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Recurrence rate and long-term course of cats with feline lower urinary tract disease

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Abstract

Objectives Feline lower urinary tract disease (FLUTD) causes clinical signs such as stranguria, pollakiuria, haematuria, vocalisation and periuria, and is often associated with recurring episodes. The primary objective of this study was to survey the long-term course of cats presenting with FLUTD in terms of recurrence rate and mortality.

Methods Data from cats that were presented with lower urinary tract signs from 2010 to 2013 were collected by telephone interview with cat owners, using a questionnaire. The observation period ranged from the first presentation due to FLUTD to the telephone interview or the cat's death. Data on diagnoses, recurrence of clinical signs and disease-free intervals, as well as implementation and impact of prophylactic measures (PMs), were collected and compared between groups with different aetiologies.

Results The study included 101 cats. Fifty-two cats were diagnosed with feline idiopathic cystitis, 21 with urolithiasis and 13 with bacterial urinary tract infection; 15 had no definitive diagnosis. Of the 86 cats with a known diagnosis, the recurrence rate was 58.1%, with no significant difference between groups. Twenty-one cats had one relapse, 12 had two relapses, 10 had three and seven had four to eight relapses within a median observation period of 38 months (range 0.5–138 months). Fourteen cats suffered from different causes of FLUTD at different episodes. Mortality due to FLUTD among all 101 cats was 5.0%. The recurrence rate in cats with urolithiasis receiving at least two PMs was significantly lower than the recurrence rate in those without PMs ($P = 0.029$).

Conclusions and relevance More than half of the cats with FLUTD presented with two or more recurrent episodes irrespective of the identified aetiology. Cats should be thoroughly investigated at each presentation as it cannot be presumed that the cause of FLUTD is the same at different episodes. The mortality due to FLUTD is lower than previously reported.

Keywords: FLUTD; feline idiopathic cystitis; urolithiasis; urinary tract infection; recurrence rate; mortality; prophylactic measures

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Introduction

Diseases of the lower urinary tract of cats that are associated with clinical signs such as stranguria, pollakiuria, haematuria and periuria are defined as feline lower urinary tract disease (FLUTD). According to the literature, 55.0–69.0% of cats with FLUTD suffer from feline idiopathic cystitis (FIC), whereas urolithiasis is found in 12.0–22.0% of affected cats.[1–6] Bacterial urinary tract infection (UTI) is the cause of 1.5–20.0% of FLUTD cases.[1,2,4–10] Neoplasia of the bladder wall is detected in 0.3–3.6% and neurological disorders are present in 0.2–3.0% of cases.[3,8] FLUTD can be aggravated by urethral obstruction (UO) in male cats, which is seen in 15.0–57.1% of cats with FIC and 20.0–66.7% of cats with urolithiasis.[4,8,11]

Recurrent episodes complicate the disease process of FLUTD. Inappropriate elimination can lead owners to give their cats to animal shelters or to decide on euthanasia.[12,13]

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In cats with FIC, recurrent episodes are seen in 17.1–65.0%.[14–17] With increasing age, there is a lower incidence of recurrence.[18] Recurrence rates in cats with urolithiasis range between 5.5% and 38.5%.[19–21] Multiple episodes appear to occur rarely in cats with UTI and were seen in 14.7% in one study.[22,23] In cats with UO due to FIC, reported recurrence rates are 17.0–58.0%.[14,17,21,24]

Although FLUTD is a common disease, few data are available on the long-term prognosis of affected cats. One study revealed a guarded prognosis for cats with UO, with 21.0% of them being euthanased because of recurrent UO. Half of these cats suffered from FIC.[21]

The primary objective of this follow-up study was to survey the long-term course of cats presented with FLUTD in terms of recurrence rate and mortality. Additional objectives included the evaluation of causes of FLUTD at different episodes and of the influence of environmental modifications on the incidence of recurring episodes.

Materials and methods

Patients

Considered eligible for this study were cats that were presented with clinical signs of FLUTD to the Clinic of Small Animal Medicine (CSAM), LMU Munich, from January 2010 to December 2013. At least one visit because of lower urinary tract signs needed to be at the CSAM. If further episodes were treated at other veterinary clinics or practices before or after the admission to the CSAM, medical records of these visits needed to be available for review or necessary data had to be provided verbally by the attending veterinarian. Enrolled cats had to be >6 months of age. Diagnosis and aetiology of FLUTD was established based on clinical signs and physical examination, urinalysis, aerobic urine culture, abdominal ultrasound and abdominal radiographs (Table 1). The minimum requirement to obtain a definitive diagnosis included a complete urinalysis, an aerobic urine culture from urine taken aseptically by cystocentesis or catheterisation, and results from at least one imaging method. In cats showing more than one episode of FLUTD, the diagnosis obtained at the first presentation to the CSAM during the years 2010–2013 was defined as the primary diagnosis. The statistical analysis and the discussion focused on the cats with a confirmed diagnosis.

Cats were excluded if the review of their medical record revealed that they did not suffer from FLUTD but from another disease causing clinical signs that could have been misinterpreted initially, such as faecal constipation or behaviour disorders. Cats were also excluded if it was impossible to contact the cat owners and follow the medical history of the cats, or if the owners declined participation in the study. Cats that were euthanased or died at their first presentation were also excluded. Comparison of parameters was performed between cats with confirmed diagnoses including FIC, urolithiasis and UTI.

