Elvis's Rock-a-Billy Goat Blues

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Introduction

Small ruminants are becoming increasingly popular as backyard pets; therefore, knowledge of their disease processes and appropriate management is more important than ever. Urolithiasis, or the formation of stones in the urinary tract, can lead to partial or complete urinary blockage. While urolithiasis is observed in both male and female small ruminants, obstructive urolithiasis in the caprine species most commonly occurs in male goats with wethers being most commonly affected.[6,8] Obstructive urolithiasis is the most common urinary tract disease affecting small ruminants and also has significant economic impact.[4,8] Many different factors contribute to urinary stone formation and obstruction including male urinary anatomy, diet, water consumption, and development of the urinary tract.[4,8] Clinicals signs of urolithiasis vary depending on severity and duration of blockage, but they commonly include lethargy, decreased appetite, posturing to urinate and anuria, stranguria, and tail flagging.[1,3,6] In these cases, ultrasonography is a useful tool in assessing the abdomen and urinary tract. Other important diagnostics include blood work to assess renal function, hydration, and electrolytes, as well as, urinalysis and abdominocentesis.[3,8] There are a vast number of surgical options including: tube cystotomy, urethrotomy, perineal urethrostomy, modified proximal perineal urethrostomy, and bladder marsupialization. Prognosis for obstructive urolithiasis in small ruminants is generally poor but varies depending on the duration of obstruction, treatment success, and future preventative management.[8]

History and Presentation

At the time of initial presentation on March 4, 2020, Elvis was a three-month old pygmy goat with a one-day history of stranguria and lethargy that did not resolve. Elvis was a pet goat kept in the back yard with one other goat. His diet consisted of free choice grain and a mineral

block, and Elvis had no history of illness prior to this event. During his initial physical examination, Elvis was quiet, alert, and responsive. He had a noticeably tense abdomen, arched back, and flagged tail. He would frequently posture to urinate and vocalize, but he never accomplished micturition. He weighed 10.5 kilograms (23 pounds 2 ounces) and had a normal body condition score. He was adequately hydrated with moist mucus membranes and a normal skin tent. He also had a capillary refill time of less than two seconds. He was tachycardic with a heart rate of 160 beats per minute and tachypneic with a respiratory rate of 64 breathes per minute. A rectal temperature was unable to be obtained. An initial work-up included a large animal complete blood count and a large animal chemistry panel. The complete blood count revealed a mildly elevated red blood cell count of $19.13x10^6$/ul (7.90 – 18.10). This relative erythrocytosis could be associated with subclinical dehydration. The large animal chemistry panel did not reveal any abnormalities including no electrolyte abnormalities. An abdominal ultrasound was also performed revealing an enlarged, globoid bladder with visible urinary crystals, but no measurements were recorded.

During his hospitalization in March of 2020, Elvis was diagnosed with obstructive urolithiasis that was initially treated with an emergency tube cystotomy on March 4, 2020. On March 23, 2020 (19 days post tube cystotomy surgery), Elvis's cystotomy tube was occluded, and he was closely monitored to evaluate his ability to urinate. Unfortunately, after 3 to 4 hours, Elvis would display signs of discomfort such as flagging his tail and vocalizing while posturing to urinate, and his cystotomy tube was unplugged to allow his bladder to empty. After multiple days of cystotomy tube challenges, Elvis was never able to produce a steady urine stream via his urethra. On March 28, 2020 (24 days after the initial surgery), Elvis was noted to have severe inguinal, scrotal, and preputial subcutaneous swelling and was diagnosed with a urethral rupture.

Elvis was once again placed under general anesthesia and a perineal urethrostomy was performed. He was also castrated at this time. He recovered from this surgery with no major complications and was discharged on April 18, 2020.

