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RESEARCH ARTICLE

Comparison of Ultrasonographic and Laboratory Findings in Feline Lower Urinary Tract Disease

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ABSTRACT

The aim of this study was to compare ultrasonographic and laboratory findings in cases of lower urinary tract disease diagnosed in cats randomly brought to the clinic with urinary tract complaints. The study material consisted of 50 cats of different breeds, age and sex diagnosed with feline lower urinary tract disease. The diagnosis was based on anamnesis, clinical findings, urine and biochemical analyses and ultrasonographic findings. Serum biochemistry and urine analysis results and ultrasonographic examination data were evaluated comparatively. The results of the study emphasise that cases of lower urinary tract disease in cats are most frequently encountered in male individuals and that there are significant differences between breeds. In the study, the most common problems in 50 cats diagnosed with lower urinary tract disease were struvite crystalluria; 30% and idiopathic cystitis; 28%, respectively. The data obtained revealed a significant positive moderate correlation between resistive index and serum phosphorus values and a significant positive moderate correlation between resistive index and blood-urea nitrogen and creatinine. There was also a significant positive moderate correlation between resistive index and urine protein values. The mean serum blood-urea nitrogen, creatinine and phosphorus concentrations measured in cats with lower urinary tract disease were relatively high, although there were individual differences between the cases. However, it is noteworthy that the mean blood urea-nitrogen and creatinine values were within normal limits, although there were individual differences, especially in cases of partial obstruction. One-month follow-up showed that the blood urea-nitrogen, creatinine and phosphorus values measured at the first presentation to the clinic were higher in cats that died than in surviving animals. The data presented in this study also revealed the presence of a positive significant correlation between urinary protein and serum blood urea-nitrogen and phosphorus values. The ultrasonographic renal measurement data evaluated in this master thesis study were recorded within the average normal values, although there were individual differences between the subjects. The mean resistive index value measured was below the upper limit of normal of 0.7. The results emphasise the importance of comparative evaluation of all measurement data in the diagnosis, patient follow-up, prognosis and determination of the correct treatment method in cases of feline lower urinary tract disease.

Keywords: Feline, FLUTD, Kidney, Resistive index, Urinalysis, USG

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Kedi Alt Üriner Sistem Hastalığında Ultrasonografik ve Laboratuvar Bulguların Karşılaştırılması

ÖZ

Bu çalışmada idrar yolu şikâyeti ile randomize olarak kliniğe getirilen kedilerde teşhis edilen alt üriner sistem hastalığı olgularında ultrasonografik ve laboratuvar bulgularının karşılaştırılması amaçlandı. Çalışma materyalini alt üriner sistem hastalığı tanısı alan, farklı ırk, yaş ve cinsiyette 50 kedi oluşturdu. Tanı; anemnez, klinik bulgular, idrar ve biyokimyasal analiz sonuçları ve ultrasonografi bulgularıyla kondu. Serum biyokimya ve idrar analiz sonuçları ve ultrasonografik muayene verileri karşılaştırmalı olarak değerlendirildi. Çalışma sonuçları kedilerde alt üriner sistem hastalığı olgularına en sık erkek bireylerde rastlandığına ve yine ırklar arası belirgin farkların olduğuna vurgu yapmaktadır. Çalışmada alt üriner sistem hastalığı tanısı alan 50 kedide en sık rastlanan promlemler, sırasıyla, strüvit kristalüri; %30 ve idiyopatik sistit; %28 olarak belirlendi. Elde edilen veriler; rezistif indeks ile serum fosfor değeri arasında pozitif orta düzeyde ve rezistif inseks ile kan-üre nitrojen ve kreatinin arasında ise pozitif orta düzeye yakın anlamlı bir ilişki ortaya koydu. Rezistif indeks ve idrar protein değerleri arasında da pozitif orta düzeye yakın anlamlı bir ilişki belirlendi. Alt üriner sistem hastalığı olan kedilerde ölçülen ortalama serum kan-üre nitrojen, kreatinin ve fosfor konsantrasyonlarının, olgular arasında bireysel farklar olmakla birlikte, nispi olarak yüksek olduğu gözlendi. Bununla birlikte; özellikle kısmi obstrüksiyonun gözlendiği vakalarda ortalama kan üre-nitrojen ve kreatinin değerlerinin, bireysel farklar olmakla birlikte, normal sınırlarda belirlenmesi dikkat çekicidir. Bir ay süreli gerçekleştirilen takip sonrası öldüğü belirlenen kedilerde, kliniğe ilk başvuruda ölçülen kan üre-nitrojen, kreatinin ve fosfor değerlerinin, sağkalan hayvanlara göre daha yüksek olduğunu belirlendi. Sunulan araştırma verileri, aynı zamanda, idrar protein ile serum kan üre-nitrojen ve fosfor değerleri arasında pozitif anlamlı bir ilişkinin varlığını da ortaya koydu. Bu yüksek lisans tez çalışmasında değerlendirmeye alınan ultrasonografik renal ölçüm verileri, olgular arasında bireysel farklar olsa da, ortalama normal değerler arasında kaydedildi. Ölçülen ortalama rezistif indeks değeri normal üst sınır olarak belirtilen 0.7'nin altındaydı. Sonuçlar; kedi alt üriner sistem hastalığı olgularında tanıda, hasta takibinde, prognozun tayininde ve doğru tedavi yönteminin tespitinde tüm ölçüm verilerinin karşılaştırmalı değerlendirmesinin önemine vurgu yapmaktadır.

