Removal of ureteral calculi in two geldings via a standing flank approach

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Case Description—Two geldings, aged 11 and 17 years, were examined for treatment of ureteroliths located approximately 10 cm proximal to the bladder.

Clinical Findings—Ureteral obstruction was an incidental finding in 1 horse that was referred because of urinary tract obstruction and a cystic calculus. This horse did not have clinical or laboratory evidence of renal failure, although severe hydrenephrosis was evident on transabdominal ultrasonography. The second patient had a serum creatinine concentration of 6.3 mg/dL (reference range, 0.8 to 2.2 mg/dL) and mild hydrenephrosis of the affected left kidney.

Treatment and Outcome—In both patients, the obstructed ureter was exteriorized through a flank incision as a standing procedure, and the calculus was crushed and removed with a uterine biopsy forceps introduced through a ureterotomy approximately 25 cm proximal to the calculus. The cystic calculus was removed through a perineal urethrostomy by lithotripsy, piecemeal extraction, and lavage. The horse without azotemia developed pyelonephritis in the affected kidney and was euthanatized because of complications of a nephrectomy 13 months later. In the horse with azotemia, the serum creatinine concentration decreased after surgery, and the horse returned to its intended use. However, it was euthanatized approximately 2 years after surgery because of progressive renal failure, and a large nephrolith was found in the previously unobstructed right kidney.

Clinical Relevance—The technique used for ureterolith removal was successful in both horses in this report, did not require sophisticated equipment, and could be effective in the early stages of ureteral obstruction as a means of restoring urine flow and renal function. The outcome in the horse with advanced unilateral renal disease without azotemia would suggest that nephrectomy should be considered as a treatment in such patients. (J Am Vet Med Assoc 2012;241:1214–1220)
and oxalate crystals were seen. All other results were within the reference range, and there was no growth on aerobic and anaerobic cultures of the urine. The owner was offered a standing perineal urethrostomy to remove the urolith and then removal of the ureterolith with a retrieval basket inserted into the right ureter under endoscopic guidance. If that failed, the owner agreed to an attempt to remove the ureterolith through a flank approach, if it was accessible, to allow drainage of urine and mucus from the kidney.

Immediately before surgery and for 6 days afterward, the horse was given potassium penicillin (22,000 U/kg [10,000 U/lb], IV, q 6 h) and enrofloxacin (4.5 mg/kg [2.05 mg/lb], IV, q 24 h). The horse was placed in stocks and sedated with detomidine hydrochloride (0.02 mg/kg [0.009 mg/lb], IV) and butorphanol tartrate (0.05 mg/kg [0.02 mg/lb], IV). A caudal epidural was performed with 0.2 mg/kg (0.09 mg/lb) morphine sulfate, 0.17 mg/kg (0.077 mg/lb) xylazine hydrochloride, and 0.22 mg/kg (0.1 mg/lb) of 2% mepivacaine diluted to a total volume of 10 mL with sterile saline (0.9% NaCl) solution. Low doses of detomidine and butorphanol were given through a jugular catheter as needed at intervals throughout the surgery for a total of 31 and 16 mg, respectively. Diazepam was given at 0.02 mg/kg, IV, early in the procedure, and N-butylscopolamine at 0.3 mg/kg (0.14 mg/lb), IV, was given toward the end of the surgery, the latter to provide smooth muscle relaxation of the bladder during removal of the cystic calculus. The penis and urinary bladder were catheterized in sterile fashion, and the right paralumbar fossa was clipped and prepared for aseptic surgery. Local anesthetic (2% mepivacaine) was infiltrated into the proposed surgery sites for perineal urethrostomy and the right flank incision.

