Evaluation for association between indwelling urethral catheter placement and risk of recurrent urethral obstruction in cats

Marc A. Seitz DVM

Jamie M. Burkitt-Creedon DVM

Kenneth J. Drobatz DVM, MSCE

From the Emergency Department, Red Bank Veterinary Hospital–Cherry Hill, 1425 Marlton Pike E, Cherry Hill, NJ 08034 (Seitz, Burkitt-Creedon); and the Department of Clinical Studies, School of Veterinary Medicine, University of Pennsylvania, Philadelphia, PA 19104 (Drobatz). Dr. Seitz's present address is Department of Clinical Sciences, College of Veterinary Medicine, Mississippi State University, Mississippi State, MS 39762. Dr. Burkitt-Creedon's present address is Department of Surgical and Radiological Sciences, School of Veterinary Medicine, University of California-Davis, Davis, CA 95616.

Address correspondence to Dr. Seitz (marc.seitz@msstate.edu).

OBJECTIVE

To test for an association between indwelling urethral catheter placement in cats with urethral obstruction (UO) and the short-term (30-day) risk of recurrent urethral obstruction (RUO).

DESIGN

Prospective cohort study.

ANIMALS

107 client-owned male cats with UO.

PROCEDURES

Owners were offered standard care for their cats, including hospitalization, placement of an indwelling urethral catheter, IV fluid therapy, and other supportive treatments (inpatient group). One-time catheterization and outpatient care were offered (outpatient group) if standard care was declined. Data regarding signalment, measures of metabolic compromise and urinalysis findings at enrollment, catheterization-related variables, and supportive treatments of interest were collected. Risk of RUO ≤ 30 days after urethral catheter removal was determined for the outpatient vs inpatient group by OR and 95% confidence interval calculation. Other variables were compared between cats that did and did not develop RUO with Fisher exact and trend tests.

RESULTS

91 cats completed the study; 19 (5/46 [11%] inpatients and 14/45 [31%] outpatients) developed RUO. Risk of RUO was significantly greater for cats of the outpatient group (OR, 3.7; 95% confidence interval, 1.2 to 11.4). Among inpatients, increasingly abnormal urine color at the time of catheter removal was significantly associated with RUO. No other significant associations were identified.

CONCLUSIONS AND CLINICAL RELEVANCE

Hospitalization and indwelling catheterization significantly reduced the risk for RUO ≤ 30 days after treatment for the population studied. Results suggested that removal of an indwelling catheter before urine appears grossly normal may be associated with development of RUO. One-time catheterization with outpatient care was inferior to the standard care protocol but was successful in many cats and may be a reasonable alternative when clients cannot pursue standard care. (*J Am Vet Med Assoc* 2018;252:1509–1520)

Diseases of the lower urinary tract account for a fairly large number of feline visits to veterinary hospitals.[1] Cats with UO have a high potential for severe illness and death due to associated hyperkalemia, azotemia, metabolic acidosis, cardiovascular compromise, arrhythmias, uremia, and acute kidney injury. These metabolic derangements develop ≤ 24 hours after obstruction occurs. In untreated cats, death results within 3 to 6 days after obstruction.[2]

Despite the potential for severe pathophysiologic consequences, most cats with UO are relatively stable on initial examination and have only mild clinicopathologic abnormalities detected.[1] As a result, the short-term prognosis is considered very good with appropriate treatment (with survival-to-discharge rates in 3 studies[1,3,4] ranging from 41 of 45 [91%] to 205 of 219 [94%]). In contrast, the long-term prognosis for RUO is guarded, with published recurrence rates ranging from 10 of 68 (15%) to 14 of 39 (36%).[3–7] The week after initial treatment appears to be the most likely interval for reobstruction.[3,5,7]

The standard approach for treatment of UO in cats is well described in the veterinary literature.[8,9] This includes immediate stabilization of life-threatening conditions, restoration of urethral patency, and hospitalization for monitoring and supportive care. An indwelling urethral catheter is placed to maintain

ABBREVIATIONS

RUO	Recurrent urethral obstruction
UO	Urethral obstruction

urethral patency and allow monitoring of urine output during hospitalization.[10] The urethral catheter is typically removed once urine output has normalized, metabolic derangements have improved, and any grossly evident urine abnormalities such as hematuria or sediment have resolved.

A disadvantage to this standard approach is the cost to the client. Cost is frequently a hurdle to standard care, and some cats with UO are euthanized as a result.[1,11] Authors of 1 study[11] have explored alternative treatments for UO. Although the short-term survival rate for cats receiving alternate treatment (12/15) was lower than that for cats receiving standard care, cats that survived to discharge had a rate of RUO (2/11 cats over 3 weeks), similar to that of cats that received standard care.[11] To our knowledge, no studies have evaluated the short-term rate of RUO for cats that undergo 1-time urethral catheterization and outpatient care.

The purpose of the study reported here was to test for an association between indwelling urethral catheter placement (with hospitalization and supportive care) in cats with UO and the short-term (30-day) risk of RUO. We hypothesized that cats receiving this standard care would have a significantly lower risk of RUO during a 30-day follow-up period, compared with cats that underwent 1-time urethral catheterization and received outpatient care.

Materials and Methods

Animals

Cats in which UO was diagnosed by a veterinarian at Red Bank Veterinary Hospital (a private, small-animal emergency and referral hospital) between January 1, 2014, and June 30, 2015, were eligible for study inclusion. Urethral obstruction was diagnosed in cats with either a large, firm, nonexpressible urinary bladder or veterinarian-witnessed stranguria without urine production. Exclusion criteria included female sex, age < 12 months, urethral catheterization prior to the qualifying examination, or lower urinary tract surgery in the 30 days prior to this examination. Additional exclusion criteria included presence of a urethral tear, spontaneous (noniatrogenic) rupture of the urinary bladder, lower urinary tract neoplasia, urolithiasis identified by diagnostic imaging, underlying neurologic disease identified as the etiopathogenesis for UO, trauma, or existing perineal urethrostomy. Cats enrolled in the study were subsequently removed and excluded from statistical analyses if they underwent lower urinary tract surgery not related to recurrence of UO ≤ 30 days after catheter removal, if they died from any cause not related to UO or were lost to follow-up prior to conclusion of the 30-day observation period, and, for cats that received standard-care treatment, if the indwelling catheter was removed ≤ 12 hours after placement. Each patient was eligible for study inclusion only once.