Anahtar sözcükler: Böbrek, FLUTD, Kedigiller, Rezistif indeks, Urinalysis, USG

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INTRODUCTION

Feline Lower Urinary Tract Disease (FLUTD) is a common syndrome in veterinary medicine (Widyawati, et.al., 2022). It is found in cats of all ages and breeds. It is frequently seen in middle-aged, overweight, neutered male cats. Indoor cats that are not mobile, restricted to outdoor environment and fed with dry food are in the risk group (Guun-Moore, 2003).

Current studies classify FLUTD into two categories: FLUTD of unknown cause (idiopathic) and FLUTD of known cause. Urethral obstruction is commonly seen in 18-58% of cases during FLUTD. Therefore, FLUTD is also divided into obstructive FLUTD and non-obstructive FLUTD (Ay et al., 2021; Sabino, 2017; Savik et al., 2011 and Woolf, 2012). During this disease, idiopathic cystitis (FIC), urolithiasis, urethral plaque, tumour, anatomical defects, behavioural disorders, urinary tract infections (UTI) are frequently encountered in cats. The clinical symptoms of FLUTD include one or more of the following: pollakuria, dysuria, haematuria, stranguria, periuria (Forrester and Roudebush, 2007). In cats brought to the clinic with urinary system problems, correct diagnosis is extremely important for the prognosis of the disease. Imaging is important in diagnosis. For this purpose, x-ray and ultrasonography are used. Complete blood count, serum biochemistry, urine analysis, microscopic examination are other basic and auxiliary diagnostic methods (Hostutler et al., 2005).

MATERIALS and METHODS

Animal Material

The animal material of this study consisted of 50 cats with a mean age of 6.322±0.658 (Mean±SE), 21 females and 29 males, randomly admitted to the clinic with urinary tract complaints and diagnosed as FLUTD. No breed, sex and age differences were sought in the selection of the material. The study was performed at Pasteur Veterinary Polyclinic (Kocaeli, Turkey). The main complaints recorded in the anamnesis of the patients were pain during urination, blood in the urine, constant urge to urinate, spending too much time in the litter box, urinary incontinence and urinating in different areas. All cats included in the study were clinically diagnosed with FLUTD. Informed consent form was obtained from each owner.

For the research, Afyon Kocatepe University Animal Experiments Local Ethics Committee (AKÜ-HADYEK) was applied and necessary permissions (04.10.2022 date and 99 number) were obtained. This article was published in Veterinarian Ender Erkoç's Master's Thesis with the same title (AKÜ, Institute of Health Sciences, Thesis no: 869155, 2024/016).

Devices and Equipment

Haematological evaluations were performed with Mindray BC 5000 Vet, biochemical tests were performed with Fujifilm Dri-Chem NX500V, and complete urinalysis was performed with Vetscan UR devices. Philips Affiniti 50 colour doppler device was used for ultrasonographic imaging. Urine samples were collected with Buster sterile cat urinary catheter (1.0x130 mm) or cytocentesis method. Microscopic examination of urine was performed with Abaxis HD microscope, VD6M HD Camera w/hd.

Method

Urine Analysis

The collected urine samples were examined macroscopically for colour and then pH, leukocyte, protein, blood and nitrite parameters were evaluated by strip examination. The samples were centrifuged at 5000 rpm for 5 min and microscopic examination was performed according to the technique. In microscopic examination, the samples were evaluated for the presence of erythrocytes, leucocytes, epithelium and crystals.

Collection of Blood Samples

Blood samples were collected from the vena cephalica antebrahium into tubes containing EDTA for haematological examination and tubes containing gel-clot activator for biochemical analyses. Haemogram and biochemical analyses were performed simultaneously, without waiting.

Haematological Analysis

Leukocyte (WBC), erythrocyte (RBC), haemotocrit (HCT), platelet (PLT) values were measured with an automatic blood counting device in blood samples taken in EDTA tubes.

Biochemistry Analysis

Blood sera obtained from the samples taken in tubes containing gel-clot activator were analysed for blood urea nitrogen (BUN), creatinine (CREA), potassium (K), phosphorus (P) and sodium (Na) using a biochemistry autoanalyzer.

Imaging Methods

5-8 Mhz microconvex probe was used in the study. Images were recorded in longitinal and ventradorsal position. Patients were not sedated to prevent any effect on ultrasonography results. Renal arterial resistive index (RI) and renal aspect-height measurement, renal volume and cortex/medulla ratio were determined using colour and PW Doppler methods in accordance with the technique.

