

Urethroscopy and laser lithotripsy for the diagnosis and treatment of obstructive urolithiasis in goats and pot-bellied pigs

Spring K. Halland, DVM; John K. House, BVMS, PhD, DACVIM; Lisle W. George, DVM, PhD, DACVIM

Objective—To explore the use of urethral endoscopy and laser lithotripsy in the diagnosis and management of urolithiasis in goats and pot-bellied pigs.

Design—Prospective clinical study.

Animals—16 male goats and 6 male pot-bellied pigs with dysuria.

Procedure—Abdominal ultrasonography and urethral endoscopy were performed on all 22 animals. Endoscopic-guided holmium:yttrium-aluminum-garnet laser lithotripsy was performed in 3 goats and 2 pot-bellied pigs.

Results—Urolithiasis was identified in 15 goats and 5 pot-bellied pigs. Primary urinary bladder paralysis and cystitis were identified in the remaining pot-bellied pig and goat. Mean bladder diameters of obstructed small- and large-breed goats were 7 and 9.5 cm, respectively. The mean bladder diameter of obstructed pot-bellied pigs was 9.5 cm. Five of 20 animals with obstructive urolithiasis had severe urethral necrosis or stricture formation at the time of urethroscopy. All of these animals were euthanatized within 6 months because of persistent dysuria. When used, laser lithotripsy successfully fractured the distally located obstructing stones in the 3 goats and 2 pot-bellied pigs.

Conclusions and Clinical Relevance—Urethral endoscopy is useful for evaluating urethral patency in goats and pot-bellied pigs. Examination of the urethral mucosa following relief of urethral obstructions aids in the assessment of the long-term prognosis for urethral stricture. Urethral endoscopy also expands the therapeutic options for management of urolithiasis by providing a route for conducting laser lithotripsy. Laser lithotripsy proved to be safe and effective for clearing distally located calculi refractory to removal by traditional urethral flushing. Lithotripsy application is restricted to calculi lodged in the urethra. (*J Am Vet Med Assoc* 2002; 220:1831–1834)

From the Veterinary Medical Teaching Hospital (Halland), and Department of Medicine and Epidemiology (House, George), School of Veterinary Medicine, University of California, Davis, CA 95616. Dr. Halland's present address is Cotati Large Animal Hospital, 8079 Gravenstein Hwy, Cotati, CA 94931.

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Address correspondence to Dr. Halland.

Urolithiasis of companion pot-bellied pigs and goats in California is a common and serious disease.¹ Urinary tract obstructions are almost exclusively observed in males as a result of the length, narrow diameter, and tortuous nature of the penile urethra.^{2,3} Common sites of obstruction within the urethra include the urethral process in goats and sheep and the sigmoid flexure in small ruminants and pot-bellied pigs.³⁻⁷ The presence of a urethral recess (or diverticulum) in small ruminants and swine confounds clearance of urinary calculi as it interferes with retrograde passage of urinary catheters into the bladder.^{1,8-10}

Methods developed to reestablish urethral patency include perineal urethrostomy, penile amputation, urethrotomy, normograde and retrograde urethral flushing, cystotomy, and tube cystotomy.^{1,4,5,8} Complications associated with treatment of urolithiasis are common and include reobstruction as a result of stone recurrence, urethral stricture, cystitis, and incomplete clearance of calculi. Retrospective review of medical records at a veterinary medical teaching hospital indicated that 25% of goats and sheep were euthanatized following treatment.⁸ Identification of high risk patients prior to surgical treatment would be prognostically and therapeutically useful, whereas less invasive methods for stone removal might hasten the recovery period and enhance the survival rate from urolithiasis. Therefore, the objective of this study was to explore the applications of urethral endoscopy and laser lithotripsy in the diagnosis and management of urolithiasis in goats and pot-bellied pigs.

Materials and Methods

Animals—Sixteen goats and 6 pot-bellied pigs admitted to the Veterinary Medical Teaching Hospital for stranguria or dysuria between January 1999 and July 2001 were included in our study. One pot-bellied pig and 2 goats had previously undergone surgery for obstructive urolithiasis. None of the pot-bellied pigs or goats included in our study had a ruptured bladder or urethra.

One goat and 2 pot-bellied pigs were managed with laser lithotripsy as a primary treatment option. This decision was made on the basis of radiographic findings of multiple calculi in the distal urethra of the goat and palpable, large, fixed calculi in the distal urethra of the pot-bellied pigs. Laser lithotripsy was used in 2 goats following unsuccessful tube cystotomy. Pygmy goats < 7 months of age were not included in our study, because the small urethral diameter precluded urethroscopy.

