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Evaluation of a Double-Pigtail Ureteral Stent Fixation in Cats with Complete Ureteral Obstruction

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Abstract : The aim of this study was to evaluate double-pigtail ureteral stent fixation in cats. Medical records of 19 cats (23 ureters) with complete ureteral obstruction that double-pigtail ureteral stent placement were carried out were retrospectively reviewed. The cats were randomly classified into two groups; 13 cats (16 ureters) with double-pigtail ureteral stent fixed to urinary bladder (SF group) and 6 cats (7 ureters) with not fixed to urinary bladder (SNF group). The average age and weight of the cats was 7.4 years and 3.73 kg, respectively. Postoperative complications included chronic renal failure (n = 11), lower urinary track diseases (cystitis, hematuria, pollakiuria) (n = 7), stent migration (n = 6), anemia (n = 5), ascites (n = 2), hyperthermia (n = 1), enteritis (n = 1), oliguria (n = 1), hypotension (n = 1), ureteritis (n = 1), and pyelonephritis (n = 1). Stent migration did not occur in the 16 ureters of the cats in SF group but did occur in 4 out of 7 ureters of the cats in SNF group. The prevention of stent migration by stent fixation was significant ($P = 0.04$). Among the 13 cats in SF group, only 2 cats developed lower urinary track diseases, while 4 of the 6 cats in SNF group showed symptoms of lower urinary track disease. Thus, the cats that underwent double-pigtail ureteral stent fixation to the urinary bladder developed significantly fewer lower urinary diseases ($P = 0.046$). In conclusion, double-pigtail ureteral stent fixation to the urinary bladder for treatment of complete ureteral obstruction in cats can effectively prevent stent migration, which is common complication of stent placement.

***Key words* :** feline, ureteral obstruction, double-pigtail ureteral stent, stent fixation, complication.

Introduction

Ureteral obstruction in cats can cause acute kidney injury or chronic kidney disease by damaging the kidney glomerulus, leading to severe azotemia. Ureteral obstruction can be caused by ureteral stones, congenital or acquired stenosis, tumors, trauma, inflammation, thrombosis, and so on. The most frequent cause is ureteral stones, primarily from calcium-oxalate (14). Ureteral obstruction can occur more often in cats with congenital circumcaval ureter (20).

The number of diagnoses of ureteral obstruction in cats has increased as the number of cats as companion animals has increased and diagnostic equipment and technology have improved (4), it is also in South Korea. It can be diagnosed, to some extent, with hydronephrosis and an enlargement of the ureter, which can be verified by radiography and ultrasonography, but the antegrade pyelography is known to be the most accurate test for ureteral obstruction (15).

Unless ureteral obstruction has progressed chronically with kidney atrophy, surgical intervention is immediately indicated before the kidney parenchyma is damaged through an irreversible process over time (7). Traditional surgical methods include various ureteral incision techniques, end-to-end ureteric anastomosis, and ureteroneocystostomy (14). Although double-pigtail ureteral stents and subcutaneous ureteral bypass (SUB) have been suggested to reduce complications of traditional surgical methods and recurrences, various complications have also been reported for these new surgical methods that have received much attention recently (7).

The complications of the double-pigtail ureteral stent procedure include dysuria, urinary tract infection, re-obstruction, pyelonephritis, hematuria, and stent migration. The complications of SUB include dysuria, urinary tract infection, dehiscence of and leak at the connection of the device, occlusion in device (stone or concentrated exudate), and subcutaneous inflammatory response at the port (8).

The purpose of this study was to evaluate the efficacy of double-pigtail ureteral stent fixation to reduce stent migration, which is a frequent complication after double-pigtail ureteral stent placement.

Materials and Methods

Animals

Medical records of 19 cats (23 ureters) with complete ureteral obstruction that were admitted to the Western Animal Medical Center from February 2017 to November 2018 were retrospectively reviewed. The cats were carried out double-pigtail ureteral stent placement and randomly classified into two groups; 13 cats (16 ureters) with double-pigtail ureteral stent fixed to urinary bladder (SF group) and 6 cats (7 ureters) with double-pigtail ureteral stent not fixed to urinary

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bladder (SNF group). Medical records included the symptoms, preoperative and postoperative blood tests, radiography, ultrasonography, underlying diseases, operation time, survival period, and postoperative complications. The complete ureteral obstruction was diagnosed with radiography, ultrasonography, and pyelography.

Laboratory tests

Perioperative complete blood counts were measured with a hemocytometer (ADVIA®2120i Hematology System, Siemens, USA), and blood urea nitrogen (BUN), plasma creatinine, and plasma phosphorus (P) were measured with a clinical chemistry analyzer (Hitachi automatic analyzer 7020, Hitachi, Japan). Symmetric dimethylarginine (SDMA) was measured by a homogenous enzyme immunoassay (Beckman AU chemistry analyzer, IDEXX Laboratories, USA).

