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Ultrasonographic and Clinical Findings in Cats with Feline Lower Urinary Tract Disease

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Abstract : Urethral obstruction is a life-threatening feline lower urinary tract disease (FLUTD). The rate of recurring urethral obstruction was 14.8-58.1% after the first occurrence. Ultrasonographic findings associated with reobstruction had been rarely reported although ultrasonography was a valuable technique for diagnosing urinary bladder calculi and distinguishing different FLUTD causes. This retrospective study aims to describe the ultrasonographic findings, urinalysis, and serum chemistry profile in cats with FLUTD and determine the associations of reobstruction with ultrasonographic findings, urinalysis, and serum chemistry profile. The present study included 141 cats that were followed up for more than 1 year. The ultrasonographic criteria included the presence of cystolithiasis, urine echogenicity, sediment, suspended linear strand, pericystic effusion, hyperechoic pericystic fat, ureteral dilation, pyelectasia, and perirenal effusion. The urinalysis criteria included hematuria, urine-specific gravity, pH, sediment, and proteinuria. The most common ultrasonographic findings in cats with FLUTD were echogenic urine and sediment. However, this study did not find an association between reobstruction and ultrasonographic findings, urinalysis, and serum chemistry profiles. Thus, an ultrasonographic examination may be insufficient to predict the risk of reobstruction although it is a useful modality for diagnosing FLUTD and making treatment direction.

Key words **:** cat, feline lower urinary tract disease, reobstruction, ultrasonography, urinalysis.

Introduction

Urethral obstruction is a life-threatening feline lower urinary tract disease (FLUTD). FLUTD includes disorders affecting the urethra and/or urinary bladder. The common causes of FLUTD are idiopathic cystitis, urethral plug, urolithiasis, urethral stricture, and idiopathic obstruction. Feline idiopathic cystitis is the most commonly diagnosed in young cats with FLUTD, occurring in approximately 50-60% of cases. Urethral plugs are diagnosed in 10-20% of FLUTD (15,26,28,31). Clinical signs of FLUTD include inappropriate urination, stranguria, pollakiuria, hematuria, vomiting, abdominal pain, vocalization, and lethargy (14). Many theories suggest that FLUTD or feline idiopathic cystitis are associated with age, gender, stress, urothelial abnormality, neuroendocrine disorder, diets, indoor/outdoor living condition including the number of cats in the household, and the number of litter boxes and their location (4,12,16). However, the causative factor of FLUTD or feline idiopathic cystitis is still unknown (11,31). After the first occurrence of urethral obstruction, the rate of recurring urethral obstruction is between 14.8-58.1% (20,26). Previous studies were performed to identify risk factors of recurrence according to treatment protocol (7,14,17). In addition, the association between laboratory findings and the recurrence of FLUTD has been studied (14,24). One study reported that increasing amounts of red blood and epithelial cells increased FLUTD recurrence (24). Meanwhile, another study reported that no specific laboratory abnormalities were associated with recurrent urethral obstruction (14).

Ultrasonography is a useful modality for diagnosing the causes of FLUTD (30). If ultrasonographic findings and urinalysis can predict reobstruction, it may be clinically meaningful for monitoring cats with previous history of FLUTD. However, only one study evaluated the association of FLUTD with ultrasonographic findings and blood analysis (26). Moreover, ultrasonographic findings at the time of hospitalization did not significantly predict uretheral reobstruction and only 87 cats with urethral obstruction were included in this study (26). This study hypothesized that studies with a larger number of cats with FLUTD may have different results. The purposes of this retrospective study were to describe ultrasonographic findings, urinalysis, and serum chemistry profile in cats with FLUTD, and determine whether ultrasonographic findings, urinalysis, and serum chemistry profile at the first time of hospitalization can predict uretheral reobstruction.

Materials and Methods

Animals

This retrospective study included feline patients with FLUTD presented to the Dasom Feline Medical Center between September 2017 and April 2019. Approval by the

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Animal Care and Use Committee of the institution of this study was not required due to the retrospective nature of the study. All feline owners signed informed consent to use their cats' data in research. Only cats with FLUTD who performed with ultrasonography and had been followed up for more than a year were included in this study. The medical records were reviewed, and breed, age, gender, body weight, history consistent with urethral obstruction, clinical signs, ultrasonographic findings including a full evaluation of the urinary system, results of urinalysis and serum chemistry profile, treatment, and recurrence of urethral obstruction were recorded.

