A 6-month-old, 9.7-kg (21.3-lb) spayed female SCWT was referred to the veterinary teaching hospital of the University of Pennsylvania after undergoing elective ovariohysterectomy 2 days previously. At the time of ovariohysterectomy, the midportion of the right ureter was mistaken for abnormal tissue adjacent to the ovarian pedicle and was inadvertently resected during collection of biopsy specimens. Once the error was recognized, a board-certified surgeon was consulted. Given the signalment of the dog, ureteral repair was recommended. Ligation of the proximal and distal portions of the ureter was performed, and the dog was referred to the teaching hospital for additional care.

At the initial referral evaluation, the owner reported that the dog had had signs of polyuria and stranguria since it underwent ovariohysterectomy but was otherwise clinically normal. Physical examination revealed a high rectal temperature of 39.6°C (103.3°F); reference interval, 37.2°C to 39.2°C (99°F to 102.5°F). The dog had an approximately 4-cm ventral midline incision from the ovariohysterectomy, which appeared intact. No other examination abnormalities were detected. Results of clinicopathologic tests (CBC and serum biochemical analysis) were unremarkable. Abdominal ultrasonography was performed for both dogs, revealing severe unilateral pyelectasia and hydronephrosis (proximal portion).

To prepare the dog for surgery, anesthesia was induced through IV administration of propofol (4 mg/kg [1.8 mg/lb]), lidocaine (1 mg/kg [0.45 mg/lb]), and diazepam (0.3 mg/kg [0.14 mg/lb]) and maintained with isoflurane in 100% oxygen. Cefazolin sodium (22 mg/kg [10 mg/lb], IV, q 1.5 h for the duration of surgery) was administered perioperatively. Celiotomy was performed in routine fashion, revealing 500 mL of urine within the abdominal cavity. Urine samples were collected and submitted for cytologic evaluation as well as microbial culture and antimicrobial susceptibility testing. The right kidney was markedly enlarged relative to the size of the left kidney, and the proximal portion of the right ureter was dilated and attached to the renal capsule by abundant fibrous connective tissue. The

### Case Description

A 6-month-old spayed female Soft-Coated Wheaten Terrier and 8-month-old spayed female Shih Tzu were referred because of complications related to inadvertent ureteral ligation and transection during recent ovariohysterectomy.

### Clinical Findings

The Soft-Coated Wheaten Terrier had a 2-day history of stranguria and polyuria that began after ovariohysterectomy. Initial examination findings were unremarkable with the exception of high rectal temperature. The Shih Tzu had a 10-day history of pyrexia, vomiting, diarrhea, and stranguria that began after ovariohysterectomy. On examination, the dog had signs of depression; clinicopathologic tests revealed hypoalbuminemia, neutrophilia, lymphocytosis, and monocytosis. Abdominal ultrasonography was performed for both dogs, revealing severe unilateral pyelectasia and hydroureter. End-to-end ureteral anastomosis was performed over the stent with the aid of an operating microscope. Stent position was confirmed via fluoroscopy, and incisions were closed routinely. Dogs continued to have intermittent signs of stranguria until stent removal via cystoscopy 6 or 7 weeks after surgery. Ultrasound examination of the urogenital tract was performed 2 or 4 months after surgery, revealing resolution of pyelectasia and hydroureter.

### Treatment and Outcome

Both dogs underwent exploratory celiotomy; ureteral ligation and transection was confirmed. Ventral cystotomy was performed to allow retrograde placement of a double-pigtail ureteral stent into the affected ureter and renal pelvis. End-to-end ureteral anastomosis was performed over the stent with the aid of an operating microscope. Stent position was confirmed via fluoroscopy, and incisions were closed routinely. Dogs continued to have intermittent signs of stranguria until stent removal via cystoscopy 6 or 7 weeks after surgery. Ultrasound examination of the urogenital tract was performed 2 or 4 months after surgery, revealing resolution of pyelectasia and hydroureter.