For blood gas analysis and electrolyte tests, preoperative and postoperative pH, Na, K, and Cl were measured using a blood gas analyzer (i-Smart 300 VET analyzer, i-sens, Korea).

For urine analysis, the urine protein to creatinine ratio (UPC) and specific gravity (SG) were measured with a chemistry analyzer (Catalyst One Chemistry Analyzer, IDEXX Laboratories, USA).

Diagnostic imaging

For radiographic inspection, the perioperative abdominal ventrodorsal (VD) and lateral views were taken with a radiographic instrument (Rotanode™ E7239FX, Toshiba Medical Systems, Japan). For ultrasonography, the position of stones and the pyelectasis and ureterectasis were determined with an ultrasonic test machine using a 5-12 MHz linear transducer probe.

Pyelogram

When stones in the ureter and dilation of the proximal ureter and renal pelvis were confirmed by radiographic and ultrasonic tests, the urine in the renal pelvis was removed with a 26G IV catheter, iohexol (Omnipaque™, GE Healthcare, Ireland) was injected, and contrast radiograph was performed to diagnose ureteral obstruction based on the flow of the contrast agent from the pelvis to the bladder. Damage to the glomerulus was reduced by collecting urine from the renal pelvis to relieve the pressure exerted on the renal pelvis. Infection of the renal pelvis, pyelonephritis, was tested through a urine culture.

Anesthesia

Anesthesia was induced with propofol (0.6 mg/kg IV, Provive 1% inj, Myungmoon pharm, Korea) and maintained using isoflurane. Tramadol (2 mg/kg IV, Maritrol inj, Jaeil pharm, Korea) was used as an analgesic. During anesthesia, the ECG, pulse rate, end-tidal CO2, oxygen saturation, noninvasive blood pressure, and body temperature were measured with a patient monitor (Datex Ohmeda S/5, GE Healthcare, USA).

Surgical techniques

After a midline celiotomy in the VD position, the posterior peritoneum of the ureter was incised, and the ureter was approached after removal of the fat surrounding the ureter. When the stone was found (Fig 1A), the ureter was longitudinally incised at the stone's location using a NO.15 blade and the stone causing occlusion was removed. Then, the posterior peritoneum and the fat near the dorsal side of kidney were separated, and an 18G IV catheter was placed in the renal pelvis. After the urine was collected, the needle was removed. A 0.018" angle-tipped hydrophilic guide wire (0.018 in Weasel wire: Infiniti Medical LLC, Menlo, CA) was inserted through the catheter. The ureteral patency from renal pelvis to the bladder was verified by observing the movement of the guide wire through the ureter (Fig 1B). Once the guide wire enters the bladder, the guide wire was secured by incising the bladder. After dilation the ureter by inserting dilators through antegrade and retrograde routes, a double-pigtail ureteral stent (Vet Stent-Ureter™: Infiniti Medical LLC, Menlo, CA) was inserted by an antegrade route. Then, the guide wire was removed and incision sites in the renal capsule and ureter were sutured by simple interrupted stiches using Maxon 6-0 sutures (Kendall-Tyco International Ltd, Mansfield, MA).

When the guide wire or dilator could not be inserted due to distal ureter stenosis, the distal ureter was removed and end-to-end anastomosis of the ureter or ureteroneocystostomy was performed (Fig 1C). Figure 1D was shown the stent attachment part of urinary bladder lumen. Among the side holes of the bladder-side pigtail, the hole facing the lumen was fixed to the bladder with the Maxon™ 6-0 suture (Fig 1D and 1E). Then, the incision site of bladder, abdominal wall, subcutaneous tissue and skin were sutured using a general suturing technique. A stone analysis test of removed stone was performed and an antibiotic culture test was performed on the urine collected from the renal pelvis. The surgeries took between 25 min to 120 min to complete.

Emergency surgery was recommended for cats diagnosed with complete ureteral obstruction after examinations at the initial visit. For patients not diagnosed with complete ureteral obstruction, movement of the stones was observed with intravenous fluid therapy, tamsulosin (21), antibiotics, and analgesics. Surgery was performed when the stone did not move to the bladder within 48 hours or moved to the distal ureter, causing complete ureteral obstruction (19).

Stone analysis, bacterial culture, antibiotic susceptibility test

Analysis of the stone samples, bacterial culture, and antibiotic susceptibility tests were carried out at a laboratory (IDEXX laboratories, Korea).