Urethral catheters were placed after the administration of anesthesia with medetomidine (Domitor®, Orion Corporation Animal Health, Finland) and propofol (Provive®, Myungmoon Pharm, Korea) or isoflurane (Ifran liquid, Hana Pharm, Korea). Urine was collected to perform urinalysis after catheterization and flushing of the bladder was performed in all cats except for the spayed females. The treatment included urine output monitoring, intravenous fluid therapy and medication including antibiotics, analgesics, and adjuvants during hospitalization. Urethral recatheterization or perineal urethrostomy were done if urethral obstruction recurred during hospitalization. Consequently, a follow-up examination was performed for 1 year to confirm the reobstruction.

Ultrasonographic evaluation

Ultrasonographic examination was performed using a commercially available ultrasound machine (RS80A, Samsung Medicine, Seoul, Korea) with blended frequencies of 4-9 MHz convex transducer and 3-16 MHz linear transducer. Moreover, ultrasound images were retrieved from the Picture Archiving and Communication System. Ultrasound images were evaluated blinded to the detailed history other than the urethral obstruction and laboratory findings. Ultrasonographic images of the urinary system were reviewed except for the urethra due to catheterization at the time of examination. Ultrasonographic findings are shown in Fig 1.

The presence of cystolithiasis (yes/no); urine echogenicity classified as normal, mild, moderate, and severe echogenics; and the presence of urine sediment (yes/no), suspended linear strand (yes/no), pericystic effusion (yes/no), and hyperechoic pericystic fat (yes/no) were the recorded urinary bladder findings. The bladder wall thickness was not measured because of overdistension with urine at the time of examination. Additional abnormalities that were seen but not listed above were also recorded when identified. Moreover, ureteral dilation, pyelectasia, and perirenal effusion (yes/no) were also recorded. Ureteral dilation is defined as the diameter of the ureter exceeding 4 mm and pyelectasia is defined as the dilated renal pelvis over 3.4 mm (2,10).

Urinalysis and serum chemistry profile

Urinalysis included hematuria, urine specific gravity, pH, sediment, and proteinuria. Urine was collected by urethral catheterization, and urinalysis was conducted within 10 min after collection. Consequently, urinalysis was performed using a urine-stick to check for hematuria, pH, and proteinuria. Urine-specific gravity was performed using a urinometer. Based on previous studies, a pH of 6.0-6.4 and urine-specific gravity of > 1.035 was used as reference ranges (8,27). The sediment was microscopically examined after urine centrifugation at 1,000 rpm for 2 min.

Serum chemistry profile included blood urea nitrogen (BUN), creatinine, and potassium concentration using DRI-CHEM NX500 (Fujifilm, Tokyo, Japan). The normal range of BUN, creatinine and potassium are 15-32 mg/dL, 0.6-2.0 mg/dL and 3.6-4.6 mEq/L, respectively (14,19,21). This study defined azotemia and severe azotemia as the serum creatinine concentrations of ≥ 2.1 and ≥ 5.0 mg/dL with increased BUN, respectively. Moreover, hyperkalemia and severe hyperkalemia were defined as the serum potassium concentrations of ≥ 4.7 and ≥ 8 mEq/L, respectively (14,22,26). However, some examinations could not be performed in emergency cases.

