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Difficult catheterization and previous urethral obstruction are associated with lower urinary tract tears in cats with urethral obstruction

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OBJECTIVE
To retrospectively assess the hospital prevalence and risk factors associated with iatrogenic lower urinary tear in cats with urethral obstruction (UO).

ANIMALS
15 client-owned cats diagnosed with concurrent UO and lower urinary tears and year-matched control population of 45 cats diagnosed with UO.

METHODS
University teaching hospital records were reviewed for cats presenting with UO between January 2010 and December 2022. Signalment, anatomic location of tear, experience of the individual passing the urinary catheter, difficulty level of catheter passage, history of previous UO, blood work parameters on presentation, presence of visible grit in urine, and survival to discharge were recorded. In addition, prevalence of lower urinary tears in cats presenting with UO was calculated.

RESULTS
The prevalence of lower urinary tears was 0.92% in UO cats. Cats with lower urinary tears were significantly less likely to survive to discharge and had a longer period of hospitalization than cats without tears. In addition, cats with tears were more likely to have a history of previous UO and had more difficult urinary catheter passage than cats in the control group. Cats with tears also had a higher Hct than the control UO cats.

CLINICAL RELEVANCE
Cats that develop lower urinary tears are more likely to have a history of previous UO and difficult catheter passage. This group of cats is also more likely to have a longer hospitalization period and lower survival to discharge rates.

Keywords: urinary tear, feline urethral obstruction, urinary catheter complication, urinary rupture, feline urinary catheter

Feline urethral obstructions (UOs) are a common presenting reason for visits to the veterinary emergency room. Urethral obstructions may lead to clinically important life-threatening metabolic disturbances including hyperkalemia, acidemia, and azotemia.[1,2] Although the survival to discharge with treatment is overall excellent, complications secondary to deobstruction with the traditional urinary catheter approach can occur, including catheter-associated bacteriuria and/or infection, urethral strictures, and urethral or bladder rupture.[1–9] Although a reportedly rare complication of deobstruction in the current literature, urethral and bladder tears can lead to serious sequelae such as tissue damage from urine extravasation into subcutaneous tissues, uroperitoneum, and urethral stricture formation.[7,10] These complications may lead to extended hospitalization times and need for surgical intervention, leading to increased cost of care and, in some cases, humane euthanasia.[7,8,11]

Based on previous literature, the urethra appears to be the most common location of injury resulting from urinary catheterization.[9] However, bladder ruptures have also been noted following urinary catheterization, possibly secondary to the retrohydropulsion technique.[10] It is possible that abnormal

urethral and bladder walls may lead to a more challenging deobstruction as well as predispose the tissue to tears with normal hydropulsion techniques. Abnormal urethral and bladder tissues have been described previously in UO cases with severe metabolic derangements as well as in cats that have been treated for previous UOs that have been associated specifically with stricture formation.[11,12] In a previous retrospective necropsy study[12] of cats with UO, hyperkalemia specifically was associated with clinically important lower urinary tract lesions including necrotizing cystitis and submucosal/mucosal changes consisting of edema, congestion, and hemorrhage. In addition, severe metabolic disturbances and hyperkalemia may lead to increased urgency of the hospital staff to establish urinary patency in unstable UO cats. This may result in rougher handling technique during urinary catheterization resulting in tissue injury and tears.

To the authors' knowledge, there is no existing literature focused on exploring the complication of lower urinary tract tears in cats presenting with UO. Therefore, the purpose of this retrospective study was to assess the incidence of iatrogenic urinary tract trauma in cats with UO and to investigate for potential risk factors that may be associated with iatrogenic urinary tract trauma. We hypothesized that a history of previous urinary catheterizations, presence of severe metabolic derangements due to the UO, and difficulty in passing the urinary catheter would be associated with an increased risk of an iatrogenic urinary tract trauma.

