Feline lower urinary tract disease in a German cat population

A retrospective analysis of demographic data, causes and clinical signs

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Key words
Bacterial cystitis, urethral obstruction, feline idiopathic cystitis, FLUTD

Summary

Objective: To investigate epidemiologic data, clinical signs, results of urinalysis and causes of lower urinary tract disease in a German veterinary hospital population of cats and to determine if the demographic data, history, clinical signs and urinalysis results correlate with a particular etiology. **Materials and methods:** Cats presented with signs of feline lower urinary tract disease (FLUTD) with a documented history and physical examination, a complete urinalysis (urine specific gravity, urine dipstick and sediment, urine culture) of urine obtained by cystocentesis or catheterization, and diagnostic imaging of the urinary tract were included into the study. Cats that had received a previous treatment during the same episode of FLUTD were excluded. **Results:** A total of 302 cats were included into the study. Cats with FLUTD presented throughout the seasons with similar frequency. The most common diagnosis was feline idiopathic cystitis (FIC) (55.0%), followed by bacterial urinary tract infection (UTI) (18.9%), urethral plug (10.3%) and urolithiasis (7.0%). Urethral obstruction was significantly more frequent in cats with FIC than in cats with UTI. Cats with FIC and urethral plugs were significantly younger and had significantly higher body weights than cats with UTI and neoplasia. FIC and urethral plugs were significantly more common causes of FLUTD in cats younger than 10 years compared to cats that were 10 years or older (65.2% versus [vs.] 35.8% and 13.3% vs. 3.0%), while the incidences of UTI and neoplasia increased with age (12.9% vs. 41.8% and 1.0% vs. 13.4%). **Conclusion and clinical relevance:** FIC and UTI are the most common diagnoses in cats with FLUTD, with a significant age-related difference in incidence.

Schlüsselwörter
Bakterielle Zystitis, Urethraobstruktion, FLUTD, feline idiopathische Zystitis

Zusammenfassung

Gegenstand und Ziel: Untersuchung der epidemiologischen Daten und Haltungsbedingungen sowie der klinischen Symptome und Urinbefunde von Katzen mit einer Erkrankung der unteren Harnwege (feline lower urinary tract disease, FLUTD) in einer deutschen Klinikpopulation sowie die Überprüfung einer Korrelation dieser Daten mit bestimmten Ursachen von FLUTD. **Material und Methode:** Aufnahme in die Studie fanden Katzen, die in den Jahren 2000 bis 2007 mit Symptomen von FLUTD vorgestellt wurden und von denen Angaben zum Vorbericht und zur klinischen Untersuchung sowie Ergebnisse einer Urinanalyse (Teststreifen, Urinsediment, Urinkultur) aus Zystozentese- oder Katheterurin und einer röntgenologischen und/oder sonographischen Untersuchung des Harntrakts zur Verfügung standen. **Ergebnisse:** In die Auswertung gingen die Daten von 302 Katzen mit FLUTD ein. Die Patienten wurden zu allen Jahreszeiten mit gleicher Häufigkeit vorgestellt. Die häufigsten Ursachen von FLUTD waren eine idiopathische Zystitis (FIC) bei 55,0% der Katzen, bakterielle Harnwegsinfektionen (18,9%), urethrale Plugs (10,3%) und Harnsteine (7,0%). Eine Urethraobstruktion wurde signifikant häufiger bei Katzen mit FIC als bei Katzen mit bakteriellen Harnwegsinfektionen diagnostiziert. Katzen mit FIC und entzündungsbedingten urethralen Pfröpfen waren signifikant jünger und hatten ein signifikant höheres Körpergewicht als Katzen mit bakteriellen Harnwegsinfektionen und Harnblasentumoren. FIC und urethrale Plugs stellten bei Katzen unter 10 Jahren signifikant häufiger die Ursache von FLUTD dar als bei Patienten im Alter von 10 Jahren und älter (62,5% versus [vs.] 35,8% bzw. 13,3% vs. 3,0%). Umgekehrt stieg die Inzidenz bakterieller Harnwegsinfektionen und Neoplasien mit dem Alter der Tiere (12,9% vs. 41,8% and 1,0% vs. 13,4%). **Schlussfolgerung und klinische Relevanz:** Idiopathische Zystitiden und bakterielle Harnwegsinfektionen sind die häufigsten Ursachen von FLUTD mit einer signifikanten altersabhängigen Inzidenz.

