Vesicopreputial anastomosis for the treatment of obstructive urolithiasis in goats

Elizabeth Erin Cypher | Sarel R. van Amstel | Ricardo Videla | Kyle Force Clark | David E. Anderson

Abstract

Objective: To describe a novel surgical technique for the correction of recurrent obstructive urolithiasis in male goats.

Study Design: Clinical case series.

Animals: Castrated male goats (n = 4).

Methods: Medical records of male goats having undergone vesicopreputial anastomosis (VPA) as a treatment for obstructive urolithiasis were reviewed for history, signalment, clinical signs, and intraoperative and postoperative complications. Long-term follow-up (≥12 months) was obtained by telephone interview with owners or by clinical examination.

Results: All goats had undergone at least one surgical procedure (median, 2.5, range 2-4) to correct obstructive urolithiasis before undergoing VPA. Postoperative complications included premature removal of the tube from the bladder (1 goat), bacterial cystitis (2), and abscess formation (1). One goat suffered stricture of the anastomosis site 3 months following the original procedure and underwent a second VPA and 1 goat died 7 months after surgery due to severe, acute hydronephrosis and renal failure. Long-term survival ≥12 months was good with 3/4 goats (75%) or 3/5 VPA procedures (60%) having unobstructed urine flow at 12 months.

Conclusion: Vesicopreputial anastomosis is a feasible surgical procedure for the correction of recurrent obstructive urolithiasis in male goats and one that can result in a favorable clinical outcome. Further investigation in a larger population of goats is warranted for the evaluation of the suitability of VPA in male goats with obstructive urolithiasis.

1 | INTRODUCTION

Obstructive urolithiasis is an important urinary tract disease of male ruminants, and one that is inevitably fatal without medical or surgical intervention.1-4 Surgically correction of urethral obstruction caused by uroliths has been reported in a variety of ruminant species, including sheep,1,2 goats,1-9 cattle,10,11 elk,12 buffalo,13 and New World camelids.14 Although the reported short-term survival for small ruminants following surgical correction is reportedly high (76%-90%),1,2 long-term prognosis remains guarded.1,5,9 Re-obstruction remains the most frequent life-threatening long-term complication15 and is reported to occur in up to 90% of small ruminants treated by amputation of the veriform appendage alone.3,15 In another study, as many as 52% of goats treated by tube cystostomy required a second surgical procedure prior to being discharged from the hospital.5 Medical management of obstructive urolithiasis in small ruminants is often unsuccessful.5

Current surgical options for correction of obstructive urolithiasis include perineal urethrostomy,16,17 modified proximal perineal urethrostomy (MPPU),18 tube cystostomy,1,4,16,17 minimally invasive tube cystostomy,1 percutaneous tube

Cystostomy,19 and urinary bladder marsupialization either by laparotomy or laparoscopy.20–22 Urethral patency also has been restored by laser lithotripsy (Ho:YAG).23 Of these techniques, only tube cystostomy, urinary bladder marsupialization, and MPPU are associated with a likelihood of long-term success.3,18 Even so, in 2 separate studies evaluating tube cystostomy in small ruminants for treatment of obstructive urolithiasis, 16%-28% of cases were ultimately euthanatized for either recurrence of urethral obstruction or associated complications.6,15 In the one report on MPPU, 82% of goats remained unobstructed at 12 months. Although the long-term success rate was good, the high level of technical difficulty and surgical skill required and the intraoperative complications, including severe hemorrhage, need to be considered when using this technique.18 While long-term success of urinary bladder marsupialization is reportedly good,82% of goats remained unobstructed at 12 months. Although the long-term success rate was good, the high level of technical difficulty and surgical skill required and the intraoperative complications, including severe hemorrhage, need to be considered when using this technique.18 While long-term success of urinary bladder marsupialization is reportedly good, the high level of technical difficulty and surgical skill required and the intraoperative complications, including severe hemorrhage, need to be considered when using this technique.18 While long-term success of urinary bladder marsupialization is reportedly good, the high level of technical difficulty and surgical skill required and the intraoperative complications, including severe hemorrhage, need to be considered when using this technique.18