Statistical analysis

Statistical analyses were commissioned by experts and per-

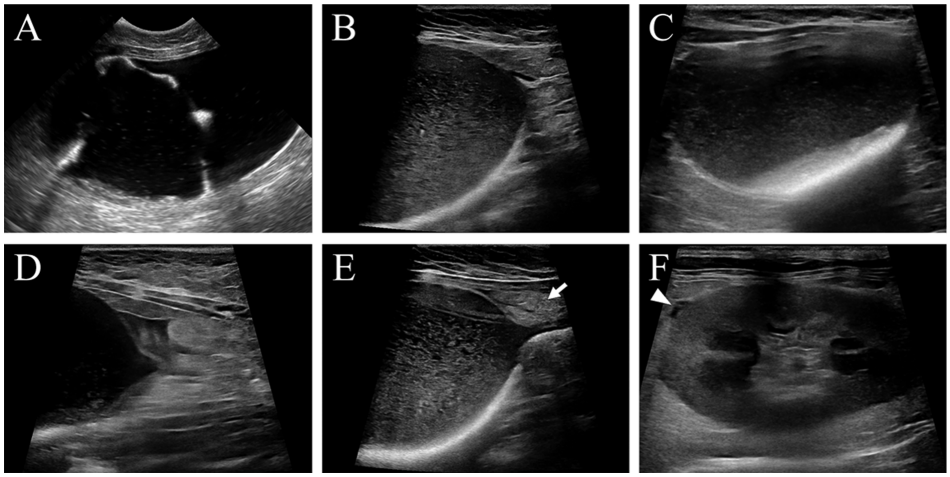

Fig 1. Ultrasonographic findings in cats with FLUTD. Suspended linear strand lined along bladder wall (A), severe urine echogenicity and sediment (B), hyperechoic cystolith with acoustic shadowing (C), and pericystic effusion (D) are noted. Hyperechoic pericystic fat (E, arrow) and a small amount of perirenal effusion (F, arrowhead) are also found.

formed using commercial software (SPSS 25.0, IBM SPSS statistics, USA). Multiple logistic regression analysis was performed to identify associations of reobstruction with ultrasonographic findings, urinalysis, and serum chemistry profile in recurrence and nonrecurrence patients. A *P*-value of < 0.05 was considered statistically significant.

Results

The present study included 141 cats diagnosed with FLUTD. The predominant breeds were Domestic short hair (77/141, 54.6%), Russian blue (17/141, 12.1%), Persian (13/141, 9.2%) and Scottish fold (11/141, 7.8%). Some breeds also represented were Siamese (3/141), Abyssinian (2/141), British short hair (2/141), Scottish straight (2/141), Turkish angora (4/141), American short hair (2/141), American curl (1/141), Bengal (1/141), British long hair (1/141), Kinkalow (1/141), Norwegian forest (1/141), Ragdoll (1/141), and mixed (2/141). The mean age of the 136 cats was 4.32 years (range, 0.67-13 years). Five stray cats had inaccurate age data. Of the cats, 139 were male (6 intact and 133 castrated) and two were spayed females. The mean body weight was 5.76 kg (range, 2.67-10.35 kg). All patients had dysuria. Other symptoms included vomiting (17/141), diarrhea (1/141), anorexia (13/141), salivation (1/141), tachypnea (2/141), and overgrooming of the penis (2/141).

Only part of the ultrasonographic records in some cats could be reviewed because of the retrospective nature of the study. The abnormal ultrasonographic findings included cystolithiasis (19/81, 23.5%), echogenic urine (128/141, 90.1%), sediment (117/141, 83.0%), suspended linear strand (32/141, 22.7%), pericystic effusion (32/141, 22.7%), perirenal effusion (4/135, 3.0%), pyelectasia (5/135, 3.7%), ureteral dilation (32/135, 23.7%), and hyperechoic pericystic fat (23/140, 16.4%). The abnormal ultrasonographic findings in recurrence and nonrecurrence patients are summarized in Table 1.

The results of urinalysis and serum chemistry profile in recurrence and nonrecurrence patients are summarized in Table 2. The total number of cats performed with each test varied. Hematuria was observed in 77 of 97 cats (79.4%). The mean urine-specific gravity of 74 cats was 1.033 (range, 1.009-1.070) and mean pH of 75 cats was 6.84 (range, 5.0-8.0). Moreover, 46 of 52 cats (88.5%) were observed with proteinuria. Urine sediments were observed in 27 of 29 cats