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Erkrankungen der unteren Harnwege (FLUTD) in einer deutschen Katzenpopulation. Eine retrospektive Analyse demographischer Daten, der Ursachen sowie der klinischen Symptomatik
Tierärztl Prax 2014; 42 (K): 231–239
Received: October 25, 2013
Accepted after revision: March 12, 2014

Introduction

Feline lower urinary tract disease (FLUTD) is a common reason for cat owners to seek veterinary care. Cats with any disease of the lower urinary tract present with similar clinical signs, such as hematuria, pollakiuria, stranguria, voiding outside the litter box and/or urethral obstruction. In the literature, there is a consensus that feline idiopathic cystitis (FIC) is the most common diagnosis in cats with FLUTD and is responsible for the symptoms in 55–69% of cats (9, 15, 17). The proportion of cats with cystourolithis is reported to be 15–30%. Urethral obstruction is a common complication of FLUTD, particularly in male cats. According to the literature, in 55% of obstructed cats, a urethral plug causes the obstruction; in 28% of cats, no mechanical obstructing agent can be identified; and in 15%, uroliths are found (12). In cats with FIC, urethritis and urethral muscle spasms as well as urethral plug formation have been proposed as the cause of obstruction (9, 21). Controversies exist regarding the proportion of cats with urinary tract infections (UTI). Studies from the United States revealed that less than 3% of young and middle-aged cats with signs of FLUTD suffer from UTI (12, 15). This is in contrast to studies from Europe (Switzerland and Norway), which found a higher proportion of cats with UTI, ranging from 8% to 20% (8, 9, 17). The investigated populations were different because studies in the United States were performed in referral hospitals, whereas studies in Europe included referrals as well as first opinion cases. In addition, age-related differences in the incidence of various causes have been described. FIC is the most common diagnosis in young to middle-aged cats (12), while in cats older than 10 years, UTI and urolithiasis are the most common reasons for clinical signs of FLUTD (2).

FIC is a diagnosis of exclusion, and a diagnostic work-up must be performed to rule out other specific causes (13). This includes a urinalysis (dipstick, urine sediment, aerobic urine culture), abdominal radiographs for the identification of radio-dense cystoliths or urethroliths and ultrasound of the urinary tract to exclude focal bladder abnormalities such as polyps or neoplasms (20). If no specific cause can be identified, the disease is classified as idiopathic cystitis.

The aim of this retrospective study was to investigate epidemiologic data, clinical signs, and causes of lower urinary tract disease in a German veterinary hospital population and to determine if the demographic data, history, clinical signs and results of urinalysis correlate with a particular etiology.

Materials and methods

Patients

A search in the medical database of the Clinic of Small Animal Medicine, Ludwig Maximilian University Munich for cats with clinical signs of FLUTD in the years 2000 until 2007 was performed using the following key words: FLUTD, FIC, FUS, pollakiuria, hematuria, voiding in unusual places, periuria, dysuria, straining to urinate, vocalization on urination, unsuccessful attempts to urinate, urethral obstruction and cystitis. The medical records of the obtained cases were reviewed to make sure that the history and clinical signs were compatible with FLUTD. Only cats with a documented physical examination, a complete urinalysis (urine specific gravity [USG], urine dipstick, and sediment) and urine culture and sensitivity performed at initial presentation as well as ultrasound and/or radiographs on presentation were included. Cats were excluded if they had been catheterized or treated with antibiotics during the same episode of FLUTD by the referring veterinarian, if perineal urethrostomy had been performed previously and the original cause of FLUTD could not be elucidated, and if urine samples were not collected via cystocentesis or catheterization. If cats were presented several times for FLUTD, only data from the first presentation were included in the analysis.

The following data were collected: signalment (age, sex, breed, weight), husbandry information, season of presentation (spring [March, April, May], summer [June, July, August], autumn [September, October, November], and winter [December, January, February]), clinical signs at presentation, presence of urethral obstruction, obtained diagnosis, results of urinalysis, and serum biochemistry. The cats were diagnosed with obstructive FLUTD if they had a history of unsuccessful attempts to void and a large, tensed and painful urinary bladder on abdominal palpation. Diagnoses were based on specific criteria (▶ Table 1).

Urinalysis and urine culture

For determination of the USG a hand refractometer (ATAGO Co. Ltd., Tokyo, Japan) was used. USG was recorded in two categories (USG < 1.035, USG ≥ 1.035). The results of urinalysis with reagent strips (Combur-9; Roche Diagnostics, Grenzach-Wyhlen, Germany) and the microscopically examined urine sediment after centrifugation at 2000 g for 5 minutes were included into the analysis. Cats were categorized as microscopically hematuric or pyuric if more than 10 red blood cells per high power field (HPF = 400-fold magnification) or more than five white blood cells per HPF, respectively, were recorded (16). Struvite crystalluria was categorized into "few" or "numerous". Other crystals were not quantified.

Urine cultures were performed at the Institute for Infectious Diseases and Zoonoses, Ludwig Maximilian University Munich. For quantitative aerobic culture, 0.1 ml of undiluted urine and 0.1 ml of a 10^3 dilution were inoculated on nutrient agar with and without 5% sheep blood. In addition, Gassner agar and nutrient agar were used for the diluted samples. Plates were aerobically incubated at 37 °C and examined after 24 and 48 hours of incubation. The results were recorded in colony forming units per milliliter (CFU/ml).

