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Original article

DIAGNOSTIC AND EPIDEMIOLOGICAL STUDIES ON OBSTRUCTIVE FELINE LOWER URINARY TRACT DISEASE (FLUTD) WITH SPECIAL REFERENCE TO ANATOMICAL FINDINGS IN EGYPTIAN TOMCATS

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Summary

Abdel-Saeed, H., R. T. Reem & H. S. Farag, 2021. Diagnostic and epidemiological studies on obstructive feline lower urinary tract disease (FLUTD) with special reference to anatomical findings in Egyptian tomcats. *Bulg. J. Vet. Med.,* **24**, No 3, 383–394.

Feline lower urinary tract disease (FLUTD) is a common urinary problem facing small animal veterinarians all over the world. There are few data about the occurrence and prevalence of this condition among tomcats in Egypt, especially regarding obstructive FLUTD. Urethral obstruction was more prevalent in the Persian breed, 2–3 years old intact tomcats kept mostly on dry food with occasional access to water. This affection occurred more commonly in winter months and especially in case of aggression and stress between tomcats. Physical, haematobiochemical evaluation and urinalysis were performed for cases with obstructive FLUTD. The anatomical analysis of the urethral anatomy of tomcats revealed that the most susceptible parts of urethra for obstructions were at the prostatic and the membranous urethra, isthmus urethrae and the penile urethra. Also, anatomical data were very helpful during treatment with catheterisation. The present study throwed a light on the diagnostic evaluation and epidemiology of the obstructive feline lower urinary tract disease among tomcats at the Small animal hospital, Faculty of Veterinary Medicine, Cairo University, Egypt.

Key words: blood biochemistry, Egypt, haematology, prevalence, obstructive FLUTD, tomcat, urethral anatomy

INTRODUCTION

The urethra is the common pathway for both urinary and reproductive tracts; it extends from the urinary bladder to the very tip of the penis. The feline penile urethra is very narrow and much shorter than the urethra of the dog (Baker & Davidson, 2015). Feline lower urinary tract disease (FLUTD) is a common problem facing small animal practice and is a collective term to denote dysfunction of urinary bladder and/or urethra especially in tomcats. Many causes are involved in occurrence of FLUTD including feline idiopathic cystitis, bacterial urinary tract infections, neurological disorders and inflammation (Kim *et al.,* 2017). Cystic calculi, neoplasms and urethral plugs are considered the major and serious causes for obstructive FLUTD (Gerber, 2008). The early conspicuous clinical sign for obstructive form of FLUTD is pollakiuria without polyuria (Kojrys *et al.,* 2017) while other concomitant clinical signs included periuria, stranguria and haematuria which commonly ended with oliguria and anuria. A remarkable number of predisposing stressors in occurrence of obstructive FLUTD was reported, including age, physical environment, diet type, feeding, cohabitation with other cats and restricted access to water (Lund *et al.,* 2016).

The aims of the present study were to carry out a survey on FLUTD caused by obstruction and associated risk factors, and haematobiochemical and anatomical findings in tomcats with FLUTD referred to the Small animal hospital, Faculty of Veterinary Medicine, Cairo University, Egypt.

MATERIALS AND METHODS

Ethical approval

All research procedures were approved by Cairo University Institutional Animal Care and Use Committee (Vet. CU-IACUC No. 03252019031). Also, the study was approved by the Department of Medicine and Anatomy and Embryology, Faculty of Veterinary Medicine, Cairo University, Egypt.

Study area

The study included all tomcats suffering from signs of obstructive FLUTD that were admitted to the Teaching Small Animal Hospital, Faculty of Veterinary Medicine, Cairo University, Egypt during a three-year period from January 2015 to January 2018.

Animals

A total number of 6,551 adult tomcats from different breeds (Persian, Himalayan and Siamese breeds) were included during the study period. This number included 4,520 diseased tomcats, among which 448 suffered from urinary system problems: obstructive FLUTD (369 cases), non-obstructive FLUTD (66 cases), urinary incontinence (9 cases) and renal failure (4 cases). The other diseased tomcats (4,072 cases) showed problems related to other systems. About 2,031 apparently healthy tomcats were admitted to the hospital either for periodical vaccination or for general health checkup. Complete diagnostic exams were applied to 80 animals including 20 apparently healthy animals and 60 cases of obstructive FLUTD.

Clinical examination

All the cases were registered in the registration book for date, age, breed, and the main complaint of their owners. Detailed clinical examination of each patient was carried out included complete medical, vaccination, dietary, management and environmental history. Visual inspection was applied while respiration, pulse rates and rectal temperature were carefully recorded. Examination of different systems and organs was also applied.

