Received: 9 March 2019 | Revised: 21 September 2019 | Accepted: 18 October 2019
DOI: 10.1111/vsu.13488

ORIGINAL ARTICLE - RESEARCH

WILEY

Postoperative outcomes of 12 cats with ureteral obstruction treated with ureteroneocystostomy

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Abstract

Objective: To report complications and long-term outcomes of cats with benign ureteral obstruction treated with ureteroneocystostomy and to determine the effects of double pigtail catheter (DPT) placement on postoperative outcomes.

Study design: Retrospective study.

Animals: Twelve client-owned cats with ureteral urolithiasis treated with ureteroneocystostomy.

Methods: Records were reviewed for signalment, location of the obstruction, diagnostic tests, surgical technique, perioperative complications, long-term measurements of kidney function, and survival. Cats were divided into two groups; in one group, a DPT was placed at the time of ureteroneocystostomy, and, in the other group, a DPT was not placed at the time of ureteroneocystostomy (NDPT).

Results: A DPT was placed in six of 12 cats. The NDPT group included four cats with temporary catheters and two cats with no catheter. Median creatinine concentration decreased from 10.4 mg/dL (range, 1.6-20.3) to 2.2 mg/dL (range, 1.1-3.6) at the time of discharge ($P = .015$) in all cats. Two cats in the NDPT group required revision surgery for uroabdomen. Eleven cats were discharged from the hospital. Long-term complications (hematuria, pollakiuria, urinary tract infections) were more common in the DPT group ($P = .047$). Seven cats were alive a median of 329 days (range, 8-1772) after surgery. Median creatinine concentration was 2.0 mg/dL (range, 0.6-6.4) at a median of 157 days (range, 43-1772) after surgery.

Conclusion: Ureteroneocystostomy resulted in acceptable long-term outcomes in 11 of 12 cats. The placement of a DPT did not influence the long-term outcome in this small population.

Clinical significance: Ureteroneocystostomy with or without intraoperative placement of a DPT should be considered to relieve benign ureteral obstructions in cats.

1 | INTRODUCTION

Ureteral obstruction in cats is a serious condition that can be fatal if it is left untreated. Surgical intervention is considered standard of care by most, and poor clinical response to medical management alone has been reported.[1] Surgical treatment of ureteral obstruction has historically been associated with high perioperative mortality and major postoperative complications, with the most common complication consisting of urine leakage.[1-4] However, Wormser et al[5] recently reported lower perioperative mortality rate (8%) and incidence of postoperative uroabdomen (6%). Nonetheless, ureteral stenting and subcutaneous ureteral bypass (SUB) devices have gained popularity to divert urine and lower morbidity in cats with ureteral obstruction.[6-12] The American College of Veterinary Internal Medicine has published a consensus statement recommending these approaches to treat and prevent uroliths in dogs and cats.[13]

Although ureteral stents and SUB are both used successfully to manage ureteral obstructions in cats, more recent evaluations of their perioperative and long-term outcomes have reported significant morbidity and mortality rates.[5,14-17] Most reported complications are secondary to the long-term presence of foreign material in the urinary system causing pollakiuria, hematuria, recurrent lower urinary tract infections, flank pain, or obstruction of the device requiring revision.[5,14-16] Morbidity associated with a double pigtail catheter (DPT) in the ureter has also been well documented in man, supporting its frequent removal in the early postoperative period when possible.[18,19] By contrast, ureteroneocystostomy relies on a biologic repair to treat ureteral obstructions. Such an approach may be advantageous to reduce implant-associated morbidity compared with procedures that place long-term foreign material in the urinary system.

The objective of this report is to describe a cohort of cats with ureteral obstructions secondary to urolithiasis treated with ureteroneocystostomy with or without the placement of a DPT, including the perioperative and postoperative complications as well as long-term survival. A second objective of the study was to determine the influence of DPT placement on postoperative outcomes. Although the technique has been successfully used in the past to treat ureteral obstructions in cats,[1] to the best of the authors' knowledge, this is the first report focusing strictly on ureteroneocystostomy in cats. We hypothesized that cats with ureteral obstructions would be successfully treated with a ureteroneocystostomy without placement of a DPT.