Survival

Patients were followed up for one month after the treatment procedure to determine the prognosis. The status at the end of one month was recorded as recovered (3), ongoing/follow-up (2) and lost (1).

Statistical Analyses

SPSS 21.0 windows package programme was used to analyse the data obtained in the study. Firstly, frequency, percentage, arrhythmic mean and standard deviation values were given for descriptive statistics. The relationships between the parameters were presented by Pearson correlation method. ANOVA (one-factor analysis of variance) was used to compare these parameters according to survival status. Statistical significance level was determined as $p<0.05$.

RESULTS

Evaluation of Clinical Findings

The breed and sex distribution of 50 cats diagnosed with FLUTD, which constituted the material of this study, were recorded. Of the 50 animals used in the study, 42% were female and 58% were male. The material consisted of 28% tabby, 22% crossbred and 22% british breed cats. Detailed data were given in Table 1.

Table 1. Breed variable findings of the cats

Race	Frequency	Percentage (%)
Ankara	1	2
British	11	22
Chinchilla	1	2
Sphenks	1	2
Melez	11	22
Persian	3	6
Scottish	6	12
Siyam	2	4
Tabby	14	28
Totally	50	100

In the survival distribution; the rate of animals that died was 14% (n=7), the rate of animals that were followed up was 18% and the rate of animals that recovered was 68%. Of the animals, 30% had struvite crystalluria, 28% had idiopathic cystitis and 20% had signs of renal disease (Table 2). Among the 50 FLUTD cases in our study, partial obstruction was detected in 17 of 29 cases (34%) with idiopathic cystitis (n=5) and struvite crystalluria (n=12) and urine flow was restored by probing in all of these cases.

Table 2. Etiological findings of the cats in the study

Race	Frequency	Percentage (%)
Haemorrhagic cystitis	1	2
Emphysematous cystitis	1	2
Diabetes	1	2
Hydronephrosis	3	6
Idiopathic cystitis	14	28
Constipation	1	2
Pathology (Neoplasia)	1	2
Signs of renal disease	10	20
Presence of sediment in urine	3	6
Struvite crystalluria	15	30
Totally	50	100

According to the data obtained from ultrasonographic evaluation, mean bladder wall thickness (MDK): 0.3590±0.35, ureter width (UG): 0.3484±0.45, kidney width (BEN): 2.6380 ± 0.349, kidney length (BBOY): 3.9024 ± 0.68963, kidney height (BYÜK): 2.5668 ± 0.48963, cortex medulla ratio (C/M): 0.9018±0.44 and renal arterial resistive index (RI): 0.6495±0.09 (Table 3).

Table 3. Mean findings of ultrasonographic values

	M (Mean)	SS (Standard deviation)	Min.	Max.
MDK (cm)	0.3590	0.35842	0.10	2.46
UG (cm)	0.3484	0.45150	0.05	2.38
BEN (cm)	2.6380	0.34930	2.00	3.57
BBOY (cm)	3.9024	0.68963	2.08	3.67
BYÜK (cm)	2.5668	0.48963	1.62	2.24
C/M (cm)	0.9018	0.44409	0.19	3.15
RI	0.6495	0.09050	0.42	0.80

MDK; bladder wall thickness, UG; ureter width, BEN; kidney width, BBOY; kidney length, BYÜK; kidney height, C/M; cortex/medulla ratio, RI; arterial renal resistive index.

According to the mean values of the measured biochemical parameters; BUN: 48.1106±40.95, CREA: 2.2334±3.06, P: 6.2445±2.97, K: 4.1815±0.68, Na: 149.1538±9.01 (Table 4).

Table 4. Descriptive statistics for biochemical parameters

	M (Mean)	SS (Standard deviation)	Min.	Max.
BUN (mg/dL)	48.1106	40.95330	8.75	140.00
CREA (mg/dL)	2.2334	3.06405	0.40	19.19
P (mg/dL)	6.2445	2.97135	0.55	15.00
K (mg/dL)	4.1815	0.68962	3.20	5.50
Na (mg/dL)	149.1538	9.01326	132.00	165.00

BUN; blood urea-nitrogen, Crea; creatinine, P; phosphorus, K; potassium, Na; sodium.

The mean values of haemogram parameters were WBC: 12.4238±8.32, RBC: 9.1592±2.66, HCT 35.0780±10.24 and PLT 243.8000±123.73. The mean values of some urine parameters were PRO: 1.6286±1.03, BIL: 1.9429±0.90, NIT: 0.3429±0.59, DANS: 1000.5143±174.07, pH 6.6541±0.63.

In the evaluation made within this framework, a positive moderate significant correlation was found between RI and P value, while a positive moderate significant correlation was found between RI and BUN and CREA values. Again, a significant correlation close to positive moderate level was found between BEN and Na values. A significant correlation close to positive moderate level was determined between BBOY and P values (Table 5).

