Modified tube cystostomy technique for management of obstructive urolithiasis in small ruminants: procedure and outcome in 17 sheep and goats

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OBJECTIVE
To describe the surgical technique and clinical outcome of small ruminants treated for obstructive urolithiasis using a modified tube cystostomy (MTC) technique.

ANIMALS
15 goats and 2 sheep treated with an MTC between March 2018 and February 2023.

CLINICAL PRESENTATION
Animals were diagnosed with obstructive urolithiasis on the basis of history, physical examination, and ultrasonographic examination. An MTC was performed with sedation and a local block. Postoperative medical management was instituted to help reestablish urethral patency, and Foley catheters were removed after successful urination.

RESULTS
Animals were hospitalized an average of 3 nights (range, 0 to 14 nights). Complications included urine spillage in the abdomen and accidental deflation of the Foley balloon. Six animals were euthanized due to poor prognosis or failure to regain urethral patency. Foley catheters were removed an average of 15.7 days postoperatively in animals that regained urethral patency. Long-term (>1-month) follow-up was available for 8 animals, with an average postoperative survival time of 19.4 months (range, 1 to 58 months). Four animals were lost to long-term follow-up.

CLINICAL RELEVANCE
This MTC technique is an effective means of catheterizing the urinary bladder in small ruminants. It can be performed under field conditions and serve as a standalone procedure for providing temporary urine egress. Patient size is limited by the length of the introducer, and an intact, distended urinary bladder and plan for reestablishing urethral patency are important considerations.

Keywords: urolithiasis, ruminant, urinary, cystostomy, obstruction

Obstructive urolithiasis is a commonly encountered emergency condition of small ruminants. Treatment outcome is unpredictable, and temporary tube cystostomy under general anesthesia is prohibitively expensive and unavailable in many isolated rural settings. Field treatment of obstructive urolithiasis is frequently limited to urethral process amputation and medical therapy. Limited on-farm treatment options and the high cost of surgical interventions with unpredictable success are factors that force some owners to elect humane euthanasia for their animal.

Percutaneous transabdominal urinary bladder catheterization has been described as a more cost-effective but temporary alternative to traditional surgical tube cystostomy. A few reports describe using a variety of catheters with small lumen diameters and a curved or expandable end to keep the catheter within the urinary bladder. Given the propensity for these catheters to become clogged or dislodged, their utility is limited to short-term patient stabilization prior to a second procedure such as a surgical tube cystostomy under general anesthesia. A slightly different percutaneous approach using a Foley catheter and sharpened metal trocar has also been described, but the trocar had to be left sutured to the animal’s side until...
the Foley could be deflated and removed from the urinary bladder.²

A minimally invasive tube cystostomy technique for goats has been reported.³ The authors describe making a keyhole incision in the left flank and using a sharpened metal trocar as a conduit to insert a length of fenestrated infusion set tubing in the urinary bladder with the goat either standing or in right lateral recumbency. While this procedure had a short surgical time, was done without general anesthesia, and did not require hospitalization, replicating the procedure is limited by access to a similar custom-made trocar. Additionally, all the animals were small lambs or kids, whereas many of the small ruminants with obstructive urolithiasis in the US are older, overconditioned pets or show animals, making accessing the urinary bladder more challenging in a standing animal. The authors’ personal experience with this procedure has resulted in complications associated with the tubing becoming clogged or dislodged from the urinary bladder because there is no balloon or pigtail to maintain the end of the catheter within the bladder lumen.

A tube cystostomy technique that can be performed under field conditions with sedation and local anesthesia using readily available inexpensive materials that can provide short-term urine egress while urethral patency is restored could benefit small ruminant producers and veterinarians. The objectives of this retrospective case series were to describe a modified tube cystostomy (MTC) procedure for small ruminants with an intact and distended urinary bladder using a commercially available introducer (Supra-Foley suprapubic catheter introducer 16F; Utah Medical Products Inc) and report short- and long-term outcomes and complications associated with the procedure.