A perineal urethrostomy was performed through a 6-cm vertical skin incision that started proximally 10 cm ventral to the anus and extended distally to the ischial arch. A stay suture was placed on both sides of the urethrostomy through the urethral mucosa, corpus spongiosum, penis, bulbospongious muscle, and retractor penis muscle and was then anchored to the adjacent skin to retract the urethrostomy edges. Several attempts were made to catheterize the ureter and pass a 5-mm-outer-diameter endoscope into it to allow insertion of a retrieval basket, but this procedure was abandoned when it could not be completed within a reasonable timeframe. It appeared that access to the ureter was impeded by the large mucous plug that filled the distal segment (Figure 3).

A right flank laparotomy was then performed through a 12-cm vertical skin incision between the last rib and tuber coxae, level with the tuber coxae. The external abdominal oblique muscle and fascia were incised sharply along the direction of the skin incision, and the internal abdominal oblique was bluntly divided along its muscle fibers. The transversus abdominis muscle was divided bluntly along its muscle fibers, and the retroperitoneal space and the peritoneal cavity were opened by blunt dissection to identify the right ureter. The right ureter, which was dilated to approximately 2.5 cm in diameter and thick walled, was freed up for approximately 10 to 12 cm in proximal and distal directions. The ureterolith could be palpated in the ure-
ter approximately 25 cm distal to the isolated segment. Two 1-inch wide Penrose drains were used to elevate 6 cm of ureter to the level of the skin incision, and a longitudinal 3-cm incision was made in this segment. Dark brown mucoid material was evacuated from the ureter by active suction. The calculus could not be manually manipulated toward the incision because it was tightly adhered to surrounding mucosa. The ureter was constricted and thin walled around the calculus. A uterine biopsy forceps (length, 36.5 cm) was introduced through the ureterotomy and advanced caudally until the calculus was encountered. The jaws of the instrument were then opened, and the calculus was digitally manipulated into its jaws by a hand in the abdomen. The calculus was too tightly adhered to the mucosa to be freed up for removal intact. Instead, it was crushed into fragments that were then removed in piecemeal fashion until the calculus was completely removed. A sterile laparotomy sponge was packed into the incision below the ureter to prevent any small fragments falling into the instrument into the abdominal incision. The last few fragments were most difficult to remove because they were small and tightly adhered to the wall of the ureter. They were easier to grasp if they were digitally maneuvered into the open jaws from the side rather than from the front.

Once the stone had been removed, a stallion catheter (6.6 mm × 137 cm)3 was inserted into the ureteral incision and directed distally to flush the ureter in normograde fashion with sterile saline solution. The catheter was then passed into the bladder and through the urethrostomy to confirm patency of the ureter. The ureterotomy was closed in a simple continuous pattern with size 2-0 polydioxanone that did not penetrate the mucosa. The peritoneum and transversus abdominis muscle were closed as 1 layer with size 1 polyglactin 910c in simple continuous pattern, and size 2 polygactin 910 was used in a simple interrupted pattern in the internal abdominal oblique muscle. The same suture material was used in a simple continuous pattern to close the external abdominal oblique muscle, and the subcutaneous layer was closed in simple continuous fashion with size 2-0 polyglactin 910. Skin was closed with size 2-0 poliglecaprone 25c in simple continuous fashion and the incision was not bandaged.

The cystic calculus was removed by stabilizing it with a hand in the rectum while inserting an osteotome through the urethrostomy to progressively break off fragments around the edges. A uterine biopsy forceps was used to grasp and remove fragments of approximately 1 cm diameter, and most of the remaining small fragments and gritty sediment were flushed from the bladder through a sterile stomach tube. The perineal urethrostomy was left open to heal by second intention.

