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Use of a subcutaneous ureteral bypass device for treatment of bilateral proximal ureteral injury in a 9-month-old cat

Joseph A Sapora[1], Robert J Hardie[2] and Natashia Evans[3]

Abstract

Case summary A 9-month-old male domestic longhair cat presented following iatrogenic ureteral trauma after an attempted laparoscopic ovariectomy. Prior to identifying that the cat was male, both ureters were transected approximately 4 mm from the renal pelves. Initial management involved a left-sided Boari flap neoureterocystostomy, cystonephropexy and right ureteronephrectomy. Thirty-six hours later, the cat developed uroabdomen due to leakage from the neoureterocystostomy site. At a tertiary referral institution, the ureter was reconstructed via end-to-end anastomosis and a left-sided subcutaneous ureteral bypass (SUB) device was placed in the event the anastomosis failed. Five weeks after SUB placement, the cat was dysuric and stranguric. A urine culture was negative and clinical signs were attributed to sterile cystitis secondary to device placement. Blood urea nitrogen (BUN) was 22 mg/dl and creatinine was 1.2 mg/dl. Contrast pyelography confirmed device patency, but no contrast was identified through the ureteral anastomosis. At 12 months, BUN and creatinine were 1.5 mg/dl and 25 mg/dl, respectively, and a subclinical urinary tract infection was identified (*Enterococcus faecalis*). Antibiotic therapy was not prescribed in order to prevent multidrug resistance. At 42 months, BUN was 38 mg/dl and creatinine was 2.0 mg/dl. The cat had occasional and intermittent signs of pollakiuria and stranguria but was otherwise doing well.

Relevance and novel information To our knowledge, this is the first case report to describe the use of a SUB device for management of traumatic proximal ureteral injury in a cat with one kidney. The case outcome provides valuable information about the direct effect of the SUB device and the presence of chronic *Enterococcus* species infection on long-term renal function.

Keywords: Subcutaneous ureteral bypass; SUB; ureteral trauma; kitten

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Introduction

Ureteral trauma in cats can be challenging to treat owing to the small size of the ureter (internal diameter 0.4 mm)[1] and the need for optical magnification for most surgical procedures. Various types of ureteral pathology have been described, including ureteroliths, inflammation, trauma, neoplasia, fibrosis, mucus plugs, congenital stenosis, acquired strictures, foreign bodies and blood clots. Current surgical treatment options include ureterotomy, neoureterocystostomy (including Boari flap procedure), ureteral stenting and the placement of subcutaneous ureteral bypass (SUB) devices.[1–11]

The recent advent of the SUB device as a salvage procedure for ureteral obstructions has proven useful when

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primary reconstruction or re-implantation of the ureter is not pursued.[1] The SUB device involves the placement of a multi-fenestrated, locking-loop pigtail catheter within the renal pelvis or proximal ureter, and a multi-fenestrated catheter within the bladder. The two catheters are then connected to a readily accessible titanium and silicone injection port placed within the subcutis.[4,8] In veterinary medicine, the SUB device has been used for the management of ureteral strictures, ureteral obstructions, circumcaval ureters and as a salvage procedure for ureteral stent reactions or intolerance.[2–4]

To our knowledge there is, at the time of publication, only one other case describing the use of a SUB device for management of traumatic ureteral injury in a juvenile cat.[4]

The purpose of this case report is to describe successful use of a SUB device for management of proximal ureteral transection in a 9-month-old cat with a single kidney with long-term follow-up of 42 months.

Case description

A 9-month-old male domestic longhair cat presented as a surgical referral for bilateral ureteral trauma following an attempted laparoscopic ovariectomy. Prior to identification that the cat was male, accidental transection of both ureters, approximately 4 mm from the renal pelves, had occurred.