Approximately three months after the perineal urethrostomy surgery, Elvis represented for a two-day history of vocalizing while posturing to urinate on July 8, 2020. He weighed 14.5 kilograms (31 pounds 3 ounces) and had a body condition score of five out of nine. When posturing to urinate, only a small amount of urine was able to be excreted. His perineal urethrostomy site was small and difficult to visualize. He was adequately hydrated with moist mucus membranes and a normal skin tent. He also had a normal capillary refill time of less than two seconds. All of his vital parameters were within normal limits with a temperature of 102.6°F, pulse of 124 beats per minute, and respiratory rate of 44 breaths per minute. Ultrasound examination of the abdomen revealed an enlarged, globoid bladder measuring 5.0 x 6.0 centimeters. Bruxism was also observed indicating that he was in pain.

Diagnostic Approach

A complete history and physical examination are crucial tools for diagnosing urolithiasis as well as diagnostic imaging, hematologic analysis, urinalysis, and abdominocentesis.[6] The physical examination findings include anuria or stranguria, tense on abdominal palpation, and decreased rumen motility.[3,6] Tachycardia, tachypnea, bruxism, and vocalization while posturing to urinate are other signs of pain associated with complete urinary blockage. Affected animals commonly have a history of anorexia and signs of colic.[6,8] Crystals or blood and swelling may also be identified around the preputial area and preputial hairs.[8] Obstructive urolithiasis can also result in rupture of the urethra or bladder. Clinical signs consistent with urethral rupture include subcutaneous edema of the prepuce and ventral abdomen and perineum; whereas, clinical signs

associated with rupture of the bladder include abdominal wall distension, lack of stranguria, and acute pain reduction.[6,8] Diagnostic imaging including radiography, contrast radiography, and ultrasound have been used to diagnose obstructive urolithiasis. While contrast radiography can be used to locate uroliths within the urinary tract, one study found that it did not add any additional diagnostic value.[6] Ultrasonography of the abdominal cavity is one of the most practical and helpful modalities for diagnosing and determining the extent of urinary blockage. It is an efficient way to evaluate the size and contents of the bladder, assess the kidneys for hydronephrosis, and determine the presence of free abdominal fluid. In one study, the median diameter of bladder in unblocked adult rams was determined to be 7.5 centimeters, but the maximum bladder diameter in blocked sheep and blocked, non-pygmy goats was found to be 10.6 centimeters and 10.0 centimeters respectively.[6,10] The maximum size of the blocked pygmy goat bladder was found to only be 7.98 centimeters.[6] Ultrasound is reported to have a sensitivity of 96% and specificity of nearly 100% for uroliths greater than 5 millimeters, and in one study it was found to be diagnostically valuable in 84% of cases.[3,6]

Hematologic analysis is important for evaluation of electrolyte abnormalities, especially before the animal undergoes an anesthetic event. The most consistent bloodwork abnormalities in obstructive urolithiasis cases are elevated blood urea nitrogen and creatinine.[6] Hemoconcentration as a result of anorexia and dehydration is also common.[3] A stress leukogram with a neutrophilia and leukocytosis can also be seen.[3] Anorexia and urinary blockage also leads to electrolyte abnormalities including: hypochloremia in 52% of cases, hyponatremia in 43% of cases, hyperkalemia in 24% of cases, and hypokalemia in 26% of cases.[3,6] Due to these electrolyte imbalances, affected animals generally develop metabolic alkalosis, but metabolic acidosis has also been reported.[3] Urinalysis is useful in non-emergent cases to determine the

types of uroliths present, and alkaline urine is also most commonly seen on urinalysis of blocked goats.[6,7] Abdominocentesis can be of value in cases where bladder rupture is suspected. Abnormalities in creatinine, creatine kinase, and packed cell volume, as well as, hyperkalemia or hypocalcemia are associated with worsening case outcome due to their correlation with severity of disease.[7]

Pathophysiology

Obstructive urolithiasis in small ruminants is a complex, multifactorial process associated with well-known risk factors such as diet, urine pH, and hydration. Uroliths are solid crystalline structures composed of an organic nucleus made up of sugars, proteins, and cells surrounded by organic and inorganic crystalloids.[4] The formation of a urolith begins with the formation of a nidus. If conditions are right and the urine is concentrated, different salts precipitate and adhere to the nidus to complete the crystalline structure.[3] Minerals such as calcium, magnesium, and phosphate are deposited onto the initial urolith structure during the process to result in various characteristic uroliths.[4] The most common types of uroliths in small ruminants are magnesium ammonium phosphate (struvite), calcium phosphate (apatite), calcium carbonate, silica, and calcium oxylate.[3,4] Urine pH influences binding and availability of these minerals. Alkaline urine typically promotes formation of struvite, apatite, and calcium carbonate stones; whereas, formation of silicate and calcium oxalate uroliths is not greatly affected by urine pH.[4]