Procedures

Two hospital protocols that were in place prior to the study and agreed upon by staff veterinarians provided that a consistent standard of care was offered to all owners of male cats with UO. The protocols were available for reference throughout the study. The inpatient care protocol was recommended to all clients and reflected current standard of care. If inpatient care was declined, the outpatient care protocol was offered. For study purposes, cats were assigned to 2 groups (inpatient and outpatient) on the basis of the owner's decision regarding treatment.

A standardized data sheet[a,b] was used to collect the following information for all cats during initial examination and treatment: group assignment, individual veterinarian who performed initial (rigid) urethral catheterization, the veterinarian's time in practice since graduation, subjective difficulty of initial catheterization[c] (scored from 1 [minimal difficulty] to 5 [unable to catheterize]; **Appendix 1**), catheter manipulation time required to achieve urethral patency (measured from the time of first attempted catheterization until urine flow was observed), whether decompressive cystocentesis was performed during catheterization, and volume of sterile crystalloid fluid used to flush the bladder following catheterization. For cats of the inpatient group, additional information recorded included the following: initial indwelling urethral catheter size, time required and difficulty in placing the indwelling catheter, duration of indwelling catheterization, and subjectively assessed urine color (clear, straw-colored, yellow, pink, or red) when the indwelling urethral catheter was removed.

The medical records of all cats were retrospectively reviewed after patient discharge to obtain information regarding age, breed, neuter status, and body weight; body condition score (from 1 to 9, where 1 = emaciated, 5 = ideal, and 9 = grossly obese)[12]; diagnosis; the presence of crystalluria, degree of hematuria, degree of pyuria, and presence of bacteriuria on urinalysis; and base excess and BUN and circulating (blood or serum, depending on the equipment used) creatinine and potassium concentrations in the blood sample obtained at the time of initial examination and treatment. Additional information collected from the medical record included administration of buprenorphine hydrochloride, drugs for treatment of urethral spasm (eg, prazosin hydrochloride or phenoxybenzamine hydrochloride), antimicrobials, and anti-inflammatories.

Although the predetermined treatment protocols were in place as described in this section, individual patient care was at the discretion of the attending veterinarian and reflected patient needs and client consent. Deviations from the protocols that might have affected secondary variables of interest were recorded.

Immediately after arrival at the study facility, patients were examined and emergency stabilization was provided if necessary. After initial evaluation and stabilization, a venous blood sample was collected for a CBC,[d] serum biochemical analysis,[e,f] and venous blood gas analysis.[f,g] Because 2 biochemical analyzers with different reference ranges were used, hema-

tologic variables were converted to a severity scale (scored from 0 [normal] to 3 [severe abnormality]) for recording and statistical analysis **(Appendix 2)**. The severity scale was determined by the authors on the basis of clinical experience. A value was considered normal if it was within the manufacturer's reference range for the equipment used. Urine was collected by catheterization or cystocentesis. When urine was collected via the catheter, the sample was obtained after discarding the first ≥ 20 mL of urine after urethral patency was achieved. When urine was collected by cystocentesis, it was obtained prior to urethral catheterization. An in-house urine sediment examination was performed ≤ 1 hour after sample collection to evaluate for the presence of crystalluria. An additional urine sample was submitted to a reference laboratory[h] for complete urinalysis and culture. An abdominal radiograph was obtained with the patient in lateral recumbency; the image was used to evaluate each cat for the presence of obvious (radiopaque) uroliths and to confirm urethral catheter placement. According to established hospital procedures, all radiographs were reviewed by a board-certified radiologist. A focal ultrasonographic examination of the bladder was performed by a veterinarian from the emergency service to evaluate the patient for presence of obvious urinary calculi or urinary bladder neoplasia. If a complete diagnostic work-up could not be performed, diagnostic tests were generally prioritized by the attending clinician on the basis of patient stability and client consent.

Each patient was sedated or anesthetized at the discretion of the attending veterinarian after evaluation and stabilization of its clinical condition. No patients received epidurally administered anesthetics. Urethral catheterization techniques varied among clinicians; commonly applied hospital standards were as follows. The fur around the prepuce was clipped, and the area was scrubbed with alternate application of 2.0% chlorhexidine gluconate solution and 70% isopropyl alcohol. The penis was extruded and cleansed with chlorhexidine gluconate solution only. An aseptic technique was used to pass a lubricated, 3.5F rigid polypropylene catheter[i] to restore urethral patency. Decompressive cystocentesis was performed at the clinician's discretion. Retropulsion was performed with saline (0.9% NaCl) solution.[j] The bladder was emptied and then flushed with ≥ 120 mL of saline solution or until grossly clear fluid was retrieved from the bladder. Catheterization variables were recorded as described.

For cats of the outpatient group, the rigid polypropylene catheter was removed and the patient was released to the owner for home care following recovery from sedation. Cats in this group were typically prescribed buprenorphine[k] (administered sublingually at a dose and frequency determined by the attending clinician) and prazosin (0.5 mg/cat if > 3 kg [6.6 lb] or 0.25 mg/cat if < 3 kg, PO, q 12 h).[l] Other supportive treatments provided at the discretion of the veterinarian were not recorded. Cats of the outpatient group typically did not have IV fluid administration unless needed for initial hemodynamic stabilization. Instead, crystalloid fluids were administered SC at a dose determined by the attending clinician.

