Treatment of pyonephrosis with a subcutaneous ureteral bypass device in four cats

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TREATMENT AND OUTCOME

All 4 cats underwent renal pelvis lavage and placement of a subcutaneous ureteral bypass (SUB) device for treatment of obstructive pyonephrosis. Postoperatively, the cystostomy tube became occluded with purulent material in 1 cat, requiring exchange. The procedure was successful in relieving the obstruction and pyonephrosis in all cats. Three of 4 cats had documented resolution of urinary tract infection. One cat had persistent bacteriuria without clinical signs 1 month after SUB device placement.

CLINICAL RELEVANCE

Results of this small series suggested that renal pelvis lavage with placement of an SUB device may be a treatment option for cats with obstructive pyonephrosis. (J Am Vet Med Assoc 2018;252:744–753)

A 7-year-old 4.28-kg (9.42-lb) spayed female domestic shorthair cat (cat 1) was referred for evaluation and treatment of suspected obstructive ureterolithiasis. Clinical signs included lethargy, inappetance, and ptyalism. The cat had a history of chronic toxoplasmosis. On physical examination, the cat was hypersalivating and had a grade 2/6 systolic heart murmur with a left parasternal point of maximal intensity. On abdominal palpation, the left kidney was small and irregular, and the right kidney was large and smooth. Two days prior to examination, laboratory testing, abdominal radiography, urinalysis (urine sample obtained by means of cystocentesis), bacterial culture of a urine sample, and transabdominal ultrasonography had been performed by the referring veterinarian. The urinalysis revealed proteinuria (+2) with a urine specific gravity of 1.017. Bacterial culture of a urine sample yielded *Escherichia coli*.

The CBC revealed leukocytosis (19,900 WBCs/µL; reference range, 4,200 to 15,600 WBCs/µL), neutrophilia (17,480 neutrophils/µL; reference range, 2,500 to 12,500 neutrophils/µL), normocytic normochromic anemia (Hct, 26%; reference range, 29% to 45%), and lymphopenia (950 lymphocytes/µL; reference range, 1,500 to 7,000 lymphocytes/µL). Serum biochemical analysis revealed a normal creatinine concentration (1.5 mg/dL; reference range, 0.8 to 2.3 mg/dL), high BUN concentration (38 mg/dL; reference range, 15 to 34 mg/dL), high sodium concentration (158 mEq/L; reference range, 147 to 156 mEq/L), and hyperglycemia (188 mg/dL; reference range, 64 to 170 mg/dL). All other values were within reference limits.

Abdominal radiography revealed a large right kidney, small left kidney, and small calculus in the right ureter. Abnormalities identified on abdominal ultrasonography consisted of infarction of the left kidney and echogenic fluid in the right renal pelvis (Figure 1). The right renal pelvis measured 0.8 cm in diameter in the transverse plane, and the right kidney was 4.9 cm long in the sagittal plane. The diameter of the right ureter proximal to the obstruction was 0.4 cm. Treatment with enrofloxacin (5 mg/kg [2.3 mg/lb], IV, q 24 h) and ampicillin (22 mg/kg [10 mg/lb], IV, q 8 h) was started.

Because of the location of the ureteral obstruction, treatment options that were considered included ureterotomy, ureteral reimplantation, ureteral resection and anastomosis, ureteral stent placement, and placement of an SUB device. The owner elected to proceed with placement of an SUB device.

The cat was anesthetized and positioned in dorsal recumbency. The ventral aspects of the abdomen, thorax, and neck were clipped and aseptically pre-
pared. A ventral midline laparotomy was performed, and the right kidney was isolated. The perirenal fat at the caudal pole of the kidney was bluntly dissected until the renal capsule was visualized. An 18-gauge, 1.5-inch-long over-the-needle catheter was inserted into the renal pelvis from this location. Once urine was obtained via pyelocentesis, antegrade ureteropyelography was performed, confirming the presence of a proximal ureteral obstruction. A sample of purulent material from the renal pelvis was submitted for aerobic bacterial culture and susceptibility testing. Then, the renal pelvis was gently and serially aspirated and lavaged with a 1:1 mixture of sterile saline (0.9% NaCl) solution and iohexol contrast medium so that the renal pelvis could be visualized with fluoroscopic guidance to avoid overdistension. The renal pelvis and proximal portion of the ureter were lavaged until purulent material was no longer aspirated and the lavage fluid appeared clear. Pyelography was then performed, confirming that the purulent material had been successfully removed on the basis of a lack of filling defects in the renal pelvis. The obstructive lesion in the proximal portion of the ureter was suggestive of a purulent focal lesion surrounding the palpable ureterolith (Figure 2).

Next, a 0.035-inch angle-tipped hydrophilic guide wire was inserted through the 18-gauge renal pelvis catheter and coiled inside the renal pelvis under fluoroscopic guidance. The catheter was removed over the wire, and a 6.5F locking-loop pigtail catheter was inserted over the guide wire into the renal pelvis under fluoroscopic guidance. The guide wire was then removed, and the pigtail catheter was locked in the renal pelvis by pulling and securing the locking string (Figure 2). Once the catheter was in the correct position, the polyethylene terephthalate cuff of the catheter was advanced onto the renal capsule and fixed in place with sterile cyanoacrylate glue. The renal pelvis was lavaged again to confirm removal of debris and then left to drain passively while a cystostomy tube was placed.

The urinary bladder was isolated, and a purse-string suture of 3-0 poliglene caprone was placed in the apex of the bladder. A stab incision was made in the center of the purse string with a No. 11 scalpel blade, and a 6.5F cystostomy tube was inserted into the bladder lumen. The polyethylene terephthalate cuff was glued to the bladder wall, and

Figure 1—Longitudinal ultrasonographic image of the right kidney in a 7-year-old 4.28-kg (9.42-lb) spayed female domestic shorthair cat (cat 1) with obstructive pyonephrosis. Notice the echogenic debris within the renal pelvis, hydronephrosis, and loss of renal architecture. The double-headed arrow represents the renal pelvis; the dotted line represents the width of the kidney.