Methods

Medical records of all male cats hospitalized at the Matthew J. Ryan Veterinary Hospital of the University of Pennsylvania between January 2010 and December 2022 were reviewed for cases of UO and concurrent lower urinary injury. Electronic medical record keyword searches to identify cases included "bladder rupture," "bladder tear," "urethral tear," "urethral injury," "urethral rupture," "uroperitoneum," and "uroabdomen." Cats were included if they were diagnosed with a UO (firm, painful, nonexpressible bladder), had urinary catheterization attempted, and had either a bladder tear or a urethral tear. Findings that were considered confirmatory of lower urinary tract injury included the following: plain radiography or abdominal ultrasonography revealing the urinary catheter within the peritoneum but outside of the urinary tract, the presence of peritoneal free gas and/or large volume of fluid identified in the peritoneum with the concurrent inability to pass the urinary catheter, contrast urethrocystogram revealing leakage of contrast outside the urinary tract, or visible ruptures during an exploratory laparotomy. All imaging studies required interpretation by a board-certified radiologist for inclusion. In addition, if peritoneal fluid was present, fluid analysis must have been consistent with a uroperitoneum. A uroperitoneum was defined as a fluid creatinine-to-serum creatinine ratio of at least 2:1 and fluid potassium-to-serum potassium ratio of at least 1.9:1[13] Patients were excluded if they did not have a confirmed urinary tract rupture by one of these methods.

Medical record data collected when available included signalment, year of presentation to the hospital, anatomic location of the tear (bladder vs urethra), imaging modality of confirmation of the tear, training status of the individual passing the urinary catheter (veterinary student, nurse, intern, resident, or faculty veterinarian), performance of a concurrent decompressive cystocentesis, and difficulty level of urinary catheter passage as scored with the use of a hospital-wide scoring system of a scale from 0 (easy to pass urinary catheter, no hydropropulsion with saline required) to 4 (unable to place urinary catheter; **Supplementary Table S1**). Additionally, information was collected on whether the cat had a previous history of UO, the number of previous UOs, and how many days had elapsed since the most recent UO. Admission blood work, including blood creatinine, ionized calcium, pH, Hct, and potassium, was recorded. Finally, the presence of cystolithiasis, the gross urine color, and the presence of visible grit in urine at the time of urinary catheterization were recorded.

The therapeutic management strategies implemented for the urinary tract trauma were recorded for each cat and divided into the following categories: (1) medical management with urinary catheter placement via standard retrograde method, (2) medical management following retrograde fluoroscopy-guided urinary catheter placement, (3) cystotomy, and (4) perineal urethrostomy. Finally, the length of hospitalization and survival to discharge were recorded. Nonsurvivors included cats that were euthanized as well as those that suffered cardiopulmonary arrest. If the reason for euthanasia was described, it was recorded.

A target number of control cases was preselected at a ratio of 3:1 (controls to cases). A population of male cats hospitalized with a diagnosis of UO without evidence of a lower urinary tear was selected by utilizing a random number generator (Random Generator; Google Workspace Marketplace) and selecting the patient that was presented as that number in chronological order for the given calendar year. Case information recorded for the control cats was the same as the cases with the exception of therapeutic management strategies for the urinary tract trauma. Cats were excluded from the control group if they did not have attempted urinary catheter placement or they had not undergone radiography or an ultrasonography by a radiologist to diagnose or rule out a urethral or bladder tear.

Statistical analysis

Hospital period prevalence of cats with a urinary tear, among all cats with a UO undergoing treatment in hospital (including those without concurrent abdominal imaging) was calculated by dividing the number of cats with a UO and a concurrent lower urinary rupture by the number of cats diagnosed with a UO during the same time period. The distribution of continuous variables was determined visually

and by the skewness and kurtosis tests for normality. Normally distributed continuous variables were reported as mean ± SD, whereas median (range) was used for variables that were not normally distributed. Continuous variables were compared using the 2-sample independent *t* test for normally distributed variables, and the 2-sample Wilcoxon rank sum (Mann-Whitney) test was used for comparison of variables that were not normally distributed. The χ^2 test was employed to determine whether there was a relationship between 2 categorical variables, unless 1 or more cells had a frequency of 5 or less, in which case the Fisher exact test was utilized. A *P* value of < .05 was considered significant for all tests. All statistical evaluations were performed using a statistical software package (Stata 14.0 for Mac; Stata Corp).