2 | MATERIAL AND METHODS

2.1 | Case selection

The medical record database of James L. Voss Veterinary Teaching Hospital at Colorado State University was reviewed for records of cats in which ureterolithiasis had been diagnosed and treated surgically by one surgeon (E.M.) between July 2013 and July 2018. The diagnosis of ureteral obstruction for each cat was based on ultrasonographic evaluation of the urinary tract revealing renal pelvis dilatation and hydroureter proximal to an obstructive lesion. Cats were entered in the DPT group when a DPT had been placed at the time of ureteroneocystostomy. Cats were placed in the no double pigtail (NDPT) group when a DPT had not been placed at the time of ureteroneocystostomy.

2.2 | Medical records review

Information collected from medical records included breed, sex, age, weight, previous pertinent history, physical examination findings, preoperative medical stabilization protocol, preoperative diagnostic tests, surgically treated side, location and etiology of obstruction, surgical technique, perioperative complications, and length of hospitalization. The location of the obstruction in the ureter was divided into three categories (proximal, middle, and distal third of the ureter) on the basis of preoperative diagnostic imaging modalities or the surgery report.

2.3 | Surgical technique

Cats were placed in dorsal recumbency, and a midline ventral celiotomy was performed to expose the urinary system. Surgical loupes with ×3.5 were used to complete all reimplantations. After the level of the obstruction had been visualized or palpated, the ureter was dissected from the retroperitoneum. A 6-0 monofilament absorbable stay suture (Biosyn; Covidien, Mansfield, Massachusetts) was placed proximal to the level of the obstruction to manipulate the ureter. The ureter was transected just distal to the suture, proximal to the level of the obstruction. The ureteral artery and vein were ligated with 6-0 monofilament absorbable suture. The ureteroliths were removed and submitted for analysis. The distal segment of ureter was ligated proximal to the bladder, resected, and submitted for histopathology. Patency of the proximal ureter was assessed with direct visualization of urine coming from the cut end of the ureter as well as by using a biologic repair to treat ureteral obstructions, retrograde passage of a 3 to 5-French (Fr) feeding tube (Covidien, Minneapolis, Minnesota). A urine sample was collected from the renal pelvis through the feeding tube for culture and sensitivity. The renal pelvis was decompressed and flushed with sterile saline. Psoas cystopexy and/or renal descensus was performed first when excessive tension on the repair was expected.[20] The distal end of the ureter was spatulated and anastomosed to the bladder mucosa with either an intravesicular or extravesicular technique with 6-0 absorbable monofilament suture.[20] Anastomoses were completed with two simple continuous suture lines when the extravesicular technique was performed and with simple interrupted sutures when the intravesicular technique was used. In all surgeries, additional interrupted sutures were placed between the serosal surface of the bladder and the wall of the ureter after reimplantation to relieve tension at the level of the mucosa.

A DPT (pediatric stent; Cook Medical, Bloomington, Indiana; or cat stent; Infiniti Medical, Redwood City, California) or temporary ureteral catheter (3 Fr to 5 Fr infant feeding tube, Covidien) was placed up the ureter at the time of surgery to divert urine and maintain ureteral patency. When an intravesicular technique was used, reimplantation was completed before the insertion of the DPT or the temporary ureteral catheter. The catheter was placed before completion of extravesicular reimplantation. When a DPT was placed, one pigtail was positioned in the renal pelvis with the other in the urinary bladder.[6] When a temporary ureteral catheter was used, the perineal area was aseptically prepared and included in the surgical field. The temporary ureteral catheter was introduced retrograde from the penis or the urethral papilla and advanced until the multifenestrated end reached the proximal ureter. Location was confirmed via palpation. The opposite end of the catheter was then connected to a closed suction bag to monitor urine production. The catheter's external portion was secured to the cat with a suture in the prepuce or vulva and held in place by using a finger trap pattern. Placement of the temporary ureteral catheter was facilitated by advancing, in a normograde fashion, a 3-Fr red rubber catheter (Covidien) from the bladder through the urethra. When the distal tip of the red rubber catheter was visible outside the urethral orifice, the temporary ureteral catheter was then attached to the red rubber catheter with a 4-0 nonabsorbable monofilament suture. The red rubber catheter was then pulled back into the bladder, dragging the temporary ureteral catheter into the bladder lumen and further advanced up the reimplanted ureter in a retrograde fashion toward the renal pelvis. With the extravesicular technique, normograde and retrograde passage of the catheters was accomplished through the ureteroneocystostomy site. For cats in which a DPT was placed, postoperative abdominal radiographs were performed to confirm adequate implant positioning. Daily bloodwork was performed to monitor the evolution of kidney function. Peritoneal fluid was analyzed only in cats in which clinical suspicion of uroabdomen was present. The decision to remove the temporary ureteral catheter was based on each cat's clinical and biochemical improvement. When it was deemed appropriate, the securing suture was cut, and the feeding tube was simply removed without an additional anesthetic procedure.