**Methods**

The electronic medical records were searched by species (sheep or goat), diagnosis (obstructive urolithiasis), and procedure (tube cystostomy) to identify small ruminants that underwent MTC for treatment of obstructive urolithiasis at Colorado State University, Kansas State University, and the University of Missouri between March 2018 and March 2023. The medical records of all small ruminants that met the search criteria were reviewed to identify those that underwent an MTC and the following information recorded: signalment, weight, body condition (thin, average, or obese), duration of clinical signs prior to admission, preoperative diagnostics, urine pH, and urolith type, if known. Details of the surgical procedure including sedation and anesthesia, intraoperative complications, and postoperative medications and management were recorded. The number of days the Foley catheter was in place and postoperative complications were also recorded. Short-term follow-up information was obtained from the record, and longer-term follow-up was obtained by telephone conversation with owners. IACUC approval was not necessary for this investigation because all animals were diagnosed and treated as clinical patients with owner consent to treat. This was a retrospective analysis of clinical cases and not a prospective study of a clinical procedure.

**Statistical methods**

Because some records were incomplete, the number of observations did not always equal the total number of animals in the study. The results of clinical treatment and follow-up data are reported using descriptive statistics. Numeric data is reported as average and range (minimum to maximum).

**Surgical procedure**

All animals were sedated with a combination of IV butorphanol (0.1 to 0.5 mg/kg), midazolam (0.2 mg/kg), ± ketamine (2 to 4 mg/kg). Two animals were also administered isoflurane via a mask when the degree of sedation was inadequate with injectable anesthesia alone. A lumbosacral epidural using 2% lidocaine at 1 ml/7 kg of body weight was administered in 12 animals to provide loss of sensation and motor function from the flank caudally. A line block of the left flank was administered in 5 animals to achieve anesthesia of the left flank when adequate regional anesthesia to the left flank was not achieved with an epidural.

For the surgical procedure, the animal was placed in right lateral recumbency and the left flank was clipped and aseptically prepared. A 3- to 7-cm incision large enough to accommodate the surgeon’s first 2 fingers was made through the body wall in the caudoventral portion of the left paralumbar fossa roughly equidistant from the flank fold and the last rib and 2 to 5 cm ventral to the transverse processes depending on patient size. The distended urinary bladder was directly palpated by inserting 2 fingers in the caudal abdomen and feeling for a smooth, taught, balloon-like viscus. Using a fingertip to guard the pointed tip of the catheter introducer from a suprapubic Foley catheter kit (Supra-Foley suprapubic catheter introducer 16F; Utah Medical Products Inc), the introducer was guided through the incision to the dorsolateral aspect of the distended urinary bladder (Figure 1). When the tip of the introducer was positioned directly over the urinary bladder without any viscus or omentum between the bladder wall and the tip of the introducer, the introducer was inserted into the urinary bladder. The stylet was then removed from the introducer and the end of the introducer sleeve immediately covered with a finger to prevent urine from forcefully escaping, causing the urinary bladder to deflate prior to placing the Foley catheter. An appropriately sized Foley catheter (the catheter must be 1 size smaller than the introducer) that had previously been confirmed to slide smoothly down the introducer sleeve before beginning the procedure was quickly threaded down the introducer sleeve, and the Foley balloon was inflated using the recommended volume of sterile saline to fill the balloon. Some urine invariably escaped into the abdomen during the process of uncovering the introducer sleeve end to thread the Foley catheter into the urinary bladder. The introducer sleeve was...
then withdrawn from the abdomen and, according to the manufacturer’s instructions, split lengthwise by pulling the tab to slide it off of the Foley catheter. To confirm the Foley catheter was inflated within the urinary bladder, gentle traction was placed on the catheter and the inflated balloon palpated within the urinary bladder. Urine was also observed flowing from the free end of the Foley catheter. The body wall was closed with the Foley catheter exiting the ventral aspect of the incision using a standard 3-layer body wall closure for the muscle layers and skin. The Foley catheter was secured to the skin using a finger-trap suture as it exited the body, and a Heimlich valve (Heimlich style one-way valve; Jorgensen Laboratories) or a glove finger with a small slit in the fingertip was taped over the dripping end of the Foley to act as a 1-way valve (Figure 2).