Statistical analysis

Analysis was performed with commercial computer programs (IBM SPSS Statistics 20, GraphPad Prism 5.04 software (Graph-

Table 1 Definition of diagnoses in cats with clinical signs of feline lower urinary tract disease (FLUTD).
Tab. 1 Definition der Diagnosen bei Katzen mit „feline lower urinary tract disease" (FLUTD)

Diagnosis	Definition	Exclusion
Feline idiopathic cystitis	Diagnosis of exclusion	• Urocystoliths identified on abdominal radiographs or ultrasound • Positive urine culture with significant bacterial growth (≥ 10^3 CFU/ml) • Evidence of neoplasia on abdominal ultrasound • Struvite crystalluria ("numerous" or "too numerous to count" or +++ on examination of the urine sediment) without obstruction
Bacterial urinary tract infection	Significant bacterial growth (≥ 10^3 CFU/ml) in urine samples obtained per cystocentesis or catheterization at the time of presentation	• Urocystoliths identified on abdominal radiographs or ultrasound • Evidence of neoplasia on abdominal ultrasound
Urethral plug	Detection of a urethral plug on catheterization and/or numerous struvite crystals on urine sediment and urethral obstruction	• Urocystoliths or urethroliths identified on abdominal radiographs or ultrasound • Evidence of neoplasia on abdominal ultrasound • Significant bacterial growth (≥ 10^3 CFU/ml) in urine samples obtained per cystocentesis or catheterization at the time of presentation
Uroliths	Uroliths identified on radiographs and/or ultrasound	• Evidence of neoplasia on abdominal ultrasound
Neoplasia	Ultrasonographically identified mass lesion (with or without a definitive histologic diagnosis)	• Urocystoliths identified on abdominal radiographs or ultrasound
Miscellaneous	• Struvite crystalluria (numerous crystals on examination of the urine sediment) without obstruction • Neurologic disorders associated with FLUTD symptoms	• Urocystoliths identified on abdominal radiographs or ultrasound • Evidence of neoplasia on abdominal ultrasound

Pad, San Diego, USA). Descriptive statistics (mean ± SD, median and range) were calculated for continuous parameters (age, weight). Comparisons of continuous parameters were performed with one-way ANOVA and Tukey's multiple comparison test. For the comparison of categorical parameters between groups, the Chi Square test was performed. Statistical significance was set at $p < 0.05$. Because of multiple testing in the comparison of individual groups, a Bonferroni correction was used, and statistical significance was set at $p < 0.005$. For statistical analyses, only groups with at least 10 cats were included. For evaluation of age-related differences in the incidences of diagnoses odds ratios and 95% confidence intervals were calculated for cats < 10 years and cats ≥ 10 years of age.

Results

Patients

The electronic search of the hospital database with extended key words with identical and similar spellings revealed 982 cats. However, 257 cats did not fulfill the historical and clinical criteria for cats with FLUTD, and 54 cats had not undergone urinalysis. Out of the remaining 648 cats, 59 had been catheterized without a previous urine culture, 95 cats had been treated with antibiotics, six cats had a previous perineal urethrostomy, 64 cats had not undergone diagnostic imaging, and in 52 cats urine sampling had not been performed by cystocentesis or urinary catheter. In 69 of the remaining 372 cats, urine culture had not been performed from the initial urine sample, resulting in a final study population of 302 cats. In 161 of these 302 cats, both abdominal radiography and ultrasound were performed. In 141 cats, either abdominal ultrasound (n = 116) or abdominal radiography (n = 25) was performed.

The age, the weight and gender of the 302 cats are illustrated in ▶Table 2, information regarding husbandry and seasonal distribution in ▶Table 3. Two hundred and twenty-six cats (75.6%) were domestic shorthair cats. There were 36 (11.8%) Persian cats, seven (2.3%) Maine Coons, six (1.97%) Siamese cats, five Chartreux (1.6%), five Oriental Shorthair cats (1.6%), and four Angora cats (1.3%). Other represented breeds with one or two cats included British Shorthair, Abyssinian, Somali, Norwegian Forrest Cat, Ragdoll, Burma, and Sacred Birman. For three cats, the breed was not recorded. In 280 cats, information concerning husbandry was available (▶Table 3). There was no difference in the number of affected cats between seasons ($p = 0.452$).

Diagnoses

In this study including 302 cats, the most common diagnoses were FIC (55.0%), bacterial UTI (18.9%), urethral plug (10.3%), urolithiasis (7.0%) and neoplasia of the bladder wall (3.6%) (▶Table 4). Six cats (2.0%) suffered from severe struvite crystalluria without urethral obstruction and in nine cats (3.0%) neurogenic disorders were the cause of abnormal voiding behavior. In 49 cats with bacterial UTI, one isolate was identified on aerobic bacterial culture: *Escherichia coli* (n = 32), *Streptococcus* spp. (n = 4), *Staphylococcus* spp. (n = 5), *Micrococcaceae* (n = 5), *Enterococcus* spp. (n = 2) and aerobic spore formers (n = 1). Two isolates were identified in eight

cats and included combinations of *E. coli* and *Streptococcus* spp. or combinations of these bacteria with *Pasteurella* spp. or *Pseudomonas* spp.