2.4 | Follow-up information

Complications were classified as perioperative or postoperative. Perioperative complications included those arising from the time of surgical intervention to hospital discharge. Postoperative complications were classified as short-term when they occurred from hospital discharge to suture removal (10-14 days postoperatively) and long-term when they occurred after suture removal.

For the follow-up, owners were contacted directly by phone and/or the primary care veterinarian's medical records were reviewed. Information collected included renal function indices (blood urea nitrogen, creatinine, phosphorus, symmetric dimethylarginine, urine specific gravity [USG]), evidence of urinary signs at home (pollakiuria, hematuria, dysuria), and evidence of recurrence of ureteral obstruction. In addition, International Renal Interest Society (IRIS) stage at their last recorded follow-up after surgery was determined (stage 1 = serum creatinine concentration within reference limits < 1.6 mg/dL and USG <1.035, stage 2 = serum creatinine concentration 1.6-2.8 mg/dL, stage 3 = serum creatinine concentration 2.9-5 mg/dL, and stage 4 = serum creatinine concentration > 5 mg/dL).

2.5 | Statistical analysis

A Wilcoxon rank-sum test was used to compare data between the DPT and the NDPT groups. A Wilcoxon signed-rank test was used to compare paired creatinine concentrations at each time point. A χ^2 analysis was used to compare the rate of urinary complications between the two groups (DPT vs NDPT). Cats that died of complications of their renal disease were included in survival analysis. Cats that were alive, lost to follow-up, or died of reasons unrelated to renal disease were censored. Survival time was calculated from the time of surgery to the moment of the last follow-up or the cat's death. Kaplan–Meier analysis was performed to determine the 1-year survival rate and median survival time. $P < .05$ was considered significant. All analyses were performed JMP (SAS Institute, Cary, NC).

3 | RESULTS

3.1 | Demographics

Thirty cats were initially identified, but 18 cats were excluded because the procedure had been performed by another surgeon or the cases involved other ureteral surgeries (SUB, primary stent placement, or ureterotomy).

In total, 12 cats met all study inclusion criteria. Six cats were in the DPT group, and six cats were in the NDPT group (Table 1). Four cats were castrated males, and eight cats were spayed females. There were nine domestic short hair cats, two Siamese cats, and one Burmese cat. The median age at the time of surgery was 7 years (range, 5-15) for the DPT group and 5 years (range, 3-12) for the NDPT group ($P = .165$). Median weight at the time of surgery was 3.5 kg (range, 2.5-4) for the DPT group and 4.4 kg (range, 3-5.2) for the NDPT group ($P = .128$). Two cats had a bilateral ureteral obstruction, four cats had the left ureter obstructed, and six cats had the right ureter obstructed (Table 1). Fourteen ureters were resected and reimplanted in the apex of the bladder. The reimplanted ureter had a circumcaval course in cat No. 4 (Table 1), and a ureterostomy was also performed on the reimplanted ureter in cat No. 7.

One cat had a history of a previous ureteral obstruction that had been successfully managed medically, and three cats had chronic kidney disease according to upon medical record review, with variably elevated kidney values. All three of these cats had IRIS stage 2 chronic kidney disease (CKD). Prior to surgical intervention, all cats were medically stabilized (range of 1-4 days). Medical management included various combinations of IV or subcutaneous fluids therapy, opioids (buprenorphine

TABLE 1 Demographics in procedural chronological order

Cat	Weight, kg	Age, y	Location of stone	Stone in renal pelvis	Stone diameter in renal pelvis, mm	Surgery technique	Type of stent	Complications	Survival time, d
1	3.7	7	Left Proximal	Yes	...	Intra	DPT[a]	Pollakiuria	1772
2	3.2	15	Left Distal	Yes	8.5	Intra	DPT[a]	Pollakiuria	54
3	4	7	Left Middle	Yes	2.8	Intra	DPT[a]	Recurrent UTI (asymptomatic)	1108
4	4.9	3	Left Proximal	Yes	2.7	Intra	NDPT	None	1005
5	3.5	15	Right Middle	No	NA	Extra	DPT[b]	Fluid overload, pollakiuria, recurrent UTI	134
6	5.2	11	Bilateral Proximal and Distal	No	NA	Intra	NDPT	None	706
7	2.5	5	Right Middle	No	NA	Extra	DPT[b]	Euthanasia	2
8	3	3	Right Distal	No	NA	Extra	NDPT	None	160
9	5	12	Right Middle	Yes	...	Intra	NDPT[c]	Uroabdomen, self-limiting hematuria	618
10	3.7	5	Right Middle	Yes	...	Extra	NDPT[c]	Uroabdomen	329
11	3.9	5	Right Proximal	No	NA	Extra	NDPT	Abdominal wall dehiscence	8
12	3.4	7	Bilateral Middle & Middle	Yes	3.8	Extra	DPT[a]	None	229