Post-operative management and follow-up

Cephazoline (20 mg/kg IV, Cefozol, Koruspharm, Korea), famotidine (0.5 mg/kg IV, Gaster inj, Dong-a ST, Korea), and metronidazole (7.5 mg/kg IV, Metrynal inj, Daihan pharm, Korea) were administered until the postoperative culture test results were obtained. They were either replaced with appropriate antibiotics or the administration was stopped based on the urine culture test results. Blood gas analysis, electrolyte tests, blood tests, and abdominal ultrasonography were performed until the azotemia improved and stayed normal. The

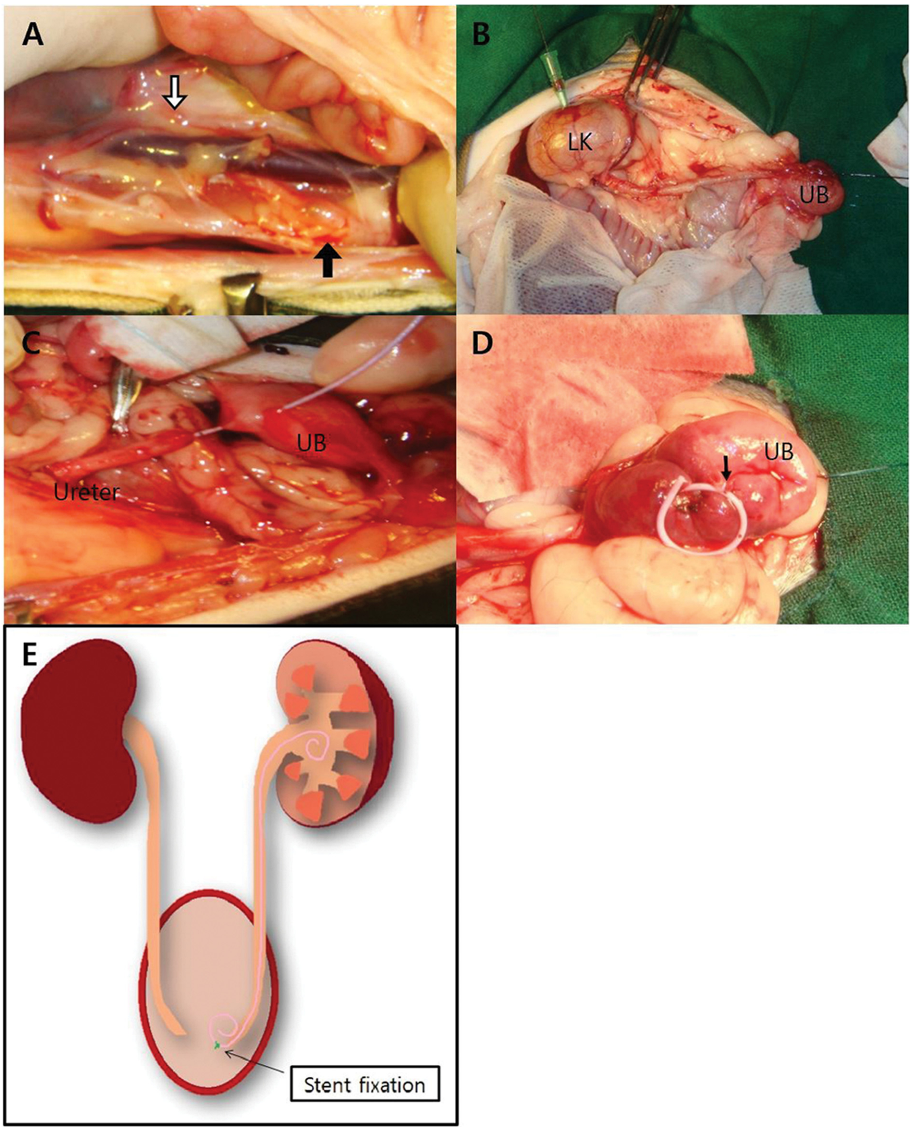

Fig 1. Surgical procedures of double-pigtail ureteral stent fixation. A. A circumcaval ureter that bypasses the dorsal side of the main vein is identified during the ureteral approach (hollow arrow) and the presence of an occlusive stone in the ureter can be seen (black arrow). B. Patency to the bladder is checked by inserting a guide wire via an antegrade route through the ureter by approaching the renal pelvis from the dorsal aspect of kidney. If patency cannot be secured, an end-to-end anastomosis or ureteroneocystostomy is performed. C. A stenosis of the distal ureter from the stone is identified and neoureterocystostomy is performed using a stent after incising the ureter. D. The pigtail of the stent is positioned in the bladder and the side hole is fixed to the bladder using Maxon 6-0 sutures (black arrow). E. Schematic shows the final position of the ureteral stent, distal pigtail is positioned with fixation in the urinary bladder, and the proximal pigtail is positioned in the renal pelvis.LK, left kidney; UB, urinary bladdder.

patients were discharged when they showed stable test results.

Ultrasonography, radiography, urinalysis, UPC, SDMA, and blood tests were performed as regular test following discharge, and a pyelogram was performed when needed. Follow-up examinations were performed in intervals of 7 days on average between days 1 and 642 after discharge, for an average of 10 times per patient between 3 and 42 times.