Cats of the inpatient group had the rigid polypropylene urethral catheter removed and replaced with an indwelling 3.5F red rubber (polyvinyl chloride) catheter.[m] The time required to place the indwelling catheter and subjective difficulty were recorded in the same manner as for the rigid catheter. The indwelling catheter was secured into place with nonabsorbable monofilament suture, and a sterile, closed collection system was attached. An abdominal radiograph was obtained as described with the patient in right lateral recumbency to confirm appropriate urethral catheter placement and to evaluate for urolithiasis. A focused, point-of-care ultrasound examination was also used to evaluate for urolithiasis. Once attached, the collection system was not disconnected unless the urethral catheter appeared clogged. The catheter and connective tubing were cleaned and kept free of gross debris with dilute chlorhexidine solution. Urine was emptied from the collection system in an aseptic manner at the distalmost point via a spigot on the bag. Collection systems were kept below the level of the patient but off of the floor. If the original 3.5F catheter became obstructed or was dislodged, the decision to place a new catheter and the size of the replacement catheter were at the attending veterinarian's discretion. The number of replacement catheters needed, their size, and other details regarding their placement were not recorded on the data sheet.

Cats of the inpatient group received a balanced, isotonic crystalloid fluid IV at a rate and duration determined by the attending veterinarian. At the time of initial examination, titrated boluses of crystalloid fluid (10 to 20 mL/kg [4.5 to 9.1 mL/lb]) were administered to restore hemodynamic stability if needed. Fluid treatments were generally started prior to or during the initial urethral catheterization procedure and continued after removal of the indwelling urethral catheter. Fluid therapy decisions were not recorded; however, clinicians followed recommendations for rate as determined on the basis of initial fluid deficit (estimated percentage dehydration multiplied by body weight in kilograms) plus maintenance fluid requirements, and this was adjusted according to any ongoing losses. Urine output was monitored at ≤ 4-hour intervals, and fluid treatments were adjusted accordingly. The total volume of fluid administered and duration of fluid therapy were not recorded for purposes of the study. Standard supportive care treatments were considered to be buprenorphine[k] (dose determined by the attending clinician; IV, every 6 to 12 hours) and prazosin[l] (as described for outpatient treatment). Alternative or additional supportive treatments were provided at the discretion of the attending veterinarian. Elizabethan collars were placed to

Table 1—Comparison of characteristics of male cats treated for UO as inpatients (according to the standard of care; n = 46) or as outpatients (when the recommended treatment was declined; 45) in a prospective study to test for an association between indwelling urethral catheterization and the risk of RUO ≤ 30 days after catheter removal.

Variable	Inpatient group	Outpatient group	*P* value
Signalment			
Age (y)	5 (1–10)	4 (1–20)	0.365
Body condition score*	7 (4–9)	6 (3–9)	0.539
Weight (kg)	6.72 (3.6–12)	6.5 (3.1–12.4)	0.391
Breed	—	—	0.563
Domestic shorthair	37/46 (80)	38/45 (84)	
Domestic longhair	4/46 (9)	3/45 (7)	
Maine Coon Cat	1/46 (2)	1/45 (2)	
American Shorthair	2/46 (4)	0/45 (0)	
Russian Blue	0/46 (0)	2/45 (4)	
Munchkin	0/46 (0)	1/45 (2)	
Norwegian Forest Cat	1/46 (2)	0/45 (0)	
Siamese cross	1/46 (2)	0/45 (0)	
Neutered (vs not neutered)	46/46 (100)	43/45 (96)	0.242
Measures of metabolic compromise			
Rectal temperature (°C)	38.3 (34.8–39.7)	38.2 (35.8–40)	0.772
Clinicopathologic scores†			
Serum creatinine concentration	0 (0–3)	0 (0–3)	0.736
BUN concentration	0 (0–3)	0.5 (0–3)	0.695
Serum potassium concentration	0 (0–3)	0 (0–3)	0.518
Plasma base excess	0 (0–3)	1 (0–3)	0.587
Urinalysis			
Urine specific gravity‡	1.042 (1.012–1.062)	1.040 (1.018–1.065)	0.456
WBCs (No. per hpf)‡	—	—	0.371
None	16/39 (41)	10/33 (30)	
0–3	11/39 (28)	12/33 (36)	
4–10	8/39 (21)	10/33 (30)	
11–20	3/39 (8)	0/33 (0)	
21–50	1/39 (3)	1/33 (3)	
> 50	0/39 (0)	0/33 (0)	
RBCs (No. per hpf)‡	—	—	0.059
None	1/39 (3)	3/33 (9)	
0–3	2/39 (5)	0/33 (0)	
4–10	3/39 (8)	0/33 (0)	
11–20	5/39 (13)	1/33 (3)	
21–50	5/39 (13)	2/33 (6)	
> 50	23/39 (59)	27/33 (82)	
Bacteria (present vs absent)‡	2/39 (5)	1/33 (3)	0.299
pH‡	7.11 ± 0.68	7.12 ± 0.48	0.967
Crystals (present vs absent)§	15/32 (47)	10/25 (40)	0.522
Supportive treatments (outside of protocols)			
Antimicrobials (yes vs no)	32/46 (70)	30/45 (67)	0.649
Anti-inflammatories	—	—	0.709
Dexamethasone	2/46 (4)	1/45 (2)	
Prednisolone	0/46 (0)	1/45 (2)	
Robenacoxib	0/46 (0)	1/45 (2)	

All cats were stabilized and sedated or anesthetized for placement of a rigid urethral catheter (with or without decompressive cystocentesis) for treatment of UO, and the urinary bladder was flushed by retropulsion with 0.9% NaCl (saline) solution. Cats of the outpatient group were released to their owners for home care upon recovery. Treatments for the inpatient group included hospitalization with placement of an indwelling urethral catheter, IV fluid therapy, monitoring, and other supportive care. Continuous data are reported as mean ± SD or median (range). Categorical data are reported as proportion (%), and the *P* value represents the overall comparison. Not all cats had all variables assessed. Values of $P < 0.05$ were considered significant.

*Scored from 1 to 9 (where 1 = emaciated, 5 = ideal, and 9 = grossly obese) as described elsewhere.[12] †Scored from 0 (within the reference interval for the equipment used) to 3 (severe abnormalities). ‡Samples were sent to a commercial laboratory for analysis. §Evaluation was performed in-house. — = Not applicable.

