Sassy's SUBstantial Recovery

Lindsay H. Thomas

Mississippi State University

College of Veterinary Medicine

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Advisor: Elizabeth Swanson, DVM, MS, DACVS-SA

Introduction

A subcutaneous ureteral bypass (SUB) device is a system that functions as a prosthetic ureter in animals without a functioning ureter. Indications for its use include obstructive ureterolithiasis, ureteral stricture, ureteral stent reaction or intolerance, and obstructive ureteral malignancy.[7] Its unique design with a subcutaneous shunting port allows for detection of patency without high-risk diagnostics.[1] It has also been proven to have less complications than alternative means for managing cases of ureteral obstruction in cats.[1]

History and Presentation

Sassy, a 7-month-old female spayed domestic shorthair cat, presented to Mississippi State University College of Veterinary Medicine (MSU CVM) Small Animal Emergency Services on June 10, 2021 for a painful abdomen, anorexia, and adipsia. Two days prior, Sassy underwent an ovariohysterectomy at her primary veterinarian. This elective spay became a two-hour abdominal exploratory procedure as the primary vet was unable to locate the right ovary and uterine horn. Sassy was prescribed Clavamox and was discharged on June 9, 2021. After she was discharged, her owners noted that she refused to eat or drink. She frequented her litter box but did not urinate or defecate. Sassy would growl and cry if her owners attempted to pick her up. Prior to her spay, Sassy was apparently healthy and lived only indoors with one other cat.

Upon presentation, Sassy was quiet and depressed. Her mucous membranes were pale pink, and her capillary refill time was less than two seconds. Sassy had a temperature of 98.8°F, a heart rate of 176 beats per minute, and a respiratory rate of 40 breaths per minute. On abdominal palpation, her abdomen was extremely painful, and there was crusting and cat litter seen around her spay incision. Her incision was about 4 inches in length. Some fleas were seen

on her, and she had fecal matter around her rectum and tail. On AFAST, there was no fluid seen around any of her organs. On TFAST, a normal glide sign was seen, and no fluid was seen around her lungs or heart. The remainder of her physical exam was unremarkable.

Diagnostic Approach

Complete blood count (CBC) revealed neutrophilia (17,280/µl), lymphopenia (470/ µl), monocytosis (920/ µl), polycythemia (RBC 13.79x10^6/ µl, HGB 16.7g/dl), low MCV (31.6 fL), low MCH (12.1 pg), high MCHC (38.3 g/dl), and low platelets (143,000/ul). This is consistent with a stress leukogram, dehydration, and mild thrombocytopenia. Serum chemistry revealed hyponatremia (141.6 mmol/L), hyperkalemia (10.04 mmol/L), hypochloridemia (100.7 mmol/L), low CO2 (7.8 mEq/L), high anion gap (43), high BUN (265 mg/dl), high creatinine (12.26 mg/dl), high total bilirubin (4 mg/dl), hyperphosphatemia (17 mg/dl), hypercholesterolemia (235 mg/dl), hypermagnesemia (4 mg/dl), and high CK (2232 U/L). These changes are consistent with either renal or post-renal azotemia. Because no urinalysis was performed and no free fluid was found in the abdomen, the cause of the azotemia was not definitely determined.

On abdominal radiographs, the right kidney was not definitively identified, likely due to dysplasia or absence. The left kidney appeared subjectively enlarged, likely due to compensatory hypertrophy. Pneumoperitoneum, peritoneal effusion, subcutaneous emphysema, and soft tissue swelling of the ventral abdomen were thought to be consistent with recent abdominal surgery. On abdominal ultrasound, an ovoid hypoechoic structure was noted in the anatomic region of the urinary bladder. This was likely either the urinary bladder or an enlarged uterine stump. There was mild nephromegaly of the left kidney, likely due to compensation. There was mild left pyelectasis, potentially secondary to a ligated ureter. The right ovary was seen adjacent to the

right renal vein but was dysplastic. Edema, cellulitis, and mild seroma formation were noted at the incision site. The mesentery was diffusely hyperechoic, which is consistent with expected postoperative change. Given the clinical history of pain and anuria following a recent difficult spay, a chemistry profile being consistent with either renal or post-renal azotemia, and the imaging suspicious for a small urinary bladder with ligation of the left ureter, Sassy was given a presumptive diagnosis of a ligated left ureter post-spay and was taken into emergency surgery.