Abbreviations: ..., no data available; DPT, double pigtail catheter; Extra, extravesicular; Intra, intravesicular; NA, not applicable; NDPT, no double pigtail catheter; UTI, urinary tract infection.

[a]Pediatric stent.

[b]Cat stent.

[c]Cat No. 9 and 10 did not have any catheter placed at initial surgery.

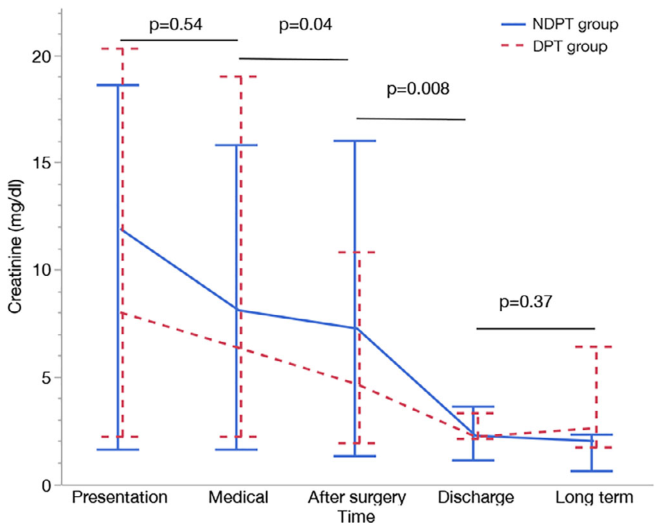

FIGURE 1 Creatinine concentration (mg/dL) at presentation, after medical management and just prior to surgery, 24 hours after surgery, before hospital discharge, and latest time point in the postoperative follow-up. Data are median and range. DPT, double pigtail catheter; NDPT, no double pigtail catheter

0.01-0.03 mg/kg oral transmucosal), α-adrenoreceptor antagonist (prazosin 0.5-1 mg per cat orally), antimicrobials (enrofloxacin 5 mg/kg IV; orbifloxacin 7.5 mg/kg orally; ampicillin sodium/sulbactam 50 mg/kg IV; ampicillin sodium 20-40 mg/kg IV), antiemetics (maropitant 1 mg/kg IV; ondansetron 0.1-1 mg/kg IV), proton pump inhibitor (pantoprazole 1 mg/kg IV), and H2 receptor antagonist (famotidine 5 mg per cat orally). Creatinine concentration did not decrease with medical management alone compared with the creatinine concentration at presentation ($P = .54$; Figure 1). Hemodialysis or nephrostomy tube placement was not attempted in any of the cats.

3.2 | Perioperative findings

Abdominal ultrasonographic evaluation (n = 12), complete blood count (n = 12), chemistry panel (n = 12), abdominal radiography (n = 11), and thoracic radiography (n = 1) were performed prior to surgery. At abdominal ultrasonographic evaluation, the ureters were divided in thirds, and the location of the obstruction was subjectively attributed to the proximal third in four ureters, middle third in seven ureters, and distal third in three ureters. The location of obstruction was confirmed at surgery and corroborated ultrasonographic findings in all cats (Table 1). Ureteroliths were visualized on radiographs in only five of 12 cats. Ureterolith location was consistent with findings on abdominal ultrasonographic evaluation. In the remaining cats, radiographic confirmation of urolithiasis was prevented by superimposition artifact with the colon (n = 4) or because uroliths were not visualized in the ureters (n = 2). On ultrasonographic images, the median luminal diameter of the ureter measured 4.4 mm (range, 4-11.9) in the DPT group and 3.1 mm (range, 2.4-6.2) in the NDPT group ($P = .030$). The median maximum length of the renal pelvis measured 8 mm (range, 5.3-12.8) in the DPT group and 5 mm (range, 3.5-13.2) in the NDPT group ($P = .463$). The median diameter of uroliths causing the obstruction was 2.4 mm (range, 1.5-5). Nephroliths were identified on preoperative radiographs and/or ultrasonography in seven cats. Ultrasonographic changes consistent with chronic kidney disease were found in six cats, including smaller kidneys, a hyperechoic cortex, loss of renal cortex and loss of corticomedullary distinction.