### Clinical Relevance

The surgical technique used provided a viable option for preserving renal function in dogs with focal, iatrogenic ureteral trauma. Use of a ureteral stent facilitated ureteral anastomosis and minimized postoperative complications. (J Am Vet Med Assoc 2015;247:92–97)

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### Abbreviations

**SCWT** Soft-Coated Wheaten Terrier

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The distal portion of the right ureter was similarly attached to the urinary bladder. A gap of approximately 6 cm was identified between the proximal and distal portions of the ureter and was attributed to the reported inadvertent ureteral resection. The proximal and distal portions of the ureter were gently dissected away from the renal capsule and urinary bladder, respectively (Figure 2). Material from the sutures that had been applied during previous ligation of the ureter was removed. The kidney was moved caudally (renal descensus) by freeing it from its retroperitoneal attachments, and the urinary bladder was moved cranially to bring the 2 cut ends of the ureter closer together.

Ventral cystotomy was performed, and a 3F, 12-cm, double-pigtail ureteral stent was inserted in a retrograde manner from the urinary bladder into the pelvis of the right kidney as described elsewhere. End-to-end anastomosis of the transected ureter over the stent was performed by use of 7-0 polypropylene suture in a simple interrupted pattern, with the aid of a microscope designed for use in a surgical setting (Figure 3). No spatulation or other techniques were used to increase the ureteral diameter at the anastomosis site. Location of the stent within the kidney was assessed via fluoroscopy. Once stent location was confirmed to be appropriate, the cystotomy incision was closed by use of 3-0 polydioxanone suture in a simple interrupted pattern. Four to five 2-0 polypropylene sutures were used to affix the right kidney and the urinary bladder to the body wall, thereby minimizing tension on the anastomosis site and decreasing mobility of the 2 organs. Abdominal lavage was performed, and the celiotomy incision was closed routinely. After surgery, abdominal radiography was performed to confirm that the ureteral stent had been placed appropriately (Figure 4).

The dog recovered from anesthesia without complication. Crystalloid fluid (3 mL/kg/h [1.4 mL/lb/h]), cefazolin (22 mg/kg, q 8 h), and buprenorphine (0.01 mg/kg [0.005 mg/lb], q 6 to 8 h) were administered IV for the first 24 hours after surgery. Afterward, fluid administration was discontinued and oral administration...
of amoxicillin–clavulanic acid (15 mg/kg [6.8 mg/lb], q 12 h for 6 weeks) was initiated. Findings of cytologic evaluation of the urine samples collected during celiotomy were suggestive of suppurative inflammation; microbial culture of urine revealed no growth of aerobic bacteria. Urogenital ultrasonography was performed 6 days after ureteral anastomosis and stent placement, revealing improvements in degrees of dilatation within the right renal pelvis (diameter, 6 mm) and right ureter (diameter, 3.5 mm). The dog was subsequently discharged from the hospital.

Two weeks after hospital discharge, the dog was brought back for removal of abdominal sutures. Three and 5 weeks after hospital discharge, it was brought back for ultrasonographic reexamination. Abdominal ultrasonography at both points revealed little improvement in degrees of pyelectasia (diameter, 6 mm) and hydroureter (diameter, 3 mm) within the right kidney and ureter. Since stent placement, the owner had noticed occasional signs of stranguria in the dog, but otherwise it had been behaving typically. A second bacteriologic culture of urine was performed 7 weeks after surgery, and results were negative for aerobic bacterial growth. At that time, the ureteral stent was removed with the aid of a cystoscope,1,e and contrast fluoroscopy was performed to confirm patency of the right ureter. The dog was reevaluated 1 month after stent removal (3 months after ureteral anastomosis with concurrent stent placement), at which time abdominal ultrasonography revealed that the pyelectasia within the right kidney had resolved and only a small degree of dilatation remained in the proximal portion of the right ureter (diameter, 2 mm). The owner reported that the dog had no signs of stranguria after stent removal. The last follow-up examination was performed 4 months later (7 months after surgery), at which point ultrasonographic findings for the right kidney and ureter were unremarkable. No additional follow-up examinations were deemed necessary.