See Appendix 2 for details of the scoring system for clinicopathologic findings.

protect IV and urethral catheters from being chewed or removed by the patient. Fresh water and food were available after recovery from sedation or anesthesia. Cats were examined ≥ 2 times/d by a veterinarian. Rectal temperature, heart rate, pulse quality, respiratory rate, mucous membrane color and moistness, and capillary refill time were evaluated at ≤ 6- to 8-hour intervals. Further monitoring (eg, continuous ECG, noninvasive blood pressure measurement, or pulse oximetry) was performed at the discretion of the veterinarian. Serum biochemical values were monitored daily or more frequently during hospitalization until deviations from the respective reference ranges were considered clinically irrelevant.

The target duration of indwelling catheterization was ≥ 24 hours or until the attending veterinarian deemed it appropriate to discontinue the treatment. If extenuating circumstances precluded catheterization for ≥ 24 hours, patients were retained in the study if the indwelling catheter remained in place for ≥ 12 hours. Goals prior to removing the urethral catheter included resolution of azotemia, normalization of the cat's metabolic status (ie, dehydration and electrolyte abnormalities), acceptable urine output (> 0.5 mL/kg/h [0.23 mL/lb/h] but less than the IV fluid therapy rate), and normal urine color (as evaluated by the veterinarian or technician without using the previously described scoring system). After catheter removal, cats were discharged from the hospital once voluntary urination was observed.

Regardless of their cat's underlying disease or treatment group, all owners were educated about environmental and dietary modifications as general preventative strategies for RUO. Follow-up with the referring veterinarian was recommended to discuss long-term management of feline lower urinary tract disease. Compliance with general management strategies or the referring veterinarian's long-term care plan was not evaluated or recorded for study purposes.

For study purposes, only RUO that developed within the 30-day follow-up period was evaluated. Owners were called 30 days after the rigid catheterization procedure (for the outpatient group) or removal of the indwelling catheter (for the inpatient group) to determine whether RUO had occurred within this interval.

Statistical analysis

The primary outcome variable of interest was RUO ≤ 30 days after the time of urethral catheter removal. Prior to the study, the power was set at 80% with a 2-sided α level of 0.05. The expected rate of RUO was estimated as 20% and 50% for cats of the inpatient and outpatient groups, respectively, resulting in an optimal sample size of 80 patients. All data were recorded in an electronic spreadsheet program[b] and imported into a statistical software program.[n] Continuous variables were assessed for normality with the Shapiro-Wilk method. Normally distributed continuous variables were reported as mean ± SD, and nonnormally distributed continuous variables were reported as median and range. The unpaired Student *t* test or the Wilcoxon rank sum test was used to compare normally and nonnormally distributed con-

Table 2—Comparison of catheterization-related variables for the same 91 cats as in Table 1.

Variable	Inpatient group	Outpatient group	*P* value
Initial (rigid) catheter placement			
Subjective difficulty score‖	2 (1–3)	2 (1–4)	0.695
Time to urethral patency (min)	3 (1–55)	2 (1–37)	0.736
Catheterizing veterinarian	—	—	0.358
A	3/46 (7)	1/45 (2)	
B	4/46 (9)	2/45 (4)	
C	4/46 (9)	10/45 (22)	
D	5/46 (11)	7/45 (16)	
E	0/46 (0)	1/45 (2)	
F	3/46 (7)	2/45 (4)	
G	2/46 (4)	0/45 (0)	
H	1/46 (2)	0/45 (0)	
I	2/46 (4)	2/45 (4)	
J	4/46 (9)	7/45 (16)	
K	1/46 (2)	0/45 (0)	
L	2/46 (4)	0/45 (0)	
M	1/46 (2)	1/45 (2)	
N	1/46 (2)	3/45 (7)	
O	2/46 (4)	2/45 (4)	
P	6/46 (13)	1/45 (2)	
Q	4/46 (9)	6/45 (13)	
R	1/46 (2)	0/45 (0)	
Experience of catheterizing veterinarian (y)	3 (1–8)	4 (1–8)	0.048

‖Scored from 1 (minimal difficulty) to 5 (unable to catheterize); ***see*** Appendix 1 for details.
See Table 1 for remainder of key.

tinuous variables, respectively, between groups. Categorical variables were expressed as proportions and percentages, and a χ^2 test or Fisher exact test (if the expected count in any cell was < 5) was used to compare these variables between groups. Odds ratios for RUO were calculated for the outpatient group, with the inpatient group used as the referent category. The test for trend across ordered groups was used to determine an association between increasing severity of gross urine color and RUO in the inpatient group.[13] Values of $P < 0.05$ were considered significant for all statistical evaluations. No adjustments were made for multiple comparisons.

Results

Study population

During the 18-month study period, 163 male cats were evaluated for treatment of UO at the study facility. Seventy-two of these cats were excluded (n = 56) or removed (16) from the study. The reasons for exclusion included euthanasia without treatment (n = 18), radiographically or ultrasonographically detected cystic or urethral calculi (16), urethral catheterization by the referring veterinarian (10), age < 1 year (2), death during stabilization attempts before further treatment could be provided (2), presence of a urethral tear (2), spontaneously occurring bladder rupture (2), owners declining treatment at the study hospital and having the cat transferred back to their regular veterinarian for care (2), and treatment that varied substantially from the established protocols (2). In the latter 2 cases, 1 cat was not sedated or aseptically prepared for catheterization and did not have its urinary bladder flushed with saline solution, and 1 was not catheterized because it urinated spontaneously after sedation. Cats were removed from the study after enrollment for the following reasons:

Table 3—Comparison of characteristics (irrespective of treatment group) potentially associated with RUO between cats that did (n = 19) and did not (72) develop the condition within the 30-day follow-up period.