Ureteroneocystostomy was performed with an intravesicular technique for seven ureters and with an extravesicular technique in seven ureters. Double pigtail catheters were placed in six cats, temporary catheters were placed in four cats, and two cats had no catheter placed initially (Table 1). The temporary ureteral catheters were removed 1.5 days (range, 1-2) after surgery. Four psoas cystopexies (cat No. 1, 4, 6, and 11) and one renal descensus (cat No. 1) were performed, all in proximal obstruction cases. One urine culture was positive for *Enterococcus* spp. All uroliths consisted of calcium oxalate. The distal ureters were submitted for histopathological evaluation in 10 cats; results for two were normal, while mild to moderate ureteritis was identified in eight ureters, with local infiltration of neutrophils, lymphocytes, and plasma cells. In four cats treated for proximal obstructions, the remaining proximal ureters measured approximately two cm in length.

Creatinine concentration decreased 24 hours after surgery in all cats compared with the preoperative value ($P = .04$). Creatinine concentration at the time of discharge from the hospital was also decreased compared with 24 hours after surgery ($P = .008$; Figure 1, Table 2). There was no difference between groups at each time point ($P > .05$). There was no interaction between the treatment group and time on the reduction of creatinine concentration (Figure 1). Perioperative complications included hypotension (n = 6), anemia requiring blood product transfusion (n = 4), uroabdomen (n = 2) and fluid overload (n = 1).

Abdominal ultrasonographic evaluation was repeated in three cats 1 day after surgery for concerns of uroabdomen based on creatinine levels and insufficient urine production (<1 mL/kg/day). The preoperative hydroureter and hydronephrosis improved and was consistent with the relief of the ureteral obstruction in all

TABLE 2 Relevant clinical pathological findings at admission and immediately after surgery

Variables	At admission	Postoperative	*P* value
BUN, mg/dL	117 (28-306)	82 (22-189)	.097
Creatinine, mg/dL	10.4 (1.6-20.3)	5.7 (1.3-16)	.0015
Phosphorus, mg/dL	8.45 (3.1-20.7)	7.8 (3-15.2)	.519
Calcium, mg/dL	9.9 (9.4-10.6)	9.1 (8.2-10.2)	.0039
Sodium, mEq/L	154 (146-164)	153 (142-159)	.218
Chloride, mEq/L	118.3 (104-121)	113.5 (106-121)	.250
Potassium, mEq/L	4.5 (3.3-6.3)	4.5 (3.5-6.9)	.917
Bicarbonate, mEq/L	15.6 (10.9-21.1)	16.7 (13-22.1)	.875
WBC, $\times 10^3/\mu L$	8.55 (3.5-22.8)	12.5 (3.1-29.1)	.084
Neutrophils, $\times 10^3/\mu L$	7.34 (3.2-20.1)	11.4 (2.3-27.9)	.027
Hemoglobin, g/dL	10.2 (8-16.4)	7.5 (3.8-13.2)	.0078

Note: Chemistry and complete blood count at admission and immediately after surgery. Values are median (range).
Abbreviations: BUN, blood urea nitrogen; WBC, white blood cells.

three cats. Two cats (cat No. 9 and 10) without initial urinary diversion required revision surgery within 48 hours of the first procedure for suspicion of uroabdomen on the basis of paired bloodwork and abdominal effusion analysis. In one cat, the ureteroneocystostomy was found to be leaking and was revised with a second reimplantation and DPT placement. In the second cat (cat No. 10), the ureteroneocystostomy was assessed as intact and patent. The source of urine leakage could not be identified but was suspected to originate from a renal pseudocyst, which had been previously aspirated. A temporary ureteral catheter was advanced from the urethra to the proximal ureter and maintained for 4 days. An active abdominal drain (Jackson Pratt, Cardinal Health, Dublin, Ohio) was also placed. This cat subsequently improved and was discharged from the hospital 5 days after revision surgery.