Following surgery, the horse had signs of mild discomfort, manifested mostly by intermittent pacing around the stall, especially during urination, but was bright and alert. A continuous rate infusion of butorphanol IV was started at 13.2 µg/kg/h (6 µg/lb/h), and flunixin meglumine was also administered (1.1 mg/kg [0.5 mg/lb], IV, q 12 h). Polyionic IV fluids were also administered at a rate of 1.8 mL/kg/h (0.82 mL/lb/h) for 7 days after surgery. It was fed coastal Bermuda grass hay and allowed free-choice water. The horse's vital parameters remained normal for 48 hours, although fecal production was reduced. After this, the horse's heart rate increased to 60 beats/min, and signs of mild abdominal pain developed. At that time, the butorphanol infusion was stopped, and the horse received a bolus of lidocaine hydrochloride at 1.3 mg/kg IV (0.6 mg/lb) over 15 minutes and then at 0.05 mg/kg/h. Palpation per rectum revealed a cecal impaction, which was corrected on day 3 after surgery by typhlotomy through a ventral midline celiotomy. Cystoscopy was performed while the horse was under general anesthesia and revealed that the bladder was less inflamed than immediately after removal of the cystic calculus and was free of all calculus fragments and debris. The horse recovered well from the second surgery and was discharged 5 days later.

Results of a CBC on day 3 after this surgery and serum creatinine concentration on postoperative day 5 were within the reference ranges.

At recheck examinations at 3 and 6 months after surgery, body weight, appetite, attitude, and vital signs were considered normal, and the flank incision had healed completely without any complications. All values on CBC and plasma biochemistry profiles were within reference ranges, and the bladder mucosa appeared normal on cystoscopy, with no evidence of calculi. The right ureter did not evacuate urine during cystoscopy, suggesting a continued lack of function of the right kidney. On ultrasound examination at both rechecks, the right kidney was unchanged from the initial examination (Figure 1), with a lack of normal renal architecture, a lobular appearance, large major calyces within each lobe, and a transverse diameter of 16 cm. The left kidney appeared normal on ultrasound examination. Continued monitoring of the horse's progress and condition of the right kidney at 3- to 6-month intervals was recommended, with a tentative plan to remove the kidney if it enlarged or signs of pyelonephritis developed. The horse was moved to another state after the 6-month visit (7 months after the flank laparotomy), and right-sided pyelonephritis was diagnosed at another university veterinary hospital at 13 months after the flank laparotomy. On ultrasound examination, the right kidney had enlarged to 28 × 24 cm, and the right ureter was amotile and unchanged in size from previous measurements. The right kidney was removed by hand-assisted laparoscopy at that hospital at 393 days after removal of the ureterolith. Pyelonephritis and advanced loss of parenchyma were confirmed by gross and microscopic examinations of the kidney, and several small ureteroliths were found in the renal pelvis. Culture of purulent renal contents yielded a multidrug-resistant strain of Klebsiella pneumoniae. The horse was euthanatized 24 days after nephrectomy because of peritonitis caused by contamination with this organism during nephrectomy, and no obvious ureteral obstruction was reported at necropsy.

A 17-year-old 513-kg (1,133 lb) Holsteiner gelding (horse 2) was referred for a history of lethargy and anorexia since it was purchased by the current owner 3 weeks previously. Abnormalities on serum biochemical analysis 3 days before admission were elevated BUN (58 mg/dL; reference range, 10 to 25 mg/dL), creatinine (5.1
mg/dL; reference range, 0.8 to 2.2 mg/dL), potassium (5.2 mmol/L; reference range, 2.5 to 4.2 mmol/L), and ionized calcium (2.01 mg/dL; reference range, 1.25 to 1.75 mg/dL) concentrations. The urinalysis on the same day revealed a specific gravity of 1.010, 3+ bilirubin, 30 mg/dL of protein, and a large amount of hemolyzed blood. On ultrasound examination before admission, the left kidney had a dilated, hypoechoic renal pelvis, indicative of hydronephrosis. Cystoscopy at the same time revealed urine flow from the right ureter, with subjectively less urine output from the left ureter. Palpation per rectum revealed a severe dilation and thickening of the left ureter proximal to a firm 1.5-cm-diameter mass located approximately 10 cm from the bladder. The creatinine concentration increased to 6.2 mg/dL despite oral and IV fluid therapy. The horse was then referred to the University of Florida Large Animal Hospital for further evaluation and treatment.