Variable	No RUO	RUO	*P* value
Signalment			
Age (y)	5 (1–20)	3 (1–12)	0.227
Body condition score*	7 (3–9)	6 (4–8)	0.213
Weight (kg)	6.7 (3.14–12.4)	6.5 (4.4–8.16)	0.329
Neutered (vs not neutered)	70 (97)	19 (100)	1.0
Measures of metabolic compromise			
Rectal temperature (°C)	38.3 (34.8–39.7)	38.1 (35.8–40)	0.513
Clinicopathologic scores†			
Serum creatinine concentration	0 (0–3)	1 (0–3)	1.0
BUN concentration	0 (0–3)	0 (0–3)	0.329
Serum potassium concentration	0 (0–3)	0 (0–3)	0.589
Plasma base excess	0 (0–3)	3 (3–3)	0.258
Urinalysis			
WBCs (No. per HPF)‡	—	—	0.645
None	21/59 (36)	3/13 (23)	
0–3	20/59 (34)	5/13 (38)	
4–10	12/59 (20)	5/13 (38)	
11–20	4/59 (7)	0/13 (0)	
21–50	2/59 (3)	0/13 (0)	
> 50	0/59 (0)	0/13 (0)	
RBCs (No. per HPF)‡	—	—	0.197
None	4/59 (7)	0/13 (0)	
0–3	2/59 (3)	0/13 (0)	
4–10	3/59 (5)	0/13 (0)	
11–20	6/59 (10)	0/13 (0)	
21–50	5/59 (8)	2/13 (15)	
> 50	39/59 (66)	11/13 (85)	
Bacteria (present vs absent)‡	2/59 (3)	1/13 (8)	0.482
Crystals (present vs absent)§	20/47 (43)	5/10 (50)	0.441
Decompressive cystocentesis (yes vs no)	5/69 (7)	3/18 (17)	0.354
Supportive treatments			
Antimicrobials (yes vs no)	48/72 (67)	14/19 (74)	0.611
Anti-inflammatories	—	—	0.279
Dexamethasone	2/72 (3)	1/19 (5)	
Prednisolone	1/72 (1)	0/19 (0)	
Robenacoxib	0/72 (0)	1/19 (5)	

See Table 1 for key.

surgery of the lower urinary tract for reasons other than RUO within the 30-day follow-up period (n = 6), lost to follow-up (5), substantial deviation from the established inpatient protocol (2), euthanasia during the follow-up observation period for reasons other than RUO (2), and death at home due to an unknown cause (1). The 2 cats removed because of protocol deviations each had the indwelling urethral catheter in place for < 12 hours (1 for 6 hours and 1 for 7 hours).

Deviations from the study protocols that did not lead to exclusion or removal of cats from the study included having the indwelling urethral catheter in place for 12 to 24 hours (n = 10), placement of a 5F indwelling urethral catheter after placement of the initial 3.5F catheter became nonfunctional in the inpatient group (3), and the use of < 120 mL or an undocumented volume of saline solution to flush the urinary bladder (3).

Finally, although primary neurologic disease was considered an exclusion criterion, suspected detrusor atony secondary to prolonged natural UO was not (n = 4). Detrusor atony was suspected in any inpatient that did not spontaneously micturate after urethral catheter removal, but had a large, soft urinary bladder that was easily expressible. If a clinician suspected detrusor atony, the urethral catheter was replaced and indwelling catheterization continued. The duration of time cats were catheterized was recorded as the total time an indwelling catheter was in place (ie, summation of both indwelling catheter events).

Of the 91 cats that completed the study, 46 and 45 were in the inpatient and outpatient groups, respectively. Breeds consisted of domestic shorthair (n = 75), domestic longhair (7), Maine Coon Cat (2), American Shorthair (2), Russian Blue (2), Munchkin (1), and Norwegian Forest Cat (1). One patient was a mixed-breed (part Siamese) cat. The mean ± SD age was 5 ± 3.3 years (range, 1 to 20 years). Eighty-nine cats were neutered, and 2 were sexually intact.

Population characteristics (signalment, measures of metabolic compromise, and urinalysis results), use of supportive treatments of interest, and variables re-

Table 4—Comparison of catheterization-related variables (other than treatment group) potentially associated with RUO between cats that did (n = 19) and did not (72) develop the condition within the 30-day follow-up period.

Variable	No RUO	RUO	*P* value
Initial (rigid) catheter placement			
Subjective difficulty score‖	2 (1–3)	1 (1–4)	0.778
Time to urethral patency (min)	3 (1–55)	2 (1–37)	0.125
Catheterizing veterinarian	—	—	0.625
A	2/72 (3)	2/19 (11)	
B	5/72 (7)	1/19 (5)	
C	12/72 (17)	2/19 (11)	
D	8/72 (11)	4/19 (21)	
E	1/72 (1)	0/19 (0)	
F	5/72 (7)	0/19 (0)	
G	2/72 (3)	0/19 (0)	
H	1/72 (1)	0/19 (0)	
I	3/72 (4)	1/19 (5)	
J	8/72 (11)	3/19 (16)	
K	1/72 (1)	0/19 (0)	
L	2/72 (3)	0/19 (0)	
M	2/72 (3)	0/19 (0)	
N	2/72 (3)	2/19 (11)	
O	3/72 (4)	1/19 (5)	
P	7/72 (10)	0/19 (0)	
Q	8/72 (11)	2/19 (11)	
R	0/72 (0)	1/19 (5)	
Experience of catheterizing veterinarian (y)	3 (1–8)	4 (1–8)	0.754
Indwelling catheterization¶			
Time to place catheter (min)	1 (1–10)	1 (1–7)	0.956
Subjective difficulty score‖	1 (1–2)	1 (1–2)	0.542
Duration of catheterization (h)	28 (12–125)	26 (14–36)	1.000
Urine color at catheter removal	—	—	0.003
Clear	7/20 (35)	0/3 (0)	
Straw-colored	3/20 (15)	0/3 (0)	
Yellow	3/20 (15)	0/3 (0)	
Pink	6/20 (30)	0/3 (0)	
Red	1/20 (5)	3/3 (100)	

¶Data collected for the inpatient group only.
See Tables 1 and 2 for remainder of key.

lated to the initial catheterization (degree of difficulty, time to establish urethral patency, and veterinarian-related factors) were compared between the 2 treatment groups **(Tables 1 and 2)**. All cats received buprenorphine for pain as well as a drug for urethral spasm (90 received prazosin, and 1 received phenoxybenzamine[o]). Although not part of the protocol, 62 cats received empirical antimicrobial treatment consisting of cefovecin sodium[p] or amoxicillin-clavulanic acid.[q] Five cats received anti-inflammatory drugs, including dexamethasone sodium phosphate,[r] prednisolone (orally administered),[s] or robenacoxib.[t] Among the characteristics evaluated, only the median number of years' experience for clinicians who performed catheterization was significantly different between the outpatient (4 years) and inpatient (3 years) groups.