Data collection

Cat owners were contacted by telephone. If the owners agreed to participate, they were asked to answer a questionnaire with open-ended and closed-ended questions regarding the character of their cats, the housing conditions, feeding and toilet management, as well as modifications of the cats' environment after an episode of FLUTD (see the supplementary material). Data on frequency of recurrence of clinical signs and hospitalisations, type of clinical signs, occurrence of UO, aetiological diagnosis and appearance of other clinical signs and modalities of treatment were collected. A relapse was defined as recurrence of clinical signs following a disease-free interval of at least 10 days after the previous episode. If a cat was treated by other veterinarians for an episode of FLUTD and its owner granted us permission to contact them, the veterinarians were also interviewed to get more detailed information. In the case of euthanasia, date of euthanasia and the respective cause were recorded. The observation period started with the first presentation of the cat because of FLUTD and ended with the telephone interview or the cat's death.

Table 1 Definition of diagnoses of feline lower urinary tract disease (FLUTD), including feline idiopathic cystitis, urolithiasis, bacterial urinary tract infection, neoplasia of the bladder and neurological disorders

Diagnosis	Definition
Feline idiopathic cystitis	Exclusion of other diseases of the lower urinary tract by diagnostic findings
Urolithiasis	Visualisation of uroliths in the bladder or the urethra by abdominal radiographs and/or ultrasound
Bacterial urinary tract infection	Detection of significant bacterial growth ($\geq 10^3$ CFU/ml in cystocentesis-derived or 10^4 CFU/ml in catheter-derived urine samples) in aerobic urine cultures and absence of urolithiasis and mass lesions in the urinary bladder
Other diagnoses	Neoplasia: mass lesion in the bladder detected by abdominal ultrasound Neurological disorders: neurological abnormalities in combination with clinical signs of FLUTD
Non-specific diagnosis	Minimum requirements to obtain a definitive diagnosis not complete

CFU = colony-forming units

Statistical analysis

Collected data were investigated using the statistical software R 3.2.5 and 3.5.1 (CRAN, 2016 and 2018) and SPSS Statistics 23.0 (IBM, 2015). Descriptive statistics included calculation of count and percentage for categorical variables, and median and range for continuous variables. Analytical statistics included the χ^2 test and Fisher's exact test for comparison of categorical variables and the Mann–Whitney U-test and one-way ANOVA and Tukey's multiple comparison test for analysis of continuous variables. Kaplan–Meier survival curves were generated to illustrate the risk of recurrence within the different groups during the observation period. Associated differences between groups were evaluated by generalised Wilcoxon test. Differences were regarded as significant at a value of $P \leqslant 0.05$. Bonferroni correction was used to reduce the probability of false-positive findings in case of multiple testing and an adjusted value of $P \leqslant 0.017$ was defined as significant.

Results

Out of a total of 176 cats identified during the database search, 75 cats did not fulfil the inclusion criteria (Figure 1). Therefore, 101 cats were finally included.

Cat population

Fifty-two cats (51.5%) suffered from FIC, 21 cats (20.8%) from urolithiasis and 13 cats (12.9%) from UTI. For 15 cats (14.9%), no definitive diagnosis could be established because urine culture was not performed (n = 7) or was invalid due to antibiotic treatment (n = 5), or urinalysis and urine culture were missing (n = 3). Five cats (9.6%) with FIC had severe struvite crystalluria and 30 cats (57.7%) with FIC had urethral plugs. Uroliths were quantitatively analysed by infrared spectroscopy. In two cats uroliths were dissolved by an acidifying diet and were therefore classified as struvite uroliths. Uroliths were composed of calcium oxalate (38.1%) or struvite (33.3%), or the composition was unknown (28.6%). Reasons for unknown urolith composition were that uroliths removed at other clinics or practices were not submitted for analysis (n = 3/6), were lost on the way to the laboratory (n = 1/6), or uroliths were submitted for analysis, but the analysis result was not traceable (n = 2/6). *Escherichia coli* (69.2%), *Staphylococcus* species (23.1%) and *Streptococcus* species (7.7%) were detected in the urine of cats with UTIs. Urine culture revealed growth of single bacterial species in all cats. Fourteen cats (13.9%) were diagnosed with different causes of FLUTD during different episodes (Table 2). Three of the 14 cats (21.4%) had four relapses, three cats (21.4%) had three relapses, four cats (28.6%) had two relapses and four cats (28.6%) had one relapse.

The majority of the 86 cats with a confirmed diagnosis were male castrated domestic shorthairs (Table 3). There was no significant difference in breed, sex and body weight between groups. Cats with UTI were significantly older than cats with FIC ($P = 0.002$). Owners of cats with UTI used wooden litter more often than owners of cats with FIC ($P = 0.003$). Concerning the character of the cat, feeding, water supply and housing conditions, no significant differences between groups were seen (see the supplementary material).

Stranguria was the predominant clinical sign in all groups (Table 4). The incidence of UO was higher in cats with FIC than in cats with UTI. No other significant differences between cats with specific diagnoses concerning clinical signs and other diseases were identified.