Table 5. Correlation analysis results for the relationship between ultrasound values and biochemistry parameters

Ultrasound values	Biochemistry values				
	BUN (mg/dL)	CREA (mg/dL)	P (mg/dL)	K (mg/dL)	Na (mg/dL)
MDK (cm)	-0.138	-0.134	-0.151	-0.132	0.034
UG (cm)	-0.207	-0.148	-0.229	-0.179	-0.242
BEN (cm)	0.140	0.206	0.045	0.039	0.365*
BBOY (cm)	-0.014	0.148	0.338*	0.189	-0.172
BYÜK (cm)	0.031	0.229	0.147	0.084	0.181
C/M (cm)	-0.034	-0.163	-0.072	0.155	0.198
RI	0.385*	0.379*	0.491**	0.277	0.044

MDK; bladder wall thickness, UG; ureter width, BEN; kidney width, BBOY; kidney length, BYÜK; kidney height, C/M; cortex/medulla ratio, RI; arterial renal resistive index, BUN; blood urea-nitrogen, Crea; creatinine, P; phosphorus, K; potassium, Na; sodium. *$p<0.05$; **$p<0.01$

According to the results of Pearson correlation analysis, a significant relationship between RI and TIT PRO values was found to be positive and close to medium level. Again, a positive medium level significant relationship was found between BBOY and NIT values. There is no significant relationship between other values (Table 6).

Table 6. Correlation analysis results for the relationship between ultrasound values and urine parameters.

Ultrasound values	Urine parameters				
	PRO (mg/dL)	BLO (urine)	NIT (urine)	DANS (urine)	pH (urine)
MDK (cm)	-0.246	0.168	-0.108	0.113	0.171
UG (cm)	-0.277	0.040	0.064	0.114	0.056
BEN (cm)	0.127	-0.065	-0.076	0.293	0.144
BBOY (cm)	0.007	0.108	0.549**	0.043	0.148
BYÜK (cm)	0.044	0.124	0.218	0.097	0.161
C/M (cm)	-0.052	-0.305	-0.011	0.056	0.220
RI	0.396*	0.037	0.178	0.103	0.078

*MDK; bladder wall thickness, UG; ureter width, BEN; kidney width, BBOY; kidney length, BYÜK; kidney height, C/M; cortex/medulla ratio, RI; arterial renal resistive index, PRO; protein, BIL; bilirubin, NIT; nitrite, DANS; density. *p<0.05; **p<0.01*

According to the results of Pearson correlation analysis, a positive strong significant relationship was found between PRO value and BUN and P values. A positive moderate significant correlation was found between PRO and CREA and K values (Table 7).

Table 7. Correlation evaluation results for the relationship between biochemistry values and urine parameters

	PRO (mg/dL)	BIL (mg/dL)	NIT (urine)	DANS (urine)	pH (urine)
BUN (mg/dL)	0.729**	0.149	-0.062	-0.008	-0.150
CREA (mg/dL)	0.557**	0.135	-0.058	0.004	-0.187
P (mg/dL)	0.662**	0.195	0.130	0.049	-0.083
K (mg/dL)	0.519**	-0.024	0.168	-0.290	-0.136
Na (mg/dL)	-0.066	-0.072	-0.206	-0.088	-0.124

*BUN; blood urea-nitrogen, Crea; creatinine, P; phosphorus, K; potassium, Na; sodium, PRO; protein, BIL; bilirubin, NIT; nitrite, DANS; density.*p<0.05; **p<0.01*

When BUN and CREA parameters were compared with survival status, a positive and highly significant relationship was found. The relationship between P, urine PRO parameters and survival status is significant at positive and strong level. The relationship between WBC, K and urine DANS parameters and survival was found to be significant at positive and strong level (Table 8).

Table 8. Comparison of some parameters according to survival status of cats.

Parameters	Groups	Mean	SS(Standart deviation)	P
BUN (mg/dL)	Dead	105.54	43.17	0.000
	Monitoring	53.73	39.01	
	Recovering	34.79	29.85	
CREA (mg/dL)	Dead	6.07	6.06	0.000
	Monitoring	2.46	2.60	
	Recovering	1.38	1.30	
P (mg/dL)	Dead	9.62	3.88	0.003
	Monitoring	5.90	1.59	
	Recovering	5.53	2.47	
K (mg/dL)	Dead	4.81	0.64	0.010
	Monitoring	4.48	0.66	
	Recovering	3.97	0.61	
WBC(10^9/L)	Dead	20.12	11.26	0.019
	Monitoring	13.09	6.23	
	Recovering	10.65	7.37	
PRO (urine)	Dead	2.60	1.14	0.009
	Monitoring	2.16	1.16	
	Recovering	1.29	0.80	
DANS (urine)	Dead	819.00	457.30	0.036
	Monitoring	1023.33	7.08	
	Recovering	1032.62	6.18	

*BUN; blood urea-nitrogen, Crea; creatinine, P; phosphorus, K; potassium, Na; sodium, PRO; protein, BIL; bilirubin, NIT; nitrite, DANS; density.*p<0.05; **p<0.01*

BUN, CREA, P and RI values measured in the 50 cats which were diagnosed as partial obstruction (n=17) and then died (n=7) are presented in the table below (Table 9).