Anatomy and Pathophysiology

Trauma, ligation, and transection of ureters are reported complications of ovariohysterectomies. If the ureter is transected, uroabdomen will result. Uroabdomen, the presence of urine in the abdomen, results from a disruption in the urinary tract, allowing urine to accumulate in the peritoneal cavity, retroperitoneal cavity, or both, depending on where the defect is located.[6] Both ureteral ligation and transection result in severe changes to electrolytes and metabolism, including azotemia and hyperkalemia, further resulting in detrimental effects on cardiac and renal function.[6]

Urine contains a much higher concentration of creatinine and potassium than does blood. In the case of uroabdomen secondary to ureter transection, as urine accumulates in the abdominal cavity, it is resorbed into circulation, moving down its concentration gradient and increasing the concentration of potassium and creatinine in the blood.[4,6] However, this resorption occurs at a slower rate than the excretion into the urine.[6] The clinical significance of this is that abdominal fluid with a potassium and creatinine concentration greater than that of peripheral blood is diagnostic for uroabdomen.[4] If the animal remains in a hyperkalemic state, then the resting membrane potential of all cells is increased, causing an increase in cell membrane excitability.[6]

This is particularly important for cardiac myocytes, for which increased excitability results in progressive, life-threatening arrhythmias and eventually cardiac arrest.[6] The type and severity of these arrhythmias directly correlate with the level of potassium in the blood.[5]

In addition to being high in potassium and creatinine, urine is hyperosmolar.[4] This pulls water from the extracellular space across the peritoneal membrane, dehydrating the animal.[4] As the animal is dehydrated, the glomerular filtration rate decreases, decreasing the excretion rate of toxic solutes such as urea, creatinine, potassium, and hydrogen ions.[4] The retention of these solutes results in azotemia, worsening hyperkalemia, and metabolic acidosis.[4]

Diagnosis

In the case of post-renal azotemia, the underlying cause must be determined. General clinical signs, such as abdominal pain, anorexia, anuria or oliguria, and vomiting may be seen with both ureteral ligation and transection. Imaging of the urinary tract will further assist in differentiating the two main differential diagnoses of ureteral ligation and ureteral transection or rupture. The absence of free fluid in the abdomen, along with hydronephrosis and a proximal hydroureter associated with a distal abrupt narrowing to a normal diameter, is consistent with a ligated ureter.

The diagnosis of uroabdomen is based on the entire clinical picture of the patient, including history, physical exam, laboratory diagnostics, and diagnostic imaging. The severity of the clinical signs varies, depending on the amount of urine in the abdomen and the length of time it has been present.[5,6] The history of a patient with uroabdomen may include recent trauma, such as surgery, vehicular trauma, or animal attack, along with a description of stranguria/anuria, lethargy, and pain.[6] The physical exam abnormalities may include abdominal pain, an abdominal

fluid wave, arrhythmias, and an unidentifiable bladder on palpation.[6] Bloodwork abnormalities consistent with uroabdomen include azotemia, metabolic acidosis, hyponatremia, hyperphosphatemia, and hyperkalemia.[6] Urine within the peritoneal cavity may present as a transudate, modified transudate, or exudate with or without signs of hemorrhage or inflammation.[6] It may result in an aseptic neutrophilic inflammation or a septic effusion.[6] With such a variable gross and cytologic presentation of the effusion, uroabdomen is diagnosed based on the chemical properties. The most specific of these is the ratio of creatinine and potassium in the effusion as compared to the serum. If the effusion creatinine or potassium is at least as high as the serum creatinine or potassium, this is suggestive for uroabdomen.[6] If the effusion creatinine is measured at twice the level of serum creatinine, this is diagnostic for uroabdomen.[6] Finally, abdominal imaging (with or without contrast), such as radiographs, computed tomography, and ultrasound may be used to evaluate disruption of the urinary tract or free fluid in the abdomen.