Statistical analysis

Statistical analysis was performed with the commercial application PRISM 8.0 (GraphPad Software). The stent migration, with or without fixation to the urinary bladder, and the frequency of urinary symptoms due to bladder stimulation were analyzed by the Fisher's exact test. The survival period was analyzed by the Kaplan-Meier method. Statistical significance was determined when the P value was lower than 0.05.

Results

Breed and sex

The largest species was the Persian cats (n = 5 [26%]), followed by the Domestic short hair cats (n = 4 [21%]), the American short hair cats (n = 2 [11%]), the Abyssinian (n = 2 [11%]), Russian blue (n = 2 [11%]), the Siamese cat (n = 2 [11%]), the Scottish fold (n = 1 [5%]), and the Turkish angora (n = 1 [5%]). The average age of the cats was 7.4 years (3 to 11 years), and the average weight was 3.73 kg

Table 1. Comparison of breed, age, sex, clinical symptoms of double-pigtail ureteral stent fixation group and double-pigtail ureteral stent non-fixation group in cats with complete ureteral obstruction

(Mean ± SE)

Variables	SNF group (n = 6)	SF group (n = 13)	P-value
Breed	Persian (n = 1) Abyssinian (n = 1) Korean short hair (n = 1) Russian blue (n = 1) American short hair (n = 1) Siamese cat (n = 1)	Persian (n = 4) Korean short hair (n = 3) Abyssinian (n = 1) Russian blue(n = 1) American short hair (n = 1) Siamese cat (n = 1) Turkish angora (n = 1) Scottich fold (n = 1)	-
Age (years)	7.8 ± 0.9	7.2 ± 0.8	0.598
Body weight (kg)	4.4 ± 0.7	3.5 ± 0.3	0.356
Sex	Castrated male (n = 3) Female (n = 1) Spayed female (n = 2)	Castrated male (n = 8) Spayed female (n = 5)	-
Clinical symptoms	Anorexia (n = 4) Vomiting (n = 4) Lethargy (n = 4) PUPD (n = 1)	Anorexia (n = 10) Vomiting (n = 8) Lethargy (n = 4) Weight loss (n = 3) PUPD (n = 1) Diarrhea (n = 1) Hematuria (n = 1)	-
Additional surgery	Nephrectomy (n = 1) Ureteral anastomosis (n = 1)	Nephrectomy (n = 2) Ureteral anastomosis (n = 4) Ureteroneocystostomy (n = 2) SUB (n = 2)	-

SF group, Double-pigtail ureteral stent fixation group; SNF group, double-pigtail ureteral stent non-fixation group; PUPD, polyuria polydipsia; SUB, subcutaneous ureteral bypass.

(1.6 to 7.3 kg). Among the 19 cats, 11 (58%) were male (all neutered) and 8 (42%) were female (7 were spayed and 1 was not neutered). Among the six cats that did not have a double-pigtail ureteral stent fixed to the bladder (SNF group), there were Persian (n = 1), Abyssinian (n = 1), Korean short hair (n = 1), Russian blue (n = 1), American short hair (n = 1), Siamese cat (n = 1) and Castrated male (n = 3), female (n = 1), spayed female (n = 2). Average age of the cats was 7.8 ± 0.9 years and average body weight was 4.4 ± 0.7 kg. Among the 13 cats for which the double-pigtail ureteral stent was fixed to the bladder (SF group), there were Persian (n = 4), Korean short hair (n = 3), Abyssinian (n =1), Russian blue (n = 1), American short hair (n = 1), Siamese cat (n = 1), Turkish angora (n = 1), Scottich fold (n = 1) and castrated male (n = 8), spayed female (n = 5). Average age of the cats was 7.2 ± 0.8 years and average body weight was 3.5 ± 0.3 kg. There were no significant differences between two groups in average age and body weight *(P* = 0.598 and *P* = 0.356) (Table 1).

Clinical symptoms

Main clinical symptoms prior to surgery were anorexia (n = 14 [74%]), vomiting (n = 13 [68%]), lethargy (n = 8 [42%]), weight loss (n = 3 [16%]), polyuria and polydipsia (PUPD) (n = 2 [11%]), diarrhea (n = 1 [5%]), and hematuria (n = 1 [5%]). The underlying diseases were chronic renal failure (n = 6), stomatitis (n = 3), liver disease (n = 2), bronchitis (n = 2), pancreatitis (n = 1), feline idiopathic cystitis (n = 1), urinary bladder calculi (n = 1), and diabetes mellitus (n = 1). Among SNF group, there were anorexia (n = 4), vomiting (n = 4), lethargy (n = 4), PUPD (n = 1)) and nephrectomy (n = 1), ureteral anastomosis (n = 1). Among SF group, there were anorexia (n = 10), vomiting (n = 8), lethargy (n = 4), weight loss (n = 3), PUPD (n = 1), diarrhea (n = 1), hematuria (n = 1) and nephrectomy (n = 2), ureteral anastomosis (n = 4), ureteroneocystostomy (n = 2), SUB (n = 2) (Table 1).