Recurrence rate in cats with FIC, urolithiasis and UTI

The median observation period of cats was 38 months (range 0.5–138). Forty-nine cats (57.0%) presented to the CSAM due to their first episode of FLUTD, 21 (24.4%) due to their second episode, six (7.0%) due to their third episode and 10 (11.6%) due to their fourth to sixth episodes. Overall, 58.1% of the 86 cats with specific diagnoses had recurrent clinical signs. One recurrence, two recurrences, three recurrences and at least four recurrences were seen in 21, 12, 10 and seven cats, respectively. No significant difference concerning the recurrence rate or number of relapses was detected between groups (Table 5). Cats with urolithiasis were significantly more often hospitalised than cats with UTI ($P = 0.015$).

Regarding cats with relapses after their first episode of FLUTD, there was no significant difference between groups concerning the risk of recurrence (Figure 2). The median time intervals were 3 months (range 0.4–64 months) between the first and the second episode, 6 months (range 0.4–49 months) between the second and third episode, and 5 months (range 0.4–38 months) between the third and fourth episode, with no significant difference between groups. Number of relapses ranged from one to five in the first year, one to two in the second year and one to four in the third to sixth year.

Prophylactic measures in cats with FIC, urolithiasis and UTI

In 63/86 cats (73.3%) with definitive diagnoses, prophylactic measures (PMs) were implemented to prevent recurring episodes of FLUTD (Table 6). After the first episode of FLUTD, 33.3% of cats received modifications of housing, 43.8% of cats received modifications of toilet management, 66.7% of cats received modifications of the proportion of canned food, 40.6% of cats received modifications of water supply and 59.4% of cats were fed a prescription diet. Feeding a prescription diet or modifying feeding, housing or toilet management was not associated with a significant difference in the recurrence rate. Cats with urolithiasis receiving modification of water supply had a significantly lower recurrence rate. For cats with FIC and UTI, there

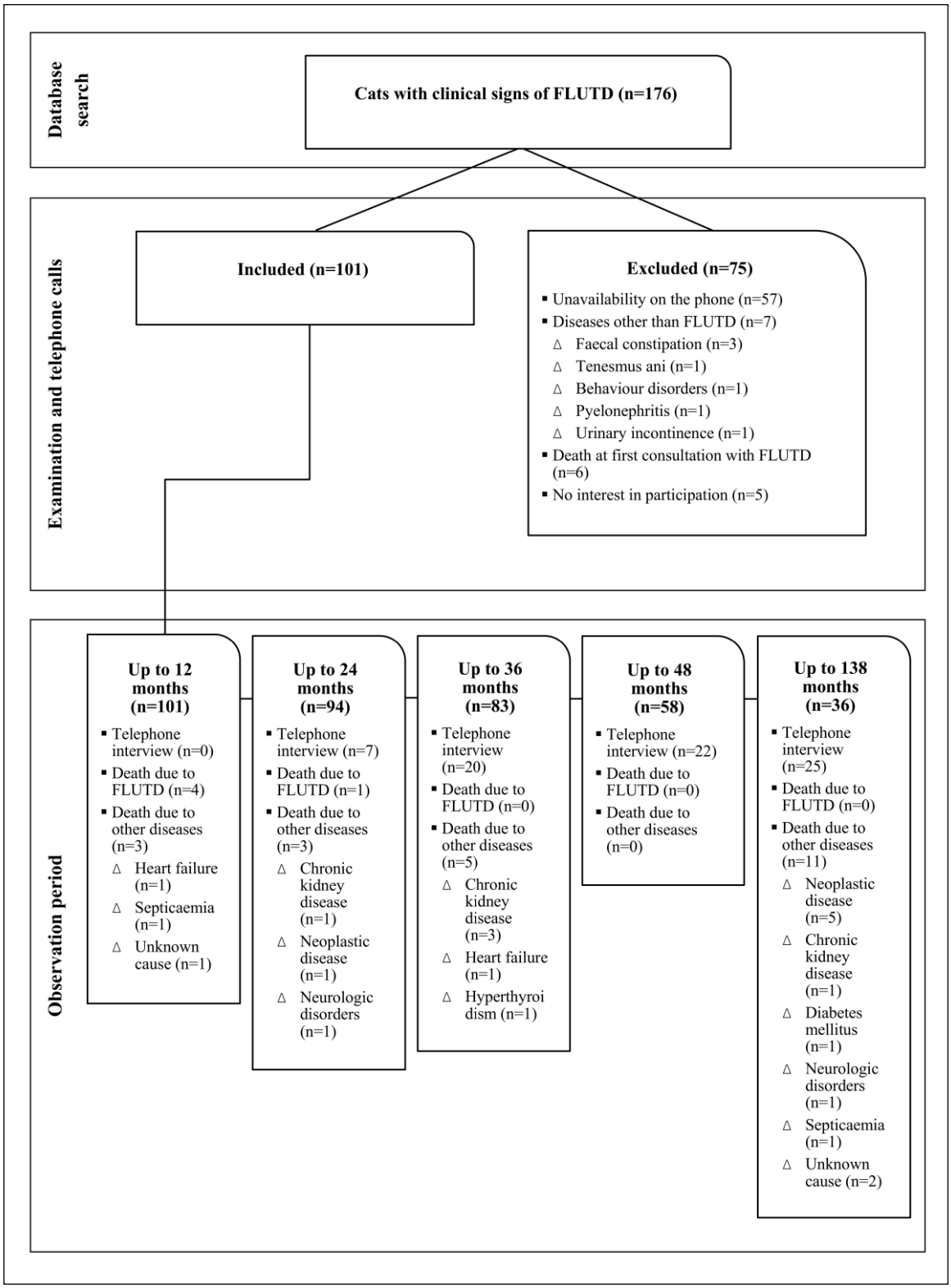

Figure 1 Flowchart of study phases, including causes of exclusion of cats with clinical signs of feline lower urinary tract disease (FLUTD), and number of cats and causes of death during different time intervals of the observation period; the observation period started with the first presentation of the cats because of FLUTD and ended with the telephone interview with the owners or the cat's death