Other factors that contribute to the development of urolithiasis and complete blockage are the convoluted male anatomy of small ruminants and hormonal changes due to juvenile castration.[4,6,7,8] Male small ruminants have a sigmoid urethra that is curved. A common site for obstruction is called the sigmoid flexure which is made up of proximal and distal curve within their urethra.[4] The distal sigmoid flexure is the most common site of obstruction followed by the

urethral process. The urethral process or vermiform appendage, is a narrower portion of the distal urethra.[4] Testosterone is known to influence urethral development, so juvenile castration often results in a narrower urethra making complete obstruction more likely.[6]

Treatment and Prognosis

Both medical and surgical treatments have been used to manage urolithiasis in small ruminants, but the vast majority of obstructive urolithiasis cases must be initially managed with surgery to relieve the primary obstruction.[3,8] Recommended surgical treatment options vary depending on the intended use of the animal, financial situation, type of urolith, and location of the urolith.[8] There are a number of surgical options for treatment of obstructive urolithiasis. The most common methods include urethral process amputation, tube cystotomy, urethrotomy, perineal urethrostomy (PU), and more recently, and modified proximal perineal urethrostomy (MPPU). Bladder marsupialization is also an option in dire situations.

Urethral process amputation is performed by sedating the affected animal and exteriorizing the penis. Injecting 1% Lidocaine into the preputial orifice can provide analgesia for the procedure, and sedatives such as acepromazine (0.05-0.1m/kg IV or IM) or diazepam (0.1 mg/kg IV) can aid in muscle relaxation and penile exteroization.[5,8] Xylazine is not indicated due to its diuretic effects.[8] The glans penis is exteriorized and the urethral process is amputated at a 60° angle to insure a wide opening remains.[8] Urethral process amputation reportedly has a re-obstruction rate of 50-90% and only has the possibility of being successful if the obstructive urolith is within the urethral process.[1,8] Urethral process amputation is the least invasive surgical option, and therefore remains a viable first option in some cases.

Tube cystotomy is by far the most common surgical solution to obstructive urolithiasis because it preserves breeding ability, but it is also the most expensive. The animal must also be

placed under general anesthesia for this surgical procedure. Cystotomy tube placement is a sterile procedure that involves making a paramedian celiotomy incision, isolating the bladder, and placing a Foley catheter through a stab incision made in the bladder. Prior to Foley catheter placement, a cystotomy and normograde flushing of the urethra are performed to remove as many uroliths as possible and attempt to relieve any urethral obstruction. Once the uroliths are removed and the bladder is lavaged, the Foley catheter is placed though a separate stab incision to divert urine flow and allow the urethra time to heal.[1,2] Urine flow is generally re-established in approximately 11 days but can take longer in some cases.[2] This procedure also provides the opportunity to visualize the health of the bladder, flush the bladder and urethra, and place a normograde urethral catheter.[1] Reportedly, tube cystotomy procedures have a short-term success rate of 76-90% and long-term success rate of 86%.[2] Tube cystotomies can be coupled with a urethrotomy to remove uroliths obstructing the urethra; however, there is a greater risk for urethral stricture formation.[1]

Similar to the tube cystotomy, PU procedures typically require general anesthesia and sterility. The PU procedure is considered a salvage procedure and is reserved for non-breeding animals with urethral rupture, stricture, or complete obstruction.[2,5] PU is the technique of forming a permanent urethral stoma for the animal to urinate through. There are different techniques for PU surgeries including the high PU near the ischium and low PU near the scrotum. It is important for the PU stoma to be proximal to the obstructive urolith while still being as distal as possible because stricture of the urethrostomy site is the most common complication.[2,5] Reportedly the mean time of stricture is 65 days.[5] Other complications include hemorrhage, re-obstruction, infection, urine scald, cystitis, and death.[5] Even though these

complications exist, it can still be a viable treatment option to buy time with pets or get production animals to slaughter.[5]