Figure 2—Intraoperative fluoroscopic images of the cat in Figure 1 obtained during placement of an SUB device. A—Antegrade ureteropyelography performed through an 18-gauge, 1.5-inch-long over-the-needle catheter inserted into the renal pelvis confirmed the presence of filling defects within the renal pelvis and ureter (white arrows) as well as the presence of a proximal ureteral obstruction. B—A 0.035-inch angle-tipped guide wire was inserted through the 18-gauge catheter and coiled inside the renal pelvis, and a 6.5F locking-loop pigtail catheter (black arrow) was then advanced over the guide wire into the renal pelvis and locked by pulling and securing the locking string. The proximal ureteral obstruction is still apparent (yellow arrow). C—Once both the renal catheter (red arrows) and a cystostomy catheter (green arrows) were in place, they were connected to a shunting port that was positioned subcutaneously (white star). The entire device was lavaged with a 1:1 mixture of sterile saline (0.9% NaCl) solution and iodinated contrast material delivered through a 22-gauge noncoring Huber needle to ensure that the device was patent, not leaking, and not kinked.
3 full-thickness simple interrupted sutures were placed through the polyethylene terephthalate cuff into the bladder with 3-0 poliglecaprone 25d (Figure 3).

The right paramedian subcutaneous fat was dissected off the ventral rectus sheath, and the bladder and kidney catheters were tunneled through the body wall by use of a hemostat and subsequently connected to the shunting port subcutaneously (Figure 3). The port and catheters were tested to ensure no leakage occurred at the junction. With digital subtraction angiography and fluoroscopic guidance, the entire device was lavaged with a 1:1 mixture of sterile saline solution and iodinated contrast material delivered through a 22-gauge noncoring Huber needle to ensure that the device was patent, not leaking, and not kinked (Figure 2). Finally, the port was sutured to the body wall with 3-0 polypropylene in a simple interrupted pattern. The subcutaneous space adjacent to the port was then splashed with bupivacaine (0.3 to 0.6 mg/kg [0.14 to 0.27 mg/lb]), and the subcutaneous tissue over the port was closed with 3-0 poliglecaprone 25d in a simple continuous pattern. The abdomen was lavaged with warm saline solution, and the ventral midline incision was closed routinely in 3 layers. Upon completion of the procedure, an esophageal feeding tube was placed in standard fashion, along with a triple-lumen jugular venous catheter. Fluoroscopic imaging confirmed appropriate esophagostomy tube placement.

The procedure time was 70 minutes, including the time required for placement of the esophageal tube and central venous catheter. There were no apparent immediate surgical complications. The cat recovered from anesthesia under close observation, and vital parameters were continuously monitored.

The cat received methadone (0.2 mg/kg [0.09 mg/lb], IV, as needed up to q 4 h) and then transitioned to buprenorphine (0.01 to 0.02 mg/kg [0.0045 to 0.009 mg/lb], IV, q 8 h) the following day. Other postoperative medications included maropitant citrate (1 mg/kg [0.45 mg/lb], IV, q 24 h), dolasetron (0.6 mg/kg, IV, q 24 h), ampicillin (22 mg/kg, IV, q 8 h), and enrofloxacin (5 mg/kg, IV, q 24 h). The cat was maintained on IV fluid therapy, with delivery rate adjusted on the basis of hydration status.

The day after the procedure, renal biochemical parameters were evaluated. The BUN concentration was now within reference limits (21 mg/dL), and the creatinine concentration had decreased (1.2 mg/dL). The cat was discharged 3 days after surgery. Bacterial culture of a urine sample obtained by means of sterile collection from the SUB device with a Huber needle did not yield any growth. The cat was reevaluated 7 days after surgery with treatment consisting of amoxicillin-clavulanic acid (14.24 mg/kg [6.47 mg/lb], PO, q 12 h) and marbofloxacin (5.70 mg/kg [2.60 mg/lb], PO, q 24 h). The owner was advised to return the cat for a follow-up examination and assessment of the left kidney 5 to 7 days later.

The cat was reevaluated 7 days after surgery. Bacterial culture of a urine sample obtained by means of sterile collection from the SUB device with a Huber needle did not yield any growth. Renal biochemical parameters were evaluated, and the BUN and creatinine concentrations were 16 mg/dL and 19 mg/dL, respectively. Hydronephrosis of the right and left kidneys was found to have resolved. The cat continued to receive antimicrobials for 17 days after surgery, but treatment was discontinued at that time owing to noncompliance. Renal biochemical parameters were reevaluated 48 days after surgery; BUN concentration was 21 mg/dL, and creatinine concentration was 1.8 mg/dL.

Figure 3—Intraoperative photographs obtained during the placement of the SUB device in the cat in Figure 1. A—The polyethylene terephthalate cuff of the cystostomy catheter has been glued to the bladder wall. Three full-thickness simple interrupted sutures were then placed through the cuff into the bladder with 3-0 poliglecaprone 25. B—The paramedian subcutaneous fat has been dissected off the ventral rectus sheath, and the bladder and renal catheters have been tunneled through the body wall with a hemostat and subsequently connected to the shunting port subcutaneously. The port was then sutured to the body wall with 3-0 polypropylene in a simple interrupted pattern.
Bacterial culture of a urine sample obtained from the SUB port failed to yield any growth.

Bacterial culture of a urine sample obtained from the SUB port 155 days after surgery yielded growth of an _Enterococcus_ sp susceptible to amoxicillin. Although the cat did not have any clinical signs of urinary tract infection, treatment with amoxicillin for 6 weeks was prescribed. Bacterial culture of urine samples collected 60, 150, 210, and 539 days after the end of the amoxicillin treatment remained positive for a similar _Enterococcus_ isolate. However, the cat continued to have no clinical signs of infection and no evidence of purulent debris in the renal pelvis on repeated ultrasonography or in urine samples collected from the SUB device. Therefore, additional treatment was not pursued. At 783 days after implantation of the SUB device, the cat was alive without clinical signs of urinary tract infection, although bacterial culture of urine samples remained positive for _Enterococcus_ spp.