Procedures—For male goats (16) and pot-bellied pigs (6) a presumptive diagnosis of urinary tract obstruction was made according to history and physical examination findings. Diagnostic imaging procedures performed prior to

endoscopy included caudal abdominal ultrasonography in all patients and caudal abdominal and urethral radiography in 10 goats and 5 pot-bellied pigs. Serum biochemical analyses were performed for 15 goats and 3 pot-bellied pigs.

A percutaneous self-retaining 18-gauge catheter^a was inserted under ultrasound guidance into the urinary bladder of patients 24 to 36 hours prior to lithotripsy surgery to relieve urinary distention and reduce the amount of azotemia. Placement of the catheter was done under sedation with the patient in lateral recumbency. The catheter allowed for stabilization of the patient during scheduling of anesthesia and lithotripsy.

Urethroscopy was performed under general anesthesia. The delicate nature of the endoscope precluded application in conscious or mildly sedated patients. Penile exteriorization was accomplished while under general anesthesia by using Allis tissue forceps to grasp the penis and placing gentle pressure over the sigmoid flexure to push the penis forward.⁸ In all patients the urethral process (vermiform appendage) was amputated if it had not been done previously by a referring veterinarian or on a prior visit. Passage of the endoscope was performed by use of the same technique used to pass a urethral catheter. Polypropylene canine urinary catheters^b were introduced into the urethra to dilate the urethral opening and to facilitate the passage of the blunt-ended endoscope. Two people were required for the procedure, one to support and drive the endoscope while the second person stabilized the penis and advanced the scope. Urethroscopy was initially performed by use of a 5.5-F (2.1-mm-diameter) 70-cm-long flexible endoscope^c with 1-way tip deflection. Navigation with 1-way deflection requires the entire endoscope to be rotated to maneuver into the proximal urethra. The friction associated with the length of the urethra proved to create excessive torque and broke optical fibers. To overcome this problem the damaged 5.5-F endoscope was replaced with a reinforced 8-F (2.7-mm-diameter) 70-cm-long flexible endoscope^d with 4-way tip deflection. The optical handle portion was the same in both instances.^e Passage of the endoscope proximal to the urethral diverticulum was possible in some patients; however, the procedure often resulted in damage to the instrument as a result of the amount of torque on the endoscope required for navigation. Image quality in the proximal urethra and bladder was poor as a result of the limited capacity of the light source^f to illuminate the large area. Consequently, attempts to endoscopically view the urethra proximal to the diverticulum (pelvic urethra) were not performed in most patients.

Laser lithotripsy was performed in 3 goats and 2 pot-bellied pigs by use of a holmium:yttrium-aluminum-garnet (Ho:YAG) laser.⁸ The laser was rented, and a laser technician was available for surgery within 24 hours of notification. During the 18-month study period, the rental fee for the laser ranged from \$400 to \$500/procedure. For performing the lithotripsy, the endoscope was passed retrograde to the level of the obstructing calculi. Pulsations of sterile saline (0.9% NaCl) solution delivered through the instrument port of the endoscope dilated the urethra and facilitated visualization of the stone. A 200- μ m-diameter low-water quartz fiber was inserted through the instrument port of the endoscope and allowed to contact the surface of each calculus. Damage to the endoscope was prevented by extending the quartz fiber past the tip of the endoscope prior to firing of the laser. The Ho:YAG laser has a 2,100-nm wavelength and a pulse duration of 250 microseconds. The laser settings used during the procedures ranged from 8 to 10 Hz at 5.5 to 8 W. Following destruction of the obstructing calculi, stone fragments and smaller mobile calculi were removed by retrograde flushing into the bladder or via retrieval by use of a wire basket.^h A cystotomy was performed in all patients to remove cystic cal-

culi, and a prepubic percutaneous Foley catheter^b was placed to facilitate postoperative bladder emptying.^{1,4,5,6,8} Foley catheters were removed in 10 to 28 days when patients were able to urinate freely through the urethra. Foley catheters were removed under light sedation. In 1 goat with complete urethral strictures, the Foley catheter was maintained for 3 months before the owner elected euthanasia.