Postoperative care
After recovering from sedation, the goats were fitted with a plastic Elizabethan collar to prevent chewing or biting of the Foley catheter as it exited the body wall. The sheep were not fitted with Elizabethan collars. All animals received systemic antimicrobial therapy with a β-lactam and anti-inflammatory therapy with either meloxicam PO or flunixin meglumine IV. The duration of antimicrobial therapy varied by case but in all animals provided coverage while the Foley catheter was in place and the animals were at increased risk of bacterial infection. Urine acidification with orally administered ammonium chloride was instituted for cases in which the uroliths were known (by dissolving one or more of the uroliths collected from the patient in a solution with a pH of 4.5 to 5) or suspected to dissolve in acidic urine. Patients were hospitalized when the animal required more intensive medical management or owners elected to have their animal monitored at a veterinary clinic rather than monitor them at home. Owners of discharged animals received instruction to confine their animal to a small enclosure with a diet of grass hay and water only and to closely monitor the animal to ensure that the Foley catheter remained patent with urine regularly dripping from the valve. Owners were instructed that their animal was to be isolated and the Foley catheter left in place while the animals were treated medically to help reestablish urethral patency using ammonium chloride when urine acidification was indicated and anti-inflammatories to reduce urethral inflammation. Once the animals were observed passing a normal stream of urine from the prepuce, owners were instructed to either bring the animal to the clinic for a urethral challenge or given instructions on how to do so at home. For the urethral challenge, the Foley catheter was occluded for 24 to 48 hours and the animal closely observed for any signs of straining or reobstruction. After successfully voiding urine during the 24- to 48-hour urethral challenge period, the Foley catheter was removed by cutting the skin sutures, deflating the balloon, and gently pulling the end of the Foley out through the body wall. The small skin opening was left to heal by second intention.

Results
Seventeen small ruminants, 2 sheep and 15 goats, underwent MTC during the study period.
There were 12 wethers and 5 intact males. The average age was 23.9 months (range, 2.5 to 84 months), and the average weight was 38.5 kg (range, 6.6 to 105 kg). Of the 15 goats, the breeds represented included Nigerian Dwarf (n = 9), Boer (4), Alpine (1), and crossbred (1). The sheep breeds were Icelandic (n = 1) and Rambouillet (1).

**History and examination**

The duration of clinical signs prior to presentation was < 1 day for 11 animals and an average of 2.2 days (range, 1 to 7 days) for the other 6 animals. An intact and distended urinary bladder was identified via transabdominal ultrasonographic examination and reported in 14 animals. The average diameter of the urinary bladder was 8.6 cm (range, 6 to 13 cm). One sheep was treated on farm and did not undergo any preoperative imaging. The other 16 animals were diagnosed and treated in a veterinary teaching hospital and underwent a variety of diagnostic testing prior to surgery. These included abdominal radiographs (n = 5), point-of-care blood lactate (Lactate Plus; Nova Biomedical; 3), PCV/total protein (5), point-of-care venous blood gas (iSTAT CHEM8+; Abbott Point of Care Diagnostics; 7), serum chemistry (7), and CBC (3). Radiographs revealed mineral opacities consistent with uroliths in the urethral process or distal urethra in 2 goats and proximal to the sigmoid flexure in 1 goat. One goat with a history of calcium carbonate–type stones underwent a retrograde urethral flush using a polypropylene catheter and retropulsion to flush any uroliths into the urinary bladder. The penis was exteriorized, and the urethral process amputated in all cases prior to surgery.