Similar to other PU procedures, a modified proximal perineal urethrostomy (MPPU) is reserved for non-breeding animals and is a salvage procedure that comes with a higher risk of hemorrhage but lower risk of urethral stoma stricture.[9] Other complications such as urinary tract infections, urine scald, and re-obstruction are similar to other PU techniques. The MPPU procedure transects penile-pelvic attachments to reduce tension on the urethra and reduce the risk of urethral stricture. An incision is made at the level of the ischial tuberosities, and the penile body is identified via digital palpation and freed from surrounding tissues down to the level of the ischium.[9] It is important to identify the dorsal artery of the penis and retract it to mitigate the extent of hemorrhage. The penile body is then transected proximal the sigmoid flexure and distal to the pubis. If there is a preexisting PU site, the penile body is transected just proximal to the previous site.[9] The urethra is then localized caudodorsal to the remaining penile body stump and catheterized to the level of the urethral recess.[9] The remaining penile body attachments including the ischial attachments, ischiocavernosus muscles, and attachments on the ventrolateral aspect of the penile body are transected with a combination of blunt and sharp dissection.[9] Once all of the pelvic attachments are removed, the urethral catheter can then be advanced into the urinary bladder to assess patency.[9] The urethra is then spatulated and sutured to the perineal skin with absorbable monofilament suture to provide the largest urethra stoma and further reduce the risk of stricture.[9] The median follow-up time of goats that survived to discharge was 17 months.[9] With proper management of associated complications, MPPU provides a viable treatment option for recurrent obstructive urolithiasis.

A last resort surgical procedure known as bladder marsupialization can be used to get production animals to slaughter, but it is not commonly used in pet goats due to its complications. The apex of the bladder is marsupialized to the ventral abdominal wall and a stoma is created to allow urine to drain directly from the bladder.[2] This leads to urinary incontinence, and animals commonly suffer from urinary tract infections, urine scald, and bladder prolapse.[2] Because these complications are often severe and undesirable, this procedure is not a viable long-term solution.

Medical management should be considered in conjunction with surgical relief of obstruction. Medical management to consider includes oral ammonium chloride administration, intravenous fluid therapy, pain management, and antimicrobials. Intravenous fluid therapy varies with each case and degree of dehydration and electrolyte derangement. Because affected animals are typically metabolically alkalotic, hyponatremic and hypochloremic, 0.9% NaCl is a common choice, but acid-base deficits should always be evaluated and considered.[2] After resolution of urolith obstruction, oral ammonium chloride administration (50 to 200 mg/kg) is recommended to acidify the urine and reduce the risk of further urolith formation.[2,9] A urine pH of 5.5 to 6.5 is the goal to dissolve remaining uroliths and to decrease the risk of further urolith formation.[2] Some animals can be sensitive to oral ammonium chloride, so it is important to assess urine pH daily and tailor the oral the dose to prevent metabolic acidosis. Nonsteroidal anti-inflammatories are useful to reduce inflammation and lower the risk of urethral stricture formation, but they should only be used in animals that are properly hydrated with adequate kidney function.[2] Broad-spectrum antimicrobials are indicated in the majority of cases during the tissue healing phase and while the Foley catheter is in place. [2]

Prevention

While there are a vast number of surgical treatments for obstructive urolithiasis, the primary cause of urolithiasis must be identified and resolved in order to prevent further obstruction. Providing a proper balanced diet, increasing water intake, and delaying castration are practical management strategies to implement and reduce urolith formation. High roughage low grain diets consisting of timothy or BGH are recommended to provide a proper calcium to phosphorus ratio of 2:1. Also, magnesium should not be more than 0.6% of the total ration because altering mineral ratios increases the risk of urolith formation.[2,3,8] High grain diets are associated with struvite and apatite stones, whereas; legume diets are associated with calcium carbonate stones. Because of this, improperly balanced grain diets and alfalfa hay should be avoided. Silicate and calcium oxalate stones are associated with grazing plants high in silicate and calcium oxalate respectively.