On admission, rectal temperature was 37.7°C (99.9°F), heart rate was 54 beats/min, and respiration rate was 24 breaths/min. Body condition score was 4 of 9 on the Henneke scale. The abnormalities in the left kidney and ureter were confirmed by ultrasound and rectal examinations. The right kidney appeared to be normal, although only a small portion of it was visible on ultrasound examination. Findings on a CBC at admission were within the reference ranges except for anemia, with an RBC count of 6.81 x 10^6 cells/µL (reference range, 6.7 x 10^6 cells/µL to 10 x 10^6 cells/µL). Both creatinine concentration (6.3 mg/dL; reference range, 0.8 to 2.2 mg/dL) and BUN concentration (55 mg/dL; reference range, 10 to 23 mg/dL) were increased.

The ureteral calculus was removed with the ureteric biopsy forceps inserted through a ureterotomy in the left flank, with the technique described for horse 1. A perineal urethrostomy was used in this patient to catheterize the left ureter, which was unsuccessful, and was also used as an exit point for an indwelling ureteral stent. For the latter, a stallion catheter was passed through the ureterotomy after lithotripsy, and the ureter was flushed several times with sterile saline solution to demonstrate patency. The catheter was then passed into the bladder to emerge at the perineal urethrostomy. The tip of a second stallion catheter was tied by suture to the first, and the first catheter was withdrawn through the ureter to pull the second catheter retrograde through the urethra, bladder, and ureter. The suture was cut, and the second catheter was advanced retrograde from the ureterotomy so that the tip rested close to the renal pelvis. A soft rubber tube was taped to the end of the catheter to prevent ingress of air, and a Chinese finger-trap pattern was used to suture the catheter to the urethrostomy.

After surgery, the horse was treated with IV polyionic fluids at 3.8 mL/kg/h (1.7 mL/lb/h) for 8 days, 2.9 mL/kg/h (1.3 mL/lb/h) for the next 2 days, and then at 1.9 mL/kg/h (0.9 mL/lb/h) for 5 days. The horse also received a bolus of lidocaine hydrochloride at 1.3 mg/kg, IV, over 15 minutes and then daily at 0.05 mg/kg for 12 days. Potassium penicillin (22,000 U/kg, IV, q 6 h) was given for 16 days and enrofloxacin (4.5 mg/kg, IV, q 24 h) for 24 days after surgery. Ammonium chloride was given by dose syringe in corn syrup at a dose of 1 oz, PO, every 12 hours from day 7 to 11, but was discontinued because it failed to acidify the urine and caused inappetance.

During the first week after surgery, the horse had signs of mild discomfort, manifested mostly by intermittent pacing around the stall with some pawing, but was bright and alert. Urine was observed to drain almost continuously from the ureteral catheter, although the catheter did become briefly obstructed with a combination of mineral (presumably calcium carbonate) and mucus on day 7 after surgery. The obstruction was resolved with replacement of the 1-way valve and gentle aspiration of the obstructing material. On days 10 and 11 after surgery, the horse appeared depressed, and its temperature increased to 38.3° to 39.4°C (100.9° to 103.0°F), respectively, on those days. On day 11, the ureteral catheter was removed and was found to be coated with a layer of crystallized material and mucus. Culture of this material produced a growth of Escherichia coli sensitive to a wide range of antimicrobial agents but resistant to gentamicin, ceftiofur, and enrofloxacin.