Treatment and Management

Treatment for a ligated ureter entails stabilization of the patient including management of hyperkalemia, if indicated, followed by emergency surgery to identify the ligature and remove it if recently placed. If the ligature is chronic, then either ureteral resection and anastomosis, transection at the site of the ligature and reimplanation into the bladder via neoureterocysostomy, or nephrectomy are indicated.

If uroabdomen is diagnosed, initial stabilization followed by appropriate treatment is critical to the case outcome. Stabilization begins with identification and correction of life-threatening system imbalances. If the patient presents in hypovolemic shock, administration of

intravenous fluids and flow-by oxygen will aid in reestablishing tissue perfusion and oxygen delivery.[6] The fluid administration will also aid in stabilization of mild-to-moderate electrolyte imbalances.[6] If the patient has severe hyperkalemia, calcium gluconate may be used to counteract the myocardial effects of hyperkalemia.[6] Serum potassium may be reduced by administration of insulin with dextrose, β_2-agonists, or sodium bicarbonate.[6] Pain management should also be considered during initial stabilization. A urinary catheter should be placed and abdominal drainage established if warranted.

After the patient is stabilized, treatment efforts are focused on identifying and repairing the urinary tract to reestablish urine flow. In the case of uroabdomen secondary to ureteral transection, surgical correction may be performed by anastomosing the ureteral ends or performing a neoureterocystostomy to reimplant the ureter into the bladder mucosa. Renal descensus can be performed in the case of a proximal ureteral transection to facilitate reimplanation into the bladder. If ureteral damage is too severe, a nephrectomy can be performed on the affected side. A ureteral stent can be placed to aid in urine flow through a damaged ureter and help minimize stricture.[6] If the ureter is unable to be salvaged, a SUB device may be placed to allow urine to flow from the kidney to the bladder. The SUB device consists of one Shunting SwirlPort and two locking loop pigtail catheters.[7] The most cranial pigtail, the nephrostomy catheter, is placed in the renal pelvis; and the most caudal pigtail, the cystostomy catheter, is placed through the wall of the apex of the urinary bladder.[7] Each end is held in place by a marker band and cuff.[7] The port is placed in the subcutaneous space along the ventral abdominal wall, allowing for flushing of the device and sampling of urine.[1]

Although great success has been achieved with the use of SUB devices, there are also complications. The most common complication seen in cats is dysuria (38%) with or without

urinary tract infection.[1] This is likely due to continued irritation of the urinary tract by the pigtail catheters. However, many cats with these complications exhibit dysuria or an infection at the time of the SUB placement.[1] The second-most-common complication is mineralization of the SUB (24.5%).[1] The incidence of mineralization and infection post-operatively has greatly been reduced with the addition of regular prophylactic flushing of the port using tetra-EDTA.[1] The tetra-EDTA may also be used to clear occlusions, preventing the need for device replacement.[2] A number of complications also result from inappropriate surgical technique and placement of the SUB device, all of which most commonly occur from lack of appropriate surgical and imaging materials.[8]

Case Progression

On the evening of June 10, 2021, Sassy underwent an abdominal exploratory surgery in anticipation of correcting a suspected ligated left ureter. Incision into the abdomen revealed copious amounts of red-yellow peritoneal effusion that was not appreciated on pre-operative workup. The urinary bladder was small. The right kidney and associated vasculature and ureter were absent. The right ovary was present but hypoplastic. The left ovarian pedicle was present with suture ligation. The left kidney and associated vasculature were intact, but the left ureter was transected 5 mm proximal to the bladder. The left ureter was implanted into the bladder using a neoureterocystostomy procedure, and a urinary catheter was placed. A Jackson-Pratt (JP) drain was placed in the abdominal cavity using a stab incision through the right body wall, and another JP drain was placed through a stab incision of the subcutaneous tissues of the left flank. An esophageal feeding tube was also placed.