In addition to a small amount of urine spillage into the abdomen that occurred in every case, complications were encountered during surgery in 3 cases. In 1 case, the Foley balloon was accidently deflated when the syringe was not removed after inflating the balloon with saline. The urinary bladder could not be palpated in 1 goat, and in the case of the Icelandic sheep, a large volume of urine escaped into the abdomen due to difficulty threading the Foley down the introducer sleeve because the end of the introducer was obscured by excessive adipose tissue.

The animals were hospitalized for an average of 3 nights (range, 0 to 14 nights), with 6 animals being discharged without hospitalization. All animals received systemic antimicrobial therapy with a β-lactam and anti-inflammatory therapy with either meloxicam PO or flunixin meglumine IV. Eleven animals received IV fluid therapy due to severe dehydration and electrolyte imbalances. Ammonium chloride was administered PO in 13 of 17 animals. Four animals were not treated with ammonium chloride because they were suspected of having calcium carbonate uroliths on the basis of history, appearance, and inability to dissolve sample calculi in an acidic solution.

Urine pH was measured using urine dipsticks and reported in 11 of 17 animals, with an average value of 8.0 (range, 6 to 9). Uroliths from 5 animals were analyzed at the Minnesota Urolith Institute. Four of the analyzed stones were identified as calcium carbonate and 1 as silica. Uroliths could not be recovered in 1 goat. Eight animals had uroliths suspected to be struvite on the basis of dietary history, visual appearance (Figure 3), and dissolution when placed in an acidic solution with a pH of 4.5 overnight. One goat had uroliths suspected of being calcium carbonate on the basis of visual appearance, but this was not confirmed by analysis.

Five animals experienced postoperative complications associated with the procedure. Two goats were painful and hypoxic in the immediate postoperative period, 1 goat’s tube became clogged with blood clots that were successfully cleared with saline lavage, azotemia recurred in 1 sheep (but spontaneously resolved), and 1 goat exhibited straining due to a suspected cystitis 4 days postoperatively and was successfully treated with urinary bladder lavage using a dilute vinegar solution.

Eleven animals regained urethral patency and had the Foley catheter removed. The Foley catheter was removed an average of 15.7 days (range, 8 to 30 days) after surgery. The Foley catheter was removed prematurely (prior to a 24-hour challenge period demonstrating normal urination) in 2 goats, but they were able to urinate normally and did not require any additional treatments. In these cases, 1 goat chewed the end of his Foley catheter at an unknown point after being discharged so the catheter was removed 14 days postoperatively and the other goat had his Foley catheter inadvertently removed by chickens 12 days postoperatively. Of the 11 animals that regained urethral patency and had the Foley catheter removed, all survived at least 30 days postoperatively.

Six animals were humanely euthanized prior to regaining urethral patency. One animal was euthanized the day of surgery after receiving a guarded prognosis.
when suspected calcium carbonate stones that were unlikely to dissolve with urine acidification were identified in the penile urethra. A show wether was euthanized 3 days after discharge when his pain could not be managed at home without medication that would have extended the meat withdrawal beyond his intended exhibition date. Two goats were humanely euthanized with the Foley catheter still in place 7 days and 2 months postoperatively because they did not regain urethral patency. The decision to euthanize the goat only 7 days after surgery was based on poor prognosis and owner financial constraints. The Icelandic ram was euthanized prior to discharge from the hospital when he reobstructed 3 days after removal of his Foley catheter. On necropsy, he was found to have a necrotic defect in the urethra.

Long-term (> 1-month) follow-up was available for 8 animals. Four animals were lost to long-term follow-up when the owners could not be contacted via telephone. One goat was euthanized 7 months after being discharged due to reobstruction. Seven animals were still alive at the time of follow-up with an average time from surgery to follow-up of 19.4 months (range, 1 to 58 months).