Table 9. Descriptive statistics in cats with partial obstruction (Mean±SE).

Status	CREA (mg/dl)	BUN (mg/dl)	P (mg/dl)	RI
Partial obstruction	1.258±0.311	36.472±7.609	5.341±0.493	0.635±0.021
Dead	6.077±2.293	105.542±16.317	9.628±1.467	0.701±0.045

BUN; blood urea-nitrogen, Crea; creatinine, P; phosphorus, K; RI; resistive index.*p<0.05; **p<0.01

DISCUSSION

Lower urinary tract diseases are frequently encountered in the clinic. The prevalence of lower urinary tract diseases in cats has been reported as 3.3%. The recurrence rate within one year is 1%. It was determined that 4.5%-8% of cats admitted to animal hospitals and veterinary clinics had FLUTD (Lekcharoensuk et al., 2001; Longstaff et al., 2017). In the present study, besides biochemistry and urine analysis data, imaging (ultrasonography) was also used to evaluate the disease. The results contain relative data for patient prognosis.

In a prevalence-based study on the relationship between lower urinary tract diseases and gender in cats, it was reported that the disease was most commonly observed in neutered males, followed by neutered females, active males and active females, respectively (Lekcharoensuk et al., 2001). In another study, it was reported that 82.1% of 185 cats diagnosed with FLUTD were male and 17.9% were female (Nururrozi et al., 2020). In a report, of 119 cats diagnosed with FLUTD; 73.9% were male and 26.1% were female (Savik et al., 2011). In all studies, it is observed that the risk of FLUTD is higher in males. In this study, 58% of the patients admitted to the clinic were male cats. The data of the study are compatible with other gender studies. The higher incidence of obstruction in male cats may be related to the anatomy of the urethra and the fact that obstructive cats are more easily recognised by the owners than others.

In this study, tabby cats were found to be the most common breed with FLUTD with a rate of 28%. The second most common breed was British and crossbred cats with the same rate of 22%. The third most common breed with FLUTD was Scottish (12%). The other breeds were Persian (6%), Siamese (4%), Angora (2%), Sphenx (2%) and Chinchilla (2%). In a study on obstructive lower urinary tract diseases conducted in Aydın province of Turkey, the breed variability was reported as; Mixed breed 48% (13), Persian 14.81% (4), British 11.11% (3), Scottish 11.11% (3), Siamese 11.11% (3), Ankara 3.70% (1) (Ay et al., 2021). In another study, the breed prevalence in 78 cats diagnosed with FLUTD was determined as Domestic Shorthair (66.7%), Persian (26.9%), American Shorthair (2.6%), Exotic Shorthair, Scottish Fold and Siamese (1.3%), respectively (Piyarungsri et al., 2020). Regional ownership preferences and the fact that the preference for ownership is probably concentrated on some breeds may have been effective on the results of this research.

In this study, in 50 cats with FLUTD, mortality was 14% (n=7) and recovery rate was 68% after one month follow-up. The rate of cats requiring follow-up was 18% (n=9). Savik et al. (2011) determined the mortality rate in cats with FLUTD as 20% (n=10/50), reported that 23 cats (46%) had no recurrence and three cats (6%) were euthanised after diagnosis. In another study, mortality and recurrences due to lower urinary tract obstruction in cats were investigated. Accordingly, mortality was determined as 8.5% and recurrences were 22% in the first six months (Segev et al., 2011).

The most important complications observed in cats with FLUTD are renal problems due to hydronephrosis and acute kidney injury. This condition is frequently encountered in obstructive FLUTD cases (Neri et al., 2016). In the present study, mortality (14%) was thought to be due to renal-related complications and evidence of renal disease (n=10 and CREA; 2.233±3.064 mg/dL, BUN; 48.110±40.953), as well as the relatively high mean age of the cats in the study (6.322±4.412 (Mean±SD) mean age).

Nururrozi et al. (2020) found idiopathic cystitis in 103, urinary tract infection in 47, urolithiasis in 24, urethral plaque in 9, and neoplasia in 1 of 185 cats diagnosed with FLUTD (Nururrozi et al., 2020). In another study, 59 (53%) cats with FLUTD had idiopathic cystitis, while urolithiasis was reported in 13 (12%) cats (Lund et al., 2013). In a study on lower urinary tract infections in cats, crystal-induced obstruction was reported in 21% and bacterial urinary tract infection in 2% of the cats included in the study (Kruger et al., 1991).

In a recent study on 77 cats with FLUTD, 57.7% had idiopathic cystitis and 18% had struvite crystalluria (Piyarungsri et al., 2020). In our study, the most common stone type was struvite 30% (15%). Idiopathic cystitis and renal disease were detected in 28% (n=14) and 20% (n=10) of the cases, respectively. These were followed by hydronephrosis, sediment, haemorrhagic cystitis, emphysematous cystitis and other pathologies (neoplasia). Similar to previous studies (Buffington et al., 1997, Piyarungsri et al., 2020), struvite calculi and idiopathic cystitis were found at high rates in this study.