As small ruminants have increased in popularity as pets, surgical techniques to restore the unimpeded flow of urine have shifted from those performed to salvage the animal toward those that provide longer-term survival and a lower incidence of morbidity. The choice of surgical technique can therefore be problematic in male goats presenting with recurrent obstructive urolithiasis, or if the goat has already undergone an unsuccessful surgical procedure. The purpose of this report is to describe a novel surgical technique for the correction of obstructive urolithiasis in male goats, which can be performed following a previous surgical procedure, as well as report the associated perioperative complications and long-term outcomes of goats undergoing this procedure.

2 | MATERIALS AND METHODS

2.1 | Case selection

Medical records for male goats undergoing vesicourethral anastomosis (VPA) for surgical treatment for obstructive urolithiasis (September 2014–October 2015) were reviewed. Only goats unable to void urine normally on presentation and that had previously undergone at least 1 surgical procedure for obstructive urolithiasis and that received a VPA were included in the study. Data retrieved included signalment, previous surgical procedure(s) to resolve urolithiasis, clinical signs, results of hematologic and serum biochemical analyses, intraoperative and postoperative complications, duration of hospitalization, stone analysis when available, and outcomes. Long-term follow-up was obtained by clinical examination or by phone communication with the owner.

2.2 | Preoperative preparation

Goats were administered flunixin meglumine (1.1 mg/kg IV) and ceftiofur sodium (2.2 mg/kg IV) through a jugular catheter. Anesthesia was maintained with isoflurane vaporized in oxygen delivered through an endotracheal tube and with a continuous rate infusion of 2% lidocaine HCl (loading dose 2 mg/kg IV; maintenance rate 6 mg/kg/h IV) and ketamine HCl (3 mg/kg/h IV). All goats received morphine sulfate administered either IV (0.1 mg/kg) or into the caudal aspect of the epidural space (0.1 mg/kg).

2.3 | Surgical procedure

Following induction of general anesthesia, the goat was positioned in dorsal recumbency, the ventral aspect of the abdomen clipped, and the surgical field prepared for aseptic surgery using a 2% chlorhexidine scrub and sterile saline solution. Aseptic preparation included lavage of the preputial cavity with dilute (0.1%) chlorhexidine solution in saline. As small ruminants have increased in popularity as pets, surgical techniques to restore the unimpeded flow of urine have shifted from those performed to salvage the animal toward those that provide longer-term survival and a lower incidence of morbidity. The choice of surgical technique can therefore be problematic in male goats presenting with recurrent obstructive urolithiasis, or if the goat has already undergone an unsuccessful surgical procedure. The purpose of this report is to describe a novel surgical technique for the correction of obstructive urolithiasis in male goats, which can be performed following a previous surgical procedure, as well as report the associated perioperative complications and long-term outcomes of goats undergoing this procedure.

After entry into the abdomen, the urinary bladder was isolated and partially decompressed by urine aspiration using a sterile 20 gauge, 1.5 inch hypodermic needle. Partial bladder decompression facilitated exteriorization of the urinary bladder and placement of 3 stay sutures of 0 polydioxanone: on the cranial lateral aspect of the bladder on either side of the apex and 4 cm caudally on the ventral aspect of the bladder. If urine was noted to have entered the abdominal cavity iatrogenically or if a large volume of peritoneal fluid was encountered, the abdomen was lavaged with warm sterile saline that was then evacuated by suction. The apex of the bladder was elevated through the paramedian celiotomy and the seromuscular layer of the bladder sutured to the cranial, caudal, medial, and lateral aspects of the incised edge of the
internal sheath of the rectus abdominus muscle using 2-0 polydioxanone in a cruciate or interrupted horizontal mattress pattern (Figure 2). The bladder was then further secured to the internal sheath of the rectus abdominis muscle with simple interrupted or cruciate sutures placed between the 4 anchoring sutures, at 0.5 cm intervals. The initial 3 stay sutures that had been placed in the apex and ventral aspect of the urinary bladder were removed.