A second dog (8-month-old, 5.1-kg [11.2-lb] spayed female Shih Tzu) was referred to the veterinary teaching hospital for evaluation of complications related to ovariohysterectomy performed 10 days previously. The owner reported that since the surgery, the dog had developed a fever, decrease in appetite, intermittent vomiting and diarrhea, and stranguria. No intraoperative complications had been reported to the owner after ovariohysterectomy. On initial examination, the dog had signs of depression, but no other abnormalities were detected. The 3-cm ventral midline incision from the ovariohysterectomy appeared to have healed. Clinicopathologic tests revealed hypoalbuminemia (1.6 g/dL; reference interval, 2.3 to 4.0 g/dL), neutrophilia (13.24 X 10³ cells/µL; reference interval, 2.95 X 10³ cells/µL to 11.64 X 10³ cells/µL), lymphocytosis (7.12 X 10³ cells/µL; reference interval, 1.05 X 10³ cells/µL to 5.10 X 10³ cells/µL), and monocytosis (2.18 X 10³ cells/µL; reference interval, 0.16 X 10³ cells/µL to 1.12 X 10³ cells/µL). Abdominal ultrasonography was performed, revealing marked dilatation of the pelvis of the left kidney (diameter, 16 mm) and proximal portion of the left ureter (diameter, 6 mm). Given these findings, iatrogenic ureteral ligation during ovariohysterectomy was suspected, and exploratory celiotomy was recommended.

The following morning, the dog was prepared for surgery. Methadone hydrochloride (0.1 mg/kg [0.045 mg/lb], IV) was administered, after which anesthesia was induced by IV administration of ketamine hydrochloride (0.2 mg/kg [0.09 mg/lb]), midazolam (0.25 mg/kg [0.11 mg/lb]), and propofol (1 mg/kg). Anesthesia was maintained during surgery, and cefazolin was administered perioperatively as described for the SCWT. Celiotomy revealed multiple fibrous adhesions between the intestines and left ovarian pedicle. Adhesions were dissected, and the proximal portion of the left ureter was identified; prior ligation and transection approximately 3 cm distal to its origin within the kidney were confirmed. The distal portion of the ureter was identified at the point of termination within the urinary bladder. Ventral cystotomy was performed, and a 3.7F; 12-cm, double-pigtail ureteral stent was inserted in a retrograde manner from the urinary bladder into the pelvis of the left kidney. End-to-end ureteral anastomosis was performed as for the SCWT by use of 8-0 nylon suture3 in a simple interrupted pattern. No spatulation or other techniques were used to increase the ureteral diameter at the anastomosis site. Intraoperative fluoroscopy was performed to confirm appropriate stent placement. The cystotomy incision was closed by use of 4-0 polydioxanone suture4 in a simple interrupted pattern (Figure 5). Pyelocentesis was performed to collect a urine sample for microbial culture and antimicrobial susceptibility testing, and the abdominal incision was routinely closed.

The dog recovered from anesthesia without complication. Crystalloid fluid (3 mL/kg/h), ampicillin sodium (22 mg/kg, q 8 h), enrofloxacin (15 mg/kg, q 24 h), and methadone (0.1 mg/kg) were administered IV for the first 48 hours after surgery. Afterward, fluid administration was discontinued, and oral administration of amoxicillin–clavulanic acid (15 mg/kg, q 12 h for 6 weeks), enrofloxacin (15 mg/kg, q 24 h for 6 weeks), and tramadol hydrochloride (4 mg/kg, q 12 h for 5 days) began. Results of microbial culture of urine indicated no growth of aerobic bacteria. The dog was discharged from the hospital 72 hours after surgery.

Two weeks after surgery, the dog was brought back to the hospital for removal of abdominal sutures, at which point the owner reported it had been having intermittent signs of stranguria. Five weeks after surgery, urogenital ultrasonography and microbial culture of urine were performed. Ultrasonography revealed marked improvement in the degree of hydronephrosis within the left kidney (diameter, 2 mm), with diffuse, mild distension of the left
ureter (diameter ≤ 2.5 mm). Microbial culture of urine revealed no growth of aerobic bacteria. The following week (6 weeks after surgery), the dog was brought back for cystoscopic stent removal, at which time contrast fluoroscopy revealed patency of the left ureter (Figure 6). Stranguria resolved completely after stent removal. Ultrasonographic examinations performed 8 weeks and 6 months after surgery revealed that the pyelectasia and hydroureter of the left kidney and ureter had resolved. No additional follow-up examinations were recommended at that point.