Incidence and risk of RUO

The incidence of RUO during the 30-day follow-up period was 5 of 46 (11%) and 14 of 45 (31%) for the inpatient and outpatient groups, respectively. Cats of the outpatient group had significantly (P = 0.018) greater risk of RUO than did cats of the inpatient group (OR, 3.7; 95% confidence interval, 1.2 to 11.4). Of the 19 cats that developed RUO, 18 (95%) had the condition ≤ 1 week after the catheter was removed (mean time to reobstruction, 2.2 ± 4.12 days).

Additional factors investigated for association with RUO

Results of analysis for association of factors (other than treatment group) with RUO during the follow-up period, including signalment, measures of metabolic compromise, urinalysis findings, supportive treatments of interest, initial (rigid) catheter placement variables, and veterinarian-related factors, were summarized **(Tables 3 and 4)**. None of these findings differed significantly between cats that did and did not develop RUO.

Among cats of the inpatient group, time required to place the indwelling urethral catheter, subjective difficulty score for placement of the indwelling urethral catheter, and duration of indwelling catheterization were not associated with the risk of RUO. However, subjective urine color at the time of indwelling catheter removal was significantly associated with development of RUO, whether evaluated as a categorical variable by the Fisher exact test (P = 0.003, with red-colored urine more common in cats that developed RUO) or with a test for trend (P = 0.007, with increasingly abnormal color associated with development of RUO).

Discussion

The aim of the present study was to evaluate for a potential association between indwelling urethral catheter placement with standard inpatient care for cats with UO and the development of RUO ≤ 30 days after catheter removal by comparing results for these patients with results for cats that underwent a single-catheterization protocol for the treatment of UO on an outpatient basis. The incidence of RUO was substantially lower for cats of the inpatient group (5/46 [11%]) than for cats of the outpatient group (14/45 [31%]), and indwelling urethral catheterization with standard inpatient care was associated with a significantly reduced risk of RUO during this short-term follow-up period, with odds of RUO for the outpatient group 3.7 times those for the inpatient group. The exact cause of the RUO was not recorded, and both functional and mechanical causes were possible.

The reported incidence of RUO for cats in previous investigations ranges from 10 of 68 (15%) to 14 of 39 (36%) and depends somewhat on the duration of the observation period and exclusion criteria applied.[3–7] Methodological differences make comparison among studies difficult. However, 2 recent studies[6,7] evaluated the incidence of RUO over a 30-day period as was done in the present study. Hetrick and Davidow[7] reported a somewhat higher incidence of 24% among 157 cats in a retrospective case series, and Eisenberg et al[6] found a more similar incidence of 15% among 68 cats in a prospective case series. Although the present study and the study by Eisenberg et al[6] both had prospective designs, we identified no other obvious reasons for the lower incidences of RUO, compared with the findings of Hetrick and Davidow,[7] on the basis of available information. However, the fact that cats hospitalized for treatment with an indwelling urethral catheter and supportive care in these 2 prospective studies had better short-term outcomes supports the idea that having a protocol in place for treatment of UO may improve clinician compliance and thereby influence patient outcomes. Use of checklists has been shown to improve outcomes in human patients requiring critical care[14] or undergoing surgery,[15] and the use of checklists has been reviewed elsewhere.[16]

Similar to the results in 3 previous studies,[3,5,7] cats in the present investigation most commonly developed RUO within the first week after urethral catheter removal (18/19 [95%] cats). The short-term incidence of RUO and the finding that most cats had RUO within the first week after treatment provide valuable information for clinicians to discuss with owners at the time of patient discharge.

The significantly greater risk of RUO in cats of the outpatient group suggested that inpatient care including placement of an indwelling urethral catheter provides better short-term results than 1-time urethral catheterization and discharge for home care. The finding that increasing abnormality of subjectively assessed gross urine color at the time of indwelling catheter removal was associated with RUO by use of a trend test suggested that maintaining urethral catheterization until urine is grossly clear may also improve short-term outcomes for cats treated as inpatients. Indwelling urethral catheterization and IV fluid therapy were the 2 main treatment differences between the inpatient and outpatient groups and could explain the significant differences observed in the

risk of RUO. Urethral catheterization ensures urethral patency while urine constituents normalize and pathological changes of the urethra and bladder improve. Simultaneously, IV fluid therapy promotes dilution of urine constituents through diuresis. Whether one or both of these factors led to a better outcome in these cats, compared with results of the outpatient group, remains unknown.

Although having the indwelling urethral catheter in place for ≥ 12 hours was a requirement for cats of the inpatient group to be retained in the study, the duration of indwelling catheterization (once this requirement was met) was not significantly associated with development of RUO among cats of this group. Previous reports[6,7] conflict regarding associations between the duration of indwelling catheterization and RUO. However, the identification of a significant association between gross evidence of hematuria at the time of catheter removal and RUO may be supported by results of a recent study[17] indicating male cats with UO are significantly more likely to have pyuria, hematuria, proteinuria, and struvite crystalluria than were male cats with nonobstructive lower urinary tract disease. It stands to reason that if the concentration or quality of urine constituents that contributed to the initial obstruction is not improved by treatment, the patient would be at an increased risk for RUO. As a result, treatments aimed at normalizing the urine content or diluting the urine may be key components to treatment success. This could also explain why Eisenberg et al[6] found that a longer catheterization period was associated with decreased incidence of RUO.