Additional surgery

Among SNF group, there were cases where a nephrectomy (n = 1) and an end-to-end anastomosis of the ureter (n = 1) were used in combination. Among SF group, there were cases where SUB (n = 2), nephrectomy (n = 2), end-to-end anastomosis of the ureter (n = 4), and ureteroneocystostomy (n = 2) were used in various combinations (Table 1).

Laboratory test findings

In the blood tests of 19 cats that visited the medical center, the mean BUN concentration was 188.5 ± 25.3 mg/dL (reference range: 7-27 mg/dL), the mean creatinine concentration was 12.2 ± 2.0 mg/dL (reference range: 0.5-1.8 mg/dL), the mean phosphorus concentration was 12.7 ± 1.7 mg/dL (reference range: 3-6.2 mg/dL), and the mean potassium concen-

Table 2. Concentrations of blood urea nitrogen, creatinine, phosphorus, and potassium before surgery and 3-8 days after surgery in cats with complete ureteral obstruction

(Mean ± SE)

Variables	Before surgery (n = 19)	After surgery (n = 13)	P-value	Reference range
BUN (mg/dL)				
SF group (n = 13)	187.4 ± 29.5	53.5 ± 11.1	0.0005	7-27
SNF group (n = 6)	190.8 ± 48.4	32.8 ± 2.8	0.0154	
Total	188.5 ± 25.3	44.0 ± 6.8	0.00001	
Creatinine (mg/dL)				
SF group (n = 13)	12.0 ± 2.1	3.0 ± 0.3	0.0005	0.5-1.8
SNF group (n = 6)	12.6 ± 4.3	3.0 ± 0.4	0.0487	
Total	12.2 ± 2.0	3.0 ± 0.2	0.0001	
Phosphorus (mg/dL)				
SF group (n = 13)	12.9 ± 2.0	7.2 ± 2.0	0.045	3-6.2
SNF group (n = 6)	12.0 ± 3.2	4.5 ± 0.4	0.052	
Total	12.7 ± 1.7	6.0 ± 1.2	0.003	
Potassium (mEq/L)				
SF group (n = 13)	5.2 ± 0.5	3.5 ± 0.1	0.004	3.5-5.8
SNF group (n = 6)	5.5 ± 0.6	4.0 ± 0.2	0.032	
Total	5.3 ± 0.4	3.8 ± 0.2	0.001	

BUN, blood urea nitrogen; SF group, Double-pigtail ureteral stent fixation group; SNF group, double-pigtail ureteral stent non-fixation group.

tration was 5.3 ± 0.4 mEq/L (reference range: 3.5-5.8 mEq/L). In the blood tests of 13 discharged cats, the mean BUN concentration was 44.0 ± 6.8 mg/dL, the mean creatinine concentration was 3.0 ± 0.2 mg/dL, the mean phosphorus concentration was 6.0 ± 1.2 mg/dL, and the mean potassium concentration was 3.8 ± 0.2 mEq/L (Table 2). The preoperative mean BUN, creatinine, and phosphorus concentrations of all the patients were significantly increased. The mean phosphorus concentration of the discharged patients restored to normal while the postoperative mean BUN and creatinine concentrations of the discharged patients were not all normal, but significantly decreased compared with preoperative values (BUN: $P = 0.00001$, Creatinine: $P = 0.0001$). In SF group, the postoperative mean BUN concentration was decreased to 53.5 ± 11.1 from 187.4 ± 29.5 mg/dL ($P = 0.0005$), the postoperative mean creatinine concentration was decreased to 3.0 ± 0.3 from 12.0 ± 2.1 mg/dL ($P = 0.0005$), the postoperative mean phosphorus concentration was decreased to 7.2 ± 2.0 from 12.9 ± 2.0 mg/dL ($P = 0.045$) and the postoperative mean potassium concentration was decreased to 3.5 ± 0.1 from 5.2 ± 0.5 mEq/L ($P = 0.004$). In SNF group, the postoperative mean BUN concentration was decreased to 32.8 ± 2.8 from 190.8 ± 48.4 mg/dL ($P = 0.0154$), the postoperative mean creatinine concentration was decreased to 3.0 ± 0.4 from 12.6 ± 4.30 mg/dL ($P = 0.0487$), the postoperative mean phosphorus concentration was decreased to 4.5 ± 0.4 from 12.0 ± 3.2 mg/dL ($P = 0.052$) and the postoperative mean potassium concentration was decreased to 4.0 ± 0.2 from 5.5 ± 0.6 mEq/L ($P = 0.032$).