A 6.9-year-old 5.32-kg (11.70-lb) castrated male domestic shorthair cat (cat 2) was examined because of azotemia and mild hydronephrosis and hydroureter of the right kidney detected on ultrasonography. The cat had initially been examined by the referring veterinarian 4 days earlier because of anorexia. On physical examination, the cat was 8% dehydrated and had a grade 3/6 left systolic heart murmur. The referring veterinarian had performed a urinalysis, which revealed 4 to 10 WBCs/hpf, proteinuria (+1), bacteriuria (>100 rods/hpf), and a urine specific gravity of 1.016. Bacterial culture of a urine specimen obtained via cystocentesis yielded _E. coli_.

A CBC performed by the referring veterinarian revealed leukocytosis (23,300 WBCs/µL; reference range, 4,200 to 15,600 WBCs/µL), neutrophilia (20,737 neutrophils/µL; reference range, 2,500 to 12,500 neutrophils/µL), and normochromic normocytic anemia (Hct, 20%; reference range, 29% to 45%). Serum biochemical analysis revealed high creatinine (4.1 mg/dL; reference range, 0.8 to 2.3 mg/dL), BUN (81 mg/dL; reference range, 15 to 34 mg/dL), and phosphorus (7.6 mg/dL; reference range, 3.0 to 7.0 mg/dL) concentrations and low albumin concentration (2.1 mg/dL; reference range, 2.3 to 3.9 g/dL).

Abdominal radiography revealed bilaterally small and irregular kidneys. Abdominal ultrasonography demonstrated right hydroureter, right hydronephrosis with floating intraluminal debris, hyperechoic fat in the retroperitoneal space consistent with right retroperitonitis, a thickened right ureter consistent with ureteritis, and left chronic nephropyathy with mild pelvic dilation. The right renal pelvis measured 0.5 cm in diameter in the transverse plane, and the right kidney was 4.0 cm long in the sagittal plane. The diameter of the dilated proximal portion of the ureter was 0.7 cm.

The cat was treated with enrofloxacin (5 mg/kg, IV, q 24 h) on the basis of results of bacterial culture and susceptibility testing of a urine sample. The owner elected to proceed with placement of an SUB device after all treatment options were discussed. A similar procedure as described for cat 1 was performed. The obstructive lesion was a right-sided ureteric stricture associated with a circumcaval ureter. A sample of purulent material from the renal pelvis and ureter was submitted for aerobic bacterial culture and susceptibility testing. The procedure time was 80 minutes, including the time to place an esophagostomy tube and central venous catheter. No major complications occurred, and the cat recovered from anesthesia uneventfully.

The cat received a continuous rate infusion of oxy-morphone (0.025 to 0.05 µg/kg/h [0.011 to 0.022 µg/lb/h], IV) for the first 24 hours after surgery for postoperative analgesia and was transitioned to buprenorphine (0.01 to 0.02 mg/kg, IV, q 8 h) the following day. Other postoperative medications included famotidine (0.5 mg/kg [0.23 mg/lb], IV, q 12 h), maropitant citrate (1 mg/kg, IV, q 24 h), enrofloxacin (5 mg/kg, IV, q 24 h), and ampicillin sulbactam (22 mg/kg, IV, q 8 h). The ampicillin sulbactam was added to provide broader-spectrum antimicrobial coverage. The cat also received 2 U of packed RBCs (approx 11 mL/kg [5 mg/lb], IV) postoperatively because of moderate anemia (PCV, 17%). The cat was maintained on IV fluid therapy with the rate intermittently adjusted according to hydration status.

The day after the procedure, renal biochemical parameters were evaluated. The cat had progressive azotemia 24 hours after SUB device placement (BUN concentration, 97 mg/dL; creatinine concentration, 3.8 mg/dL), and abdominal ultrasonography revealed a persistently dilated renal pelvis. During flushing of the SUB device, it was determined that the cystostomy catheter was not patent. It was suspected that the catheter was occluded with purulent material or a blood clot. Therefore, the cat was anesthetized, and the cystostomy tube was replaced. A large amount of coagulated purulent material surrounded the distal tip of the cystostomy catheter that was removed. Recorded anesthesia time was 1 hour, and recovery from anesthesia was unremarkable.

Throughout hospitalization, the BUN concentration improved, but the creatinine concentration progressively increased (BUN concentration, 81 mg/dL; creatinine concentration, 4.8 mg/dL). The cat was hospitalized for 10 days. At the time of discharge, bacterial culture of a urine sample was positive for _E. coli_, and the cat was prescribed amoxicillin–clavulanic acid (13.67 mg/kg [6.21 mg/lb], PO, q 12 h) on the basis of results of susceptibility testing. Metronidazole (12.43 mg/kg [5.65 mg/lb], PO, q 12 h) was also prescribed because of the cat’s persistent diarrhea during hospitalization. The cat continued to receive antimicrobials for 50 days after surgery.

The cat was reevaluated 34 days after surgery. The BUN and creatinine concentrations were essentially unchanged, at 76 mg/dL and 4.6 mg/dL, respectively, and bacterial culture of a urine sample did not yield any growth. Reevaluation of renal biochemical parameters 55 days after surgery showed an improved creatinine concentration at 3.7 mg/dL. Results of bacterial culture of a urine sample obtained from the SUB device when the cat was no longer receiving antimicrobials did not yield any growth. The cat did not experience any long-term complications or recurrence of urinary tract infection and was alive 511 days after placement of the SUB device.

A 14-year-old 4.85-kg (10.67-lb) neutered male domestic shorthair cat (cat 3) was evaluated because of anorexia.
ia and weight loss. The cat had a history of mild increases in renal biochemical parameters according to the owner, along with increased thirst and 2 episodes of pollakiuria and stranguria. On physical examination, the cat was 7% to 9% dehydrated, and on auscultation, a grade 3/6 systolic parasternal heart murmur was appreciated. On abdominal palpation, both kidneys felt irregular, and the left kidney felt large. A urinalysis indicated a urine specific gravity of 1.010 with a slightly high WBC count (2 to 5 WBCs/hpf) and normal RBC count (0 to 2 RBCs/hpf). Bacterial culture of a urine sample obtained via cystocentesis did not yield any growth.