Table 1. Ultrasonographic findings of 141 cats, including 20 recurrent cats

		Total (number of cats)		Recurrence (number of cats)		Nonrecurrence (number of cats)	
		Yes	No	Yes	No	Yes	No
Cystolithiasis		19	62	4[a]	9[a]	15	53
Sediment		117	24	17[a]	3	100	21
Suspended linear strands		32	109	7[a]	13[a]	25	96
Pericystic effusion		32	109	1[a]	19[a]	31	90
Hyperechoic fat		23	117	2	18[a]	21	99
Perirenal effusion		4	131	0	20[a]	4	111
Pyelectasia		5	130	0	20[a]	5	110
Ureteral dilation		32	103	5[a]	15[a]	27	88
Urine echogenicity	Normal	13		1		12	
	Mild	51		10[a]		41	
	Moderate	36		2		34	
	Severe	41		7[a]		34	

[a]Included data on three cats having twice recurrence

Table 2. Results of urine and blood analysis in cats

	Recurrence		Nonrecurrence	
	Total	Mean ± SD (range)	Total	Mean ± SD (range)
USG	14	1.040 ± 0.013 (1.015-1.070)	60	1.032 ± 0.011 (1.009-1.053)
pH	13	6.62 ± 0.52 (6-8)	62	6.89 ± 0.59 (5-8)
Proteinuria	7		39	
Hematuria	13		64	
Urine sediment	10		17	
BUN (mg/dL)	18	61.27 ± 46.8[a] (18-140[a])	118	75.31 ± 49.30[a] (11-140[a])
Creatinine (mg/dL)	18	4.42 ± 3.96 (0.8-15.5)	117	6.83 ± 6.44[a] (0.8-24[a])
Potassium (mEq/L)	18	4.32 ± 1.09 (2.707.0)	109	5.00 ± 1.82 (3.0-10.0)

SD, standard deviation; USG, urine-specific gravity
[a]Diagnostic equipment cannot read more than 140 of BUN and 24 of creatinine

(93.1%) and most sediments were identified as struvite on urine sediment examination. Of the 135 cats, 89 (65.9%) and 59 (43.7%) were azotemic and severely azotemic, respectively. In addition, 48 (37.8%) and 13 (10.2%) were hyperkalemic and severely hyperkalemic, respectively.

Reobstruction was observed in 20 cats. Recurrence was observed twice in three cats. No statistically significant association was noted between reobstruction and ultrasonographic findings, serum chemistry profile, or urinalysis results at first hospitalization. The first reobstruction occurred most frequently after 1 (6/20, 30%) and 5 months (5/20, 25%). Three of the 20 cats experienced recurrence within 1 week (3/20, 15%). Consequently, another three of 20 cats experienced recurrence within 1 month (3/20, 15%). Each of the 20 cats experienced recurrence after 8, 12, and 16 months, respectively. In three cats who experienced reobstruction twice, each cat had recurrence at 1 and 2 months, 2 weeks and 1 month, and 5 and 7 months after the first time of hospitalization.

Small cystoliths were removed in 19 cats through catheter by flushing or managing by dietary prescription rather than cystectomy. There were 2 cats with clinical presentation consistent with Pandora syndrome. One cat was diagnosed as Pandora syndrome due to clinical presentation including loss of appetite, refractory cystitis, calicivirus infection, anemia, and cholecystitis. After treatment for 1 month, this cat improved but had mild clinical symptoms and did not develop reobstruction for 1 year. The other cat had increased hepatic enzyme concentration and calicivirus infection, and died of Pandora syndrome. These 2 cats with Pandora syndrome extended their hospitalization for 2 weeks and received symptomatic treatment including fluid therapy, antibiotics, adjuvants, urethrostomy or urethral catheter placement. Two cats with Pandora syndrome extended their hospitalization for 2 weeks. One cat died of Pandora syndrome and the other had improved clinical symptoms after 1 month. The mortality due to FLUTD among 140 cats was 0.71% (1/140) except for the patient that succumbed due to a lung tumor. The mean time of hospitalization was 4.6 days (range, 0-18 days). Moreover, diets were mostly composed of wet food, and all patients were similarly treated with fluid therapy, and administrations of antibiotics, analgesics, and adjuvants during hospitalization.