The cat was immediately referred to a local private specialty practice for further assessment and surgical repair of the ureteral injury. At that time, serum creatinine was 2.1 mg/dl and blood urea nitrogen (BUN) was 31 mg/dl (reference intervals [RI]: creatinine 0.9–2.3 mg/dl and BUN 13–35 mg/dl). Owing to the proximity of the transected ureters to the renal pelves, a left-sided Boari flap and cystonephropexy procedure was performed followed by a right ureteronephrectomy. Thirty-six hours after surgery, creatinine was 8.3 mg/dl and BUN was 155 mg/dl, and no urine output had been observed. Uroabdomen was suspected and the cat was referred to a tertiary referral center.

Upon presentation, 48 h following the second surgical procedure, the cat was quiet, alert and painful on abdominal palpation. Heart rate was 240 beats per minute, respiratory rate was 24 breaths per minute and rectal temperature was 100.7ºF (38.2ºC).

Initial treatment included intravenous plasmalyte with 2.5% dextrose (10 ml/h) and buprenorphine (0.02 mg/kg q6h). Bloodwork revealed azotemia (creatinine 11.3 mg/dl, BUN 140 mg/dl), hyperkalemia (5.8 mmol/l) and hyperphosphatemia (11.4 mg/dl) (RIs: creatinine 0.9–2.3 mg/dl, BUN 15–35 mg/dl, potassium 3.5–5.1 mmol/l, phosphorus 2.6–8.8 mg/dl).

Abdominal-focused assessment with ultra sonography for trauma scan revealed free peritoneal fluid. Diagnostic abdominocentesis revealed a creatinine of 12.2 mg/dl and potassium of 5.6 mmol/l, consistent with uroabdomen. A peritoneal dialysis catheter was placed, and dialysis was performed with 50 ml of Lactated Ringers Solution + 1.5% dextrose, with a 1 h dwell time every 4 h for three consecutive cycles. Between each treatment, urine was allowed to flow from the dialysis catheter. The previously placed Tomcat urethral catheter (Argyle; Medtronic) was replaced with a 3.5 Fr urethral catheter (MILA).

Approximately 12 h later, creatinine was 11.9 mg/dl and BUN was 158 mg/dl. Based on the evidence of uroabdomen and progressive azotemia, surgical management involving anastomosis of the transected ureter and placement of a SUB device as a means of urinary diversion was performed.

Surgical management

Exploratory laparotomy revealed urine leakage from the anastomosis of the Boari flap to the left renal capsule. The previously ligated and transected distal left ureteral segment, measuring several centimeters in length, was identified proximal to the urinary bladder. A sample of abdominal fluid was submitted for aerobic culture, which was negative.

The Boari flap was taken down, revealing the previously transected end of the proximal ureter approximately 4 mm from the renal pelvis. Multiple suture holes were present in the renal pelvis that were actively leaking urine. The bladder was reconstructed with 4-0 glycomer 631 (Biosyn; Covidien) with a single-layer closure in a simple interrupted pattern. With the aid of an operating microscope, the transected ends of the left ureter were debrided, stented with 4-0 polypropylene suture (Prolene; Ethicon) and an end-to-end anastomosis was performed using 9-0 polyglactin 910 suture (Vicryl; Ethicon).

Following anastomosis of the ureter, the SUB device was placed in the left kidney as a diversionary procedure to minimize leakage from the ureteral anastomosis site and renal pelvis and as a salvage procedure in case the ureteral anastomosis was not successful.

A 6.5 Fr nephrostomy catheter (Norfolk Vet) was placed through the caudal pole of the kidney and into the pelvis using the modified Seldinger technique. Proper positioning of the catheter tip was confirmed with contrast fluoroscopy using iohexol (Omnipaque; GE Healthcare) diluted 1:1 with sterile saline. The nephrostomy catheter was secured to the renal capsule with cyanoacrylate glue and four simple interrupted sutures (4-0 glycomer 631) placed through the Dacron cuff to provide additional stability and minimize the risk of migration due to the tenuous nature of the renal pelvis.