Results

All of the pot-bellied pigs and 15 of 16 goats were male castrates. The pot-bellied pigs ranged in age from 2 to 9 years, whereas the goats ranged between 4 months and 8 years of age. The duration of each hospital stay ranged from 3 to 60 days. Common complaints at the time of admission included depressed mentation in 10 goats and 3 pot-bellied pigs, anorexia in 8 goats and 3 pot-bellied pigs, and straining in 11 goats and 6 pot-bellied pigs. Abnormal physical findings included tachycardia in 9 goats, tachypnea in 5 goats and 5 pot-bellied pigs, and fever in 2 goats and 2 pot-bellied pigs. Serum biochemical analyses were evaluated for 15 goats and 3 pot-bellied pigs. Hyperkalemia was observed in 5 goats and no pot-bellied pigs, high serum creatinine concentrations in 10 goats and 1 pot-bellied pig, and high blood urea nitrogen concentrations in 11 goats and 1 pot-bellied pig. Intravenous administration of balanced electrolytes was used to correct these disturbances. In all animals, the electrolyte imbalances and azotemia had resolved within 1 to 5 days after surgery.

Cystic or urethral calculi were observed radiographically in 8 of 10 goats. Seven of the 8 radiographically evident calculi were calcium carbonate and 1 was struvite. The composition of the remaining calculi encountered in goats was apatite (calcium phosphate) and silicate. Calculi were not detected by radiographic examination in any of the pot-bellied pigs. The composition of the calculi encountered in all 6 pot-bellied pigs was apatite.

Abdominal ultrasonography in goats revealed distended bladders with diameters ranging between 4 and 15 cm (mean, 7 cm) in small breed goats and 8 to 12 cm (mean, 9.5 cm) in large breed goats. The bladder diameters of the pot-bellied pigs ranged between 6 and 12 cm (mean, 9.5 cm). Hydronephrosis and uroperitoneum was observed in 3 and 9 goats, respectively. None of the goats with hydronephrosis subsequently went into renal failure, and all recovered upon successful resolution of the urinary tract obstruction. Hydronephrosis resolved within 10 days as determined by percutaneous ultrasonography. In all goats with uroperitoneum, surgery revealed pinpoint leaks rather than rents in the bladder. Resolution of the urinary blockage and placement of the Foley catheter resolved the uroperitoneum.

One pot-bellied pig and 1 goat were found to be free of urinary calculi by the use of urethroscopy. The pot-bellied pig had atony of the urinary bladder and the goat had cystitis. The pot-bellied pig had resided in an apartment and successfully recovered after it was turned out into a pasture. The goat was successfully treated with antibiotics and anti-inflammatory drugs.

Of the remaining 20 patients that underwent ure-

throscopy, 12 goats and 3 pot-bellied pigs were evaluated after tube cystotomy to assess urethral patency and mucosal integrity. Severe circumferential pressure necrosis of the urethral mucosa as a result of a calculus was observed via endoscopy following clearance of urethral calculi in 3 goats. All of these patients developed persistent dysuria and were subsequently euthanized at their owners' request. Urethroscopy was used to evaluate 1 goat referred to the teaching hospital for persistent dysuria following a cystotomy. In this goat, urethroscopy provided a diagnosis of dysuria secondary to suture occluding the lumen of the urethra. The penis had inadvertently been included in closure of the subcutaneous tissue during the cystotomy. This goat was also euthanized when the owner did not wish to pursue further treatments such as a perineal urethrostomy or bladder marsupialization.

Three goats and 2 pot-bellied pigs underwent urethroscopy in conjunction with laser lithotripsy. Four of the 5 animals that had lithotripsy recovered uneventfully. One goat was readmitted to the teaching hospital for stranguria and failure to urinate following occlusion of the prepubic Foley catheter. At the time of lithotripsy, this goat was observed to have had a circumferential area of urethral narrowing and marked mucosal pressure necrosis secondary to the calculi. At readmission, the area of circumferential damage had formed a tight stricture that precluded retrograde passage of the endoscope. The goat was subsequently euthanized for persistent stranguria as the owner did not wish to pursue further treatments such as a perineal urethrostomy or bladder marsupialization.

Calcium carbonate and apatite calculi were disrupted via laser lithotripsy in 3 goats and 2 pot-bellied pigs, respectively. At the time of laser lithotripsy, the calculi seen were larger in diameter than the diameter of the endoscope (2.7 mm). The diameter of the calculi removed from the patients' bladders at the time of the tube cystotomy ranged from 1 to 6.1 mm. The time and fluence required to disrupt calculi were recorded for a goat with multiple calcium carbonate calculi and a pot-bellied pig with a single apatite calculi. One hundred sixty-three seconds and 1,594 J at 8 W were used to disrupt 3 calcium carbonate calculi. Disruption of the apatite calculus took 42.3 seconds and 234 J at 5.5 W.