Throughout hospitalization, the horse's heart rate remained approximately 52 beats/min, the PCV ranged from 19% to 25%, and TP from 5.5 to 6.3 g/dL. Serial monitoring of creatinine concentration throughout hospitalization revealed an increase to 6.5 g/dL on day 1 after surgery and then a fairly steady decline to 3.0 g/dL on day 9 after surgery. On day 11 after surgery, a urinalysis was performed on samples obtained separately from both the left and right kidneys, and both were within reference limits with no evidence of casts, bacteria, or abnormal cells. At that time, urine creatinine concentration was 72 mg/dL. The glomerular filtration rate as determined by endogenous creatinine clearance for both kidneys was 0.46 mL/min/kg (0.21 mL/min/lb), which is approximately one-third the reported values for clinically normal horses.

On day 12, cystoscopy revealed that both ureters emptied with streams of similar magnitude. On palpation per rectum, the left ureter could no longer be palpated. Urine was mostly voided through the penis rather than the urethrostomy after the catheter was removed. The flank incision healed without complications, and skin sutures were removed on day 14. The horse was discharged from the hospital on day 16 after surgery. The calculus was submitted for analysis and determined to be 100% calcium carbonate. Transabdominal ultrasound examination at time of discharge revealed resolution of the previously noted hydronephrosis of the left kidney. Body weight remained consistently between 508 and 525 kg (1,118 and 1,155 lb) throughout hospitalization. At the time of discharge, serum creatinine concentration was 3.6 mg/dL, BUN concentration was 41 mg/dL, and potassium concentration was 4.7 mmol/L (reference range, 2.5 to 4.2 mmol/L).

The horse returned to work shortly after discharge and improved to make a full recovery and perform to the owner's expectations in dressage. The serum creatinine concentration remained consistently between 2.5 and 2.7 mg/dL over most of the first 14 months after surgery. The BUN concentration was 56 mg/dL (reference range, 10 to 25 mg/dL), the Hct was 28% (reference range, 30% to 43%), the RBC count was 5.73 x 10^6 cells/µL (refer-
ence range, 6.7 × 10^6 cells/µL to 10 × 10^6 cells/µL), and the serum potassium concentration was 2.9 mmol/L (reference range, 2.5 to 4.2 mmol/L) at 429 days after surgery. The horse was readmitted 741 days after removal of the ureterolith with weight loss and serum creatinine concentration of 4.9 mg/dL (reference range, 0.8 to 2.2 mg/dL). On ultrasound examination, the left kidney had mild hydronephrosis and 2 small calculi in the renal pelvis. The right kidney was difficult to see but appeared to be small, and the normal parenchymal architecture was lost. The horse was treated with IV fluids as on the first admission and was euthanatized 6 days after admission because of a poor prognosis. At necropsy, the left kidney was of normal size but had interstitial nephritis with multifocal infarcts in the cortex. The right kidney was small, with most of the parenchyma reduced to 1- to 1.5-cm thickness surrounding an 11.5 × 7.5 × 7-cm nephrolith that weighed 604 g.

**Discussion**

The method used for removal of ureteroliths in the horses of this report appears to offer some advantages over previously described techniques. In both patients, the ureterolith obstruction caused the entire proximal portion of the ureter to increase in diameter, wall thickness, length, and tortuosity. These changes, especially the apparent increase in length, made it possible to exteriorize a substantial portion of it through a flank incision, where a ureterotomy could be retained for repeated access and closure. Separation of 10 to 12 cm of ureter for the procedure described apparently did not disrupt blood supply to this ureteral segment. Blood supply to the ureter is provided through branches from the renal, testicular, and umbilical arteries that probably ramify along intervening segments of ureter so that blood supply is preserved, despite separation from surrounding tissues.

The major advantage of the uterine biopsy forceps over shorter grasping instruments, such as arthroscopic forceps, was its length and robust design. Also, the jaws of the instrument have blunt leading edges that could pass under the stone without risk of engaging or injuring the mucosal surface. In each horse, the degree of ureteral adhesion to the stone and the severe thinning of the ureteral wall around it gave the impression that retrieval baskets and similar devices dependent on instrument passage around the stone and removal by traction would be difficult to use and could injure the ureter or damage the instrument.