3.3 | Postoperative findings

Eleven cats were discharged from the hospital a median of 2.5 days (range, 2-5) after surgery for the DPT group and 4 days (range, 3-6) after surgery for the NDPT group ($P = .083$). One cat in the DPT group was euthanized 48 hours after the procedure at the owner's request because of a lack of clinical improvement and worsening renal values. Creatinine concentration was 7.6 mg/dL at the time of euthanasia; it had been 6.7 mg/dL at the time of presentation. At the time of discharge from the hospital for all other cats, the median creatinine concentration was 2.2 mg/dL (range, 1.1-3.6; Figure 1).

Long-term complications included hematuria and pollakiuria in three cats in the DPT group and culture-confirmed urinary tract infections in three cats (two cats in the DPT group and one cat in the NDPT group). Both cats with urinary tract infections in the DPT group had at least three positive cultures performed during the follow-up period, with methicillin-susceptible *Enterococcus* spp identified in all samples. Cats in the DPT group had an increased rate of urinary complications in the long-term compared with the NDPT group ($P = .047$).

Creatinine concentration in 10 cats at a median follow-up time of 157 days (range, 43-1772) was 2 mg/dL (range, 0.6-6.4) and did not differ from the concentration at the time of discharge from the hospital ($P = .37$; Figure 1). Creatinine concentration did not differ between cats in the DPT group (2.3 mg/dL; range, 1.7-6.4) and those in the NDPT group (1.95 mg/dL; range, 0.6-2.3; $P = .39$). At their last known examination, three cats had creatinine concentration levels that were considered normal, one had IRIS CKD stage 1, four had IRIS CKD stage 2, one had IRIS CKD stage 3, and one had IRIS CKD stage 4 disease. Two cats, one in each group, had ultrasound repeated as part of their follow-up 2 months after the procedure. Hydroureter and hydronephrosis were improved in one cat (DPT group) and had normalized in the other cat (NDPT group).

During the follow-up period, two cats in the DPT group were euthanized because of a lack of improvement in the quality of life and worsening renal function at 54 and 134 days after discharge from the hospital, respectively. In the former, both kidneys had chronic degenerative changes without evidence of ureteral obstruction or pyelonephritis at the time of postmortem examination. Its kidney values had improved from the time of discharge (2.2 mg/dL) to the day of euthanasia (1.8 mg/dL). In the latter, the cat's creatinine concentration increased

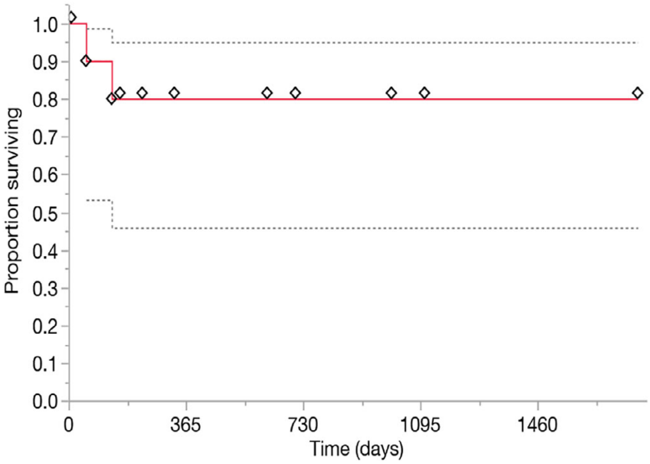

FIGURE 2 Kaplan–Meier survival curves of cats treated with ureteroneocystostomy for benign ureteral obstruction. Lozenges above the line represent censored observations. Dashed lines represent 95% CI

from 3.3 mg/dL at the time of discharge to 6.4 mg/dL at 134 days after surgery. This cat was euthanized after this recheck. No ultrasound was performed to evaluate the renal pelvis or the ureter prior to euthanasia. A third cat was euthanized eight days after surgery because of abdominal wall dehiscence after a trauma. This death was not considered disease related. One cat was lost to follow-up 160 days postoperatively but its creatinine concentration level had been assessed to be normal before that time. At a median follow-up time of 329 days (range, 8-1772) postoperatively, seven cats were still alive. The 1-year and 2-year survival rates were 73.3% (Figure 2).

4 | DISCUSSION

Ureteroneocystostomy relieved the benign obstructions in the 12 cats of this case series, consistently reducing the preoperative creatinine concentrations. Intraoperative placement of a DPT did not influence postoperative creatinine concentrations and was associated with a higher rate of long-term complications. Most (11/12) cats survived to discharge, and only two cats required revision surgery for uroabdomen.