Investigators of numerous studies have attempted to identify factors associated with the development of RUO. The present study evaluated some secondary factors in addition to treatment group for potential associations with RUO. Regarding age, cats > 4 years old were found to be protected against RUO in one study[5] but not in another.[3] A third study[6] that investigated age as a continuous variable found an association between RUO and increasing age. In contrast, our study did not find a similar risk of increasing age associated with RUO. Historically, excessive body weight has been associated with increased risk for feline lower urinary tract disease.[18,19] The present study found no association between body weight or body condition score and RUO, similar to the findings of Eisenberg et al.[6] Although neuter status was not associated with RUO in the present study, the number of sexually intact male cats in the present study was very small, and the result should be interpreted cautiously.

The degree of metabolic compromise at the time of initial evaluation and treatment was evaluated by measurement of rectal temperature, calculation of plasma base excess, and determination of BUN and serum potassium and creatinine concentrations. Similar to the results of another study,[6] none of the clinicopathologic findings were significantly associated with development of RUO. This suggested that duration of UO prior to treatment may not impact the potential for short-term recurrence. Similarly, we found no association between urinalysis findings on initial evaluation and the development of RUO. These findings agreed with results of one study[6] but not with another,[4] in which urine specific gravity was higher and urine pH was lower in cats that developed RUO than in cats that did not. The lack of a significant association between specific urinalysis findings and development of RUO in the present study suggested that no particular underlying etiopathogenesis, such as crystalluria, is expected to lead to recurrence more than another. Most cats in our investigation had abnormal urinalysis results, with varying degrees of pyuria, hematuria, and crystalluria, when they were examined and treated for the initial UO.

The veterinarian who performed the initial catheterization, the number of years that individual had been in practice, the time required to achieve urethral patency, subjective difficulty of catheterization, and use of decompressive cystocentesis were not associated with RUO in our study. The study by Eisenberg et al[6] had similar results regarding the subjective difficulty of catheterization. Collectively, these findings suggest that the time required to achieve urethral patency or the difficulty of urethral catheterization should not be considered to have prognostic value for RUO in the first month after treatment.

Finally, we found no significant association between the additional supportive treatments of antiinflammatory or empirical antimicrobial drug administration and RUO. These findings corresponded with results of 2 studies,[6,7] which did not find any association between the use of analgesics and antimicrobials and the development of RUO over a 30-day follow-up period. One retrospective study[7] did find that the rate of RUO was significantly lower in cats that received prazosin than in those treated with phenoxybenzamine; however, the present study was not designed to evaluate this factor, as phenoxybenzamine was used in only 1 patient.

To the authors' knowledge, only 1 other study[11] has evaluated an alternative treatment protocol to standard inpatient care for treatment of UO in cats. Cooper et al[11] described treatment of 15 cats by use of a protocol consisting of sedation, reduced environmental stress, and intermittent cystocentesis without urethral catheterization after standard care was declined. Two of the 11 cats that survived to hospital discharge developed RUO. Hypothesized factors that may have led to improved outcomes with that protocol included lack of inflammation and trauma related to catheterization. However, the study was limited by its small sample size. Furthermore, a smaller proportion of cats survived to hospital discharge (12/15), compared with those reported in other literature: 205 of 219 (94%),[1] 41 of 45 (91%),[3] and 65 of 71 (92%).[4]

Of the 163 cats that were evaluated for treatment of UO during the enrollment period for the present study, only 3 (1.8%) died spontaneously. Two of these

cats died during stabilization attempts shortly after arrival at the clinic, and 1 died several days after outpatient treatment. In contrast, 18 (11.0%) cats were euthanized without treatment. This observation was in keeping with the current literature regarding prognosis of cats with UO, which suggests that although rates of survival to discharge after relief of the urinary obstruction and indwelling urethral catheterization are good,[1,3,4] the possibility remains that euthanasia will be requested because of cost or guarded long-term prognosis.[3] Although our data indicated that results for the outpatient care protocol used were inferior to those for inpatient care, the short-term success rate of 31 of 45 (69%) suggests that 1-time catheterization for cats treated on an outpatient basis and released to the owner for home care can still be of benefit if the client can afford it.

This study had limitations. Given the observational nature of the study and the fact that treatment group was owner-determined, selection bias was possible. For example, subjective appearance (or some other unquantified variable) may have biased clinicians to advocate for inpatient care more persuasively or to move on to outpatient care more quickly. However, results for statistical comparison between groups for potential confounding variables found that factors related to signalment, degree of metabolic compromise, urinalysis, catheterization procedure, and supportive treatments were similar between groups, except for the degree of experience of the catheterizing clinician. The association between experience level of the clinician and group assignment (although determined on the basis of client choices) could be explained by a selection bias, in that increased clinical experience makes it more likely that a clinician would feel comfortable deviating from the standard of care or exploring alternative treatment options rather than euthanasia. Although the results of this study may provide veterinarians with a representation of what is faced in clinical practice when client-related constraints limit the ability to provide treatment according to the standard of care, the study design could not eliminate selection bias; however, a randomized, placebo-controlled study with a group of cats intentionally treated with only a single catheterization would not be considered ethical.

Fluid therapy volumes and routes of administration were not recorded and thus not evaluated for differences between treatment groups or potential associations with RUO. Fluid administration increases urine production, which promotes the clearance of gross urinary constituents. Theoretically, higher fluid volumes could reduce the risk of RUO. Despite this, a recent study[6] did not find any association between RUO and the total volume of fluid administered during hospitalization or the duration of fluid administration after indwelling urethral catheter removal. To our knowledge, no study has evaluated the influence of a single SC dose of fluids on RUO; however, 1 study[20] failed to show any benefit of such treatment in reducing clinical signs associated with feline idiopathic cystitis.