Table 2 Observation period, number of relapses and hospitalisations, diagnoses and time intervals between episodes of cats with different aetiologies of lower urinary tract signs at different episodes

Cat	Observation period (months)	Number of relapses	Number of hospitalisations	Episode 1		Episode 2		Episode 3		Episode 4		Episode 5		Death due to FLUTD
				Age (years)	Diagnosis	TI (months)	Diagnosis	TI	Diagnosis	TI	Diagnosis	TI	Diagnosis	
1	129	4	2	1	NSD	17	NSD	9	FIC	0.4	NSD	64	UL	No
2	108	4	1	4	NSD	13	UL	22	NSD	16	NSD	16	FIC	No
3	100	4	3	3	UL	39	NSD	6	UTI	20	FIC	32	NSD	No
4	79	3	1	1	NSD	2	FIC	1	UTI	38	UL			No
5	72	3	2	1	NSD	1	FIC	1	NSD	32	UL			No
6	56	3	0	7	UTI	37	NSD	11	NSD	2	FIC			No
7	74	2	2	6	UL	12	FIC	63	NSD					No
8	45	2	2	8	NSD	9	UL	17	FIC					No
9	32	2	2	4	FIC	23	NSD	9	UL					No
10	15	2	1	15	UL	11	BC	4	BC					Yes
11	119	1	2	7	UTI	64	UL							No
12	72	1	2	2	FIC	1	UL							No
13	63	1	2	5	UL	59	UTI							No
14	43	1	2	2	FIC	1	UL							No

FLUTD = feline lower urinary tract disease; TI = time interval; NSD = non-specific diagnosis; FIC = feline idiopathic cystitis; UL = urolithiasis; UTI = urinary tract infection; BC = bladder cancer

Table 3 Signalment of 86 cats with feline idiopathic cystitis (FIC), urolithiasis and urinary tract infection (UTI)

Parameter	Total (n = 86)	FIC (n = 52)	Urolithiasis (n = 21)	UTI (n = 13)	*P* value
Breed (n [%])					
DSH	56 (65.1%)	35 (67.3%)	13 (61.9%)	8 (61.5%)	0.870
Other breeds	30 (34.9%): Persian (8), Maine Coon (7), BSH (4), Chartreux (2), DLH (2), Norwegian Forest Cat (2), Egyptian Mau (1), Neva Masquerade (1), Siamese (1), Turkish Angora (1), Turkish Van (1)	17 (32.7%): Maine Coon (6), Persian (5), BSH (2), Chartreux (1), Egyptian Mau (1), Norwegian Forest Cat (1), Turkish Angora (1)	8 (38.1%): BSH (2), DLH (1), Maine Coon (1), Neva Masquerade (1), Norwegian Forest Cat (1), Persian (1), Siamese (1)	5 (38.5%): Persian (2), Chartreux (1), DLH (1), Turkish Van (1)	
Sex (n [%])					
Male	76 (88.4%): neutered (73), intact (3)	47 (90.4%): neutered (45), intact (2)	20 (95.2%): neutered (19), intact (1)	9 (69.2%): neutered (9), intact (0)	0.336
Female	10 (11.6%): neutered (8), intact (2)	5 (9.6%): neutered (4), intact (1)	1 (4.8%): neutered (1), intact (0)	4 (30.8%): neutered (3), intact (1)	
Age (median [range]) (years)	6 (1–18)	5 (1–15)	7 (1–15)	10 (1–18)	0.003*
Body weight (median [range]) (kg)	5.4 (2.2–9.2)	5.7 (2.2–9.2)	5.4 (3.3–8)	5.1 (2.6–6.8)	0.266

*Cats with UTI were significantly older than cats with FIC ($P = 0.002$)
DSH = domestic shorthair; BSH = British Shorthair; DLH = domestic longhair

was no significant influence of PMs on the recurrence rate. Twenty-three cats (36.5%) received one PM and 40 cats (63.5%) received two or three PMs. The recurrence rate for cats with urolithiasis with two or three PMs was significantly lower than the recurrence rate for cats without PMs in this group. Feeding a prescription diet and modification of water supply was the most frequent combination of PMs for cats receiving more than one PM (n = 15/40).

Survival of cats with FLUTD

Seventy-four of the 101 included cats (73.3%) were alive at the time of the telephone interview. Five cats (5.0%) had died because of FLUTD (2/15 cats [13.3%] without a definitive diagnosis, 3/86 cats [3.5%] with a confirmed diagnosis). Three of the five cats had two relapses and one cat each had one and four relapses, respectively. One of them died during anaesthesia for catheterisation and four were euthanased. UO was present in the cat that died and in three cats that were euthanased. Associated diagnoses at the time of death were urolithiasis (n = 1), non-specific diagnosis (n = 3) and suspicion of bladder carcinoma (n = 1). Four cats died in the first year after their first episode of FLUTD and one in the second year. Twenty-two cats died or were euthanased for reasons other than FLUTD (Figure 1).