Discussion

Restoring ability to urinate normally is critical to short- and long-term survival in small ruminants with obstructive urolithiasis. In this study, urethral patency with normal urination was restored in 64.7% (11/17) of cases. Other authors have reported a similar 76% success in restoring normal urination following surgical tube cystostomy in small ruminants. Because the MTC technique does not provide an opportunity to directly remove calculi from the urinary bladder or for normograde urethral flushing at the time of surgery, case selection is critical. Establishing urethral patency prior to surgery with retrograde urethral catheterization and flushing, radiographs, and selecting cases in which dietary history and gross (Figure 3) or radiographic appearance of calculi make urine acidification likely to restore normal urination are important factors when considering this modified approach. It is important to note the limitations of this procedure compared to a traditional tube cystostomy. The MTC provides a less expensive (a traditional surgical tube cystostomy under general anesthesia and patient hospitalization is generally 3 to 5 times more expensive than an MTC at the participating institutions) and less invasive option for cases in which owner finances or facilities are limited and is not intended to replace surgical tube cystostomy under general anesthesia as the gold standard. In the study reported here, 1 goat was euthanized when calcium carbonate-type stones were identified because the likelihood of restoring urethral patency was considered low and the animal was given a guarded prognosis for survival. It should be noted that radiographs are recommended for situations in which calcium carbonate-type uroliths are identified or suspected to identify the location and number of uroliths and provide the most accurate prognosis.

Another goat with a history of calcium carbonate-type uroliths underwent a retrograde urethral flush using a polypropylene catheter, during which a urolith was retropulsed into the urinary bladder (confirmed radiographically) prior to surgery. Smaller calculi within the urinary bladder can pass through the Foley catheter, but larger uroliths that remain may result in reobstruction of the urethra.

Reobstruction of the urethra following tube cystostomy is a commonly reported complication. In the cases reported here, 1 sheep and 1 goat reobstructed after normal urination was restored and the Foley catheter was removed. The larger lumen diameter and balloon of the Foley catheter likely helps decrease the incidence of complications such as dislodgement, clogging, or loss of patency, with only 1 of 17 Foley catheters becoming obstructed by blood clots compared to 19 of 84 goats experiencing complications with transabdominal catheter placement using a different catheter. One complication that could have been avoided was the large amount of urine that spilled into the abdomen during placement of the Foley catheter in the Icelandic sheep. In hindsight, this animal was too large at 105 kg with a body condition score of 9/9 to be a good candidate for the MTC procedure. No attempt was made to suction the urine or lavage the abdomen in this animal or any of the others with less urine contamination. While the Foley catheter was successfully inserted into the urinary bladder and there was no pathology associated with the urine contamination of the abdomen when the animal was later necropsied following reobstruction, this animal was larger than optimal for this modified technique. The largest patient in which the urinary bladder was easily accessed with this technique was 70 kg.

Unlike transabdominal urinary bladder catheterization that is suitable for short periods of only a few days and requires a second follow-up surgery, the Foley catheters in this modified procedure stayed in place for an average of 15.7 days. This is similar to what is reported for traditional surgical tube cystostomy. In the cases reported here, only 2 tubes were accidentally removed prematurely. In both cases, one that was chewed by the patient and the other that was removed by chickens, accidental tube removal could have been avoided with better patient management at home.

Surgical time can also be reduced using less invasive procedures. Surgery time is an important consideration, especially when performing surgery in suboptimal field conditions, since reducing surgical duration is a well-established method of reducing the risk of surgical site infection. Fazili et al reported surgery times of 9.7 to 18 minutes using a specialized trocar in a minimally invasive tube cystostomy procedure. Although surgery times were not available for all of the cases in the current report, injectable sedation protocols did not need to be re-administered in any of the patients, indicating the general brevity of the MTC procedure described here. It should be noted that the animals in this report were sedated without fasting or control of the airway.
via endotracheal intubation, and owners should be made aware of the risk for aspiration and associated complications. Laparoscopic-assisted cystotomy has been described in normal sheep, and urethral urolith removal via cystoscopy has been described in a pig. Laparoscopy may be another method of minimally invasive resolution of obstructive urolithiasis in small ruminants but would require use of expensive and specialized equipment and would not be easily performed in a field setting.