A CBC revealed mild normocytic normochromic anemia (Hct, 28.4%; reference range, 29% to 45%) and lymphopenia (856 lymphocytes/µL; reference range, 1,500 to 7,000 lymphocytes/µL). Serum biochemical analysis revealed high creatinine (13.5 mg/dL; reference range, 0.8 to 2.3 mg/dL), BUN (214 mg/dL; reference range, 15 to 34 mg/dL), and phosphorus (13.8 mg/dL; reference range, 3.0 to 7.0 mg/dL) concentrations.

Abdominal radiography revealed retroperitoneal effusion and left renomegaly. Abdominal ultrasonography demonstrated a dilated left ureter with echogenic debris as well as a moderately enlarged left kidney in comparison with the right kidney, consistent with ureteral obstruction and acute nephritis. Additional findings included a hyperechoic retroperitoneal space containing fluid consistent with retroperitonitis, severe pancreatic duct dilation (approx 1.5 cm in diameter), and incidental biliary cystadenomas. The left renal pelvis was 1.0 cm in diameter in the transverse plane, and the left kidney was 4.2 cm long in the sagittal plane. The ureter proximal to the obstruction was 0.3 to 0.5 cm in diameter. The cat was empirically treated with enrofloxacin (5 mg/kg, IV, q 24 h).

After discussion of all medical and surgical options, the owner elected to proceed with placement of an SUB device for treatment of the pyonephrosis and ureteral obstruction. During surgery, the left ureteral obstruction was found to be secondary to a ureterolith. Purulent material from the left renal pelvis was submitted for cytologic examination and aerobic bacterial culture and susceptibility testing. On cytologic examination, there was evidence of cocci with septic inflammation, but bacterial culture did not yield any growth. The procedure was 65 minutes long. There were no surgical complications.

The cat was administered a continuous rate infusion of oxymorphine (0.025 to 0.05 µg/kg/h, IV) for postoperative analgesia and then transitioned to buprenorphine (0.01 to 0.02 mg/kg, IV, q 8 h) the following day. Other postoperative medications included famotidine (0.5 mg/kg, IV, q 12 h), maropitant citrate (1 mg/kg, IV, q 24 h), and meropenem (12 mg/kg [5.45 mg/lb], IV, q 12 h). Antimicrobial treatment was changed owing to the presence of septic urine. The cat was maintained on IV fluid therapy with the rate adjusted on the basis of changing hydration status.

The day after the procedure, renal biochemical parameters were evaluated. The BUN and creatinine concentrations had improved to 171 and 11.3 mg/dL, respectively. Throughout the hospital stay, the creatinine concentration continued to improve, and the patient was discharged 6 days after surgery with a BUN concentration of 62 mg/dL and creatinine concentration of 5.7 mg/dL. The hospitalization time was prolonged for the owner's convenience and for boarding rather than because of medical concerns. Although bacterial culture of samples collected at the time of surgery did not yield any growth, the cat was prescribed broad-spectrum antimicrobial treatment consisting of amoxicillin–clavulanic acid (1294 mg/kg [5.88 mg/lb], PO, q 12 h) and marbofloxacin (5.18 mg/kg [2.35 mg/lb], PO, q 24 h) at the time of discharge, because of concerns that bacterial culture results may have been falsely negative as a result of antimicrobial administration prior to surgery and sample collection.

The cat was reevaluated 11 days after surgery. Renal biochemical parameters were evaluated, and the BUN and creatinine concentrations were 45 and 5.1 mg/dL, respectively. At another reevaluation 21 days after surgery, bacterial culture of a urine sample did not yield any growth, and cytologic examination did not reveal any bacteria. Renal biochemical parameters were evaluated, and the BUN and creatinine concentrations were 47 and 4.5 mg/dL, respectively. Values 42 days after surgery were 59 mg/dL and 4.0 mg/dL, respectively, and bacterial culture of a urine sample was again negative. This cat continued to receive antimicrobials for 36 days after surgery.

Approximately 4 months after surgery, the cat was reevaluated because of vomiting, inappetence, and signs of discomfort. The BUN and creatinine concentrations were 101 and 5.9 mg/dL, and the SUB port was difficult to flush, but no renal pelvic dilation was evident ultrasonographically. The cat was treated with marbofloxacin for 7 days, pending results of bacterial culture of a urine sample. Subsequent to this treatment, renal biochemical parameters remained high (BUN, 93 mg/dL; creatinine, 6.1 mg/dL). Urinalysis revealed no active sediment, and bacterial culture of a urine sample did not yield any growth. Two weeks after antimicrobial administration was completed, bacterial culture of another urine sample also did not yield any growth. Renal biochemical values were improved (BUN, 86 mg/dL; creatinine, 5.3 mg/dL). However, the cystostomy catheter of the SUB system now appeared to be occluded, with no ability to drain urine or flush the catheter with sterile saline solution under ultrasonographic guidance. Abdominal ultrasonography was repeated and revealed minimal to no dilation of the left renal pelvis as well as no evidence of hydronephrosis. Ureterography was performed through the renal catheter of the SUB device system with fluoroscopic guidance, which revealed a patent ureter and no evidence of ureteral obstruction. Therefore, exchange of the SUB device was not considered warranted.