On the morning of June 11, 2021, Sassy was dull and aggressive. Her urinary catheter output decreased overnight from 6 ml/kg/hr to 1.18 ml/kg/hr. She had not defecated since presentation and would not eat or drink willingly. Neurochemistry revealed improvement in the renal values (BUN - 160 mg/dl, creatinine - 6.36 mg/dl), along with a high anion gap (24), elevated glucose (172 mg/dl), elevated total bilirubin (5.2 mg/dl), decreased total protein (6.2 g/dl), decreased globulin (3.8g/dl), elevated phosphorus (10.5 mg/dl), elevated magnesium (3.2 mg/dl), and elevated creatinine kinase (5234 U/L). Throughout the night, Sassy urinated around her urinary catheter, and the urinary catheter was pulled on the morning of June 12, 2021. Starting later that morning, she became progressively more lethargic and an increase in abdominal drainage into the JP drain was noted. Neurochemistry revealed an elevated BUN (225 mg/dl) and an elevated creatinine kinase (2125 U/L). Analysis of the abdominal fluid revealed a creatinine of 9 mg/dl (compared to 7.2 mg/dl in the blood) and a potassium of 7.74 mmol/L (compared to 8.5 mmol/L in the blood). These numbers were consistent with recurrence of uroabdomen.

That afternoon, Sassy underwent an abdominal exploratory surgery. Her JP drains were removed. A leak was identified at the uretero-vesicular anastomosis site and a seal could not be obtained with suture due to the fragility of the small ureter. The ureter was removed from the bladder and the end was debrided. A weasel guidewire was placed into the ureter to identify the lumen and the ureter was reimplanted into the bladder. Urine flowed into the bladder with the guidewire in place, but edema at the implantation site prevented urine flow once the guidewire was removed. A ureteral stent placement was then attempted to allow urine to pass until the swelling could resolve, but the stent was too large for the ureter. Additionally, the weasel wire was found to have punctured the renal parenchyma during placement, resulting in subcapsular

hemorrhage. The hemorrhage was attenuated with suture. Sassy was blood-typed and administered 55 mL of type A blood. At that point, attempts to place a stent or reimplant the ureter were aborted due to the friable nature of the ureteral wall. Because a nephrectomy was not an option in this case, the remaining ureter was ligated at the distal end, retaining the proximal portion of the ureter for potential reimplantation at a later date when the tissues were more mature, and preparations were made for placement of a SUB device to circumvent the injured ureter.

Sterile 50% dextrose solution was applied to the bladder mucosa to reduce the marked edema that had developed to facilitate closure of the cystotomy incision. The abdomen was then copiously lavaged. The nephrostomy tube of the SUB device was placed in the renal pelvis and the cystostomy tube was placed in the bladder mucosa. The tubes were then tunneled through the abdominal wall and attached to the subcutaneous access port. The system was checked for leaks using fluoroscopy and none were found. After another lavage, the abdomen was closed.

Case Outcome

Within two days of her SUB placement, Sassy showed signs of improvement. She started eating small amounts of food, appeared brighter, and began to interact with people. Also, her azotemia and atrial fibrillation had resolved. On June 15, 2021, her SUB was flushed using tetra-EDTA and ultrasound monitoring. Finding no leaks, the SUB system was patent and flushed easily.