Discussion

In this follow-up study, the recurrence of FLUTD episodes in cats with FIC, urolithiasis and UTI over a median observation period of 38 months was 58.1%. So far, there have only been three studies reporting on the long-term recurrence rate of FLUTD, two with considerably lower recurrence rates than the present study, in which clinical signs recurred in 30/85 cats (35.3%) and 11/50 cats (22.0%) within 6 months and in 20/39 cats (51.3%) within 13 months.[21,25,26] Even though most of the recurrent FLUTD episodes occurred within the first year after presentation, there were also cats that had a first recurrent episode after 2 or 3 years. In the present study, there were only 3/86 cats (3.5%) with a confirmed diagnosis followed up for <6 months. The longer observation period in most of the included cats can be considered as the most important reason for the higher recurrence. Moreover, comparison of studies is difficult because the majority of previous studies only included cats with UO and defined relapse as recurrent UO, whereas the present study included cats with and without UO and recurrence of clinical signs included obstructive and non-obstructive episodes. Interestingly, there was neither a significant difference in the recurrence of clinical signs between cats with different aetiologies of FLUTD nor a difference in the number of recurrent episodes.

The fact that more than 50% of cats with UTI had more than one episode of FLUTD is interesting and considerably higher than the previously reported recurrence rate of 14.7%.[22] According to other studies, recurrent

Table 4 Clinical signs, occurrence of urethral obstruction and indication of other diseases in cats with feline idiopathic cystitis (FIC), urolithiasis and urinary tract infection (UTI)

Parameter	Total (n = 86)	FIC (n = 52)	Urolithiasis (n = 21)	UTI (n = 13)	*P* value
Clinical signs					
Stranguria	67 (77.9)	40 (76.9)	18 (85.7)	9 (69.2)	0.531
Macroscopic haematuria	50 (58.1)	30 (57.7)	14 (66.7)	6 (46.2)	0.497
Microscopic haematuria	77 (89.5)	47 (90.4)	20 (95.2)	10 (76.9)	0.057
Pollakiuria	44 (51.2)	24 (46.2)	14 (66.7)	6 (46.2)	0.263
Vocalisation	31 (36.0)	19 (36.5)	7 (33.3)	5 (38.5)	0.949
Periuria	28 (32.6)	14 (26.9)	9 (42.9)	5 (38.5)	0.373
UO	50 (58.1)	34 (65.4)	13 (61.9)	3 (23.1)	0.023*
Number of UOs					
1	42 (84.0)	28 (82.4)	11 (84.6)	3 (100)	0.737
2	8 (16.0)	6 (17.6)	2 (15.4)	0 (0)	
Other diseases					
Renal disease	18 (20.9)	7 (13.5)	5 (23.8)	6 (46.2)	0.036†
Heart disease	12 (14.0)	6 (11.5)	3 (14.3)	3 (23.1)	0.495
Other diseases	10 (11.6): feline asthma (2), hyperthyroidism (2), ophthalmic disease (2), diabetes mellitus (1), epilepsy (1), FIV (1), food allergy (1)	5 (9.6): diabetes mellitus (1), FIV (1), food allergy (1), hyperthyroidism (1), ophthalmic disease (1)	5 (23.8): epilepsy (1), feline asthma (2), hyperthyroidism (1), ophthalmic disease (1)	0 (0)	0.119

Data are n (%)
*Cats with UTI had significantly less urethral obstruction than cats with FIC ($P = 0.011$)
†No significant difference between groups in consideration of the Bonferroni correction with $P \leqslant 0.017$
UOS = urethral obstructions; FIV = feline immunodeficiency virus

infections of the lower urinary tract appear to be an uncommon event without predisposing risk factors.[22,23] The prevalence of UTIs in cats with lower urinary tract signs differs significantly between other studies depending on the geographical area and the inclusion of primary first-opinion cases or referral cases. Studies performed in the USA with referral cases documented a UTI prevalence of <3.0%.[3,4] In contrast, European studies including predominantly primary cases showed a noticeably higher prevalence of 8.0–20.0%.[1,2,8] This was also the case in the present study, with 12.9% of cats suffering from UTIs. UTI was not diagnosed in any cat at the time of a urolithiasis diagnosis, which has been reported in 5.0% of cats with urolithiasis in another study.[6] However, in the present study 4/14 cats with different diagnoses at different time points had UTI and urolithiasis.

UTI is more often diagnosed in older cats, with a mean age between 8 and 11 years.[22,27] In the present study, the median age of cats with UTIs was 10 years (range 1–18 years). They were significantly older than cats with FIC. However, local and systemic comorbidities are known predisposing factors for the development of UTI.[28–31] UTI is also a complication in cats with obstructive FLUTD undergoing transurethral catheterisation, with an incidence of 22.0–33.0%, even if a standardised protocol, an aseptic technique and a closed urine collection system are applied.[29,32] Bass et al[33] reported that 23.0% of cats that were treated surgically with perineal urethrostomy suffered from UTI and 15.0% of cats had up to 10 recurring episodes of UTI. In the present study, 4/7 cats (57.1%) with UTIs and recurring episodes of FLUTD signs had laboratory evidence of chronic kidney disease and in one cat perineal urethrostomy had been performed during a previous episode of FLUTD. Many risk factors for UTI in cats permanently affect the local defence mechanisms of the urinary tract or the systemic immune system, and predispose cats to reinfections or persistent infections.