Five months after surgery, the cat had a decline in appetite and energy level and continued to have high BUN (115 mg/dL) and creatinine (8.0 mg/dL) concentrations. Results of bacterial culture of a urine sample were negative, and abdominal ultrasonography revealed a fluid-filled pancreatic lesion with no evidence of ureteral obstruction. The pancreatic lesion was drained percutaneously, and results of cytologic evaluation of a fluid specimen were consistent with suppurrative inflammation and necrosis. Pancreatitis and pancreatitis abscess formation were diagnosed, and the cat was hospitalized for 1 day for sup-
portive care and then medically managed at home with famotidine (1.0 mg/kg, PO, q 24 h), marbofloxacin (2 mg/kg [0.9 mg/lb], PO, q 24 h), marbofloxacin (5.8 mg/kg, PO, q 24 h), and lactated Ringer solution (40 mL/kg [18.18 mL/lb], SC, q 24 h). Approximately 450 days later, or 600 days after SUB device placement, the cat developed worsening azotemia (BUN, 154 mg/dL; creatinine, 10.2 mg/dL). The owner declined further diagnostic evaluation or treatment. The cat was ultimately euthanized 607 days after SUB device placement.

A 6.5-year-old 3.01-kg (6.62-lb) spayed female domestic shorthair cat (cat 4) was referred for evaluation and treatment of pyelonephritis and suspected ureteral obstruction. The cat had initially been examined by the referring veterinarian 1 day earlier because of weight loss and inappetence. The cat had a history of increased thirst and hairballs. On physical examination, the cat had diffuse muscle wasting and was occasionally sneezing. On abdominal palpation, the right kidney felt smooth and large, and the left kidney felt normal.

A urinalysis had been performed by the referring veterinarian, which revealed pyuria (21 to 50 WBCs/hpf), hematuria (<10 RBCs/hpf), proteinuria (+5), and bacteriuria (<10 coccii/hpf). However, a urine sample had not been submitted for bacterial culture. A CBC was performed, which revealed leukocytosis (21,400 WBCs/µL; reference range, 4,200 to 15,600 WBCs/µL), neutrophilia (19,688 neutrophils/µL; reference range, 2,500 to 12,500 neutrophils/µL), lymphopenia (642 lymphocytes/µL; reference range, 1,500 to 7,000 lymphocytes/µL), and normocytic normochromic anemia (Hct, 23.9%; reference range, 29% to 45%). Serum biochemical analysis revealed high creatinine (2.8 mg/dL; reference range, 0.8 to 2.3 mg/dL) and BUN (61 mg/dL; reference range, 15 to 34 mg/dL) concentrations.

Abdominal radiography had been performed by the referring veterinarian and revealed renal asymmetry and bilateral renomegaly, with the right kidney larger than the left. Abdominal ultrasonography performed at our hospital indicated that the right ureter contained a moderate amount of echogenic debris. The right renal pelvis was 2.4 cm in diameter in the transverse plane, and the right kidney was 5.07 cm long in the sagittal plane. The proximal portion of the right ureter could be followed for only 1 to 2 cm, after which it was difficult to identify. A ureterolith was not visualized. The cat was empirically treated with enrofloxacin (5 mg/kg, IV, q 24 h). The cat also received 1 U of packed RBCs (9.6 mL/kg [4.4 mg/lb]) because of anemia (PCV, 17%).

After discussion of all medical and surgical options, the owner elected to proceed with placement of an SUB device. During surgery, the right ureteral obstruction was found to be secondary to a proximal ureterolith that was not visualized on radiography or ultrasonography. The purulent material from the right renal pelvis was submitted for anaerobic and aerobic bacterial urine culture and susceptibility testing, and an *Enterococcus* sp was isolated. During surgery, partial occlusion with purulent material was seen in the renal catheter, and the catheter could not be easily flushed. The occlusion was resolved with frequent lavage prior to closure.

The cat was administered a continuous rate infusion of oxymorphone (0.025 to 0.05 µg/kg/h) for postoperative analgesia and then transitioned to buprenorphine (0.01 to 0.02 mg/kg, IV, q 8 h) the following day. Other postoperative medications included famotidine (0.5 mg/kg, IV, q 24 h), maropitant citrate (1 mg/kg, IV, q 24 h), and meropenem (12 mg/kg, q 12 h). This antimicrobial regimen was chosen pending results of bacterial culture and susceptibility testing owing to prior antimicrobial exposure and the presence of septic urine. The cat was maintained on IV fluid therapy postoperatively, with the rate adjusted on the basis of changing hydration status.

The day after the procedure, renal biochemical parameters were evaluated, and improvements in the BUN and creatinine concentrations were seen (63 mg/dL and 2.6 mg/dL, respectively). The patient was discharged 5 days after surgery, at which time the BUN and creatinine concentrations were 53 and 3.2 mg/dL, respectively. On the basis of results of bacterial culture and susceptibility testing, the cat was treated with marbofloxacin (7.8 mg/kg [3.55 mg/lb], PO, q 24 h) and chloramphenicol (25 mg/kg [11.36 mg/lb], PO, q 12 h).

The cat was reevaluated 17 days after surgery. A urine sample was submitted for bacterial culture and susceptibility testing, and an *Enterococcus* sp similar to that found at the time of surgery was isolated even though the cat was still receiving the previously prescribed antimicrobials. Serum biochemical testing demonstrated progressive azotemia (BUN, 141 mg/dL; creatinine, 9.2 mg/dL) despite a patent SUB device and no evidence of ureteral obstruction on either side. The cat was switched to amoxicillin (25.20 mg/kg [11.45 mg/lb], PO, q 12 h) and marbofloxacin (9 mg/kg [4.10 mg/lb], PO, q 24 h) owing to improved susceptibility of the bacterial isolate to these drugs. Additional serum biochemical testing performed by the referring veterinarian 28 and 35 days after surgery showed improved renal function (BUN and creatinine 28 days after surgery, 53 and 4.1 mg/dL, respectively; BUN and creatinine 35 days after surgery, 64 and 3.8 mg/dL, respectively). Urine was not submitted for bacterial culture at that time.

The cat was examined by a local veterinarian 61 days after surgery because of vomiting, decreased appetite, and weight loss. The owner elected euthanasia at that time, despite previously improved renal biochemical parameters. A necropsy was not performed.

**Discussion**

For all 4 cats described in the present report, implantation of an SUB device successfully relieved ureteral obstruction and allowed treatment of associated pyonephrosis. No cat died in the perioperative period despite the severity of illness in each patient. Ureteral obstruction was caused by a urolith in 3 cats and by a ureteral stricture associated with a circumcaval ureter in 1. All obstructions were quite proximal, which would have made traditional surgical treatments relatively challenging.