Using the probe positioned within the prepuce to delineate the caudal boundaries of the preputial cavity to the level of the fornix, the subcutaneous tissue between the paramedian incision and the preputial cavity were dissected medially to create a pathway for connection of the caudal prepuce to the apex of the urinary bladder. After the caudal aspect of the preputial cavity was isolated, a circumferential incision was made around the fornix, separating the prepuce from its attachment to the penis. The distal portion of the penis was then elevated digitally through the preputial incision and exposed through the skin incision.

One or 2 transfixation sutures of 2-0 polydioxanone were placed circumferentially around the shaft of the penis at the level immediately caudal to the previous attachment of the prepuce (fornix) to compress the corporeal tissue and the vasculature of the penis. After suture ligation, the penis was transected immediately distal to the circumferential ligature(s) and the penile stump was oversewn with cruciate or horizontal mattress sutures of 2-0 polydioxanone to ensure closure of the tunica albuginea over the cavernous tissue.

A 3 cm longitudinal cystotomy was created through the apex on the ventral aspect of the secured urinary bladder in a cranial to caudal orientation (Figure 2). Any residual urine present was removed from the bladder using suction. The cut edge of the preputiotomy incision was opposed to the cut edge of the cystotomy incision. Metzenbaum scissors were used to carefully trim the free edge of the transected prepuce so as to ensure a smooth preputial mucosal edge for

FIGURE 1  Approximate location of the left paramedian incision site for vesicopreputial anastomosis. Medical illustrations by DK Haines © 2016 The University of Tennessee

FIGURE 2  Left parasagittal plane showing (A) the anatomical position of urinary bladder and relative location of sterile probe and (B) the relative location of the penile stump and the anastomosis site between the urinary bladder and the preputial mucosa (vesicopreputial anastomosis). Medical illustrations by DK Haines © 2016 The University of Tennessee
anastomosis with the urinary bladder. In goats where the prepuce was smaller in diameter than the cystotomy incision, the size discrepancy between the preputial opening and the subsequent bladder incision was addressed by enlargement of the preputiotomy using an angled incision in the preputial mucosa. The sterile stainless steel probe was removed, and a Foley catheter, ranging in size from 20 to 24 Fr and having a minimum length of 20 cm was inserted retrograde through the preputial orifice, preputiotomy, and cystotomy incisions until the Foley catheter was positioned within the midportion of the lumen of the urinary bladder. The Foley catheter was used as a stent over which the epithelium of the cut edge of the preputiotomy was sutured, circumferentially, to the cut edge of the cystotomy using simple interrupted sutures of 2-0 polyglactin 910 at 0.5 cm intervals. On completion of this VPA, 3-4 cm length stoma had been created between the bladder and the prepuce (Figure 2). The bulb of the Foley catheter was inflated with 5-10 mL sterile saline to ensure that the catheter was placed and secured within the lumen of the bladder. A body wall defect, if present beyond the stoma site in the rectus abdominis muscle, was closed with 0 polydioxanone in a simple continuous or cruciate pattern. The Foley catheter was secured to the edge of the preputial orifice with a finger-trap suture using 2-0 polydioxanone or polypropylene (Figure 3). The Foley remained in situ to ensure patency of the stoma during the postoperative healing period.

The external rectus fascia and subcutaneous tissue were closed with 2-0 or 0 polydioxanone in a simple continuous pattern. The skin incision was closed with 2-0 polydioxanone in a simple continuous subcuticular pattern. The exposed end of the Foley catheter was covered with a sterile surgical glove with perforated finger to decrease contamination after surgery. The glove was attached to the end of the Foley catheter using adhesive tape.