Comparison of diagnosis groups

Signalment and husbandry

Epidemiologic data (age, body weight, sex) of cats with the most common diagnoses are presented in ▶Table 2. Cats with UTI or neoplasia were significantly older than cats with FIC, urethral plugs and urolithiasis ($p < 0.005$). UTI and neoplasia were significantly more often ($p < 0.001$), and FIC ($p < 0.001$) was significantly less often diagnosed in cats older than 10 years of age (▶Table 4). Cats with bacterial UTI and cats with bladder neoplasia had a significantly lower body weight than cats with FIC and cats with urethral plugs ($p < 0.005$) (▶Table 2). There was no difference in breed distribution between groups ($p = 0.880$). Regarding sex, comparison of individual groups with each other revealed a significantly higher proportion of males among cats with FIC and urethral plugs compared to cats with bacterial UTI ($p = 0.001$) and neoplasia ($p < 0.005$).

There was no significant difference in outdoor access ($p = 0.411$) and in the number of cats living alone or in a multi-cat household ($p = 0.381$). There was also no difference in seasonal distribution between the groups ($p = 0.470$) (▶Table 3).

History and clinical signs

The number of cats with clinical signs such as stranguria, dysuria and periuria was not different between the groups ($p > 0.05$) (▶Table 5). Pollakiuria was noticed by owners significantly more frequently in cats with UTI and FIC than in cats with urolithiasis ($p = 0.002$). Gross hematuria was significantly more frequently observed by owners of cats with idiopathic cystitis, UTI, uroliths and neoplasia than in cats with urethral plugs ($p < 0.005$). Per definition, all cats with urethral plugs were classified as obstructed. Among the other groups, the proportion of obstructed cats with FIC was significantly higher than the proportion of obstructed cats with UTI ($p < 0.005$).

Table 2 Age, weight, sex and breed of all cats with FLUTD and of cats within the five most common diagnosis groups (number of cats, %). Age and weight between diagnosis groups were compared with ANOVA and Tukey's post-test ($p < 0.05$) (significant results in bold). For comparison of sex and breed of cats between diagnosis groups, a contingency analyses (Chi Square test) was performed with p set at 0.05 (significant results in bold). If results were significant, comparison of individual groups with the Chi Square test was performed. Due to the multiple comparisons, a Bonferroni correction was applied, and $p \leq 0.005$ was considered significant.

Tab. 2 Alter, Gewicht, Geschlecht und Rasse aller Katzen und der Katzen mit den fünf häufigsten Diagnosen (Anzahl der Katzen, %). Der Vergleich von Alter und Gewicht wurde mittels ANOVA und Post-Hoc-Test nach Tukey durchgeführt ($p < 0.05$). Zum Vergleich von Geschlecht und Rasse zwischen den Gruppen wurde der Chi-Quadrat-Test angewendet. Aufgrund multiplen Testens erfolgte eine Bonferroni-Korrektur und das Signifikanzniveau wurde auf $p < 0.005$ gesetzt.

	All cats n = 302	FIC n = 166	UTI n = 57	Urethral plug n = 31	Uroliths n = 21	Neoplasia n = 11	p
Age in years mean ± SD (median, range)	6.74 ± 4.22 (6, 0.5–19)	5.78 ± 3.12 (5, 1–14)	9.3 ± 4.99 (11, 1–16)	5.4 ± 2.9 (5, 1–12)	5.8 ± 3.85 (4.5, 1–14)	12.8 ± 3.73 (12, 6–19)	**< 0.001**[1]
Weight in kg mean ± SD (median, range)	5.26 ± 1.48 (5.2, 1.8–9.9)	5.48 ± 1.39 (5.4, 1.8–9.5)	4.70 ± 1.64 (4.6, 2.1–9.9)	5.82 ± 1.35 (5.7, 2.6–8.6)	5.43 ± 1.35 (5.6, 2.8–7.6)	3.9 ± 0.73 (4.1, 3.0–5.0)	**< 0.001**[2]
Sex	247 male (81.8%) (195 mc, 52 mi) 55 female (17.2%) (40 fs, 15 fi)	149 male (89.8%) (124 mc, 25 mi) 17 female (10.2%) (11 fs, 6 fi)	35 male (61.4%) (27 mc, 8 mi) 22 female (38.6%) (16 fs, 6 fi)	29 male (93.5%) (19 mc, 10 mi) 2 female (6.5%) (2 fs)	16 male (76.2%) (11 mc, 5 mi) 5 female (23.8%) (5 fs)	5 male (45.5%) (5 mc) 6 female (54.5%) (6 fs)	**< 0.001**[3]
Proportion of DSH cats	75.6%	77.4%	72.4%	77.4%	70.0%	70.0%	0.880

FLUTD = feline lower urinary tract disease, FIC = feline idiopathic cystitis, UTI = bacterial urinary tract infection, mc = male castrated, mi = male intact, fs = female spayed, fi = female intact, DSH = domestic shorthair cats

[1] Cats with UTI or neoplasia were significantly older than cats with FIC, urethral plugs and urolithiasis (all $p < 0.005$).

[2] Cats with bacterial UTI and cats with bladder neoplasia had a significantly lower body weight than cats with idiopathic cystitis ($p < 0.005$) and cats with urethral plugs ($p < 0.005$).