Discussion

Ultrasonography is a valuable technique for diagnosing urinary bladder calculi and/or plugs and distinguishing the different causes of FLUTD (30). The common ultrasonographic findings in cats with feline urethral obstruction are urine sediments, bladder wall thickening, hyperechoic pericystic fat, and pericystic effusion (26). In addition, common ultrasonographic findings of nonobstructive FLUTD are urine sediments and bladder wall thickening (30). Moreover, the most common ultrasonographic findings in cats with FLUTD in the present study were echogenic urine and sediments. Because idiopathic cystitis is the main cause of FLUTD (12), and ultrasonographic findings which are common in cystitis may be also common in FLUTD patients. Most patients in the present study showed severe bladder dilation due to urethral obstruction on ultrasonography. Thus, bladder wall thickness could not be evaluated. Perirenal effusion and pyelectasia were observed at a lower frequency and were not identified in recurrence patients. The dilation of the ureter and pelvis was associated with the duration of obstruction in humans (9). Therefore, if the duration and severity of obstruction are not severe in cats, renal findings (e.g., perirenal effusion and pyelectasia) may not be seen. In addition, identifying associations may not be enough because of the small number of recurrent patients and only nine cats with abnormal renal findings.

Previous studies reported that lower urine-specific gravity and higher urine protein were detected in FLUTD patients (1,29). The results of the present study are similar to previous studies, except for the absence of difference in urine-specific gravity and frequency of proteinuria between recurrence and nonrecurrence patients. Moreover, urine sediments were microscopically found in 27 cats. Consequently, most sediments, especially crystals, were identified as struvite by microscopic examination. Struvite is associated with urine pH and formed well at high pH. The acidic condition with low pH decreases precursors available to form uroliths and increases struvite solubility in urine (13). However, struvite and urine pH was not significantly associated with reobstruction in the present study. Struvite in urine can be normally detected in cats (25). Furthermore, the differences in handling and storing urine samples may influence urinalysis interpretation (24). The urine collected by the catheter may vary in urine contents according to the time of collection. In addition, urine coming out immediately and at a later time after opening may have a lot of plugs and a lot of sediments, respectively. Although this study showed no reobstruction correlation with the results of urinalysis, prospective studies minimizing the dilution or contamination of urine are warranted excluding factors affecting urinalysis (3,18).

The mortality in this study was lower than 5.0-12.5% in previous studies (11,20). This may be because euthanasia was not performed in this study. The cat which succumbed to Pandora syndrome had chronic constipation and had many complications including viral infection and gastrointestinal disorders. These factors make treatment difficult. Cats with Pandora syndrome have a more sensitive and overactive sympathetic nervous system, which is thought to be associated with abnormalities in intestinal, behavioral, dermatologic, epithelial, neurologic, endocrine, or immune systems (5). These comorbidities can occur in any combination and some of them may precede the development of lower urinary tract signs. Thus, it is important to check not only the urinary system but also the other systems (5,6).

The previous as well as the present study did not show an association between reobstruction and ultrasonographic findings or urinalysis. Reobstruction was affected by many factors (e.g., food and environment) and occurred with different causes for each occurrence (23). Each patient may be influenced by multiple different factors and these factors could result in different ultrasonographic findings and urinalysis results. Therefore, the evaluation of factors influencing reobstruction during the nonrecurrent period could be performed in further studies by using a questionnaire for food and the

environment. The recurrent interval in a previous study was 3-6 months (19). Although the number of recurrence patients was small, reobstruction occurred most frequently after 1 and 5 months. This result supported the importance of performing a follow-up examination for at least 1 year.

The limitations of this study were missed examinations in several cats and a few recurrent patients. Patients who did not have all the information due to the nature of the retrospective study were also included. In addition, the possibility of reobstruction can be influenced by perineal urethrostomy.

Conclusion

The ultrasonographic examination was useful for diagnosing and identifing the causes of FLUTD. The results of this study may support the use of ultrasonographic examination for treatment planning in cats with FLUTD, but not as a method for predicting the risk of reobstruction. However, further prospective follow up study including FLUTD cats having similar environment is needed to identify correlation urethral reobstruction with ultrasonographic findings just prior to reobstruction.

Conflict of Interest

No conflicts of interest have been declared.

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