2.4 | Postoperative care

All goats were administered postoperative antimicrobial and anti-inflammatory therapy with ceftiofur sodium (2.2 mg/kg subcutaneously every 12 hours) or procaine penicillin (22 000 IU/kg subcutaneously every 12 hours) for 10-14 days and flunixin meglumine (1.1 mg/kg IV every 12 hours) for 1-5 days and then meloxicam (1 mg/kg orally once daily) for 14-21 days. Intravenous fluid therapy was continued as needed based on serum biochemistry and cardiovascular status. Patency and position of the Foley catheter within the bladder were monitored daily both visually and with abdominal ultrasonography while goats were hospitalized. Foley catheters were removed after 10-30 days. Two goats were administered ammonium chloride (300 mg/kg orally once daily). Urine specific gravity and or urine pH were monitored once to twice daily for 1-3 days. BUN was not available for all goats due to limitations of the point-of-care instrument used on admission (Element POC, Heska, Loveland, Colorado). One goat had an increased PCV and total solids (Table 1). Urine pH was alkaline in 3 goats (median, 8) on presentation. Despite oral ammonium chloride administration postoperatively, no substantial clinically appreciable acidification of the urine (pH range 8-7) was observed. Stone analysis was performed for 2 goats, with 100% calcium oxalate stone in one and a composite of calcium oxalate (90%) and silica (10%) in the other.

3 | RESULTS

Four castrated male goats having undergone surgical treatment for obstructive urolithiasis were included in this study (Table 2). A median of 2.5 previous surgical procedures per goat were performed, including amputation of the vermiform process (4 goats), tube cystostomy (3), perineal urethrostomy (1), and modified perineal urethrostomy (2). Breeds included 3 mixed-breed and 1 pygmy goat. Age ranged from 3 to 6 years old (median, 3 years) and weight ranged from 31.0 to 50.7 kg (mean, 40.9 kg).

All goats had clinical signs consistent with urinary obstruction at the time of presentation. Clinical signs included dribbling of urine (3 goats), anuria (1), bruxism (1),
stranguria (4), anorexia (2), vocalization (4), shivering (1), and signs of abdominal discomfort (2). Duration of clinical signs ranged from 24 hours to 2 months (median, 24 hours). Serum biochemical abnormalities included hyperglycemia (4 goats), increased serum creatinine (3), hypochloremic metabolic alkalosis (1), and mild metabolic acidosis (1; Table 2).

All goats underwent VPA surgery ≤12 hours following admission. Adhesions between the bladder and body wall of 1 goat, likely secondary to a previous tube cystostomy procedure, were broken down. Total time of anesthesia ranged from 180 to 225 minutes (median, 165 minutes) and duration of surgery ranged from 105 to 150 minutes (median, 130 minutes).

**TABLE 1** Serum chemistry and venous blood values at admission for goats undergoing vesicopreputial anastomosis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Goat 1</th>
<th>Goat 2</th>
<th>Goat 3</th>
<th>Goat 4</th>
<th>Reference interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.39</td>
<td>7.32</td>
<td>7.51</td>
<td>7.47</td>
<td>7.35-7.45</td>
</tr>
<tr>
<td>PCO₂</td>
<td>38.6</td>
<td>29.6</td>
<td>44.2</td>
<td>33.8</td>
<td>34-45</td>
</tr>
<tr>
<td>HCO₃ (mmol/L)</td>
<td>23.7</td>
<td>15.4</td>
<td>35.5</td>
<td>24.5</td>
<td>19.6-29.4</td>
</tr>
<tr>
<td>Base excess</td>
<td>−1.1</td>
<td>−10.7</td>
<td>12.6</td>
<td>0.8</td>
<td>−1-1</td>
</tr>
<tr>
<td>Sodium (mmol/L)</td>
<td>147</td>
<td>147</td>
<td>145</td>
<td>145</td>
<td>140-150</td>
</tr>
<tr>
<td>Potassium (mmol/L)</td>
<td>4.0</td>
<td>3.4</td>
<td>4.2</td>
<td>5.3</td>
<td>3.4-5.7</td>
</tr>
<tr>
<td>Chloride (mmol/L)</td>
<td>111</td>
<td>110</td>
<td>102</td>
<td>106</td>
<td>104-116</td>
</tr>
<tr>
<td>TCO₂ (mmol/L)</td>
<td>24.9</td>
<td>16.3</td>
<td>30.9</td>
<td>25</td>
<td>22-28</td>
</tr>
<tr>
<td>Anion gap (mmol/L)</td>
<td>16</td>
<td>17</td>
<td>12</td>
<td>20</td>
<td>9-24</td>
</tr>
<tr>
<td>PCV (%)</td>
<td>47</td>
<td>31</td>
<td>34</td>
<td>36</td>
<td>22%-42%</td>
</tr>
<tr>
<td>Total protein (g/dL)</td>
<td>8.8</td>
<td>6.8</td>
<td>7.2</td>
<td>7.6</td>
<td>6.0-7.5</td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
<td>154</td>
<td>231</td>
<td>253</td>
<td>200</td>
<td>52-81</td>
</tr>
<tr>
<td>Lactate (mmol/L)</td>
<td>2.48</td>
<td>-</td>
<td>1.71</td>
<td>4.49</td>
<td>-</td>
</tr>
<tr>
<td>Creatinine (mg/dL)</td>
<td>0.88</td>
<td>1.18</td>
<td>4.30</td>
<td>4.56</td>
<td>0.7-1.0</td>
</tr>
</tbody>
</table>