Pyonephrosis is a rare condition that has been infrequently described in the human1 and veterinary literature2 and has never been reported in a series in cats, to our knowledge. It is defined as infective hydronephrosis,
is typically associated with renal pelvis abscess forma-
tion,1,2 and is most commonly a complication of a ureteral obstruc-
tion. This condition is typically considered a uro-
logical emergency, as patients are often septic on initial ex-
amination and require drainage of the renal pelvis be-
cause antimicrobial penetration is poor.1,2 If treatment is
delayed, destruction of the renal parenchyma and loss of
renal function can occur.3,4 Reported causes of ureteral obstruc-
tion include ureterolithiasis, ureteral strictures (congenital or acquired), dried solidified blood clots or
calculi, and neoplasia.2,5–10 In small animal patients, ure-
terolithiasis is the most common cause of ureteral ob-
struction, with 92% to 98% of feline ureteroliths docu-
mented to be composed of calcium oxalate stones, which
are not considered infection induced.3–8

In human patients, the treatment for obstructive
pyonephrosis is typically drainage and decompression
with either a percutaneous nephrostomy tube or a ure-
teral stent inserted by means of minimally invasive tech-
niques.3,11 The overall success rates for percutaneous
nephrostomy tube placement range from 83% to 100%,
depending on the experience of the operator.11 This ap-
proach may benefit veterinary patients that are severely
debilitated and for which a longer surgical procedure
should be avoided. However, an additional procedure will
often be needed later to address the underlying cause of
the ureteral obstruction and provide a more permanent
decompressive method. The use of ureteral stents is com-
mon in human medicine, as they allow for renal pelvic
lavage and drainage as well as indwelling decompression
of the renal pelvis, while avoiding renal puncture and an
externalized tube.1 In human patients, 1 study12 reported
a 94% success rate for stenting of intrinsic obstructions.

The literature regarding specific treatment options
for obstructive pyonephrosis in veterinary medicine is
sparse.2 However, the most common treatments for ure-
teral obstruction include traditional surgical techniques,
such as ureterotomy or ureteral reimplantation, as well
as interventional drainage techniques, such as neph-
rostomy tube placement,13 ureteral stenting,5,14 and the
placement of an SUB device.5,8–10,15,16,e Traditional surgical
treatment options for ureteral obstructive disease
were reported in 2 separate retrospective studies5,6 of
cats with ureterolith-induced obstructions. In a retro-
spective study7 of 101 cats undergoing surgical removal
of ureteral calculi, 31% had perioperative complications,
and there was a 29% perioperative mortality rate, with 13
cats not surviving the surgery and an additional 16 cats
dying of complications prior to discharge. The most com-
mom complications were urine leakage (15%) and persis-
tent or recurrent ureteral obstruction (7%).7 In another
retrospective study8 evaluating ureterotomy in 47 cats,
postoperative abdominal effusion was reported in 34% of
cats and 6% of cats had confirmed uraoadenom. Thir-
ten percent of cats required a second surgery during the
same hospitalization, and there was a 21% perioperative
mortality rate.10 The presence of pyonephrosis was not
reported in any of the cats in these studies.

Ureteral stenting has become a common treatment
option in veterinary medicine. Our group recently re-
ported2 the results for 13 dogs with obstructive pyone-
phrosis. In that study, renal pelvic lavage was performed,
and double-pigtail ureteral stents were placed success-
fully in all dogs, with most procedures performed end-
doscopically. Twelve of 13 (92%) dogs survived to dis-
charge. The median survival time was > 480 days, and
most dogs were still alive at the time of last follow-up.
That report supported that ureteral stenting can be an
effective treatment option for dogs with obstructive pyo-
 nephrosis, avoiding invasive surgery in septic patients
and providing lower morbidity and mortality rates than
traditional techniques.17

We also reported the use of ureteral stenting in a
large retrospective series8 of 69 cats (79 ureters) with
ureteral obstruction, although only 1 cat was noted to
have obstructive pyonephrosis. In that study, the peri-
operative mortality rate was 7.2% (5/69). Cats had a med-
ian survival time of 498 days (range, 2 to > 1,278 days),
but if their death was not associated with a renal cause,
they had a median survival time of > 1,250 days.8 Long-
term complications in cats with ureteral stents included
pollakiuria (38%), stent migration (6%), ureteritis, (2%),
chronic mild hematuria (18%), chronic urinary tract in-
fecions (13%), and reobstruction of the stent and ureter
(19%).5,8 Another study14 of 26 cats found a 52% 12-month
survival rate after ureteral stenting, but none of those
cats had pyonephrosis. The high rate of dysuria (38%) report-
edly associated with ureteral stenting5,8,15,e and the mod-
erate risk for stent reocclusion (19%).8,9,15,e particularly
in cats with ureteral obstruction secondary to a ureteral
stricture, led to the development of the SUB device.

The SUB device described in the present report has
been used for treatment of cats with a ureteral obstruc-
tion since 2009 at the authors’ practice. This device uses
a subcutaneous shunting port connected to a locking-
loop nephrostomy catheter and cystostomy catheter.
Preliminary data have suggested a perioperative mortality
rate of 5.8%.10,16,e To date, both the short- and long-term
morbidity and mortality rates for cats with ureteral ob-
struction treated with the SUB device have been shown
to be superior to rates for previously reported treatment
methods.10,15,16,e Recently, outcomes following implanta-
tion of 174 SUB devices in 134 cats were reported,9 and
the main complications of the device were found to con-
sist of occlusion with calculous material (25%), chronic
infection (8%), perioperative occlusion with a blood clot
(8%), leakage (5%), and kinking (5%) of the tubing. Only
12.7% of cats needed a device exchange owing to reestab-
lishment of a patent native ureter. The median survival
time was 827 days (range, 1 month to > 6,757 years), with
only 30% of patients dying or being euthanized for renal
causes throughout the entire follow-up period.10,16,e

Initial clinical signs for the cats of the present report
were mostly vague and nonspecific (eg, anorexia, leth-
argy, and weight loss). In a case series2 of obstructive
pyonephrosis in dogs, this was also the case. However,
in that report, 4 of 13 dogs also had signs of urinary tract
disease such as polyuria, polydipsia, incontinence, stran-
guria, hematuria, or flank pain. The only sign potentially
associated with urinary tract disease in the present study
was a change in thirst, which was reported in 3 cats. On
physical examination, the only specific signs of renal dis-
case included an enlarged kidney felt on palpation (n = 3) and an irregular, small kidney felt on palpation (2). Detection of irregular kidney size on palpation in dogs with obstructive pyonephrosis was only reported in 2 of 13 patients. However, it is likely easier to identify irregular kidneys on physical examination in cats than in dogs.