The cystostomy catheter was then placed in the apex of the bladder and secured with a purse-string suture

and four simple interrupted sutures (4-0 glycomer 631) placed through the Dacron cuff. Both catheters were tunneled through the left ventrolateral body wall, terminating within the subcutaneous tissues. The catheters were attached to the silicone access port, which was secured to the body wall with simple interrupted sutures using 4-0 nylon (Dermalon; Covidien). Proper positioning and patency of the SUB device was confirmed with contrast fluoroscopy similar to the previous pyelogram. Once the SUB device was in place, leakage from the holes in the renal pelvis decreased, presumably due to the decompression of the renal pelvis. However, a small amount of urine leakage remained so Gelfoam (Pfizer) was packed over the renal pelvis to help promote a fibrin seal over the holes.

The 3.5 Fr urethral catheter was left in place to allow for monitoring of urine output and to maintain continuous and complete decompression of the urinary system. Postoperative pain was controlled with buprenorphine (0.01 mg/kg IV q6h). Forty-eight hours after SUB placement, the creatinine and BUN were 1.7 mg/dl and 27 mg/dl, respectively, and remained normal for the duration of hospitalization.

The urethral catheter was left in place for 5 days to maintain decompression of the urinary system. An aerobic culture of the urine obtained from the urethral catheter on day 3 was negative for bacterial growth. Twenty-four hours after removal of the urethral catheter, a progressive hyperkalemia (from 4.3 to 6.9 mmol/l within 48h) was noted and an abdominal ultrasound revealed a scant amount of free fluid around the left kidney (volume too small to be sampled). Persistent urine leakage from the renal pelvis was suspected and so the urethral catheter was replaced for an additional 5 days during which time the hyperkalemia resolved. During these additional 5 days, a urinary tract infection (*Enterococcus faecalis* >100,000 colony-forming units [CFU]/ml) developed and was treated with ampicillin–sulbactam (30 mg/kg IV q8h) until a repeat urine culture 7 days later was negative. Day 10 after SUB placement, the urethral catheter was removed and no free fluid was noted upon repeat ultrasound.

Follow-up

Five weeks after SUB placement, the cat was intermittently stranguric and pollakiuric. The subcutaneous port had rotated 90º from its original position but remained accessible (Figure 1). A contrast pyelogram was performed with approximately 6 ml of iohexol (diluted 1:1 with sterile saline) injected through the SUB device until there was complete filling of the bladder and renal pelvis. There was no evidence of contrast flow through the ureteral anastomosis site and so it was assumed that the site had strictured. A complete blood count and serum biochemistry profile were normal with a BUN and creatinine of 22 mg/dl and 1.2 mg/dl, respectively. A urine sample obtained directly from the SUB device revealed hematuria and pyuria (white blood cells too numerous to count [WBCs TNTC], many cocci), although aerobic culture was negative. The stranguria and pollakiuria were attributed to sterile cystitis secondary to SUB placement or possibly due to irritation from the cystostomy catheter. No treatment was administered.

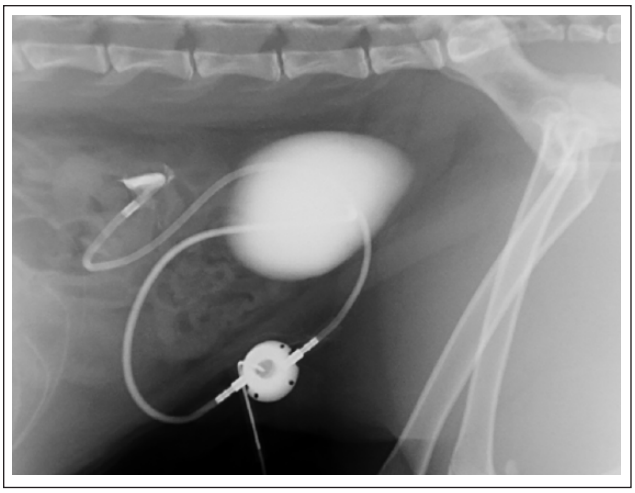

Figure 1 Lateral abdominal radiograph demonstrating 90° rotation of the subcutaneous ureteral bypass port within the subcutaneous tissue