The major advantages of the method described in the present report were low cost and easy access to a part of the urinary tract that is very difficult to approach surgically in a large horse. A single report describes the removal of 3 uroliths from the left ureter through a combined midline and paralumbar incision in the anesthetized horse after much of the large and small intestines were exteriorized. A caudal ventral midline was used for successful removal of a ureterolith in a mare but did not allow sufficient access for closure of the ureterotomy.

Uterine biopsy forceps are readily available in most hospitals, whereas instruments used specifically for lithotripsy, such as electrohydraulic, ballistic shock wave, radial extracorporeal shock wave, pulsed dye laser treatment and holmium:yttrium-aluminum-garnet laser all require specialized and expensive equipment and expertise with their use. Also, these minimally invasive methods have been used predominantly for cystic or urethral calculi in horses, which are more readily accessible than ureteral calculi. A ureterolith was successfully removed in a Thoroughbred colt with an electrohydraulic lithotripsy probe inserted through a perineal urethrostomy under general anesthesia. For this purpose, a rigid endoscope was used to facilitate ureteral catheterization. A Dormia basket has been used for removal of a ureterolith in a mare; however, ureteral entry with such instruments in mares can be facilitated by digital guidance through the urethra, and such guidance would be impossible through a perineal urethrostomy in male horses. We were unable to insert a transendoscopic retrieval basket into the ureter of our patients in this report, and a previously described attempt to do the same in a Thoroughbred colt failed also.

The ureteral calculus was approached before the bladder stone was removed in horse 1 because we recognized that this would be the more difficult procedure and the one requiring more strict aseptic technique. The advantage of doing a urethrostomy as the first step in geldings with our method is to allow retrieval of a catheter through the affected ureter to assess patency and to use as a stent over which the obstructed portion of ureter could heal (as in horse 2). It can also facilitate endoscope insertion for repeated cystoscopy, although urethrostomy is not essential for this purpose. In general, urethrostomy is a simple procedure in horses and has a low complication rate.

The horses described in this report had contrasting initial clinical signs of ureteral obstruction. In horse 1, the ureterolith was an incidental finding, and the primary reason for referral was the cystic calculus. This case underscores the observation that urolithiasis can affect multiple sites. Unlike the typical clinical signs for urolithiasis, this horse was otherwise in good health on the basis of clinical assessment and repeated measurements of plasma creatinine, BUN, and electrolyte concentrations. The goals of treatment in this patient were to remove the cystolith standing because this was causing clinical signs and to remove the ureterolith as a standing procedure at the same time, to allow drainage of mucous secretions and any urine that it might produce. Removal of the ureterolith was also considered to be a safer and less invasive procedure than nephrectomy and therefore better suited as a second procedure combined with surgery for the cystic calculus. A renal biopsy was not taken to determine the prognosis because we considered it unlikely that the results would change our negative prognosis for recovery of renal function and because the procedure carries risks.

In retrospect, a nephrectomy should have been performed earlier on horse 1, as recommended, and would have avoided the severe pyelonephritis that led to the demise of this patient; however, it was kept as an option if renal changes indicated it on planned recheck examinations. Our opportunity to monitor the
diseased kidney on a schedule was lost when the horse was moved out of our hospital range. Although ureteroliths could arise from pyelonephritis, there was no growth on a culture of this horse’s urine at admission. However, we did not culture fragments of the ureteral calculus, which might have improved chances of bacterial recovery. Presumably, failure of the right kidney to continuously produce urine created the risk of ascending urinary tract infection and caused pyelonephritis in this horse. It is possible that surgery for removal of the cystic calculus might have caused a transient lower urinary tract infection that then spread to the upper urinary tract.