Regarding cats with FIC, 61.5% had recurrent clinical signs, which is lower than the reported proportion of 65.0% over a 6-month period in another study.[34] This was a prospective study and cats were more closely monitored by owners, who kept a record of 'cystitis events'. With this prospective approach it is likely that more subtle and mild FLUTD signs were observed and recorded accordingly. In the study of Defauw et al,[15] which evaluated risk factors of cats with FIC, 50/64 cats

Table 5 Observation period, number of hospitalisations, recurrence rates and number of relapses in cats with feline idiopathic cystitis (FIC), urolithiasis and urinary tract infection (UTI)

Parameter	Total (n = 86)	FIC (n = 52)	Urolithiasis (n = 21)	UTI (n = 13)	*P* value
Observation period (median [range]) (months)	38 (0.5–138)	45 (0.5–116)	39 (2–138)	32 (10–85)	0.706
Hospitalisation	72 (83.7)	42 (80.8)	21 (100)	9 (69.2)	0.022*
Number of hospitalisations					
1	57 (79.2)	34 (81.0)	16 (76.2)	7 (77.8)	0.141
2–3	15 (20.8)	8 (19.0)	5 (23.8)	2 (22.2)	
Recurrence					
Yes	50 (58.1)	32 (61.5)	11 (52.4)	7 (53.8)	0.729
No	36 (41.9)	20 (38.5)	10 (47.6)	6 (46.2)	
Number of relapses					
1	21 (42.0)	13 (40.6)	4 (36.4)	4 (57.1)	0.656
2	12 (24.0)	8 (25.0)	3 (27.3)	1 (14.3)	
3	10 (20.0)	6 (18.8)	2 (18.2)	2 (28.6)	
⩾4	7 (14.0)	5 (15.6)	2 (18.2)	0 (0)	
Recurrence in the first year	37 (43.0)	24 (46.2)	9 (42.9)	4 (30.8)	0.677
Number of relapses in the first year					
1	22 (59.5)	13 (54.2)	6 (66.7)	3 (75.0)	0.621
2	11 (29.7)	8 (33.3)	3 (33.3)	0 (0)	
⩾3	4 (10.8)	3 (12.5)	0 (0)	1 (25.0)	
Recurrence in the second year	12 (14.8)	6 (12.0)	4 (22.2)	2 (15.4)	0.551
Number of relapses in the second year					
1	10 (83.3)	5 (83.3)	4 (100)	1 (50.0)	0.366
2	2 (16.7)	1 (16.7)	0 (0)	1 (50.0)	
Recurrence in years 3–6	19 (27.1)	11(23.9)	5 (35.7)	3 (30.0)	0.667
Number of relapses in years 3–6					
1	10 (52.6)	4 (36.4)	3 (60.0)	3 (100)	0.219
2	2 (10.5)	2 (18.2)	0 (0)	0 (0)	
⩾3	7 (36.8)	5 (45.4)	2 (40.0)	0 (0)	

Data are n (%) unless otherwise indicated
*Cats with urolithiasis were hospitalised significantly more often than cats with UTIs ($P = 0.015$)

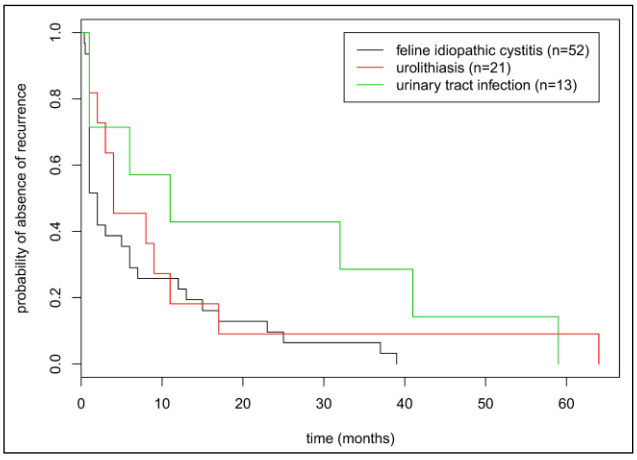

Figure 2 Risk of recurrence after the first episode of lower urinary tract signs during the observation period in cats with feline idiopathic cystitis, urolithiasis and bacterial urinary tract infection illustrated by Kaplan–Meier survival curves; there was no significant difference between groups with identified aetiologies ($P = 0.154$)

(78.1%) had more than one episode with clinical signs of FLUTD. Compared with 57.0% of cats with FLUTD that presented during their first episode in the present study, only 39.0% had the first episode on their clinical presentation in that study.[15] Most of the included cats were referred by other veterinarians and suffered most likely from more severe or persistent FIC, also causing a considerably higher recurrence rate than in cats of the present study. In three other studies, lower recurrence rates of 17.1%, 18.8% and 35.1% were reported.[14,16,17] However, in these studies the cats were monitored for a much shorter period of time (4 days, 1 week and 3 months).