The presence of uroliths may vary according to the diet of cats (Osborne et al., 2009). In a study of 131 cats, 44.3% struvite stones and 43.5% calcium oxalate stones were found (Ortega et al., 2023). The results of another 25-year study showed that the rate of urinary stones encountered in cats in 1981 was 78% struvite and 2% calcium oxalate, while this rate increased to 55% for calcium oxalate and decreased to 33% for struvite between 1994-2002. In 2006, the incidence of struvite increased again and reached 50%, while calcium oxalate was found to be 39% (Osborne et al., 2009).

Although FLUTD is a disease of the lower urinary tract, it may be associated with different diseases. If FLUTD progresses and/or treatment is started late, renal failure may occur (Guun-Moore, 2003). FLUTD may be accompanied by other systemic diseases such as diabetes mellitus. Results of a study in 141 cats with diabetes mellitus showed that 18 cats also had urinary tract infections (Bailiff et al. 2006). In another study investigating urinary tract infections in cats with hyperthyroidism, diabetes and chronic kidney disease, it was reported that urinary tract infections were observed in 12% of 90 cats with hypertroidism, 12% of 57 cats with diabetes and 22% of 77 cats with chronic kidney disease (Mayer-Roenne et al., 2007). In another study on chronic renal failure, bacterial urinary tract infection was determined in 16.7% of 74 cats (Hostutler et al., 2005). In the present study, the 'n' number was lower than in the aforementioned studies, and 10 of the 50 cats with FLUTD had evidence of renal diseases, only one cat had emphysematous cystitis and one cat had diabetes mellitus. These results also indicate that FLUTD may present clinically in different ways.

FLUTD is affected by systemic diseases and renal pathologies. Therefore, blood parameters may vary in each FLUTD patient (Guun-Moore, 2003). In a study, HCT 35.26 ± 3.82 and WBC 17.436 ± 7.757 were determined in cats with obstructive FLUTD, while HCT 34.65 ± 4.73 and WBC 6.088 ± 2.728 were determined in cats with nonobstructive FLUTD (Evangelista et al., 2023). In the present study, WBC was 12.4238± 8.32 and HCT was 35.0780± 10.24.

WBC and HCT are affected by systemic diseases, secondary infections and conditions such as chronic renal failure (Wood, 2017). The results of the present study are similar to the results mentioned above.
In a study, serum biochemistry values were checked in cats with urethral obstruction. It was reported that 28 of the cats constituting the material were nonazotemic, 19 cats had moderate azotemia, and 35 cats had severe azotemia. It was also reported that 33 of these cats had severe hyperkalaemia (Nevins et al., 2015). In another study, urea was determined above the reference value in 21 of 26 cats with obstructive FLUTD. Creatinine was determined above the reference range in 20 cats (Neri et al., 2016). In our study, the mean BUN value of the cats was 48.11±40.95 and the mean CREA value was 2.23±3.06. This result is compatible with the studies of Nevins et al. (2015) and Neri et al. (2016). Among the 50 FLUTD cases in our study, 'partial obstruction' was detected in 17 (34%) of a total of 29 cases of idiopathic cystitis and struvite crystalluria. In all of these patients, the obstruction was opened by probing. Of these patients, 5 were found to have idiopathic cystitis and 12 had struvite crystalluria. The mean BUN, CREA and P values measured in these cases (n=17, partial obstruction) were 36.4718±7.6099, 1.2588±0.3109 and 5.3407±0.4928, respectively (mean±SE). Urethral obstruction can be seen at a high rate of 18-58% in FLUTD cases. FLUTD can also be classified as obstructive and non-obstructive (Ay et al., 2021; Sabino, 2017; Sevik et al., 2011 and Woolf, 2012). In obstructive FLUTD cases, the kidneys are affected due to the disruption of urine flow. Therefore, an increase in BUN and CREA levels is observed. RI values measured in FLUTD cases in which the kidney is affected also increase (Evangelista et al., 2023). In the present study, a significant positive correlation was found between RI and BUN and CREA values in the evaluation of 50 cats (partially obstructive and non-obstructive). The RI value measured for all cases was below the reference range of 0.7, and when evaluated separately; 0.6350±0.021 (mean±SE) in cases of partial obstruction (n=17) and 0.7014±0.045 (mean±SE) in dead cats (n=7), which were higher in this group, were determined in the measurements made at the first presentation to the clinic in all the cats.