Twelve months after SUB placement, the cat was normal with no clinical signs of stranguria, pollakiuria or hematuria. Serum creatinine was 1.5 mg/dl and BUN was 25 mg/dl. Fluoroscopic pyelogram and cystogram using iohexol diluted 1:1 with saline injected through the subcutaneous port confirmed proper positioning and patency of the SUB device. Urine culture obtained from the SUB port revealed recurrence of a urinary tract infection (UTI) with the same organism *E faecalis*. A urine analysis revealed a specific gravity of 1.020 with trace amounts of protein via a sulfosalicylic acid (SSA) precipitation test, a small amount of blood and pyuria (WBCs TNTC, many cocci). Owing to the lack of clinical signs associated with the UTI, and to prevent the development of multidrug-resistant bacterial pathogens, no antibiotics were prescribed.

Twenty months after SUB placement, the cat continued to do well with no clinical signs of a UTI. Creatinine was 1.8 mg/dl and BUN was 27 mg/dl. Fluoroscopic pyelogram and cystogram confirmed patency of the SUB device. Urine culture showed a persistent infection with *E faecalis*. Urine specific gravity was 1.021 with trace protein (SSA), a small amount of blood and pyuria (WBCs TNTC, many cocci).

Thirty months after SUB placement, the cat remained clinically normal with no reported stranguria or hematuria. Urine analysis obtained from the SUB device revealed a specific gravity of 1.020, 3+ protein (SSA), a large

amount of blood and pyuria (WBCs TNTC, many cocci). Aerobic culture again confirmed persistence of the *E faecalis* infection. Owing to the lack of reported clinical signs, antibiotic therapy was not prescribed.

Thirty-eight months after SUB placement, the cat presented to a separate specialty center for pollakiuria and an open wound over the SUB port with partial exposure of the metallic base. The cat had been licking at the port, resulting in an open wound. Physical examination revealed further rotation of the port and dislodgement of the previously placed tacking sutures around the port. BUN and creatinine at that time were 44 mg/dl and 2.6 mg/dl, respectively, indicating a progressive azotemia. The cat was placed under general anesthesia and the SUB port was oriented in the appropriate position and reattached to body wall using 3-0 polypropylene suture (Prolene; Ethicon). A short course of Clavamox (unknown duration) was prescribed and the pollakiuria resolved for approximately 4 months.

Forty-two months after SUB placement, the cat represented for pollakiuria and stranguria. Physical examination revealed healing of the skin over the subcutaneous port. BUN and creatinine at that time were 38 mg/dl and 2.0 mg/dl, respectively. Urinalysis revealed a specific gravity of 1.020, 2+ protein (SSA), a large amount of blood, with no bacteria or white blood cells observed. Urine culture at that time revealed a persistent *E faecalis* infection (>100,000 CFUs) with a wide susceptibility. An abdominal ultrasound revealed that the SUB remained in place and was patent, with mild focal fibrosis, granulation tissue or cystitis at the cystostomy site. A short course of meloxicam (0.02 mg/kg PO for 5 days) was prescribed for the suspected underlying cystitis. Additional diagnostics including blood pressure and urine protein: creatinine ratio were recommended for further staging of the cat's underlying CKD; however, the owner declined additional diagnostics owing to financial concerns.

Discussion

This case report demonstrates the successful use of a SUB device for long-term management of traumatic proximal ureteral transection in a cat. Additionally, the fact that this cat was very young at the time of the original injury (with presumably normal renal function) and underwent a contralateral nephrectomy provides valuable information about the direct effect of the SUB device and the presence of chronic *E faecalis* infection on long-term renal function.

The first attempts at bypassing ureteral obstructions with silicon prostheses in humans were made in the 1960s and 1970s, and complications with extravasation, obstruction at the site of anastomosis and encrustations were gradually overcome by improvement in materials and surgical technique.[12,13] Long-term follow-up regarding their use for ureteral strictures following renal transplantation is well documented.[13] The use of nephrovesicular subcutaneous ureteral bypass devices in humans have more recently been used as minimally invasive yet highly effective treatment options for patients with hydronephrosis resulting from advanced oncologic disease.[14] They have been shown to improve mobility and quality of life in human patients that would otherwise receive nephrostomy tube placement for various ureteral pathologies.[12,14,15]