Abbreviation: PCO₂, partial pressure of carbon dioxide; HCO₃, bicarbonate; TCO₂, total carbon dioxide; PCV, packed cell volume; TCO₂, total carbon dioxide; Anion gap, difference between chloride and bicarbonate concentrations.

**TABLE 2** Summary data and long-term outcome in goats undergoing vesicopreputial anastomosis

<table>
<thead>
<tr>
<th>Goat</th>
<th>Breed</th>
<th>Sex</th>
<th>Age (years)</th>
<th>Body weight (kg)</th>
<th>Previous surgical procedures</th>
<th>Long-term outcome (&gt;12 months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mixed</td>
<td>MC</td>
<td>3</td>
<td>50.7</td>
<td>Vermiform appendage amputation; tube cystotomy; perineal urethrostomy; modified perineal urethrostomy</td>
<td>Alive</td>
</tr>
<tr>
<td>2</td>
<td>Mixed</td>
<td>MC</td>
<td>3</td>
<td>31.0</td>
<td>Vermiform appendage amputation; tube cystotomy; modified perineal urethrostomy</td>
<td>Deceased at 7 months due to severe acute hydronephrosis secondary to complete stricture of the surgical site</td>
</tr>
<tr>
<td>3</td>
<td>Pygmy</td>
<td>MC</td>
<td>6</td>
<td>48.2</td>
<td>Vermiform appendage amputation; tube cystotomy</td>
<td>Alive</td>
</tr>
<tr>
<td>4</td>
<td>Mixed</td>
<td>MC</td>
<td>3</td>
<td>-</td>
<td>Vermiform appendage amputation; modified perineal urethrostomy²; vesicopreputial anastomosis</td>
<td>Alive</td>
</tr>
</tbody>
</table>

Abbreviation: MC, male castrated.

²Unsuccessful at the time of surgery, instead a second vesicopreputial anastomosis was performed during the same anesthetic episode.
minutes). No goats had hemorrhage from the penile stump. Urine was observed to flow freely from the Foley catheter before and after the goats recovered from anesthesia.

Postoperative complications included iatrogenic removal of the Foley catheter in 1 goat 7 days postoperatively, which resulted in occlusion of the stoma and necessitated replacement of the Foley catheter with the goat anesthetized. Replacement of the Foley catheter was facilitated by the use of a sterile probe and stylet. Correct placement was verified by ultrasound. Two goats developed clinical signs of ascending cystitis, one 10 days and one 28 days after surgery, although no cultures or urinalysis were performed. Both goats were treated with empirical antimicrobial therapy, ceftriaxone sodium (2.2 mg/kg subcutaneously every 12 hours) and phenazopyridine HCl (3 mg/kg orally every 8 hours). Duration of hospitalization after VPA ranged from 2 to 18 days (median, 7 days). Another goat developed a subcutaneous abscess 15 cm caudal to the VPA site between the hind limbs 12 weeks after surgery. Ultrasound of the abscess found no communication with the urinary bladder, anastomosis site, or body wall. The abscess was lanced and the goat was administered ceftriaxone sodium (2.2 mg/kg subcutaneously every 12 hours) for 14 days. The cavity of the abscess was irrigated with sterile saline once to twice daily for 14 days.