Increasing water intake is also important part of prevention because dehydration leads to super saturation of the urine making precipitation of urolith minerals more readily available.[4] To encourage water consumption, salts can be increased up to 4 percent of the overall diet.[3] Ammonium chloride that is commonly used to acidify the urine, can also be used to encourage water intake. Clean, fresh water should be supplied year-round at all times, and in the winter, it is especially important to ensure that the water supply is not frozen. Castration should also be delayed until after puberty, which occurs around 4 to 6 months of age, to allow the urethra time to develop fully.

Case Outcome

Because Elvis is kept as a pet, all efforts were taken by the owners to improve his quality of life. As previously mentioned, his initial presentation of obstructive urolithiasis was treated with an emergency tube cystotomy on March 4, 2020. He was pre-operatively treated with

procaine penicillin G (PPG) and flunixin meglumine. For this procedure, Elvis was placed under general anesthesia and a paramedian approach was taken to enter the abdomen. A cystotomy was performed and multiple presumptive struvite stones were removed from the bladder. A normograde urinary catheter was then placed to determine if urethral patency was present, but urethral patency could not be established. Finally, a Foley catheter was placed through a separate stab incision in the bladder and left abdominal wall to allow time for dissolution of urethral stones and urethral healing. Post-operatively, Elvis was managed with PPG (44,000 IU/kg SQ every 24 hours), ammonium chloride (50 mg/kg PO every 24 hours), Meloxicam (0.75mg/kg PO every 24 hours), and butorphanol (0.05 mg/kg IV as needed). His urine pH was routinely assessed daily, and he was maintained on Bermuda grass and timothy hay. He was offered Gatorade water and 2% of his dry matter intake consisted of salt to encourage water intake. His Foley catheter was monitored hourly to assess patency, and he was monitored for stranguria. His urine pH was maintained within the target range of 5.5-6.5 by adjusting his oral ammonium chloride dose accordingly. Twenty-one days after the emergency cystotomy, his cystotomy tube was occluded, and he was challenged to urinate through his urethra. Unfortunately, Elvis was never able to establish complete urethral patency, and his urethra ruptured on March 28, 2020.

Elvis then underwent a low PU surgery to create a new urethral stoma at the level of the distal sigmoid flexure on April 1, 2020. He was also castrated, and a scrotal ablation was performed at this time. Oxytetracycline (20mg/kg SQ every 72 hours) was also added to his treatment plan. During the low PU procedure, a urinary catheter was placed, and urethral patency was established. After 9 days, the urinary catheter was removed, and he continued to urinate appropriately. His cystotomy tube remained in place from his original surgery until he was able

to be challenged and maintain urethral patency through the PU surgical site. It was pulled on April 14, 2020 without complication, and he was discharged on April 18, 2020.

Elvis's case was textbook in that he experienced typical complications associated with the PU procedure. In June of 2020, he was treated for a urinary tract infection, and approximately 90 days after his procedure, his PU site began to stricture. On July 9, he underwent a MPPU procedure as previously described, and he recovered from anesthesia uneventfully. He was managed with flunixin meglumine (1mg/kg IV every 24 hours) and ceftiofur hydrochloride (2.2 mg/kg SQ every 24 hours for 3 days). He was then switched to Meloxicam (1mg/kg PO every 24 hours) for pain management 24 hours after the procedure, and he was closely monitored similar to his previous surgery. He was then discharged on July 14, 2020 and has had no further complications since.

Conclusion

Obstructive urolithiasis is a costly disease that commonly affects male small ruminants. Important diagnostics include a thorough physical examination, baseline blood work, and ultrasonography in order to assess the severity of disease on presentation. To select the most appropriate treatment for each case, the intended use of the animal, economic impact, urolith type, and urolith location must be considered. Tube cystotomy is the most common and most viable long-term treatment option, and salvage procedures such as PU, MPPU, and bladder marsupialization should only be considered under certain circumstances. Overall, the long-term prognosis is generally poor for obstructive urolithiasis due to the risk of re-obstruction; therefore, preventative management of obstructive urolithiasis rather than treatment should be the primary goal.[2]

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