[3] The proportion of male cats was significantly higher in the group of cats with FIC than in cats with UTI ($p < 0.001$) and neoplasia ($p < 0.001$), and significantly higher in the group of cats with urethral plugs than in cats with UTI ($p = 0.001$) and neoplasia ($p = 0.002$).

Table 3 Living conditions, feeding regimens, and seasonal distribution of presentation of all cats with FLUTD and cats within the five different diagnosis groups (number of cats, %). For the comparison of groups the Chi Square test was performed.

Tab. 3 Haltungsbedingungen, Fütterung und jahreszeitliche Vorstellung aller Katzen mit FLUTD und der Katzen mit den fünf häufigsten Diagnosen (Anzahl der Katzen, %). Der Gruppenvergleich wurde mithilfe des Chi-Quadrat-Tests durchgeführt.

	All cats n = 302	FIC n = 166	UTI n = 57	Urethral plug n = 31	Uroliths n = 21	Neoplasia[1] n = 11	p
Living conditions[2]							
Indoor	233 (83.8%)	127 (83.0%)	42 (80.8%)	27 (93.1%)	19 (90.5%)	8 (72.7%)	0.411
Outdoor	45 (16.2%)	26 (17.0%)	10 (19.2%)	2 (6.5%)	2 (9.5%)	3 (27.3%)	
Single cat household	159 (61.4%)	84 (59.6%)	31 (66.0%)	15 (53.6%)	9 (50.0%)	11 (100%)	0.719
2 cat household	66 (25.5%)	40 (28.4%)	9 (19.1%)	9 (32.1%)	5 (27.8%)	0	
3 cat household	17 (6.6%)	11 (7.8%)	2 (4.2%)	2 (7.1%)	2 (11.1%)	0	
≥ 4 cat household	17 (6.6%)	6 (4.3%)	5 (10.6%)	2 (7.1%)	2 (11.1%)	0	
Feeding regimens							
Dry food only	50 (24.7%)	30 (26.3%)	11 (19.3%)	3 (11.5%)	5 (38.5%)	0	0.566
Wet food only	21 (10.4%)	12 (10.5%)	3 (8.3%)	4 (15.4%)	0	0	
Dry and wet food	107 (53.0%)	61 (53.5%)	19 (52.8%)	14 (53.8%)	6 (46.2%)	4 (80%)	
Special diet	24 (11.9%)	11 (9.6%)	3 (8.3%)	5 (19.2%)	2 (15.4%)	1 (20%)	
Seasonal distribution							
Spring	71 (23.5%)	34 (20.5%)	19 (33.3%)	8 (25.8%)	3 (19.0%)	4 (36.4%)	0.432
Summer	82 (27.2%)	48 (30.1%)	18 (29.8%)	6 (16.1%)	5 (33.3%)	1 (9.1%)	
Autumn	81 (26.8%)	42 (26.5%)	12(24.6%)	9 (25.8%)	6 (28.6%)	4 (36.4%)	
Winter	68 (22.5%)	42 (25.9%)	8 (15.8%)	8 (22.6%)	7 (38.1%)	2 (9.1%)	

FLUTD = feline lower urinary tract disease, FIC = feline idiopathic cystitis, UTI = bacterial urinary tract infection

[1] Not included in statistical analysis of feeding regimens and numbers of cat in the household.

[2] Data were not available for all cats. Percentages present proportions of cats with available information.

Urinalyses findings

In 193/302 cats (63.9%) urine samples were obtained via cystocentesis and in 109/302 (36.1%) via urinary catheter. The number of catheter derived samples was significantly higher in cats with urethral plugs than in cats with UTI ($p < 0.001$). Microscopic hematuria (> 10 erythrocytes/HPF) was noted in all groups with similar frequency (▶Table 6). Pyuria (> 5 leukocytes/HPF) was observed significantly more often in cats with UTI than in cats with FIC ($p < 0.001$).

In all cats with urethral plugs, identified crystals were struvites. Among cats with urolithiasis, four cats had struvite crystals and two cats had calcium oxalate crystals. The type of crystal could not be classified in one cat. Crystals were more often identified in cats with urethral plugs than in cats with FIC, UTI, and neoplasia ($p < 0.001$) and more often in cats with urolithiasis than in cats with UTI ($p = 0.002$).

Discussion

In the present study investigating cats with FLUTD, FIC was the most frequent diagnosis (55% of cases). This result is in accordance with the results of other studies recording an incidence of 51 to 63% (9, 12, 15, 17). The proportion of cats with UTI was higher than previously reported (4, 9, 12, 17). The very low incidence of UTI in previous studies from the United States of less than 3% (4, 12) can be attributed to different study populations that included mainly referred cases. In contrast, the present study comprises first-opinion cases and referred cases with a predominance of first-opinion cases. The study conducted by Saevik et al. (17) also included mainly first-opinion cases, however excluded cats with concurrent diseases such as chronic kidney disease, hyperthyroidism or diabetes mellitus. This may explain the lower incidence of UTI in Saevik's study (15.1%) compared to the present study (18.9%). The exclusion of cats with FLUTD symptoms that have concurrent diseases predisposing the cats to urinary tract infections probably leads to an underestimation of the incidence of UTI in the general cat population.