To our knowledge, there is only one other case report describing the successful use of a SUB device as a primary means of treatment for iatrogenic ureteral ligation in a kitten.[4] In that report, a left-sided SUB device was placed in a 17-week-old female Sphynx 3 weeks after accidental ligation of the left ureter during an elective ovariohysterectomy. The right kidney was unaffected and the kitten was clinically normal 16 months following SUB placement.[4]

A second case report described the use of a SUB device following traumatic ureteral injury in an adult cat.[16] In that report, a 7-year-old spayed female Burmilla cat presented with abdominal pain and worsening azotemia following suspected blunt-force trauma. An exploratory laparotomy confirmed bilateral ureteral trauma that was initially treated with bilateral placement of 12 cm, 2.5 Fr double-pigtail stiff ureteral stents. The proximal and distal ends of the ureters were then anastomosed over the ureteral stents; however, 2 months later, the cat developed sterile cystitis unresponsive to medical management. The ureteral stents were replaced with softer stents (Vet Stent-Ureter; Infiniti Medical). The sterile cystitis persisted and ultimately the stents were removed and bilateral SUB devices were placed, which alleviated clinical signs for up to 12 months.[16]

In the presented case, despite stricture of the left ureteral anastomosis, renal function was preserved with placement of the SUB device in the remaining kidney. The placement of a temporary nephrostomy tube would have been a suitable option for urinary diversion during healing of the ureteral anastomosis and traumatized renal pelvis; however, use of the SUB device allowed for a more long-term or even permanent solution in a single procedure, in the event of failure of the ureteral reconstruction.

There is limited information available on the complications and outcome of SUB placement in cats. One study evaluating the feasibility of SUB placement without fluoroscopic guidance in 13 cats revealed a short-term (7–30 days) complication rate of 63%, including urinary tract infections (n = 3), non-infectious cystitis (n = 3) and obstruction of the SUB device (n = 1), which resolved with manual flushing.[8] In this study, median age was 4.5 years. Ten cats were still alive at a median follow-up of 225 days (range 60–600 days) with a 6 month survival rate of 73%. The overall mortality rate was 15.4%.

Another study evaluated the short- and long-term outcomes of cats with ureterolithiasis treated with

double-pigtail ureteral stents or SUB devices.[17] Thirty stents were placed in 27 cats and 30 SUB devices were placed in 23 cats. Median duration of surgery was longer in the stent group (77 mins, range 44–160 mins) than the SUB group (47 mins, range 35–85 mins). Complications seen in the SUB group included stranguria and pollakiuria (n = 5), dysorexia (n = 1), hematuria (n = 4) and occlusion of the device (n = 1). Mortality rate in the SUB group prior to hospital discharge was 13%, with only two cats requiring additional surgical procedures because of SUB occlusion and lower urinary tract obstruction.

The most common complications associated with SUB placement appear to be stranguria, pollakiuria, UTI, sterile cystitis and kinking of the catheter tubing. There is one report of bladder catheter dislodgement 25 months after SUB placement.[11]

Long-term complications encountered in the case reported here included a UTI with *E faecalis* that was diagnosed 10 days after the procedure. The UTI was initially treated successfully, but a repeat urine culture at 12 months identified re-infection with the same organism. Also, the subcutaneous port rotated 90º 5 weeks after placement, which initially did not interfere with flushing or sampling of the device but ultimately led to self-trauma of the overlying skin and necessitated surgical revision to replace the tacking sutures.