Results

Nineteen cats with the diagnoses of a UO and concurrent lower urinary rupture were identified after a medical record search of the Ryan Veterinary Hospital's medical record system. Four cats were excluded due to either lack of complete medical records (2 cats) or a presumptive diagnosis being made without one of the above imaging or surgical modalities being performed for confirmation (2 cats). Fifteen cats (UO-R group) that met the inclusion criteria were included. During the years of inclusion, 1,631 total cats were treated in hospital for UO. This equates to a lower urinary tract rupture prevalence of 0.92% (15/1,631). Forty-five year-matched control cases (UO-C) were also identified.

The median age for the UO-R group was 3 years (range, 0.25 to 16 years) and for UO-C group was 4 years (range, 0.6 to 16 years). No significant difference in median age was noted between the 2 groups (*P* = .7). All 15 (100%) cats in the UO-R group were classified as domestic shorthair cats. For the UO-C group, 2 (2/45 [4.4%]) cats were listed as domestic longhair and 1 (1/45 [2.2%]) cat was listed as a Russian Blue. The remainder (42/45 [93.3%]) were classified as domestic shorthair cats. All cats in both groups were castrated males.

Lower urinary tract rupture was confirmed in the majority of cats (7/15 [47%]) with contrast urethrocystogram. In the other 8 (8/15 [53%]) cats, it was confirmed on plain abdominal radiography (2/15 [13.3%]), abdominal ultrasonography (3/15 [20%]), or exploratory laparotomy (3/15 [20%]). The location of the tear was confirmed to be the urethra in 13 (13/15 [86.7%]) of the cases, the urinary bladder in 1 (1/15 [6.7%]) case, and in an unconfirmed location in 1 (1/15 [6.7%]) case. In the cat with the unconfirmed location of the tear, the presence of a uroperitoneum was confirmed via paired serum and fluid creatinine and potassium, and a potential sealed tear of the bladder was identified on ultrasonography. Concurrent cystolithiasis on abdominal imaging was noted in 4 of the UO-R cases (4/15 [26.7%]) compared to 3 (3/45 [6.67%]; *P* = .058) cats in the UO-C group.

Most cats in the UO-R group were managed medically either with a urinary catheter placed in the standard fashion (6/15 [40%]) or placed in a retrograde fashion via fluoroscopy (2/15 [13.3%]). Six cats were ultimately managed surgically either by a perineal urethrostomy (5/15 [33.3%]) or cystotomy (1/15 [6.67%]). One cat was euthanized prior to implementation of any treatment strategy once rupture was confirmed.

Patients in the UO-R group were more likely to have had a history of previous UOs compared to the UO-C group (8/15 [53.3%] vs 8/45 [17.8%]; *P* = .007). The median number of previous UOs was 1 in both the UO-R group (range, 1 to 4) and the UO-C group (range, 1 to 2). The median number of days since last obstruction for the UO-R group was 6 days (range, 2 to 30 days) and 14 days for the UO-C group (range, 1 to 30 days).

No significant differences in admission creatinine, pH, potassium, or ionized calcium were noted between the UO-R and UO-C group. However, the Hct was significantly higher in the UO-R group than the UO-C group (*P* = .0013; **Table 1**).

The difficulty of catheterization score was significantly higher in the UO-R group than the UO-C group with a mean score of 3.1 (range, 0 to 4) versus 1.5 (range, 0 to 4; *P* = .0001), respectively. A catheter was unable to be passed in 7 cats in the UO-R group (7/15 [46.7%]) versus 1 cat in the UO-C group (1/45 [2.2%]). A decompressive cystocentesis was performed in 5 of the UO-C group (5/15 [33.3%]) and also in 5 of the UO-R group (5/45 [11.1%]), which was not statistically significant (*P* = .06).