In the complete blood counts, the mean white blood cell (WBC) of SNF group was 9.1 ± 1.1 K/μL and WBC of SF group was 13.7 ± 2.1 ($P = 0.04$), the mean hematocrit (Hct) of SNF group was 28.0 ± 1.8% and Hct of SF group was 33.0 ± 1.9 ($P = 0.04$).

In the blood gas analysis, pH of SNF group was 7.2 and pH of SF group was 7.1 ($P = 0.27$).

In the electrolytes, the mean natrium (Na) and chloride (Cl) of SNF group was 156.7 ± 2.4 mmol/L and 119.2 ± 2.24 mmol/L. The mean Na and Cl of SF group was 157.5 ± 2.1 mmol/L ($P = 0.41$) and 114.6 ± 1.7 mmol/L ($P = 0.09$).

In the serum profile of SNF group, the mean alanine aminotransferase (ALT) was 81.2 ± 19.1 U/L, the mean alkaline phosphatase (ALP) was 31.8 ± 5.3 U/L, the mean total protein (TP) was 7.3 ± 0.2 g/dl, the mean albumin (Alb) was 3.3 ± 0.1 g/dl, and the mean glucose (Glu) was 179.0 ± 50 mg/dl. In SF group the mean ALT was 51.5 ± 7.7 U/L ($P = 0.12$), the mean ALP was 28.9 ± 5.0 U/L ($P = 0.36$), the mean TP was 7.8 ± 0.3 g/dl ($P = 0.06$), the mean Alb was 3.4 ± 0.1 g/dl ($P = 0.37$), and the mean Glu was 139.8 ± 15.3 mg/dl ($P = 0.26$).

Urine analysis findings

In the urine analysis, the mean urine-protein ratio (UPC) and specific gravity (SG) of SNF group was 0.55 ± 0.14 and 1.024 ± 0.007. The mean UPC and SG of SF group was 0.33 ± 0.1 ($P = 0.27$) and 1.022 ± 0.007 ($P = 0.43$).

Stone analysis findings

The stones that were analyzed for composition were all found to be calcium oxalate (n = 14 [100%]).

Urine culture test findings

In the urine culture test, *Enterococcus faecium* (n = 1, susceptible to vancomycin, resistant to amikacin, amoxicillin/clavulanic acid, ampicillin, azithromycin, cefotaxime, cephalothin, clindamycin, cefovecin, doxycycline, enrofloxacin, imipenem, oxacillin, and trimethoprim/sulfamethoxazole) and *Pseudomonas aeruginosa* (n = 1, susceptible to amikacin, colistin, imipenem, and meropenem, and resistant to ampicillin/sulbactam, cefotaxime, ceftazidime, ciprofloxacin, gentamicin, minocycline, piperacillin, piperacillin/tazobactam, ticarcillin/clavulanic acid, trimethoprim/sulfamethoxazole, and tigecycline) were cultured.

Operation time

The mean operation time was 86.1 ± 32.4 minutes (min), and includes the operation times for unilateral or bilateral stent procedures, SUB placement, nephrectomy, end-to-end anastomosis of the ureter, or ureteroneocystostomy, which were performed simultaneously with the stent procedure. The mean operation time of SNF group was 95 ± 8.4 min and the mean operation time of SF group was 81.9 ± 9.9 ($P = 0.176$) min.

Post-operative complications

Postoperative complications included chronic renal failure (n = 11 [58%]), lower urinary track diseases (cystitis, hematuria, pollakiuria) (n = 7 [37%]), stent migration (n = 6 [32%]) (Fig 2), anemia (n = 5 [26%]), ascites (n = 2 [11%]), hyperthermia (n = 1 [5%]), enteritis (n = 1 [5%]), oliguria (n = 1 [5%]), hypotension (n = 1 [5%]), ureteritis (n = 1 [5%]), and pyelonephritis (n = 1 [5%]). Among SNF group, there were chronic renal failure (n = 5), lower urinary track diseases (n = 3), stent migration (n = 6), ureteritis (n = 1), pyelonephritis (n = 1). Among SF group, there were chronic renal failure (n = 6), lower urinary track diseases (n = 4), anemia (n = 5), ascites (n = 2), hyperthermia (n = 1), enteritis (n = 1), oliguria (n = 1), hypotension (n = 1).