Mortality in renal diseases is associated with kidney-related complications, tumour presence and geriatrics (Bartges et al., 1996; Segev et al., 2011; Sabino, 2017; Webb, 2018). In this study, when BUN and CREA levels were compared with survival status, it was revealed that there was a positive very strong significant relationship (0.05<p).
Urine analysis is an easy, fast and practical method for the diagnosis and prognosis of FLUTD. Microscopic examination of urine samples is a necessary application in diagnosis (Lulich 2007). In this study, struvite crystalluria was found in 15 of 50 cases and the presence of inflammatory sediment was found in three cases. On the other hand, PRO 1.63±1.03, BIL 1.94±0.90, NIT 0.34±0.59, DANS 1000.5±17.41 and pH 6.65±0.63 were determined in complete urine analysis (TIT).
Proteinuria in cats is usually associated with conditions such as urinary tract infections, high-protein diet feeding, urinary tract-related pathologies, hypertension, diabetes, parasites and acute/chronic renal failure (Wood, 2017). Evangelista et al. (2023) in their study, according to TIT analysis data in 21 cats with obstructive FLUTD; determined the protein level as +3 and +2 in non-obstructive cats. Obstructive FLUTD is the most common and fatal cause of postrenal acute renal injury. Acute renal injury results from increased pressure within the renal pelvis and ureter reducing renal blood flow and glomerular filtration rate. Loss of renal function was determined within 24 hours after the obstructive event and acute kidney injury was detected. Azotemia and hyperkalemia are mainly encountered in acute renal damage (Fischer et al. 2009). In this thesis study, serum potassium concentration was measured as 4.18±0.68, while proteinuria in TIT was on average; It was detected in the +1, +2 range. Hyperkalaemia is an early sign of acute urinary obstruction. It is not surprising to see hyperkalaemia in obstructive FLUTD cases. In the study, a positive moderate significant correlation was found between TIT PRO and CREA and serum potassium values. In addition, a positive moderate significant correlation was found between TIT PRO and measured RI values. According to the results of Pearson correlation analysis, a positive strong significant correlation was found between TIT PRO value and BUN and P values (0.05<p). In this study, the relationship between WBC, potassium and TIT DANS parameters and survival was found to be strongly positive and significant (0.05<p).
In veterinary medicine, urine density can be measured by complete urinalysis (TIT) or refractometry. In the study, densitometry was evaluated by TIT. In healthy cats, an average concentrated urine of 1.035 and above is produced. Many factors can cause high or low density. Apart from the kidney, endocrine diseases, steroid use, diuretic drugs, fluid therapy or organic solutes such as protein and amino acids affect the density (Wood, 2017). In a study performed in 21 obstructive cats, the mean pH was found to be 6.6 ± 0.7 and the density was found to be 1.025.
In cats with non-obstructive FLUTD, the mean pH was determined as 7.8 ± 1.5 and the density was determined as 1.040 (Evangelista et al., 2023). TIT results in cats with FLUTD experiencing short- and long-term obstruction were reported as follows: In short-term obstruction; pH was 7.92±0.12, in long-term obstruction 8.25±0.35 and the density was 1.022.36±3.27 in short-term obstruction and 1018.75±6.46 in long-term obstruction. The amount of TIT protein was determined as +2 and +3 in both groups, respectively (Ay et al. 2021). In the presented