Unfortunately, survival following tube cystostomy in small ruminants is unpredictable, with reported short- and long-term mortality rates varying. While short-term survival to discharge following temporary tube cystostomy has been reported to be as high as 100%, the long-term mortality rate for goats in that report was 48.4%. Fortier et al. reported that 52% of small ruminants undergoing surgical tube cystostomy survived to discharge. The cornerstone tube cystostomy description by Rakestraw et al. reported that tube cystostomy was successful in restoring urethral patency in 80% of small ruminants, and 70% of animals for which follow-up information was available were alive with no recurrence of urinary obstruction at least 1 month after discharge. In another report of small ruminants, 78% had normal urination by the time of discharge following tube cystostomy and 16% did not survive to discharge because they either died or were euthanized for failure to urinate.

In the study reported here, 35% (6/17) of animals were euthanized for reasons associated with the urinary system. Given the variable survival rates for small ruminants treated with traditional surgical tube cystostomy, it can be difficult for owners and producers to justify investing a large amount of money in surgery and hospitalization. Because the modified procedure reported here is done through a small flank incision without the need for general anesthesia, the cost of the procedure is much lower than a traditional surgical tube cystostomy. Additionally, because all the supplies needed for the procedure, including the commercially available catheter introducer, are readily available, inexpensive, and portable, this procedure can easily be replicated and implemented in a clinic or field setting. One of the cases reported here was treated on farm in a covered shed, and 6 animals were discharged the same day to be treated and monitored at home. Animals treated on farm instead of a veterinary clinic are at increased risk of surgical infection, and every attempt should be made to optimize cleanliness of the procedure through adequate patient restraint and selection of a relatively clean and dry location. It is important to provide strict instructions for proper management at home including monitoring appropriate analgesia and pain monitoring, isolating the animal away from other goats or animals that might chew the Foley catheter, and monitoring daily for any signs of stranguria that could indicate the tube has become obstructed or dislodged.

Two points should be highlighted regarding the MTC procedure itself. First, the dorsolateral insertion point on the urinary bladder is important to help minimize urine leakage into the abdomen, as would more likely occur with a more dependent insertion point. Unlike a surgical tube cystostomy procedure in which a purse-string suture is placed around the Foley as it enters the ventral aspect of the urinary bladder and the inflated Foley balloon is drawn to the body to form a seal and prevent urine leakage into the abdomen when the Foley is removed, the modified procedure relies on the extremely sharp, acutely angled point of the introducer to make a small hole in the bladder wall that will heal by second intention after the Foley is removed. It should also be noted that because of this dorsal insertion and lack of purse-string suture in the urinary bladder wall, saline lavage or agitation of the bladder to increase yield of cystoliths was not attempted because of the risk for contamination of the abdomen. Second, the procedure requires that the urinary bladder be sufficiently distended with urine to be palpated and pierced blindly via the flank incision. A flaccid urinary bladder wall cannot easily be distinguished from surrounding viscera, and one would risk accidentally stabbing through the far wall of the bladder if the lumen were collapsed.

In conclusion, the MTC technique reported here describes a potentially useful treatment option for managing obstructive urolithiasis in small ruminants, particularly in cases with limited financial resources or being treated in field conditions. The procedure is technically simple, requires only easily obtained materials, and because it can be done with sedation and local block it offers a field treatment option for rural and ambulatory practitioners. Case selection focused on appropriate patient size, presence of an intact and distended urinary bladder, and a plan for reestablishing urethral patency is critical. Similar to other tube cystostomy procedures, treatment success hinges on a multitude of often unpredictable factors, but with thoughtful application, this MTC procedure can provide an accessible alternative to surgical tube cystostomy for small ruminants.

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