As with many horses that develop ureterolithiasis or nephrolithiasis, horse 2 developed signs of renal failure, as if the disease were bilateral. No abnormality was identified in the right kidney on initial examination, although it was difficult to visualize on both visits. It did appear small and had abnormal parenchymal architecture on the second visit, although the nephrolith was not evident. This kidney was observed to produce urine on cystoscopy at the first visit, but presumably declined in function over time, consistent with progressive failure induced by a large nephrolith. Although this horse had persistent anemia during hospitalization and subsequently a cause for this could not be identified, it was tentatively attributed to reduced renal production of erythropoietin.

Removal of the ureteral calculus was considered a reasonable option in horse 2 to restore some function to the right kidney, on the basis of a previous report of a horse with similar initial clinical signs and severity of azotemia. Unfortunately, most patients are initially examined too late in the disease course to restore renal function by removal of the obstruction. In a case such as this, with an apparently normal contralateral kidney on ultrasound examination at the time of initial examination, owners should be counseled that removal of the ureterolith might not resolve renal failure, even if it did resolve hydronephrosis on the affected side.

By leaving the stallion catheter in place for as long as we did in horse 2 (11 days), a urinary tract infection probably developed around it, as evident by a transient high fever and culture of *E. coli* from the catheter tip. The ureters can empty by smooth muscle contraction, but an indwelling catheter could retain urine, causing stagnation and mineral deposits, followed by ascending infection. A mare that had a smaller-diameter catheter in place for 3 weeks to allow second intention healing of a ureteral rent also developed severe mineral encrustation around the catheter, but without evidence of sepsis. The purpose of the stent in horse 2 was to allow the damaged mucosa in the obstructed ureteral segment to heal without stricture, but the need for this is unknown.

Cecal impaction is a well-recognized disease of hospitalized horses that have undergone unrelated surgical procedures, including surgery to relieve ureteral obstruction. This complication developed in horse 1, presumably from motility-modifying effects of frequent dosing with detomidine and butorphanol during surgery and the butorphanol continuous rate infusion after surgery. Pain management after surgery can be a challenge in such patients because nonsteroidal anti-inflammatory drugs would be contraindicated in a horse with renal failure. Although lidocaine continuous rate infusion would seem a good choice and was used in both horses, it is of questionable benefit as a visceral analgesic agent. Also, its effects on bladder and urethral pain are unknown, and these would be the most likely causes of postoperative discomfort. Flunixin meglumine was used in horse 1 because of the perceived need for additional pain control after surgery and for colic from cecal impaction and because of the belief that the functional left kidney would not be adversely affected by short term treatment in conjunction with appropriate fluid therapy.

Neither horse in this report was discharged with instructions to receive urine acidifiers, which are recommended but not proven to prevent recurrence of calculi. Ammonium chloride can increase urinary fractional excretion of calcium in goats and could actually increase the risk of calcium-based uroliths in other species. Although ammonium chloride and ammonium sulfate can acidify equine urine, they cause inappetance, which was a problem in horse 2. Also, ammonium chloride at a dose and over a time frame that would be expected to yield a positive response failed to acidify the urine in this horse. Ascorbic acid is also effective but must be given daily by stomach tube. Diets that are low in cation-anion balance can decrease urinary pH and avoidance of NSAIDs.

The surgical treatment described in this report has not been described previously, to the best of our knowledge. Although we used a uterine biopsy forceps for stone removal, other intraluminal methods could be applied through the same approach. Appropriate case selection is critical. As in many cases of nephrolithiasis and ureterolithiasis, unilateral renal disease in horse 1 was too far advanced to be improved by surgical removal of the calculus. Although pyelonephritis is regarded as a risk in horses with unilateral renal failure from urolithiasis, this report is the first to confirm this risk, to the best of our knowledge. One advantage of our technique over previously described methods was easy access to the calculus, without the need for expensive and specialized equipment that is not readily available. On the basis of these observations, we suggest that horses in early stages of ureteral obstruction, before irreversible renal failure develops, may benefit from the described surgical approach.

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