study, it was evaluated that the underlying factors causing FLUTD, although they did not lead to severe renal failure, could affect renal function acutely.

In this study, the pH value was determined as 6.65±0.63. pH in cats is affected by urinary tract infections and bacteria causing infection can increase urine pH (Rizzi 2014). The urine pH of cats diagnosed with struvite crystalluria is usually high, that is, alkaline (≥6.6). On the other hand, calcium oxalate crystalluria is more common in male cats, which usually have acidic urine pH (Grauer 2015). It has been observed that the urine pH of cats fed in their natural environment varies between 6.0 and 7.0 (Timothy 1996). Similar results were obtained in this study, and reasons such as feeding with commercial dry food, inactivity, drinking little water, and the cat being a male are all causes of struvite crystalluria (Kelliher 2022).

Morphological evaluation of kidney and urinary bladder is important in patients with FLUTD. Measurements contribute to the diagnosis of the disease. It has been explained that kidney size may vary according to race, previous disease, and gender in ultrasonographic evaluation (Debruyn et al. 2012). In our study; mean MDK was determined as 0.36±0.35, UG as 0.35±0.45, BEN as 2.638±0.349, BBOY as 3.902±0.689, BYUK as 2.567±0.489, C/M as 0.90±0.44, RI as 0.65±0.09. In one study, kidney thickness (cm) was determined as 0.26 ± 0.11 in cats with non-obstructive FLUTD and 0.19 ± 0.06 in cats with obstructive FLUTD. Kidney length (cm) in the left kidney was 3.87 ± 0.24 in non-obstructive and 4.49 ± 0.43 in obstructive. In a study on obstructive and non-obstructive FLUTD, urinary bladder wall measurements (cm) were measured as 0.12 ± 0.05 in the control group, 0.26 ± 0.11 in the non-obstructive group and 0.19 ± 0.06 in the obstructive group. Renal pelvis (cm) was found to be 0.09 ± 0.02 in healthy cats, 0.08 ± 0.03 in non-obstructive cats, and 0.28 ± 0.16 in obstructive cats (Evangelista et al., 2023). In our study, kidney measurements of obstructive and non-obstructive cats were determined to be within the normal range. According to a study, kidney length was calculated as 3.93 ± 0.23 in the right kidney and 3.87 ± 0.24 in the left kidney in cats with non-obstructive feline lower urinary tract disease (n=8), and 4.51 ± 0.47 in the right kidney and 4.49 ± 0.43 in the left kidney in cats with obstructive feline lower urinary tract disease (n=11) (Evangelista et al. 2023). In our study; a renal thickness value similar to the study conducted by Evangelista et al. (2023) was found. However, this value was determined as an average of 0.19 in obstructive patients, and our value is lower compared to the results of the aforementioned study. This situation may be related to the partial obstruction detected in 17 of the 50 cats constituting the material in this presented study, the absence of complete obstructive cases in the material, and the continuation of urine output, albeit intermittently (in the anamnesis), in these semi-obstructive patients. Again, in our study, the urinary bladder wall thickness was found to be higher compared to the results of the study conducted by Evangelista et al. (2023). Struvite crystalluria (30%), idiopathic cystitis (28%), emphysematous cystitis (2%) and hemorrhagic cystitis (2) detected in the cases constituting the material in our study are factors that generally increase the urinary bladder wall several times (Lemberger et al. 2011). Renal resistive index (RI); It is the sonographic doppler index of intrarenal arteries, also defined as (peak systolic velocity - end-diastolic velocity) / peak systolic velocity. Calculation is made after obtaining images with Pulsed Wave Doppler (PW Doppler). Renal resistive index is a non-specific prognostic marker in vascular diseases affecting the kidney. It can be used in the evaluation of renal function (Tipisca et al. 2015). In a study conducted, RI measurement was evaluated in healthy cats. The mean left kidney RI value in 31 cats included in the study was found to be 0.61±0.05 (Ostrowska et al. 2016). A general mean of up to 0.7 can be considered healthy (Novellas et al. 2007). In another study conducted on 116 cats, the mean RI value was determined as 0.59 ± 0.08 in 24 healthy cats, while it was measured as 0.73 ± 0.12 in chronic renal failure cases and 0.72 ± 0.08 in acute renal failure cases in 92 sick cats. Gender and age did not affect RI (Tipisca et al. 2015). In another study conducted on cats with FLUTD, the RI value was determined as 0.65 (0.54–0.68) in the measurements performed on the left kidney in the control group, while it was determined as 0.73 (0.61–0.75) in non-obstructive FLUTD cases and 0.69 (0.54–0.93) in obstructive FLUTD cases. Regardless of obstructive or non-obstructive FLUTD, chronic or acute renal failure accompanying the disease definitely leads to an increase in the renal resistive index (Evangelista et al., 2023).

In this thesis study, the mean RI value in the left kidney was measured as 0.65±0.09. When compared with other studies, it was evaluated that the normal RI values measured in this study could be related to reasons such as the partial obstruction observed in the animals forming the material, the cases being uncomplicated and not having developed severe renal damage. It is a fact that renal blood flow changes in cats with FLUTD need to be investigated in detail.

CONCLUSSION

The results of this study emphasize that FLUTD cases are mostly seen in male cats (58%) and that there are significant differences between breeds. While the mortality rate in 50 FLUTD cats was determined as 14% (n=7), the recovery rate was determined as 68%. The most common problems in the study were struvite crystalluria (30%) and idiopathic cystitis (28%), respectively. The mean serum BUN and CREA concentrations measured in cats with FLUTD were found to be relatively high, although there were individual differences. However, it is noteworthy that in cases where partial obstruction was observed among 50 FLUTD cases (n=17), neither values increased in terms of mean value, although there were individual differences. Hemogram değerleri de ortalama olarak normal sınırlar arasında belirlenmiştir. Hemogram values were also determined to be within normal limits on average. It was determined that BUN, CREA and P values measured in cats determined to be dead during follow-up were higher than in surviving animals. It is noteworthy that the average density value determined in TIT was low. A positive significant relationship was determined between urine protein and serum BUN and P values. Renal measurement data evaluated in this study were recorded within average normal values, although there were some individual differences between the cases. The resistive index value measured in the study was below the normal upper value of 0.7. It is noteworthy that blood urea-nitrogen and creatinine values were high in cases with partial obstruction in this study. After a one-month follow-up, it was determined that in cats that were determined to have died, blood urea-nitrogen, creatinine and phosphorus values measured at the first application to the clinic were higher than in surviving animals. The results emphasize the importance of comparative evaluation of all measurement data in the diagnosis, patient follow-up, determination of prognosis and determination of the correct treatment method in cases of cat lower urinary tract disease. In these cases, special medical treatment applications and diets can be preferred according to the type of cat lower urinary tract disease and the underlying primary cause, and these may prevent possible recurrences. Additional studies with increased material numbers should be conducted in order to reveal the relationship between the parameters in more detail.

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Authors' Contributions: EE and TC contributed to the project idea, design and execution of the study. EE and TC contributed to obtaining the data. TC and EE analyzed the data. EE and TC drafted and wrote the article. EE and TC critically reviewed the manuscript. All authors read and approved the final manuscript.

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