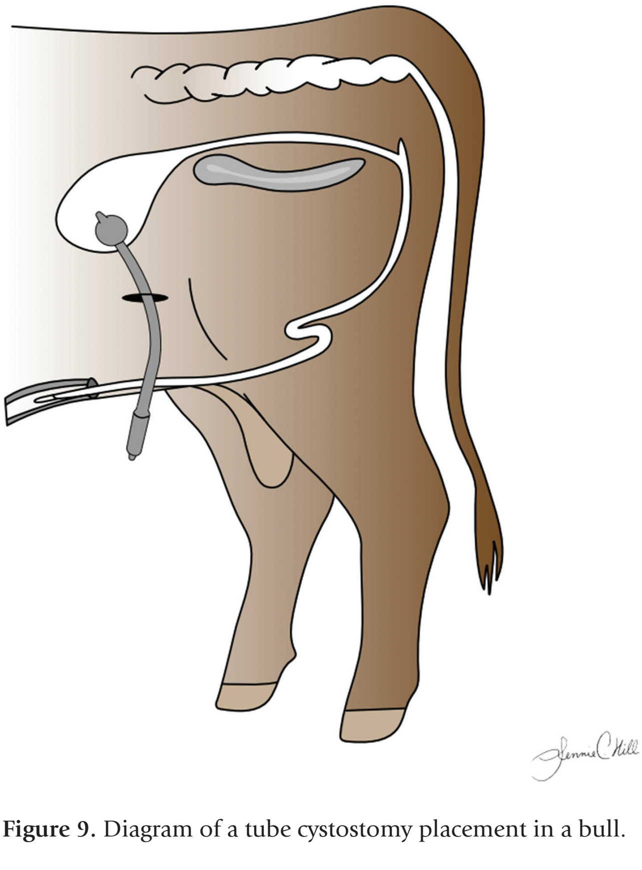

Figure 9. Diagram of a tube cystostomy placement in a bull.

Surgical considerations

The surgical procedure chosen is highly case specific with important consideration given to the systemic health of the patient. The success of a tube cystostomy procedure relies on establishing normal urine flow, which is only accomplished after passing of the obstructive stones. Oral urinary acidifying agents are used to break down phosphatic stones. If silica- or calcium-based calculi are suspected, other surgical techniques besides a tube cystostomy, for example, an ischial urethrostomy, should be considered.

Post-operative management

After surgery, all blood work abnormalities should be reassessed and corrected. Continued assessment of hydration status is necessary and mild diuresis is helpful to correct azotemia and prevent blood clot formation. Antimicrobial therapy is warranted to prevent urinary tract infections when an indwelling tube is present. Beta-lactams (penicillins and cephalosporins) are commonly chosen due to their good spectrum of activity and urinary excretion.[15] It is recommended to submit urine cultures for antimicrobial decisions since the most common bacteria present after Foley catheter placement are Aerococcus and Enterococcus and 42% of cultures were resistant to two or more antibiotics.[16] Currently, there are no approved antibiotics labeled for post-operative surgical procedures or for treatment of urinary tract infections in ruminants and regulations for extra-label drug use must be followed.

Prevention

It may not always be easy to pinpoint the causes of urolith formation. The most important preventative measure is always ready access to water. Maintenance of appropriate hydration will result in less concentrated urine, preventing supersaturation and crystallization. Increasing salt intake may increase water intake, producing more dilute urine. Provision of loose salt, rather than salt blocks, increases cattle intake.

Analysis of the diet, including minerals, may be useful to identify predisposing factors. A general guideline for prevention of phosphatic calculi is to maintain the calcium-to-phosphorus ratio at a level greater than 2:1.[4] This calcium-to-phosphorus

Figure 10. Placement of a Foley catheter after a tube cystostomy procedure in a bull.

ratio may be facilitated by decreasing the amount of grain fed. Prevention of silicate uroliths is difficult when pastures contain high levels of unpolymerized silicic acid. Management is dependent on adequate water intake. Prevention of calcium carbonate uroliths can potentially be accomplished by substituting grass hay for alfalfa.

Conclusion

When treating bulls for urolithiasis, an important consideration is maintenance of their breeding capacity by ensuring integrity of the urethra. Surgical and medical management are often combined to ensure the best prognosis and return to breeding service. Prevention of urolithiasis is based on free choice water availability, but other production techniques can be implemented depending on the type of offending stones. Familiarizing oneself with the diagnosis, pathophysiology, treatment, and prevention of urinary stones in breeding bulls is helpful for any practitioner.

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Conflict of interest

None to declare.

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