One goat died 7 months after VPA due to severe acute bilateral hydronephrosis secondary to complete stricture at the anastomosis site. One goat developed clinical signs of obstruction that included straining, anorexia, lethargy, and reduced urine flow 3 months following the initial surgery secondary to granulation tissue formation. Consequently, this goat underwent a second successful VPA surgery to enlarge the stoma narrowed by granulation tissue.

4 | DISCUSSION

Choice of surgical technique to relieve urethral obstruction caused by urolithiasis is dependent on multiple factors, including cost, technical difficulty of the procedure, previous surgical correction(s), site of obstruction, concurrent disease, intended use of the animal, and owner expectations.3-5,24 All goats in our report had previously failed to respond to medical therapy, and as a result, had undergone an average of 2 surgical procedures prior to VPA. This includes 2 of the 4 goat that had previously undergone MPPU between 1 and 2 years prior to presentation. In both of those cases, the primary complication was stenosis of the stoma site resulting in stranguria. Despite previous surgical intervention, 2 other goats had recurrence of obstructive urolithiasis following veriform appendage amputation and tube cystostomy. In the goats in this report, VPA therefore offered an alternative surgical procedure for treatment of recurrent obstructive urolithiasis when previous surgical intervention had been unsuccessful. In our hospital, the cost of the VPA surgical procedure itself was equivalent to those associated with a tube cystostomy, our most commonly performed surgical procedure for the correction of obstructive urolithiasis in male ruminants.

Other techniques for urethral translocation have previously been described in the veterinary literature, including a similar technique for the relief of obstructive urolithiasis in pot belled pigs.25 However, by directly anastomosing the urinary bladder to the preputial mucosa, VPA avoids the difficulty of an extra-pelvic urethral anastomosis, while still bypassing the anatomically predisposed sites of urethral obstruction. In addition to being anatomically advantageous, required equipment and level of surgical skill required to perform a VPA are no greater than those required to perform a tube cystostomy at our institution.

Stenosis of the urethral stoma is a complication reported in small animals and ruminants.2,16,18,26 Causes of stricture include, formation of granulation tissue, excessive inflammation, inadequate apposition of mucosal tissue, and excessive tension on sutured tissue.18,26 Granulation tissue causing stenosis of the stoma was found in 1 goat 3 months after surgery and stricture of the stoma in another goat at 7 months. Care should therefore be taken to mitigate these factors when performing VPA by creating adequate apposition of the preputial and bladder mucosa, as well as ensuring minimal tension on the anastomosis site to prevent leakage of urine and reduce granulation tissue formation. Male goats can develop bilateral hydronephrosis as soon as 1 day following complete obstruction of the urethra.27 Based on clinical signs and necropsy findings, which included a complete stricture of the previous VPA site, this is likely the cause of the acute death of 1 goat 7 months following surgery. Owners should be therefore, be made aware that animals having undergone VPA should be evaluated promptly by a veterinarian if the animal fails to urinate or if the volume of its urine stream decreases.

Another advantage of the VPA procedure is that it has the potential to avoid both urine scald, a complication that has been reported with tube cystostomy, MPPU and bladder marsupialization,18,20 as well as bladder prolapse, a complication seen secondary to bladder marsupialization.20 No goats in our study developed either of these complications. In addition, redirection of urine flow through the prepuce provided a good cosmetic and functional outcome in these goats as reported by the owners and at short-term follow-up evaluation.