Clinicopathologic abnormalities in cats of the present report were similar to those previously reported for dogs and included anemia, leukocytosis, neutrophilia, and lymphopenia. Interestingly, 10 of 13 dogs with obstructive pyonephrosis also had thrombocytopenia, although none of the 4 cats in the present report did.

All 4 cats in the present study were azotemic. Because azotemia has been associated with a theoretical 75% loss in overall renal function, even though all 4 cats initially had only unilateral ureteral obstruction, the presence of azotemia suggested that there was decreased function in the contralateral kidney also. Additionally, in previous reports, 95% of cats with ureteral unilateral obstruction had concurrent azotemia. This reinforces the importance of using renal-sparing procedures when treating ureteral obstruction in cats and suggests that performing renal pelvis lavage and allowing for subsequent drainage may be in the patient’s best interest when treating cats with ureteral obstruction and pyonephrosis.

For all 4 cats in the present report, a sample obtained from the renal pelvis at the time of surgery was submitted for bacterial culture, but only 3 cats had a urine sample collected by means of cystocentesis prior to the procedure submitted for bacterial culture. At the authors’ institution, bacterial cultures are typically grown for 72 hours if there is not any growth. In a previous study, 5 of 9 dogs with pyonephrosis that had urine samples from multiple locations submitted for bacterial culture had discordant results (positive for one location and negative for another). Similar to these findings, results of bacterial culture of urine samples from the bladder versus renal pelvis for cats in the present report were inconsistent, suggesting that both should always be evaluated for the most accurate results. In people with pyonephrosis, a third of bacterial cultures of urine from the bladder or renal pelvis does not confirm the absence of pyonephrosis. Therefore, a negative culture result for urine from the bladder or renal pelvis does not confirm the absence of pyonephrosis. Also, our inconsistent culture findings may be associated with the timing of antimicrobial administration prior to sample collection. All 4 cats received antimicrobials prior to surgery. Three cats did not receive antimicrobials prior to cystocentesis, but in 1 cat, it was unclear from the referring veterinarian’s medical records whether antimicrobials had been administered.

All 4 cats of the present report underwent abdominal ultrasonography prior to surgery. In 1 cat (cat 1), a unilateral proximal ureteral obstruction resulting from a stone in the ureter was definitely identified on the basis of hydroureter, hydropneumephrosis, and a shadowing stone at the junction of the dilated and nondilated portions of the ureter. In the other 3 cats, the exact cause of the obstruction could not be identified, although the severe hydronephrosis and hydroureter were highly suggestive of ureteral obstruction. In 1 cat (cat 2), hyperechogenicity of the retroperitoneum and retroperitoneal fluid were identified, consistent with retroperitonitis. Retroperitonitis is not typically seen with ureteral obstructions, and its presence may have been related to the severity of renal pelvis abscess formation or the acute nature of the ureteral obstruction. Echogenic debris was seen ultrasonographically in the affected renal pelvis in 2 cats and the affected ureter in 1 cat. In the remaining cat, purulent material was not visualized ultrasonographically but was seen during pyelocentesis at the time of surgery. Ultrasonography is a valuable tool in identifying renal disease, ureteral obstruction, and possible causes for ureteral obstruction. However, it is not always diagnostic, and ureteropyelography performed during surgery, in combination with typical ultrasonographic findings, is considered the diagnostic modality of choice in our practice.

A minor complication was encountered during placement of the SUB device in 1 cat (cat 4) in the present report, but was resolved during surgery. In another cat (cat 2), a complication occurred the day after surgery, requiring another procedure. In cat 4, partial occlusion of the renal catheter was noticed at the time of surgery but was resolved with copious lavage with saline solution and passage of a guide wire. In cat 2, the cystostomy tube became occluded with purulent material and had to be replaced the day after surgery. Because of these 2 complications, we now more aggressively lavage the renal pelvis and ureter during surgery prior to connecting the SUB system to ensure that as much purulent material as possible is removed.

One cat in the present report (cat 1) developed contralateral hydronephrosis secondary to a ureterolith 3 days after surgery, which was identified prior to hospital discharge and resolved within 72 hours. This scenario again emphasized the desirability of renal-sparing treatments in cats with ureteral stones. Most cats with unilateral ureteral obstruction have azotemia, suggesting that the contralateral unobstructed kidney is not functioning normally. In 1 study, ultrasonography indicated that the contralateral kidney was small in 39 of 70 (56%) cats with unilateral ureteral calculi, and there was mild or moderate dilation of the contralateral renal pelvis or ureter in 26 of 71 (37%) cats. Further, in a recent evaluation of cats in which a SUB device was implanted, 33% of the cats had had bilateral obstructions at some time in their lifetime.

One cat (cat 4) in the present report was euthanized 61 days after surgery. In this cat, an Enterococcus sp was isolated from a urine sample 17 days after SUB placement despite an improvement in renal biochemical values. This cat was eventually euthanized because of vomiting, decreased appetite, and weight loss, but ultrasonographic findings were not supportive of persistent ureteral obstruction or pyonephrosis. Unfortunately, a urine sample for culture was not obtained at the time of euthanasia, so persistent urinary tract infection could not be definitively ruled out.