Diagnosis	Cats < 10 years (n = 210)	Cats ≥ 10 years (n = 67)	p	Odds ratio (95% CI)
FIC	65.2%	35.8%	< 0.001	0.297 (0.167–0.528)
UTI	12.9%	41.8%	< 0.001	4.866 (2.587–9.153)
Urethral plugs	13.3%	3.0%	0.022	0.200 (0.046–0.863)
Uroliths	7.6%	6.0%	0.791	0.770 (0.248–2.388)
Neoplasia	1.0%	13.4%	< 0.001	16.14 (3.391–76.79)

FIC = feline idiopathic cystitis, UTI = bacterial urinary tract infection, 95% CI = 95% confidence interval

Table 4
Incidence of the five most common diagnoses in cats less than 10 years of age and cats aged 10 years or older.

Tab. 4
Inzidenz der fünf am häufigsten gestellten Diagnosen bei Katzen unter 10 Jahren und Katzen im Alter von 10 Jahren oder älter

The higher number of cats with UTI in the present study could also explain the slightly higher mean age of all cats (6.7 years) compared to other studies (5.1 and 5.6 years) (4, 17), because cats with UTI were significantly older than cats with urethral plugs and FIC. The mean age of cats with FIC, urethral plugs and urolithiasis was similar to the previous reported average age between 4 and 6 years (9, 17). The likelihood for a certain diagnosis was clearly age dependent, and the incidences of UTI and neoplasia were significantly higher in cats that were 10 years or older. Similar findings of age-related incidences of diagnoses have been described by

Table 5 History and clinical signs of all cats with FLUTD and cats within the five diagnosis groups (number of cats, %). If comparison of all diagnosis groups with Chi Square test was significant ($p < 0.05$) (significant results in bold), comparison of individual groups was performed. Due to the multiple comparisons, a Bonferroni correction was applied and $p \leq 0.005$ was considered significant.

Tab. 5 Vorbericht und klinische Symptome aller Katzen mit FLUTD und der Katzen mit den fünf häufigsten Diagnosen (Anzahl der Katzen, %). Der Gruppenvergleich wurde mithilfe des Chi-Quadrat-Tests durchgeführt. Bei signifikantem Ergebnis ($p < 0.05$) (signifikante Resultate in Fettdruck) erfolgte ein Vergleich der einzelnen Gruppen miteinander. Aufgrund multiplen Testens wurde dabei eine Bonferroni-Korrektur durchgeführt und das Signifikanzniveau auf $p \leq 0.005$ gesetzt.

	All cats n = 302	FIC n = 166	UTI n = 57	Urethral plug n = 31	Uroliths n = 21	Neoplasia n = 11	p
History							
1st episode	235 (77.8%)	128 (77.1%)	52 (91.2%)	22 (71.0%)	15 (71.4%)	9 (81.8%)	0.145
2nd episode	41 (13.6%)	24 (14.5%)	3 (5.3%)	7 (22.6%)	3 (14.3%)	0 (0%)	
3rd or more	23 (7.6%)	13 (7.8%)	2 (3.5%)	2 (6.5%)	3 (14.3%)	1 (9.1%)	
N.A.	3 (1.0%)	1 (0.6%)	0	0	0	1 (9.1%)	
Clinical signs							
Stranguria	163 (54.0%)	93 (55.3%)	31 (53.4%)	13 (41.9%)	13 (61.9%)	5 (45.5%)	0.826
Pollakiuria	77 (25.5%)	46 (27.4%)	18 (31.0%)	2 (6.5%)	2 (9.5%)	2 (18.2%)	**0.040**[2]
Periuria	36 (11.9%)	19 (11.3%)	7 (12.1%)	2 (6.5%)	2 (9.5%)	0 (0.0%)	0.733
Hematuria	128 (42.4%)	69 (41.1%)	32 (55.2%)	3 (9.7%)	16 (76.2%)	8 (72.7%)	**< 0.001**[3]
Obstruction	159 (52.6%)	96 (57.1%)	16 (28.5%)	31 (100%)[1]	14 (66.7%)	2 (18.2%)	**< 0.001**[4]

FLUTD = feline lower urinary tract disease, FIC = feline idiopathic cystitis, UTI = urinary tract infection; N.A. = data not available

[1] Not included in statistical analysis because per definition all cats had obstructive disease.

[2] Pollakiuria was significantly more often observed in cats with UTI than in cats with uroliths ($p = 0.002$) and in cats with FIC than in cats with uroliths ($p = 0.002$)

[3] Hematuria was significantly more often observed in cats with idiopathic cystitis, UTI, uroliths and neoplasia than in cats with urethral plugs (all $p < 0.005$).

[4] Obstruction was significantly more often observed in cats with FIC than in cats with UTI ($p = 0.002$).