The Foley catheter was left in situ for 10-30 days (mean, 22 days). Early removal of the catheter from 1 goat at 7 days resulted in obstruction of the stoma by swollen soft issue, necessitating replacement with the goat anesthetized. It is our recommendation that the Foley catheter be left in situ for a
minimum of 14 days, a time frame comparable to the range reported for tube cystostomy, as removal at 7 days resulted in inadvertent occlusion of the anastomosis site.\textsuperscript{6,15}

Although never cultured, 2 goats that developed clinical signs of cystitis had resolution of these signs after receiving empirical antimicrobial therapy and phenazopyridine HCl. Phenazopyridine HCl is a medication with analgesic effects in the urinary tract, although a clinically efficacious dose has not, to the authors’ knowledge, been established in small ruminants and no discoloration of the urine was recorded in the goats reported here. Goats suspected of having developed ascending cystitis should receive a urinalysis, the urine should be cultured for bacteria, and antimicrobial susceptibility testing performed on bacterial isolates.

Why 1 goat developed an abscess caudal to the surgical site is not entirely known. Inflammation and infection in this region have been reported to occur in veterinary species, including ruminants, secondary to urethral trauma or rupture.\textsuperscript{28-30} Reports of infection and necrosis secondary to a lodged urethral urolith and or the subcutaneous deposition of urine has been documented.\textsuperscript{28-30} Although other etiologies cannot be fully ruled out, we postulate that in this case abscess formation may have been secondary to urethral trauma or a lodged urolith. Although not performed, perioperative radiographs may have been helpful in this case.

The alkaline nature of the small ruminant urine aids in the formation of uroliths by facilitating the precipitation of crystalline components within the urinary bladder. All goats in this report had alkaline urine, despite reported dietary changes prior to presentation. Acidification of urine, by administration of oral ammonium chloride, has been prescribed as adjunctive therapy to both promote the chemical dissolution and reduce formation of certain uroliths in these animals.\textsuperscript{3,4} Dose ranges for ammonium chloride from 100 mg/kg orally every 12 hours up to 450 mg/kg orally once daily have been reported in goats.\textsuperscript{16,31} A dose of 300 mg/kg orally once daily was chosen for postoperative urine acidification in 2 goats in this report. Unfortunately, this dose did not result in substantial clinically appreciable acidification of the urine (pH range 8-7). Urine pH in ruminants is influenced by a number of complicating factors, including diet, metabolic status, water intake, and electrolyte balance.\textsuperscript{1,3,31} Inadequate dosing, dietary factors, and metabolic conditions were all considered as potential causes for the failure of acidification of the urine in the 2 goats in this study.

Advantages of VPA include ease of technique, minimal intraoperative complications, and improved cosmetic appearance as compared to other techniques such as MPPU. VPA also allows voiding of urine through the prepuce, avoiding the major complication of urine scald that can be seen with other techniques such as MPPU, bladder marsupialization, and tube cystostomy. In addition, VPA can be performed successfully when other surgical techniques, including tube cystostomy, perineal urethrostomy, and MPPU have all failed. Conversely, VPA does not preclude the use of other surgical techniques, including bladder marsupialization, tube cystostomy, or MPPU. Lastly, as was demonstrated in 1 goat, VPA has the potential for successful surgical revision following stenosis of the stoma site, resulting in a good long-term outcome. Of the 3 goats in this study alive at long-term follow-up, including the goat having undergone 2 VPA procedures, clinical outcome and owner satisfaction was acceptable in all cases.

This report is therefore offered as a methods paper to both describe the technique and demonstrate proof-of-concept, for consideration in goats with recurrent urethral obstruction. Due to our small sample size, we are unable to statistically compare outcome of goats undergoing VPA to goats undergoing other surgical procedures for the resolution of obstructive urolithiasis. As such, and together with the stoma complications seen in 2 goats, care should be taken when considering the clinical results of this study. Further investigation is warranted before VPA can be recommended as a viable alternative to currently established surgical procedures. Even so, in the cases reported here, both the short-term and long-term outcomes, minimal intraoperative complications, and ease of procedure, indicate that VPA has the potential to be a successful surgical option in the male small ruminants for the correction of recurrent obstructive urolithiasis.

CONFLICT OF INTEREST
The authors declare no conflicts of interest related to this report.

REFERENCES