Stent migration did not occur in the 16 ureters that underwent double-pigtail ureteral stent fixation to the urinary bladder but did occur in 4 out of 7 ureters that did not undergo double-pigtail ureteral stent fixation to the urinary bladder. Thus, the prevention of stent migration by stent fixation was significant ($P = 0.04$). Among the 13 cats that underwent double-pigtail ureteral stent fixation to the urinary bladder, only 2 cats developed lower urinary track diseases, while 4 of the 6 cats that did not undergo double-pigtail ureteral stent fixation to the urinary bladder showed symptoms of lower urinary track disease. Thus, the cats that underwent double-pigtail ureteral stent fixation to the urinary bladder developed significantly fewer lower urinary diseases ($P = 0.046$). In the 4 cats that experienced stent migration, 3 developed lower urinary track diseases, while in the 15 cats who did not experience stent migration, only 3 cats developed lower urinary track diseases ($P = 0.07$) (Table 3).

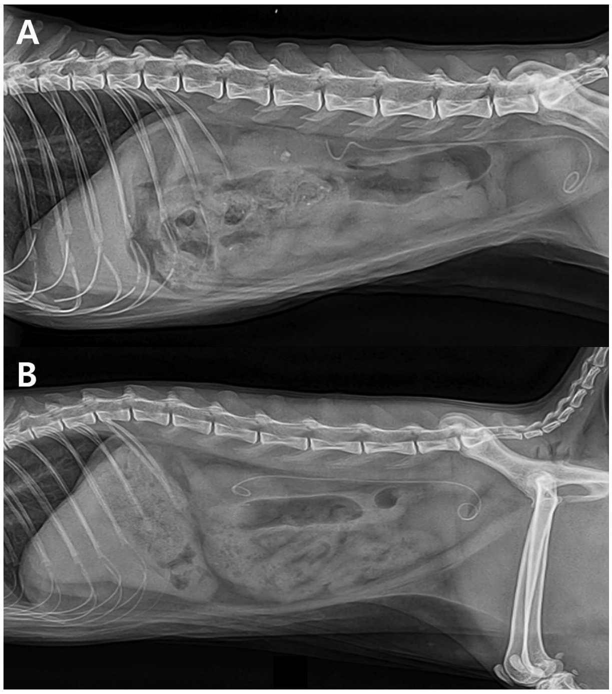

Fig 2. Radiographs from follow-up examinations: A. The radiograph of a Perisian cat one month after surgery shows that the stent has migrated distally. The cat showed symptoms of pollakiuria and cystitis due to stent stimulation. B. The radiograph of a Siamese cat 5 months after surgery shows that the stent stays immobilized with no migration. No clinical symptoms due to the stent were found.

Survival period

The survival period was analyzed by the Kaplan-Meier method. The survival rates during 1, 3, 8, and 12 months after the surgery were 76%, 63%, 63%, and 54%, respectively, and the mean survival period was 225 days (range 1-642) (Fig 3).

Table 3. Comparison of postoperative complications such as stent migration and lower urinary tract diseases between double-pigtail ureteral stent fixed and double-pigtail ureteral stent non-fixed cats

	Stent migration	Stent non-migration	P-value
SF group	0	16	0.040
SNF group	4	3	
	With FLUTD	Without FLUTD	
SF group	2	11	0.046
SNF group	4	2	
	With FLUTD	Without FLUTD	
Stent migration	3	1	0.07
Stent non-migration	3	12	

SF group, Double-pigtail ureteral stent fixation group; SNF group, double-pigtail ureteral stent non-fixation group; FLUTD, feline lower urinary tract disease (cystitis, hematuria, pollakiuria).

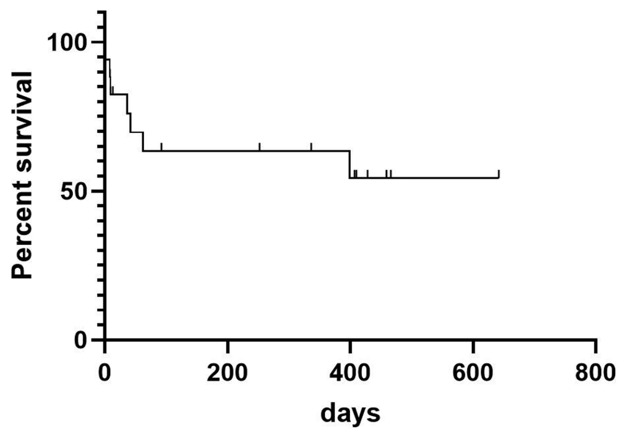

Fig 3. Kaplan-Meier survival curve after surgery in cats with complete ureteral obstruction. The survival rates during 1, 3, 8, and 12 months after the surgery were 76%, 63%, 63%, and 54%, respectively, and the mean survival period was 225 days (range 1-642).

Discussion

Double-pigtail ureteral stents, in present study, were successfully placed in all 19 cats regardless of obstructive location, whether unilateral or bilateral, number of stones and 16 stents were fixed to urinary bladder in 13 cats. Breeds, age, sex, body weight, presenting clinical signs do not seem to distinguish between SNF group and SF group. There was significant difference in incidence of migration ($P = 0.04$) and lower urinary track disease ($P = 0.046$) between SNF group and SF group.