Difficulties encountered during application of urethral laser lithotripsy were related to positioning the laser fiber on the calculus. Calculi firmly lodged in the distal urethra were amenable to disruption, whereas attempts to disrupt nonfixed calculi (those freely moveable in the area of the urethral diverticulum) were unsuccessful as the result of calculi movement precluding accurate placement of the laser fiber. Another challenge was the spherical, smooth surface of calcium carbonate calculi that made application of the laser beam difficult, as the fiber could be easily deflected from the stone's surface. Conversely, the irregular shape of apatite calculi promoted direct application of the beam onto the surface of the stone. As the endoscope was retracted, a small amount of mucosal irritation was observed in most urethras; however, similar mucosal irritation was observed after passage of a urethral catheter.

Discussion

Individual susceptibility to urolithiasis reflects the influence of genetics on urinary excretion and production of urinary crystal inhibitors.¹¹ High urinary concentrations (supersaturation) of soluble, ionized minerals promote the formation and propagation of uroliths.¹² Risk factors for the development of urolithiasis include dietary imbalances, water restrictions, and urine pH.^{11,12} Dietary management impacts urine concentration and pH. Calcium carbonate stones are associated with the feeding of forages rich in calcium and oxalates that are low in phosphorus and magnesium.¹² Silica urolithiasis develops where there is a high silicone content in forage in combination with deficiencies of copper and zinc.¹² Struvite calculi are associated with the feeding of grain-based diets containing high concentrations of phosphorus relative to calcium.¹² Feeding pelleted rations may also predispose to the development of phosphate calculi (struvite or apatite) by reducing salivary excretion of phosphorus.¹² Acidic urine (pH < 7.0) favors the formation of silicate stones, whereas alkaline urine (pH > 7.0) favors the formation of apatite, calcium carbonate, and struvite stones.^{11,12}

Incomplete clearance of urethral calculi and stricture formation following clearance of urethral calculi are common causes of long-term treatment failure in small ruminants and pot-bellied pigs with obstructive urolithiasis. Historically there has not been a reliable method for resolution of urethral obstruction following urethral flushing. In our hospital, urethral calculi have been retained in the urethra following an apparently successful urethral flush. Additionally, urethral calculi are not consistently detected by use of radiography. On the basis of our observations, endoscopic evaluation of the distal urethra is recommended to ensure complete removal of stones. In our study urethral endoscopy proved useful for diagnosing, assessing prognosis, and treating urolithiasis in goats and pot-bellied pigs.

Urethroscopy and laser lithotripsy are routinely used in human medicine for the diagnosis and treatment of renal, ureteral, and cystic calculi.¹³⁻¹⁷ The most recent advancement in human laser technology in the field of urology is the use of the Ho:YAG laser.^{13,16,18-20} The 2,100-nm wavelength of the Ho:YAG laser allows for a short absorption length in soft tissues. It causes a superficial thermal injury zone in the range of 0.5 to 1.0 mm when placed directly on the tissue.¹⁶ This distance is less than the irritation induced by an neodymium:yttrium-aluminum-garnet laser but more than that caused by a CO₂ laser.¹⁶ Results of safety tests performed in pig ureters indicate the laser is safe and effective at fragmenting various types of calculi, and direct application to the ureteral wall is needed to create perforation.^{19,20} The Ho:YAG laser has been used with some difficulty to remove cystic and urethral calcium carbonate calculi in horses.²¹ The difficulty is attributable to the large size and hardness of the calculi. The calcium carbonate calculi in goats were also observed to be hard and required more energy and time to etch and crack than apatite calculi.

In our study, endoscopic examination of the ure-

thral mucosa following cystotomy and urethral flushing provided a means of verifying clearance of urethral calculi and a method for assessing the health of the urethral mucosa. Prolonged obstruction was observed to induce substantial pressure necrosis of the urethral mucosa. Observation of circumferential urethral mucosal necrosis was observed to have a poor prognosis because of subsequent postoperative urethral stricture. As a therapeutic tool, laser lithotripsy provided an additional management option for obstructive urolithiasis in pot-bellied pigs and goats with distal urethral calculi refractory to clearance using traditional procedures.

^aBonnano, Becton, Dickinson & Co, Franklin Lakes, NJ.

^bSherwood Medical Co, St Louis, Mo.

^cUreteroscope model No. 41807, 5-Star Medical Inc, Hayward, Calif.

^dUreteroscope built to our request based on model number 32507, 5-Star Medical Inc, Hayward, Calif.

^eComplete eyepiece and C mount video coupler model number 30201, 5-Star Medical Inc, Hayward, Calif.

^f5-Star Medical Inc, Hayward, Calif.

^gPaladin Medical, San Carlos, Calif.

^hACMI CIRCON, Stamford, Conn.

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