Table 6 Urinalysis findings of all cats with FLUTD and cats within the five diagnosis groups (number of cats, %). Cats were categorized as hematuric or pyuric if more than 10 red blood cells per high power field (HPF = 400-fold magnification) or more than five white blood cells per HPF were identified, respectively. If comparison of all diagnostic groups with Chi Square test was significant ($p < 0.05$) (significant results in bold), comparison of individual groups was performed. Due to the multiple comparisons, a Bonferroni correction was applied, and $p \leq 0.005$ was considered significant.

Tab. 6 Ergebnisse der Urinanalysen aller Katzen mit FLUTD und der Katzen mit den fünf häufigsten Diagnosen (Anzahl der Katzen, %). Eine Hämaturie oder Pyurie lag vor, wenn sich bei 400facher Vergrößerung (HPF) mehr als 10 Erythrozyten bzw. mehr als 5 Leukozyten identifizieren ließen. Der Gruppenvergleich wurde mithilfe des Chi-Quadrat-Tests durchgeführt. Bei signifikantem Ergebnis ($p < 0.05$) (signifikante Resultate in Fettdruck) erfolgte ein Vergleich der einzelnen Gruppen miteinander. Aufgrund multiplen Testens wurde dabei eine Bonferroni-Korrektur durchgeführt und das Signifikanzniveau auf $p \leq 0.005$ gesetzt.

	All cats n = 302	FIC n = 166	UTI n = 57	Urethral plug n = 31	Uroliths n = 21	Neoplasia n = 11	p
> 10 RBC/HPF	260 (90.9%)	151 (91.0)	51 (89.5)	28 (90.3)	21 (100%)	9 (81.8%)	0.448
> 5 WBC/HPF	145 (50.7%)	72 (43.4%)	44 (77.2)	14 (45.2%)	10 (47.6%)	5 (45.5%)	**< 0.001**[1]
Crystals	85 (29.7)	30 (18.1)	3 (5.3%)	23 (74.2)	7 (33.3%)	0	**< 0.001**[2]
USG < 1.035	134 (46.9%)	69 (41.6%)	35 (61.4%)	10 (32.3%)	10 (47.6%)	10 (90.9%)	**< 0.017**[3]

FLUTD = feline lower urinary tract disease, FIC = feline idiopathic cystitis, UTI = urinary tract infection, HPF = high power field, RBC = red blood cells, WBC = white blood cells USG = urine specific gravity

[1] Pyuria (> 5 leukocytes/HPF) was significantly more often seen in cats with UTI than in cats with FIC ($p< 0.001$).

[2] Crystals were significantly more often found in cats with urethral plugs than in cats with FIC, UTI and neoplasia (all $p < 0.001$) and more often in cats with urolithiasis than in cats with UTI ($p = 0.004$).

[3] Cats with neoplasia had significantly more often a USG < 1.035 than cats with FIC ($p = 0.003$) and cats with urethral plugs ($p = 0.001$).

Bartges and Barsanti (2). In cats older than 10 years with clinical signs of FLUTD, 45% suffered from UTI, and 17% of cats suffered from urolithiasis in combination with UTI (1). This has been attributed to the higher incidence of concurrent diseases such as chronic kidney disease, hyperthyroidism and diabetes mellitus.

The incidence of UTI of 12.9% in cats younger than 10 years in the present study was higher than previously reported and comparable to the results of Saevik et al. (17). Currently, textbooks describe feline UTI as an uncommon disease, that affects less than 3% of young to middle-aged cats with clinical signs of FLUTD (20, 21). However, these data rely on studies of referral populations in the United States (4, 12). In contrast, two previous studies from Switzerland (9) and Norway (17) and the present one clearly demonstrate that bacterial UTI should be considered as an important cause of FLUTD in cats of all ages. Routine urine culture and sensitivity testing should be performed in all cats with clinical signs of FLUTD.

As in previous studies (9, 17), the majority of affected cats were male, and the majority of male cats were castrated. Urethral obstruction was diagnosed in 52.6% of cases. This is higher than reported by Saevik et al. (17) with 28.6% obstructed cats but similar to the results reported by Gerber et al. (9) (58.4%). One reason for the high proportion of male obstructed cats in the present study population is that male cats are predisposed to obstruction due to their narrow penile urethral lumen, and that these patients often present as emergencies during the 24 hour emergency service of the hospital. The proportion of male cats was significantly higher in the group of cats with FIC and urethral plugs compared to cats with UTI and neoplasms. This mirrors the proportion of obstructed cats in different diagnosis groups, which was lowest in cats with UTI and neoplasia. In contrast to cats with FIC and urethral plugs, the sex distribution in these two groups of cats was almost balanced.

In the present study, the majority of cats were domestic shorthair and indoor cats. The breed distribution is in accordance with the hospital population and with other studies, in which domestic cats clearly outnumber the purebred cats. While in one previous study being pedigreed was identified as a risk factor for FIC (6), in all groups of the present study, the majority of cats were domestic shorthair cats and a predominance of purebred cats was not observed in the group of cats with FIC. This is in accordance with results of a study conducted in Belgium (7) that did not identify a higher incidence of FIC in purebred cats.