Urine color at the time of urinary catheter placement was only reported in 5 (5/15 [33.3%]) cats in the UO-R group and 36 (36/45 [80%]) cats in the UO-C group, which precluded statistical analysis. The presence of grit during passage of the urinary catheter was not significantly different between the UO-R and UO-C cats (*P* = .4). However, this was also less frequently recorded in the medical records and

Table 1—Clinicopathologic variables recorded on admission in a population of cats diagnosed with urethral obstruction with concurrent lower urinary tear (UO-R) and a population without diagnosed lower urinary tear (UO-C) between January 2010 and December 2022.

Variable	UO-R group (range or mean)	UO-C group (range or mean)	*P* value
Creatinine (mg/dL)	2.55 (0.7–13)	1.5 (0.8–18.4)	.5
Ionized calcium (mmol/L)	1.12 ± 0.12	1.08 ± 0.16	.5
pH	7.31 (7.14–7.45)	7.33 (7.06–7.46)	.8
Potassium (mEq/L)	4.18 (3.73–11)	4.1 (3.18–11.26)	.5
Hct (%)	44.43 ± 7.50	35.22 ± 9.87	.001*

P < .05 considered statistically significant.
*Significant finding.

was only available in 7 cats in the UO-R group and 28 in the UO-C group. Grit was noted in 6 (6/7 [85.7%]) cats in the UO and 17 (17/28 [60.7%]) cats in the UO-C group. The experience level of the person performing the unblocking procedure was infrequently recorded (3 of the UO-R group and 10 of the UO-C group), which precluded statistical evaluation.

Only 10 (10/15 [66.7%]) cats in the UO-R group survived to discharge, which was significantly lower than the UO-C group in which 44 (44/45 [97.8%]) cats survived (P = .003). In the nonsurvivor population, 1 cat in the UO-R group suffered cardiopulmonary arrest while the remainder were euthanized. One cat in the UO-R group was euthanized for a perceived poor prognosis and 1 for financial reasons. The remaining 2 cats euthanized in the UO-R group and the 1 individual in the UO-C group were euthanized for reasons not recorded in the medical record. The UO-R group also had a significantly longer duration of hospitalization with a median stay of 6 days (range, 1 to 11 days) as compared to the UO-C group, which had a median stay of 2 days (range, 1 to 7 days; P = .002).

Discussion

To the authors' knowledge, this was the first study to investigate for risk factors and incidence of urinary tract rupture in UO cats. This study found that the prevalence of iatrogenic urinary tract rupture resulting from urinary catheterization is low at 0.92%. This information can be useful to prepare cat owners for the actual risk of this complication and additionally can be used as a benchmark to monitor adverse events. Additionally, we identified that a more difficult urinary catheter placement and a previous history of UO were significantly associated with urinary rupture.

The urethra was the most common location of the rupture identified in our study. This was similar to a previous retrospective study[9] that noted that out of 7 cats that developed a uroperitoneum following urinary catheter placement, 71% had rupture of the urethra and the remainder (29%) had rupture of the bladder. The urethra is likely the most common site of injury, as it receives direct trauma from the catheter during placement and is also the site of obstruction and, therefore, greatest resistance. Two cats in our study had a confirmed or suspected bladder tear. This condition could have developed as a result of urohydropropulsion when saline is flushed to facilitate urinary catheter placement. Excessive distension and elevated intraluminal pressure within the bladder caused by instillation of fluid leading to bladder rupture has been previously described in people, although it is an extremely rare complication.[14]

Cats with urinary tract rupture had a significantly higher difficulty in catheterization score compared to UO-C cats. An association between difficult catheterization and urinary tear in the feline population has not been previously described in existing veterinary literature. However, it has been reported as a known risk in difficult urinary catheter placement in human males.[15,16] When faced with a difficult urethral catheterization in people, a variety of techniques including urethral dilation, cystoscopy-guided placement, and passage of an initial guidewire are typically implemented, and continued attempts at blind placement are strongly discouraged given the risks for iatrogenic damage.[17] This study suggests that a similar relationship between difficult catheterization and lower urinary tear also exists in the feline population.