In this study, even though suture materials were used to fix the double-pigtail ureteral stent to the urinary bladder, the incidence of lower urinary track diseases, which are most frequent complications (17), was lower in SF group than SNF group ($P = 0.046$). Many previous studies found that suture materials in the bladder became nidus or caused recurrences of stones (1,9). This may suggest that the stimulation of stent to the bladder due to stent migration by peristalsis of the ureter has a greater effect on the incidence of lower urinary diseases than the existence of suture materials. However, in another study, the stiffness of the stent or stimulation of the bladder neck and the bladder triangle by the stent position appeared to be the cause of postoperative lower urinary track diseases (7). Further studies are required to fully understand the cause of postoperative lower urinary track disease.

A double-pigtail ureteral stent is generally placed when there is ureteral obstruction by stones, stenosis, or tumors in human medicine (17). In the veterinary medicine, diagnosis of ureteral obstruction is increasingly common due to the developments in diagnostic equipment (4). Double-pigtail ureteral stents have been used frequently since ureteral obstruction in dog and cat patients was first reported in 2007 (5,6). However, complications, such as discomfort and pain during urination have been reported in 40-55% of human patients after stent placement. Thus, the stents are generally removed between 2 days and 2 weeks after surgery (16). Veterinary medicine has also reported various complications, such as dysuria, urinary tract infection (UTI), re-obstruction, pyelonephritis, hematuria, and stent migration (8). However, stent removal requires careful consideration and monitoring because there is a risk of stenosis and re-obstruction after the stent removal (13).

One study reported that cats with stents had no complications for an extended period (780 days or longer). It is suggested that cats could endure stents better than people (6). Therefore, this study examined a method to reduce complications, without removing stents that stimulate the bladder and have confirmed that stent migrations significantly decreased when the double-pigtail ureteral stent were fixed to the urinary bladder ($P = 0.04$).

SUB is used frequently because it is applicable to patients with ureteral tumors, extensive stenosis, or defects to which stents cannot be applied; in addition, the surgery time is shorter than that of double-pigtail ureteral stent, and some comparative studies have reported that SUB has fewer complications than stents (7). However, SUB also has complications, such as dysuria, UTI, leaks at the connection of the device, occlusion in the device due to stone or concentrated exudate, and subcutaneous inflammatory responses at the port (8). Even in human medicine, permanent SUB is indicated for patients with end stage tumors in the abdominal or pelvic cavities, and long-term use of SUB is not recommended (10,11). Thus, the removability of device is an advantage of double-pigtail ureteral stents that permanent SUB does not have (5,13). Moreover, SUB is thought to need to be improved because it is a fairly new application to the veterinary medicine (2).

SUB should be used in cases where stents cannot be placed, when there is only one kidney function, or when the patient is geriatric. Otherwise, it is ideal to place a stent and then remove it after a sufficient recovery period. Biodegradable double-pigtail ureteral stents, which degrade and are discharged after some time, are also being studied as a way to improve the complications that occur after stent placement and the another surgery required to remove the stent (3). When this device is commercialized, it is expected that the biodegradable double-pigtail ureteral stent could be fixed with an absorbable suture material to reduce the complications that occur during stents placement and will negate the need for a separate stent removal surgery.

Compared with another study whose subjects consisted of 76% domestic short hair cats, the present study showed a greater various in species (22). The age (7.4 vs. 8 years) and sex (58% males vs. 51% males) of the cats did not show significant differences. The most frequent clinical symptoms upon arrival at the medical center were anorexia, nausea, and lethargy which were identical to other studies. Increased BUN and creatinine were identified via a blood test in other studies, but the values of BUN and creatinine were higher in the present study and may have affected the survival rate. However, another study found that the blood test results on arrival at the medical center did not have a significant effect on the survival period (10). Thus, further studies regarding relations between survival time and azotemia are warranted. The stone component test results showed that all analyzed stones were composed of calcium oxalate in this study, showing no differences with previous studies (18). In the urine culture test, bacteria were cultured in only 2 of 19 cats (5%) in this study, but another study (12), bacteria were cultured in 5 of 20 cats ($P = 0.17$). *Enterococcus faecium* and *Pseudomonas aeruginosa* were found in cultures from both studies.

The limitations of this study include its retrospective nature, short postoperative periods, small number of application cases and the degree of experience with stent placement, ureteral resection and ureteral anastomosis was varied over the study periods. Despite of these limitations, result from this study suggest that means of stent fixation treated for complete urinary track obstruction was considered effective in preventing migration and decreasing incidence of lower urinary track disease. However, further studies are required to confirm these findings.

Conclusion

Double-pigtail ureteral stent fixation to the urinary bladder for treatment of complete ureteral obstruction in cats can effectively prevent stent migration, which is a common complication of stent placement.

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