Several risk factors for FLUTD and FIC have previously been identified (6, 7). These include being overweight, the use of a litter box, a lower activity level, and having less access to outside. The majority of cats in all groups (80–93%) and also with FIC in the present study lived strictly indoors. This reflects a population of cats in an urban environment. Most of the cats were therefore exposed to several risk factors for FLUTD and FIC. The etiology of FIC is still unknown but the current consensus is, that local abnormalities of the bladder wall (14), an altered stress response (19) and neuroendocrine function (18) predispose certain cats for FIC and that environmental stress factors may act as trigger for clinical episodes (5). Although it has been shown that a deficient environment is not enough to provoke clinical signs of FIC (7), living strictly indoors may represent the trigger for clinical disease for predisposed cats because of a poorly stimulating environment or restricted possibilities and room for retreats from displeasing situations.

Results of several studies indicate that FLUTD and FIC occur more commonly during winter months (7, 8, 15). Such a seasonal predominance was not observed in the present study. Cats of all groups presented throughout the seasons with similar frequency. A possible explanation could be the high proportion of cats living strictly indoor in the present study with a more or less constant environment regarding temperature, humidity and hunting possibilities.

It is difficult and sometimes impossible to differentiate urethral plugs from obstructive FIC, as discussed by Gerber al. (9) and Saevik et al. (17). Urethral plugs can easily be missed due to flushing them back into the urinary bladder, which might be one reason for the relatively low proportion of cats with urethral plugs in the present study. Many urethral plugs are composed of struvite with a proteinaceous matrix (20), while some urethral plugs are so densely mineralized that they can be identified on radiographs. It has been proposed that crystalluria itself is not harmful to the bladder, and struvite crystalluria in the absence of other bladder pathologies is more likely a consequence of urethral obstruction than a cause of it (10). Several hypotheses for formation of struvite crystals in obstructed cats have been proposed (3, 20). Likely, the most important and accepted theory is that vasodilation and leakage of plasma proteins from the inflamed urethral wall leads to an increase of urine pH and protein precipitation, subsequent formation of struvite crystals and trapping of struvite crystals (20). It has been shown that crystalluria was significantly more likely in cats with FIC than in control cats or cats with other forms of FLUTD (12). In the present study as well, cats with urethral plugs and cats with uroliths had struvite crystals identified on urinalysis significantly more frequently than cats with other diagnoses. Although it is well accepted that urethral matrix crystalline plugs can form in cats with FIC and lead to obstruction, it is unclear if FIC is truly the underlying disease in cats with mineralized plugs and severe crystalluria or if abundant struvite crystalluria is a cause of FLUTD itself.

The observed clinical signs are similar to previous reported signs (9). Stranguria and hematuria were the most clinical signs observed by the owners. Pollakiuria was documented relatively infrequently but was observed in cats with FIC and UTI significantly more frequently than in cats with urolithiasis. FIC and UTI are known to be disorders that can be very painful and be associated with a permanent urge to urinate, which could explain the higher voiding frequency observed in cats with these diseases. In addition, the involvement of the urethra in the inflammatory process and partial obstruction of it in FIC can contribute to a higher proportion of cats with pollakiuria. Hematuria was less commonly noticed in cats with urethral plugs than in cats with any other diagnosis. Cats with urethral plugs and complete urethral obstruction do not pass any urine; therefore, grossly hematuric urine may not be noticed by the owners.

This was a retrospective study, and several limitations need to be mentioned. Firstly, information regarding the living conditions and history was not available in detail for all cats. A standardized questionnaire for the collection of all relevant information in cats with FLUTD was not designed at that point of time, and all informations were extracted from the regular medical record. Secondly, not all procedures were performed in all cats. In all cats, diagnostic imaging of the urinary tract was performed, and in more than half of the cats, ultrasound plus radiography were performed. Still, because not all cats were radiographed, radiodense urethroliths may have been missed. Thirdly, retrograde urethrography was not performed in these patients. Therefore, strictures of the urethra and radiolucent urethroliths may have been missed. Urethral strictures may be seen as a consequence of urethral trauma (iatrogenic or spontaneous) or as a congenital malformation. More than 80% of cats presented with their first episode of FLUTD, and there were only two non-adult cats included; therefore, the risk that these conditions may have been missed is acceptable. In addition, more than 90% of feline uroliths are composed of struvite or calcium oxalate (11), which are both radiodense and are visible without contrast studies.

Conclusion and clinical relevance

The results of the present study demonstrate that the predominant incidence of FIC in cats with FLUTD is comparable to results from other European studies and studies from the USA. However, the incidence of UTI was higher than reported in studies from the USA. There is an age-related difference in the frequency of diagnoses, with significantly higher incidences of FIC and urethral plugs in cats younger than 10 years and significantly higher incidences of UTI and neoplasia in cats 10 years of age or older.

Conflict of interest statement

None of the authors of this paper has a financial or personal relationship with other people or organizations that could inappropriately influence or bias the content of the paper.

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