Discussion

Ureteral obstruction is a life-threatening condition in human and veterinary patients that requires aggressive and timely intervention to preserve functional renal tissue and minimize the degree of irreversible renal damage. Such obstruction can occur secondary to intraluminal disease, mural lesions, or extraluminal compression. Common causes include ureteral calculi, neoplasia, and blood clots. Other less common causes of ureteral obstruction include trauma, inflammation, fibrosis, congenital stenosis, acquired stricture, and foreign body. Improper placement of ligatures during ovariohysterectomy is a rare but reported cause of ureteral obstruction in dogs. Specifically, use of a spay hook and small laparotomy incision to locate the uterine horns during ovariectomy, combined with the mobile nature of ureters in dogs, may result in inadvertent incorporation of the ureter within ligatures placed around the ovarian vessels.

Ureteral obstruction leads to an abrupt restriction of urine flow, resulting in hydronephrosis, distension of the proximal portion of the ureter, and pressure injury to the renal parenchyma. The physiologic response to ureteral obstruction is complex. Immediately after onset in otherwise healthy dogs, a marked increase in ureteral pressure occurs. This excessive pressure spreads throughout the entire nephron, and renal blood flow and glomerular filtration rate begin to decrease via concurrent release of vasoactive mediators, influx of leukocytes, and subsequent fibrosis. The degree of renal damage that occurs is proportional to the duration and severity of ureteral obstruction. Experiments involving healthy dogs have revealed that after 7 days of complete ureteral obstruction, glomerular filtration rate decreases permanently by 35%, and when the obstruction persists for 14 days, that rate decreases permanently by 54%. After ureteral obstruction is relieved, >24 hours may elapse before ureteral pressure begins to decrease, and >4 months may elapse before renal function is maximally restored.

Common signs of ureteral obstruction include abnormalities in urination (eg, dysuria, stranguria, and polyuria), persistent urinary tract infection, abdominal discomfort, vomiting, inappetence, signs of depression, or lethargy. A diagnosis is typically made on the basis of results of abdominal imaging, in particular abdominal ultrasonography. Common findings include hydronephrosis, hydroureter, and perirenal effusion. Medical management of obstructive uropathy is typically designed to stabilize the condition of affected dogs and involves fluid diuresis, administration of muscle relaxants, and treatment of azotemia as needed by
nephrostomy tube placement or dialysis. Multiple surgical techniques to restore ureteral patency in dogs have been described, choice of technique is influenced by underlying cause and location of the ureteral obstruction. In animals with obstruction secondary to mural lesions or extraluminal compression, or in situations involving local ureteral trauma or ureteral transection, ureteroneocystostomy or ureteral resection and anastomosis may be needed to allow reconstruction of the ureter and preservation of function in the ipsilateral kidney.2,22,23 Ureteral resection and anastomosis is technically challenging given the small diameter of the canine ureter (1.3 mm to 2.7 mm as suggested by results of CT). Furthermore, anastomosis is associated with a higher incidence of postoperative ureteral reobstruction attributable to excessive inflammation and scar tissue or stricture formation, compared with the incidence for other ureteral surgeries such as ureterotomy or ureteroneocystostomy.2,24

In the dogs of the present report, iatrogenic ureteral trauma was surgically treated by end-to-end ureteral anastomosis and ureteral stent placement. Ureteral stents typically used in veterinary and human patients have a double-pigtail, multifilenestrated design comprised of a loop portion that is positioned within the renal pelvis, a long shaft portion that is inserted within the ureteral lumen, and another loop portion that is positioned within the urinary bladder. The double-pigtail (loop) portions of the stent anchor the device within the renal pelvis and urinary bladder to prevent stent migration. The multifilenestrated nature of the stent allows for urine flow through and around the stent. After the stent is placed into position, the ureter passively dilates, facilitating urine drainage from the kidney into the urinary bladder.