The demographics and history of our population were similar to those previously reported in cats with benign ureteral obstruction.[1,4,5,9,14-16] Similarly to previous reports, preoperative azotemia was detected in all cats, although most obstruction was unilateral in most. This finding is consistent with an impaired function of the contralateral kidney.[2,21] Cats were treated medically before surgery to reduce their azotemia and/or evaluate motion of the ureteral uroliths. Half of the nonobstructed kidneys were smaller than the obstructed kidney according to preoperative radiographs or ultrasonographic evaluation. Creatinine levels were reduced after medical treatment, as previously reported[1,5,6,14-16]; however, this reduction was not significant or clinically sufficient to avoid surgical intervention.

Ureteroneocystostomy was performed to decompress the renal pelvis and the ureter. Although a previous report identified proximal ureteral obstruction as a contraindication for ureteroneocystostomy in cats,[2] the procedure was performed for obstruction located in the proximal third of the ureter, as formerly described by Kyles et al.[1] A cystopexy to the psoas muscle allows advancement of the urinary bladder toward the caudal pole of either kidney to prevent tension on the ureteroneocystostomy.[20] Such cystopexy did not interfere with the ureteroneocystostomy. A Boari tube can also be created to facilitate reimplantation if the bladder cannot be mobilized and the ureter is very short.[22] The procedure was also possible for bilateral ureteral obstruction in two cats in this study. In one of those two cats, the obstruction was proximal in one ureter and in the middle third for the other ureter.

During the follow-up period, none of the cats in this study were reported to have recurrent ureteral obstruction. Reobstruction rates requiring revision surgery for SUB, stents, and ureteral surgeries range from 5% to 17%, 8% to 32%, and 11% to 31%, respectively.[1,5,6,15,16] In our study, nephroliths were identified in seven cats at the time of surgery, but none were diagnosed with recurrence. A DPT was placed in five of these cats. In a study of 117 cats with ureteral obstruction,[5] the presence of a DPT did not reduce the incidence of reobstruction, and the presence of nephroliths did not influence the rate of postoperative reobstruction. The risk of subsequent obstruction from newly formed uroliths or those left in the renal pelvis is thought to be low with the technique described in this report and attributed to the wider lumen and shorter length of the reimplanted proximal ureter. However, the postoperative diameter of the ureters was not documented with repeat ultrasonography.

The ureteroneocystostomy was changed from an intravesicular to an extravesicular technique during our study, according to the surgeon's preference. This change was prompted by clinical impression of superior apposition of the ureteral and bladder mucosa and decreased intraoperative bleeding from the bladder wall. With the extravesicular technique, two continuous, appositional suture patterns were used to perform the ureteroneocystostomy. The serosa of the bladder was closed over the stoma incorporating the adventitia of the ureter. This technique was possible even when a cystopexy was performed. Another change in technique consisted in the implantation of a temporary ureteral catheter rather than a DPT in more recent cases. Placement of a ureteral catheter provided the same early benefits of the DPT, while early postoperative removal prevented long-term implant-associated complications such as pollakiuria, hematuria, or chronic recurrent urinary tract infection.[5,15,17-19] The temporary ureteral catheter must be small enough (ie, 3–5-Fr infant feeding tube) to allow introduction in the ureter without obstruction of the urethra, allowing urination around the catheter. After ureteral surgeries in cats, postoperative complication rates range from 6% to 31%, with the most common complication consisting of uroabdomen.[1-5] The two cats reported with a postoperative uroabdomen in our study were the only ones that did not have a catheter placed during the initial surgery. The authors suspect that the intrinsically small ureteral lumen in cats combined with ureteritis secondary to urolithiasis and surgical inflammation increased resistance to urine flow in the early postoperative period, resulting in leakage. Placement of a urinary diversion catheter, permanent or temporary, may decrease the resistance in the ureter and the likelihood of postoperative uroabdomen. By contrast, ureteroneocystostomy to treat ectopic ureters in dogs is not commonly associated with uroabdomen, likely due to the larger ureteral diameter in that species.[23,24] Intraoperative magnification is crucial for successful ureteral surgeries in cats and surgical loupes (×3.5) were consistently used in our study. Ureteroneocystostomy for kidney transplantation in cats is usually performed with a surgical microscope and is rarely associated with postoperative uroabdomen.[25,26] Surgical microscopes are, however, not routinely available in most veterinary practices. The influence of the type of magnification (microscope vs loupes) on the incidence of complications after treatment of ureteral obstructions in cats remains unknown. Placement of a DPT was associated with increased long-term morbidity in this cohort of cats. Stents and SUB irritate the urinary tract, leading to persistent lower urinary tract signs or infections in some cats.[5,6,15-17] Noticing such morbidity in cats treated with a DPT prompted us to use temporary urinary diversion in subsequent cats. A temporary device easily extractable in the postoperative period has significant advantages for long-term quality of life by eliminating residual foreign material within the urinary system. The temporary ureteral catheters were removed by transecting the finger trap suture and pulling the catheter, as performed to remove a standard urinary catheter. Furthermore, cat owners were not required to follow a rigorous recheck schedule, as recommended for maintenance of other devices.[16]