Urinary tract infections with enterococci are typically considered nonpathogenic in veterinary and human medicine. The enterococci are gram-positive facultative anaerobic bacteria that can grow in an aerobic or anaerobic environment. They are one of the most common organisms isolated from the urinary bladder in dogs, cats, and humans. In a recent study, 11 of 29 cats had en-
terococci isolated from a urine specimen collected under aseptic conditions; however, only 5 of the 11 cats had clinical signs consistent with lower urinary tract disease. In human health care, most patients with enterococci in the urinary tract but without clinical signs are believed to be colonized rather than infected, and treatment is not required. The only bacteria isolated from cat 4 was an Enterococcus sp initially obtained from a renal pelvis sample collected at the time of surgery. The cat remained persistently infected despite appropriate antimicrobial treatment and relief of the renal pelvic abscess. Whether this cat’s clinical decline resulted from progressive chronic kidney disease, pyelonephritis secondary to persistent infection, or some other condition was uncertain. Prior to euthanasia, the cat’s creatinine concentration had been improving, so progressive kidney dysfunction was not suspected.

Two cats in the present report (cats 3 and 4) were treated with meropenem after surgery before results of bacterial culture and susceptibility testing of the renal pelvis sample were obtained. The choice to treat them with this antimicrobial was made on the basis of concerns about previous antimicrobial treatment by the referring veterinarian; the presence of clinical signs of urosepsis, such as hypothermia, worsening azotemia, and low blood pressure; and the possibility of abdominal sepsis developing after surgery because of purulent material draining from the renal pelvis. Considering the case management for these 4 cats and their associated bacterial susceptibility profiles, we believe that none of them required this antimicrobial. Therefore, this antimicrobial would likely not be recommended for future cases unless determined to be the best choice on the basis of susceptibility testing results. Three of the 4 cats in this report were prescribed a fluoroquinolone at the time of discharge. This was done because there are data to support that fluoroquinolones should be used after placement of urinary implants to help prevent biofilm formation.

One cat in the present report (cat 3) had evidence of cystostomy catheter occlusion 131 days after placement of the SUB device. However, the device was not exchanged, as there was no ultrasonographic evidence of ureteral or renal pelvis dilation and results of ureterography suggested that the ureter was patent. Occlusion of an SUB device has been recently shown to occur in 25% of cats after SUB device placement, but only 12.7% of these cats required exchange of the device owing to development of a patent native ureter over time. Device mineralization was found to be most commonly associated with idiopathic hypercalciemia, but can be seen in any stone-forming cat. None of the previous cases involving cats with stricture-induced obstructions were documented to have any long-term SUB device occlusions. Nevertheless, possible occlusion is a complication of SUB device placement that should always be discussed with clients when choosing the best long-term renal pelvic decompression option. Recently, a new antiseptic flush solution containing tetrasodium ethylenediaminetetraacetic acid that purportedly prevents and treats biofilms and mineralization on urinary tract devices became commercially available. This solution has been used in the authors’ practice as a flush solution and shown promising results with the SUB device. It is currently being prospec-tively evaluated for treatment and prevention of both biofilms and mineralization in animals.

The biggest concern about placing an implant in a patient with an active infection, like pyonephrosis, is the risk of persistent colonization and biofilm formation on the device, resulting in the inability to clear the infection over the long term. This did not appear to be a concern for 3 of the 4 cats in the present report.

Results of this small case series suggested that placement of an SUB device may be a treatment option for cats with obstructive pyonephrosis. Unlike nephrectomy, it is a renal-sparing procedure, and it avoids complications such as ureteral stricture or ureteral leakage associated with traditional surgical alternatives. Ureteral stenting would have been considered an option in these cats, but does not allow for placement of a large-lumen catheter for renal pelvic lavage, as is recommended for human patients with pyonephrosis. Additionally, ureteral stents are not typically recommended in cats with ureteral strictures, because they are reported to have a high risk of reobstruction (approx 50%).

The SUB device procedure may be preferable to some traditional surgical techniques because it maintains the integrity of the kidney and ureter and provides an expedited method for renal pelvic decompression. It also has been associated with a high perioperative survival rate, compared with the perioperative survival rate for traditional alternatives for cats with ureteral obstruction. Although these traditional alternatives have not been assessed as treatment options for cats with pyonephrosis, results of the present study supported the idea that the SUB device is a viable alternative. However, placement of an SUB device can be technically challenging, and advanced training is recommended prior to considering the procedure.

Footnotes


References


From this month's AJVR

Determination of anatomic landmarks for optimal placement in captive-bolt euthanasia of goats

Paul J. Plummer et al

OBJECTIVE
To determine the optimal anatomic site and directional aim of a penetrating captive bolt (PCB) for euthanasia of goats.

SAMPLE
8 skulls from horned and polled goat cadavers and 10 anesthetized horned and polled goats scheduled to be euthanized at the end of a teaching laboratory.

PROCEDURES
Sagittal sections of cadaver skulls from 8 horned and polled goats were used to determine the ideal anatomic site and aiming of a PCB to maximize damage to the midbrain region of the brainstem for euthanasia. Anatomic sites for ideal placement and directional aiming were confirmed by use of 10 anesthetized horned and polled goats.

RESULTS
Clinical observation and postmortem examination of the sagittal sections of skulls from the 10 anesthetized goats that were euthanized confirmed that perpendicular placement and firing of a PCB at the intersection of 2 lines, each drawn from the lateral canthus of 1 eye to the middle of the base of the opposite ear, resulted in consistent disruption of the midbrain and thalamus in all goats. Immediate cessation of breathing, followed by a loss of heartbeat in all 10 of the anesthetized goats, confirmed that use of this site consistently resulted in effective euthanasia.

CONCLUSIONS AND CLINICAL RELEVANCE
Damage to the brainstem and key adjacent structures may be accomplished by firing a PCB perpendicular to the skull over the anatomic site identified at the intersection of 2 lines, each drawn from the lateral canthus of 1 eye to the middle of the base of the opposite ear. (Am J Vet Res 2018;79:276–281)