Ureteral stents are commonly used in human patients with benign (eg, ureteroliths) or malignant ureteral disease and to provide urinary diversion after ureteral anastomosis. Moreover, placement of ureteral stents at the time of ureteral surgery (ureterotomy, ureteral resection and anastomosis, or neoureterocystostomy) can help minimize postoperative complications such as urine leakage and ureteral stricture formation. Ureteral stents can be easily placed during celiotomy, as we experienced with the dogs of the present report. However, minimally invasive techniques can also be used, such as cystoscopic or percutaneous radiologic approaches when patient size permits.

Use of ureteral stents is becoming more common in the treatment of obstructive ureteral disease in cats and dogs. However, to the author’s knowledge, the present report is the first description of successful double-pigtail ureteral stent placement in combination with ureteral anastomosis in dogs. A few other case reports exist regarding the use of end-to-end ureteral anastomosis as a treatment for dogs with ureteral injury. Interestingly, temporary placement of red rubber catheters within the ureteral lumen, in a manner similar to that used for stent placement in the present report, resulted in comparably good outcomes in the dogs of those reports. We believe that the technique of concurrent ureteral stent placement and ureteral anastomosis has several advantages in the treatment of dogs with ureteral trauma. In the SCWT of the present report, stent placement appeared to have reduced the amount of tension on the anastomosis site caused by the considerable gap between the proximal and distal portions of the ureter. This method of tension reduction would be of particular value for cases in which conventional tension-relieving techniques (eg, renal descensus or psoas cephaly) might be insufficient. Ureteral stent placement may also facilitate the anastomosis procedure, as was observed for both dogs of the present report. Furthermore, stents may be useful to maintain patency of the ureteral lumen and prevent postoperative complications such as ureteral obstruction caused by severe ureteritis or ureteral stricture formation.

Both dogs in the present report had stranguria following stent placement, and the stranguria subsided after stent removal. Signs of lower urinary tract disturbance (eg, dysuria, stranguria, and hematuria) reportedly develop in 40% to 80% of humans with ureteral stents and are believed to develop as a result of bladder irritation. Although such signs have been less commonly reported for companion animals with ureteral stents, self-limiting stranguria has been reported for several cats after ureteral stent placement. Other reported complications of ureteral stent placement in humans include flank pain, urinary tract infection, stent migration, and stent encrustation. In the dogs of the present report, stents were removed by use of a cystoscope 6 or 12 weeks after placement, which might explain the lack of stent-related complications. In human medicine, the recommendation is that stents be removed or replaced every 3 to 6 months to minimize potential complications. In cats and dogs, ureteral stents are often left in place for longer periods than in humans, with reportedly few deleterious consequences.

Ureteral obstruction reportedly increases the risk of renal pelvis infection in human and veterinary patients. Bacteria responsible for such infections can originate from the lower urinary tract by bloodstream. Both dogs of the present report received antimicrobials for 6 weeks after stent placement, with drugs selected on the basis of clinician preference given negative results for aerobic growth after microbial culture of urine. However, because Staphylococcus intermedius is commonly isolated from urine samples in humans and dogs with obstructive pyelonephritis, cephalosporin antimicrobials may be a more appropriate choice.

End-to-end anastomosis with double-pigtail ureteral stent placement was performed with minimal complication in the 2 dogs with focal ureteral trauma described in the present report. Complete resolution of secondary hydronephrosis and hydrourereter was achieved in both dogs. Ureteral anastomosis is technically challenging in companion animals and requires specialized equipment and microsurgical skill. However, in dogs and cats in which renal damage associated with ureteral trauma is believed to be reversible or of limited extent, the technique described here may be a viable option for preserving kidney function. Furthermore, use of a ureteral stent may facilitate anastomosis and reduce the likelihood of postoperative complications in affected animals.
References