The postoperative improvement in creatinine values is consistent with alleviation of ureteral obstruction, as reported previously with different techniques.[1,5,6,15,16] Creatinine concentrations remained stable during long-term follow-up of cats in our study, including cats without a DPT. Ureters likely remained patent without local recurrence or stenosis of the ureteroneocystostomy. However, abdominal ultrasonographic evaluation was not consistently repeated after surgery to evaluate the diameter of the renal pelvis and ureter. Creatinine levels increased 134 days after surgery in one cat treated with a pigtail catheter, possibly due to the progression of CKD or obstruction of the pigtail catheter. Unfortunately, ultrasonographic reexamination was not available in this cat.

The long-term survival rate reported in this study is comparable to those reported after ureteral stenting (86%) or SUB (74%) placement.[6,16] Kyles et al[1] reported that cats surviving beyond a month after ureteral surgery had a 91% survival rate at 2 years postsurgery. In this study, 18% of cats died within the first month after surgery of progression of renal disease, as reported in other studies.[1,5] Cats with ureteral obstructions often have compromised kidney function prior to presentation for an acute onset of obstruction.[1] Predicting long-term survival in cats with ureteral obstruction is challenging because kidney function is difficult to evaluate during ureteral obstruction. Furthermore, the duration of the obstruction influences renal recovery, as has been shown in canine models,[27] but the exact time from the onset of obstruction is seldom known before surgery. Therefore, despite surgical intervention, acute worsening of underlying chronic injuries and progression over time of kidney disease is an important risk for those cats. Inflammatory changes were commonly identified by histopathology and were most probably secondary to migration of the uroliths. However, the authors believe that primary inflammation of the ureter may be an underlying risk factor for ureteral obstruction, as has been seen in cats with lower urinary tract inflammation and subsequent urethral obstruction.[28] Additional investigation is required to establish whether ureteritis in obstructed cats is a cause or a consequence of the obstruction.

This study has multiple limitations, most notably the small size of the population and inconsistent follow-up, which are inherent to the retrospective nature of the study. All owners were contacted to inquire about clinical signs at home and general health. Full bloodwork was rechecked at least once for all cats after they had been discharged from the hospital, but additional recheck appointments varied greatly during the follow-up period. Diet and medical management were not controlled after discharge from the hospital. A prospective randomized clinical trial would be appropriate to evaluate and compare the different options to treat upper urinary tract obstruction in cats. Only cats surgically treated by the same surgeon were entered in the study to study the progression of the technique from an intravesicular to extravehicular approach and from DPT to temporary ureteral catheter. Ureteroneocystostomy is considered the standard of care by the main surgeon of this study without regard the number of uroliths present in the ureter or their location.

Ureteroneocystostomy with or without placement of a DPT at the time of surgery relieved all benign obstructions and led to a significant reduction in creatinine values. Survival to discharge from the hospital was good, with favorable long-term outcomes. The presence of a DPT was associated with more frequent long-term complications.

ACKNOWLEDGMENTS

Author Contributions: Lorange M, DVM: acquisition, analysis, and interpretation of data for the work, drafting the work and final approval of the verison to be published; Monnet E, DVM, PhD, DACVS, DECVS: conception and design of the work, revising the draft critically for important intellectual content and final approval fo the verison to be published. Both authors are accountable for all aspects of the work

CONFLICT OF INTEREST

The authors declare no conflicts of interest related to this report.

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How to cite this article: Lorange M, Monnet E. Postoperative outcomes of 12 cats with ureteral obstruction treated with ureteroneocystostomy. *Veterinary Surgery*. 2020;1–10. https://doi.org/10.1111/vsu.13488