Sassy remained in the hospital a total of eight days. On June 17, 2021, she was discharged to the care of her owners. She returned the following day for a port flushing. At this time, she was eating very well on her own without the esophageal tube. However, she was

continuing to make frequent trips to the litter box, where she would dribble small amounts of urine. Her SUB port was flushed and confirmed to be patent. Her urine did have a significant amount of blood in it, but the urine culture showed no growth. Sassy returned again for a port flushing on July 7, 2021, August 2, 2021, November 9, 2021, and March 2, 2022. At each visit, her owners reported that Sassy was maintaining her inappropriate litter box habits such as squatting in the litter box for a long time and dribbling urine in places outside of the litter box. These signs improved with each visit, according to her owners. Sassy appeared clinically healthy at each visit, and the SUB system remained patent and sterile. Sassy will return to MSU CVM every three-to-six months for the rest of her life to have her SUB port flushed with tetra-EDTA to confirm patency and sterility of the device.

Conclusion and Prognosis

The sterile cystitis and dysuria seen in Sassy's case is a common complication occurring in reportedly 35% of cats after a SUB placement.[3] The reported cystitis ranges from mild to severe and may have such a severely negative impact on the cat's quality of life as to warrant humane euthanasia.[3] Taking all major and minor complications of SUBs into account (including an in-hospital mortality rate of 10%), median survival time is reported greater than two years.[3] Negative prognostic factors include International Renal Interest Society Acute Kidney Injury (IRIS AKI) grade III-V at the time of surgery, old age, lack of appropriate materials, and inappropriate surgical technique.[3,8] It should be noted that the reported complications and prognosis statistics associated with SUBs are based in studies on cats with SUB placements as a treatment for ureterolithiasis. Since Sassy has only one kidney and her cause for a SUB is

iatrogenic ureter transection, her complications and prognosis may not be directly inferred from these reports.

In conclusion, in cats with uroabdomen secondary to a transected ureter that cannot be repaired by more traditional means, a subcutaneous ureteral bypass system is an appropriate surgical treatment. As the name suggests, it bypasses the missing, injured, or obstructed ureter completely, allowing urine to flow from the kidney to the bladder. There are a number of complications associated with SUB placements, and these may be mitigated with immediate SUB placement at the time of injury, appropriate surgical technique, and having the appropriate surgical and imaging materials available.

Ureteral injury is an uncommon but known complication of ovariohysterectomies in cats. If the ureter is transected completely, as in Sassy's case, the result is urine accumulation in the peritoneal cavity. Since Sassy only had one kidney and one ureter, the transected left ureter was an especially life-threatening condition. Sassy's uroabdomen could not have been resolved by more traditional surgical approaches, due to the small size and fragility of her ureter. Therefore, a SUB device was a life-saving surgical option for her unique case.

References

1. Berent A, Weisse C. The SUB 2.0: A Surgical Guide. *Norfolk Vet Products*. Available at: https://norfolkvetproducts.com/PDF/SUB/SUB2_Surgical_Guide_2018-03-email.pdf. Accessed 2 Jan. 2022.

2. Chik C, et al. Therapeutic use of tetrasodium ethylenediaminetetraacetic acid solution for treatment of subcutaneous ureteral bypass device mineralization in cats. *J Vet Intern Med* 2019; 33: 2124-2132.

3. Kulendra NJ, et al. Survival and complications in cats treated with subcutaneous ureteral bypass. *J Small Anim Pract* 2020; 62:4-11.

4. Mayhew P, Holt D. Ruptured Bladder in Dogs and Cats. *Standards of Care Emergency and Critical Care Medicine* 2004; 6:1-6.

5. Seitz M. Feline Urethral Obstruction: Diagnosis and Management. The Feline Patient. Mississippi State University College of Veterinary Medicine, 2021, lecture.

6. Stafford JR, Bartges JW. A clinical review of pathophysiology, diagnosis, and treatment of uroabdomen in the dog and cat. *J Vet Emerg Crit Care* 2013; 23:216-229.

7. SUB 2.0. *Norfolk Vet Products*. Available at: https://norfolkvetproducts.com/products/sub-2/. Accessed 2 Jan. 2022.

8. Vrijsen E, et al. Complications and survival after subcutaneous ureteral bypass device placement in 24 cats: a retrospective study (2016-2019). *J. Feline Med. Surg.* 2020; 23:1-11.