There is not extensive literature exploring the risks associated with specific catheter types (rigid vs flexible) in either human or veterinary patients. During the study period, an open-ended stylet urinary catheter (3.5-F 25-cm Tomcat catheter with stylet; MILA International Inc) was the standard catheter in use in our hospital for initial treatment of UO. However, in cases of difficult catheter passage (scores of > 3) multiple types of catheters used may have included open-ended Tomcat catheters, red rubber catheters, or even stainless-steel olive tip cannulas, some of which are more rigid and could have resulted in additional trauma and contributed to urinary tract rupture. The experience of the individual performing the catheterization, exact number of catheterization attempts, and exact types of catheters used could not be assessed as individual risk factors for urinary rupture in our study because they were unreliably recorded in the medical record. These individual factors warrant additional prospective investigation.

Consistent with our hypothesis, cases in the UO-R group were significantly more likely to have had a history of previous UO treated with urinary catheterization. Previous UO may lead to sequelae such as urethral stricture, thinning of the tissue, or fibrosis of the urethral tissue predisposing the cat to urethral injury and rupture. In people, it is known that challenging catheterization and urethral trauma often leads to the development of chronic urethral strictures, presenting a challenge for future catheterizations.[18] Although diagnosing stricture formation in cats is challenging, a similar relationship could exist on the basis of these study results. Additionally, recent urethral catheterization may lead to additional inflammation secondary to the iatrogenic trauma, which may lead to increased tissue friability and inflammation.

Contrary to our hypothesis, the severity of disease as reflected by creatinine, pH, and ionized calcium was not significantly different between groups. Although a previous necropsy study identified more severe urinary tract lesions such as mucosal/submucosal edema and necrosis in cats that were more severely ill, this did not appear to be a risk factor for urethral or bladder rupture in our study.[12] Of the admission blood work parameters, only Hct was significantly different between the UO-R cats and the control group, with the UO-R cats having a significantly higher Hct. The clinical significance of this finding is unknown, as the Hct in both groups was still within the normal reference range for cats. There is a possibility that the higher median Hct in the UO-R cats could reflect hemoconcentration secondary to dehydration. Dehydration has been shown to affect the structure of collagen, which is normally a highly water-bound

protein that has been shown to be the main determinant of urethral tissue integrity at high luminal pressures.[19] Dehydration leads to shrinkage of collagen fibers and increased stiffness, which may lead to changes in the tissue's performance under high stress conditions, contributing to tissue rupture.[20,21]

The duration of hospitalization was significantly longer and survival to discharge was significantly lower in the UO-R group than the UO-C group. This includes both cats that were euthanized as well as the single cat that had a cardiopulmonary arrest in hospital. Cats may have been more likely to have been euthanized due to perceived poor prognosis and/or owner financial limitations. Treatment of urinary rupture leads to increased hospitalization time, which may carry a substantial cost to owners, resulting in decisions to euthanize. The increased death in the UO-R cats may also be related to potential complications of the urinary tract rupture such as uroperitoneum, urosepsis, and persistent azotemia.[22] Additionally, more intensive treatment interventions including surgical repair carries additional risks associated with general anesthesia and risks such as infection and persistent cystitis associated with these invasive procedures.[23,24] The retrospective nature of the study and the confounding factor of euthanasia makes prognosis and true mortality rate challenging to assess.

There were several limitations of this study. This was a retrospective study with a small sample size. Given the small sample size, the study population may not accurately reflect the true population and some cases were not able to be included in the study given the lack of conclusive imaging studies and/or incomplete records. In addition, as mentioned above, the experience level of the person performing the urinary catheterization and catheter type used were not able to be assessed as risk factors and warrant additional investigation in larger multicenter prospective studies.

Overall, urethral and bladder tears are an uncommon sequela of UO in cats presenting to the emergency room. A previous history of UO and difficult catheter passage should alert clinicians to an increased incidence of this complication. Cats with urethral and bladder tears have a significantly longer period of hospitalization and decreased survival to discharge than their counterparts that do not suffer this complication.

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Supplementary Materials

Supplementary materials are posted online at the journal website: avmajournals.avma.org