Cats with FIC are reported to have fewer recurrent episodes with increasing age.[18] In the present study, the median age of cats with FIC at their last episode was 6 years (range 1–15 years), which was lower than that of cats with urolithiasis and UTI, at 7 years (range 2–16 years) and 10 years (range 8–21 years), respectively. However, cats with FIC entered the study at a significantly lower age than cats with UTIs and the observation

Table 6 Number and types of prophylactic measures and recurrence rates with and without their implementation in cats with feline idiopathic cystitis (FIC), urolithiasis and urinary tract infection (UTI)

Parameter	Total (n = 86)	*P* value (total)*	FIC (n = 52)	*P* value (FIC)*	Urolithiasis (n = 21)	*P* value (urolithiasis)*	UTI (n = 13)	*P* value (UTI)*
Prophylactic measures								
Yes	63 (73.3)	–	38 (73.1)	–	19 (90.5)	–	6 (46.2)	–
No	23 (26.7)	–	14 (26.9)	–	2 (9.5)	–	7 (53.8)	
Recurrence								
With PMs	18 (28.6)	0.502	13 (34.2)	1.000	3 (15.8)	0.043	2 (33.3)	1.000
Without PMs	9 (39.1)		5 (35.7)		2 (100)		2 (28.6)	
Number of PMs								
1	23 (36.5)	–	15 (39.5)	–	6 (31.6)	–	2 (33.3)	–
2	27 (42.9)	–	14 (36.8)	–	10 (52.6)	–	3 (50.0)	–
3	13 (20.6)	–	9 (23.7)	–	3 (15.8)	–	1 (16.7)	–
Recurrence after PMs								
After 1 PM	10 (43.5)	1.000	6 (40.0)	1.000	2 (33.3)	0.429	2 (100)	0.167
After 2 PMs	5 (18.5)	0.193	4 (28.6)	1.000	1 (10.0)	0.045	0 (0)	1.000
After 3 PMs	3 (23.1)	0.468 0.176†	3 (33.3)	1.000 0.889†	0 (0)	0.100 0.029†	0 (0)	1.000 0.491†
MOH	6 (7.0)	–	6 (11.5)	–	0 (0)	–	0 (0)	–
Type of MOH								
Access outside	2 (33.3)	–	2 (33.3)	–	–	–	–	–
Others	4 (66.7): separation from other pet (2), access to balcony (1), cessation of dog visits (1)	–	4 (66.7): separation from other pet (2), access to balcony (1), cessation of dog visits (1)	–	–	–	–	–
Recurrence after MOH	2 (33.3)	1.000	2 (33.3)	1.000				
MOF	30 (34.9)	–	19 (36.5)	–	8 (38.1)	–	3 (23.1)	–
Type of MOF								
Conversion to canned food	24 (80.0): increased proportion of canned food (18), sole feeding of canned food (6)	–	15 (78.9): increased proportion of canned food (12), sole feeding of canned food (3)	–	7 (87.5): increased proportion of canned food (4), sole feeding of canned food (3)	–	2 (66.7): increased proportion of canned food (2)	–
Conversion to reduced-calorie food	6 (20.0)	–	4 (21.1)	–	1 (12.5)	–	1 (33.3)	–
Recurrence after MOF	8 (26.7)	0.505	5 (26.3)	0.844	2 (25.0)	0.133	1 (33.3)	1.000
Prescription diet	32 (37.2)	–	16 (30.8)	–	15 (71.4)	–	1 (7.7)	–
Recurrence after prescription diet	13 (40.6)	1.000	8 (50.0)	0.676	4 (26.7)	0.110	1 (100)	0.375
MOW	32 (37.2)	–	18 (34.6)	–	10 (47.6)	–	4 (30.8)	–

(continued)

Table 6 (continued)

Parameter	Total (n = 86)	*P* value (total)*	FIC (n = 52)	*P* value (FIC)*	Urolithiasis (n = 21)	*P* value (urolithiasis)*	UTI (n = 13)	*P* value (UTI)*
Type of MOW								
Installation of drinking fountains	23 (71.9)	–	11 (61.1)	–	9 (90.0)	–	3 (75.0)	–
Watering of food	11 (34.4)	–	6 (33.3)	–	4 (40.0)	–	1 (25.0)	–
Increase in number of water bowls	7 (21.9)	–	4 (22.2)	–	2 (20.0)	–	1 (25.0)	–
Others	4 (12.5): aromatisation of water (2), change of drinking facility (2)	–	4 (22.2): aromatisation of water (2), change of drinking facility (2)	–	0 (0)	–	0 (0)	–
Recurrence after MOW	7 (21.9)	0.276	5 (27.8)	0.923	1 (10.0)	0.045	1 (25.0)	0.375
MOT	16 (18.6)	–	11 (21.2)	–	2 (9.5)	–	3 (23.3)	–
Type of MOT								
Increase in number of litter boxes	16 (100)	–	11 (100)	–	2 (100)	–	3 (100)	–
Conversion to litter box without hood	1 (6.3)	–	1 (9.1)	–	0 (0)	–	0 (0)	–
Recurrence after MOT	9 (56.3)	0.466	7 (63.6)	0.238	0 (0)	0.333	2 (66.7)	0.500

Data are n (%)
*Comparison between cats with and without prophylactic measures
†Comparison between cats receiving at least two prophylactic measures and cats without prophylactic measures
PM = prophylactic measure; MOH = modification of housing; MOF = modification of feeding; MOW = modification of water supply; MOT = modification of toilet management

period varied among included cats, irrespective of the diagnosis. It is not known if cats with FIC in the present study suffered from further episodes later on.