Although the prospective study design and defined protocols were chosen as means to reduce the number of potentially confounding variables, the authors acknowledge that the inclusion of cats with small deviations from the inpatient group treatment protocol could have influenced results. For example, 3 cats were managed with a 5F indwelling urethral catheter after failure of the initially placed 3.5F catheter to maintain patency. If a deviation from the protocol was not considered contraindicated or was medically necessary, it was allowed in an attempt to increase the external validity and thereby generalizability of the results. Furthermore, number of replacement catheters and the circumstances surrounding replacement were not recorded. This may have increased the potential for iatrogenic urethral trauma in some cats. One final possible confounding variable was the potential inclusion of cats with a history of UO. Given the nature of the doctor-client-patient relationship at an emergency department, it was not possible to accurately determine the complete history of previous UO episodes or the nature of how they were treated for cats in the study. As a result, no conclusions can be drawn regarding whether previous episodes influence the success or failure of inpatient versus outpatient care.

Another possible limitation was that 5 cats (3 in the inpatient group and 2 in the outpatient group) were lost to follow-up. The exclusion of data for these cats from the analyses might have influenced the results. It is also important to note that the subjective evaluation of gross urine color characteristics at the time of indwelling urethral catheter removal was not standardized with a descriptive scale or pictorial reference to be used during evaluation. This lack of standardization could have influenced the results. Logistic regression analysis could not be performed on all secondary measures owing to their smaller sample sizes, and these may have enhanced other risk relationships with RUO. Finally, although the sample size was appropriately powered to test the primary hypothesis, it may have been insufficient to evaluate significance among many of the secondary factors potentially associated with RUO, resulting in a type II error.

Results of the present study supported the hypothesis that treatment of cats with UO by indwelling urethral catheterization and supportive care as hospital inpatients significantly reduces the 30-day risk of RUO, compared with that following 1-time urethral catheterization and supportive care on an outpatient basis. Furthermore, the results suggested that maintaining indwelling urethral catheterization until urine is grossly clear may also help to prevent RUO in the short term. Further studies evaluating duration of catheterization and urine quality at catheter removal as primary measures are indicated. Finally, these results highlighted the need for further investi-

gation into outpatient protocols for treatment of cats with UO when clients are unable to pursue the standard of care treatment, such as allowing an indwelling urethral catheter at home for 24 to 48 hours in metabolically stable cats. Until further information is available, inpatient care with indwelling urethral catheterization remains the gold standard for treatment of UO because of the reduced short-term risk of RUO.

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Footnotes

a. A copy of the datasheet is available from the corresponding author upon request.
b. Excel, Microsoft Corp, Redmond, Wash.
c. Reineke EL, Takacs J, Cooper E, et al. A multicenter study evaluating decompressive cystocentesis for treatment of feline urethral obstruction (interim analysis) (oral presentation). Int Vet Emerg Crit Care Symp, Nashville, Tenn, Sept 2017.
d. Idexx Procyte Dx, Idexx Laboratories Inc, Westbrook, Me.
e. Idexx Catalyst Dx, Idexx Laboratories Inc, Westbrook, Me.
f. i-Stat Handheld, Abbott Laboratories, Abbott Park, Ill.
g. Idexx VetStat Electrolyte and Blood Gas Analyzer, Idexx Laboratories Inc, Westbrook, Me.
h. Antech Diagnostics Regional Laboratory, Irvine, Calif.
i. Argyle open-end catheter with adaptor, Covidien, Mansfield, Mass.
j. Saline (0.9% NaCl) solution for injection, Hospira Inc, Lake Forrest, Ill.
k. Buprenex injectable, Reckitt Benckiser Healthcare, Hull, England.
l. Prazosin, 0.5 mg/mL, compounded by Stokes Pharmacy, Mount Laurel, NJ.
m. Kendall feeding tube and urethral catheter, 3.5F, Covidien, Mansfield, Mass.
n. Stata, version 14.0 for Mac, Stata Corp, College Station, Tex.
o. Phenoxybenzamine, 2.5-mg tab, compounded by Stokes Pharmacy, Mount Laurel, NJ.
p. Convenia, Zoetis Inc, Florham Park, NJ.
q. Clavamox, Zoetis Inc, Florham Park, NJ.
r. Dexamethasone sodium phosphate, VetOne, Boise, Idaho.
s. PrednisTab, Lloyd Inc, Shenandoah, Iowa.
t. Onsior, Elanco, Greenfield, Ind.

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Continued on next page.

Appendix 1

Subjective scoring system[c] used to assess the difficulty of catheterization in 91 cats enrolled in a study to test for an association between indwelling urethral catheter placement for treatment of UO and the short-term risk of RUO.

Score	Difficulty category	Description
1	Minimal	Urinary catheter passes without effort; flushing not necessary. No physical blockage is detected.
2	Moderate	Urinary catheter passes with very minimal effort. Physical blockage is detected, the urinary catheter is flushed once, and the catheter passes with ease.
3	Severe	Multiple blockages are detected; multiple flushes are involved, and the urinary catheter advances slowly and with difficulty but does pass.
4	Extreme	Multiple blockages are detected; multiple flushes are involved, as well as several different types of catheters to relieve the obstruction. Hydropulsion may be indicated. Imaging may be indicated to assist in the process.
5	Unable to catheterize	Surgical intervention is indicated.

Appendix 2

Severity scale used for assessment of hematologic variables at the time of initial evaluation and treatment at the study facility for the same 91 cats as in Appendix 1.

	Score			
Variable	0	1	2	3
Serum creatinine concentration (mg/dL)	—	0.1 to 1.5	1.6 to 4.0	> 4.0
BUN concentration (mg/dL)	—	1 to 25	26 to 50	> 50
Serum potassium concentration (mmol/L)	—	0.1 to 1.5	1.6 to 3.0	> 3.0
Plasma base excess (mmol/L)	—	–0.1 to –4	–4 to –8	< –8.0

Values represent the increase from the upper limit of the manufacturer's reference range for the equipment used for all variables except base excess (for which values represent the decrease from the lower limit of the applicable reference range).

— = Not applicable (result within the manufacturer's reference range).