In humans, pyuria accompanied by asymptomatic bacteriuria is not an absolute indication for antimicrobial treatment in adults; however, individualized conditions are considered (pregnancy, diabetes, immune status, the elderly, etc).[18,19] One recent study showed that human renal transplant patients that have asymptomatic bacteriuria and are treated have a greater likelihood of repeat hospitalization than untreated patients with asymptomatic bacteriuria. In that study, clearance of the bacterial infection was successful in 48.8% of patients (20/41); however, 47.6% went on to develop bacterial resistance (10/21). In contrast, 14/20 (70%) patients in the untreated group had spontaneous resolution of their bacteriuria.[20]

In the case reported here, antimicrobial therapy was withheld at the time of diagnosis of the recurrent UTI (12 months) owing to the lack of clinical signs and in an attempt to minimize the development of multidrug resistance. At 42 months after SUB placement, the cat continued to have a positive urine culture (*E faecalis*) with mild intermittent clinical signs of pollakiuria and stranguria. The significance of the *E faecalis* UTI in this case is uncertain. *Enterococcus* species are widely considered non-pathogenic in the urinary tract.[21] There is concern that overtreatment of *Enterococcus* species UTI can lead to resistance or superinfection with other, more pathogenic organisms. Pollakiuria and stranguria may be caused by the SUB device itself.[16] As such, the decision of whether to treat persistent *E faecalis* infection of the urinary tract is difficult. In humans, there are clinical algorithms to determine if a patient should be treated or not. No such algorithms currently exist in veterinary medicine. We made the decision not to treat persistent *E faecalis* infection, and acknowledge that persistent pyelonephritis may have been present. Given that the cat fulfilled the criteria for International Renal Interest Society stage 2 chronic kidney disease progression in azotemia (1.2 mg/dl at 5 weeks, 1.5 mg/dl at 12 months, 1.8 mg/dl at 20months, 2.0 mg/dl at 42 months) additional diagnostics were recommended, including urine protein creatinine ratio and blood pressure. A low-protein renal diet was also discussed.

A recent case series looked at treatment for obstructive pyonephrosis with renal pelvis lavage followed by SUB device placement in four cats.[22] Pyonephrosis is defined as infective hydronephrosis and is most commonly a complication secondary to ureteral obstruction. In this case series, all cats were relieved of their obstruction and 3/4 cats had documented resolution of their urinary tract infections. One cat had persistent bacteriuria (*Enterococcous* species) without clinical signs 1 month after device placement. Antimicrobial therapy was prescribed for 6 weeks, but at 783 days after the procedure, the cat remained positive for a similar *Enterococcus* species without signs of a UTI.

A standardized protocol for flushing SUB devices has yet to be published. Recommendations for long-term management include periodic flushing with sterile saline, using fluoroscopy or ultrasound guidance to evaluate patency of the tubing, serial BUN and creatinine measurements, and aerobic culture and sensitivity every 3–9 months. Reported protocols for flushing and sampling of the SUB port vary from every 3–9 months to only if the device obstructs.[4,7,16,17,23] Norfolk Vet Products provides a surgical guide for SUB devices in which they recommend flushing every 3–6 months using fluoroscopy or an ultrasound-guided technique. The Norfolk Vet Products website also recommends a standardized protocol of flushing the device immediately postoperatively, at 1 month and then at 3 months. Most recently, the website has recommended infusion of a novel solution, tetra-EDTA, which may help prevent biofilm formation.[23]

In the case reported here, scheduled rechecks for long-term follow-up to confirm SUB patency were recommended every 6 months. Fluoroscopic cystogram and pyelogram were performed by injecting approximately 6 ml of iohexol (diluted 1:1 with saline) into the SUB port and visualizing contrast enhancement in the renal pelvis and urinary bladder. The initial rationale for performing contrast fluoroscopy versus ultrasonographic evaluations in this case was to attempt to assess patency of the ureteral anastomosis.

While both fluoroscopy and ultrasonography will allow for an objective assessment of renal pelvis diameter, ultrasonography may be a more sensitive imaging modality for detection of subtle changes in the

renal parenchyma.[7,24] Further investigation evaluating expected long-term changes in renal pelvis size secondary to the presence of an indwelling SUB device are needed.

Conclusions

The use of the SUB device in this case proved to be an invaluable option for management of proximal ureteral injury not amenable to other forms of primary repair and highlights the value of being familiar with the device and placement technique when faced with such an injury. Functionality of the SUB device is possible for up to 42 months, despite chronic *E faecalis* infection. Additional information on the effects of chronic subclinical infection, and the ideal flushing protocol is necessary to further guide usage of SUB devices in cats.

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