For cats with urolithiasis, the recurrence rate in the present study (52.4%) was higher than in previous studies, which observed relapses in 5.5%, 27.6% and 38.5%, respectively.[19–21] Two of those studies were performed at urolith centres and included a considerably higher number of cats (4435 and 1767 cats, respectively)[19,20] than the present study. Albasan et al[19] mainly included cats whose uroliths were sent to the same urolith centre during the following episode, and Hesse et al[20] received information about previous episodes on only 36.0% of included cats. Therefore, relapses in cats suffering from other causes or cats whose uroliths were analysed at another institute were not included. In the present study, another approach was used by evaluating whether cats with urolithiasis suffered from further episodes with FLUTD signs. None of the cats having relapses were diagnosed with another episode of urolithiasis in the present study, but 5/11 cats had crystalluria during other episodes. Most of the cats were not examined by imaging methods during further episodes. Therefore, uroliths could have been missed. Gerber et al[21] reported a recurrence rate of 38.5%. The shorter median follow-up time (17 months) and the exclusive inclusion of cats with UO could be reasons for the lower recurrence rate.

Calcium oxalate uroliths are reported to occur more often in older cats than struvite uroliths.[20,35] In the present study, cats with calcium oxalate uroliths had a median age of 7 years (range 5–11 years) and were older than cats with struvite uroliths with a median age of 5 years (range 2–9 years) without reaching statistical significance in this relatively small group of cats with urolithiasis.

Different episodes of FLUTD in the same cat can be due to different aetiologies. In the present study, 14/50 cats (28.0%) with recurring FLUTD episodes were diagnosed with different causes of FLUTD at different episodes. The most common combination of diagnoses in these cats was FIC and urolithiasis. Causes for this could be the predominance of these disease patterns in cats with FLUTD and the similarity of corresponding risk factors, such as male sex, obesity, dry food only or less water intake.[1,6,15,20,36,37] As FIC is a diagnosis of exclusion and diagnostic imaging in the present study did not include both radiographs and ultrasound in every cat, it is possible that small uroliths were missed and cats were falsely diagnosed with FIC during FLUTD episodes preceding or following episodes in which urolithiasis was diagnosed. A recently published case series describes six cats with FLUTD with recurrent episodes due to different causes.[38] These cats were prospectively included in a bigger study on FLUTD and very thoroughly evaluated during every episode. Therefore, the likelihood that uroliths were missed was lower in that study and the authors discussed potential inter-related disease mechanisms between the different aetiologies. In this scenario, FIC could act as a potential predisposing condition for the development of other diseases of the urinary tract such as bacterial cystitis. Whether such a relation truly exists or not, this case series and the present study highlight the need for thorough investigation and diagnostic imaging of cats at each episode of FLUTD.

Implementation of at least two PMs led to significantly lower recurrence in cats with urolithiasis, and modification of water supply as the sole PM was beneficial for cats with urolithiasis in the present study. The results should be regarded carefully as the number of cats was small in each PM subgroup. Nevertheless, water intake has been shown to be important in the prevention of recurrent FIC episodes, as well as in the prevention of urolithiasis.[37,39,40] In addition, multimodal environmental enrichment and removal of stress factors is a major component in the treatment of cats with FIC.[41] Therefore, owners should be encouraged to implement environmental enrichment, and modification of feeding and water supply in all cats with FLUTD.

Mortality due to FLUTD among all 101 cats in the present study was 5.0% and lower than the mortality rate in cats with FIC of 12.5% reported by Defauw et al.[15] This study included cats with and without UO. The most common reason for FIC-related death was euthanasia due to recurrent UO. Only a few cats without UO were euthanased, owing to the persistence of clinical signs. Similarly, in the present study, all FLUTD-associated deaths were due to UO or associated metabolic complications. Reported mortality rates in studies including only cats with obstructive FLUTD or FIC are even higher – up to 21.0%.[21,25,26,42] Therefore, recurrent UO appears to be the primary cause of death in cats with FLUTD and efforts to prevent recurrent UO should be taken.

Limitations of the present study are missing diagnostic methods in some cats and the small number of cats within the groups. As a result, the statistical power for comparing the groups was low and the probability of false-negative findings increased. The observation period varied from 0.5 to 138 months. There were only 3/86 cats (3.5%) with definitive diagnosis with an observation period of <6 months, but it cannot be excluded that the shorter observation period in these cats could have influenced the recurrence rate and mortality rate. Additionally, the time lag of up to 6 years between presentation to the CSAM and telephone interview in some cases led to uncertainty in the information provided about the course of disease.

Conclusions

Recurrent episodes of FLUTD occur in >50.0% of cats with FLUTD, irrespective of the underlying cause. More than half of the cats with recurrent episodes suffer from at least two relapses. A thorough investigation

should be performed at every relapse as it cannot be presumed that the cause of FLUTD is the same at different episodes. The implementation of more than one prophylactic measure was promising in cats with urolithiasis. Particularly, modifications that increase the water intake contributed to the prevention of recurrent episodes in cats with urolithiasis. Despite the high recurrence rate, mortality due to FLUTD is lower than previously reported, with UO being the most common reason for euthanasia or death.

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Supplementary material The following files are available online:
Tables containing character and housing conditions of cats with FIC, urolithiasis and UTI, and questions and response options of the questionnaire.

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