Diagnostic approach

After clinical examination, each case was subjected to faecal examination including direct faecal smear examination and concentration floatation technique to rule out the presence of adult worms, parasitic eggs and protozoal oocysts. Advanced diagnostic procedures including radiography and ultrasonography were applied for the cases suspected for obstructive FLUTD. Laboratory analysis included whole blood examination for estimation of packed cell volume (PCV), haemoglobin concentration, red blood cells count (RBCs), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), total white blood cells count (WBCs) and differential leukocyte counts including absolute numbers of neutrophil, lymphocytes, monocytes, eosinophils and basophils. Estimated biochemical blood constituents were serum BUN and creatinine using specific kits supplied by Spectrum diagnostic Co. (MDSS, GmbH, Hannover, Germany). Serum sodium concentration was determined with specific kits supplied by Stanbio Laboratories (Boerne, USA) while serum potassium – by kits supplied by QCA Co. (Amposta, Spain). Urinalysis was performed on urine dipstick samples that were collected through catheterisation and cystocentesis under complete aseptical conditions for microbiological estimation. Urinalysis was done by using Meditest; Combi-10 SGL urine strip test detecting blood, urobilinogen, protein, nitrite, ketones, glucose, pH, specific gravity and excess leukocytes. Also, microscopic examination of urine sediment was performed for detection of abnormal crystals, cast and inflammatory cells. Microbiological examination was applied on urine samples from diseased animals including culture on mannitol salt agar and XLD agar.

Anatomical approach

The anatomical approach was conducted using six adult tomcats' carcasses of mixed breeds of different weights that have recently died at the Small Animal Hospital. The carcasses were flushed with warm normal saline through the common carotid artery then fixed by injection of 10% formalin solution and left in a cold room for 2 days before dissection. The specimens were dissected to detect the anatomical features of the tomcat's urethra. All specimens were photographed by Sony camera h400, 20.1 megapixels, 63× optical zoom cyber shot. *Nomina Anatomica Veterinaria* (2017) was used for nomenclature.

Statistical analysis

All data from clinical examinations (respiratory rate, pulse rate and rectal temperature), haematobiochemical findings, some urinary measurements (pH and specific gravity) and anatomical urethral diameters were recorded, imported to a Microsoft Excel 2010 spreadsheet. The t-test was applied. A P value ≤ 0.05 was considered significant.

RESULTS

Data about obstructive FLUTD collected through the three years of the study showed that out of 6,551 tomcats, about 4,520 diseased were recorded. Among the latter, 448 tomcats suffered from urinary system problems. The obstructive form of FLUTD was diagnosed in 369 tomcats (Table 1).

Regarding risk factors (stressors) favouring the occurrence of obstructive FLUTD (Table 2), data revealed that Persian breed was the most susceptible to this condition (Fig. 1) followed by mixed and Siamese breeds. The most susceptible recorded age for the condition in tomcats ranged between 2–3 years followed by age less than two years. Recorded information revealed that intact tomcats suffered more from urinary tract obstruction than neutered ones. Presence of aggres-

Table 1. Prevalence of urinary system problems in tomcats including obstructive FLUTD during a 3-year period from January 2015 to January 2018

Group of tomcats	Apparently healthy	Diseased				
Sub-group	–	Urinary system problems				Other health problems
Problem category	–	Obstructive FLUTD	Non-obstructive FLUTD	Inconti-nence	Kidney injuries	–
Number (%)	2031 (31%)	369 (82.3%)	66 (14.7%)	9 (2%)	4 (0.89%)	
		448 (9.9%)				4072 (90.1%)
Total number diseased		4520 (69%)				
Total number		6551(100%)				

Fig. 1. Different cases with obstructive FLUTD in tomcats. **A, B.** application of urinary catheter; **C.** the animal after evacuation of urine following removal of urethral plug.

sion between tomcats that live together at the same place was found to be a remarkable risk factor for obstructive FLUTD while successful cohabitation was found to be less prevalent. During the study period, data showed that winter and spring months supported the occurrence of the condition. In constrast, it was less prevalent in summer and autumn months. It was evident that tomcats having free access to food were more prone to obstruction than those with scheduled feeding programme. In the same context, toms fed on dry food were markedly predisposed to obstruction followed by those fed on canned food and wet (fresh) food respectively. Another

Table 2. Risk factors (stressors) associated with obstructive FLUTD in tomcats through a 3-year study period (2015–2018)

Risk factors	Category	Prevalence (2015–2018)	
		No. of cases	Percentage
Breed	Persian	222	60.0%
	Mixed breeds	136	37.0%
	Siamese	11	3.0%
Age	Less than 2 years	147	40.0%
	2–3 years	163	44.0%
	More than 3 years	59	16.0%
Neutering status	Neutered	148	40.2%
	Intact tomcats	221	59.8%
Cohabitation with other cats	Cohabitate well	177	47.9%
	Presence of aggression	192	52.1%
Season	Winter	180	48.8%
	Spring	117	31.7%
	Summer	27	7.3%
	Autumn	45	12.2%
Feeding program	Free access	203	55.1%
	Scheduled	166	44.9%
Diet type	Dry food	189	51.4%
	Soft canned food	74	20.0%
	Fresh food (wet food)	19	5.1%
	Mixed type food	87	23.5%
Watering program	Free access	89	24.1%
	Adjusted (times/day)	280	75.9%
Relapse after 1st catheterisation	Relapsed	130	35.3%
	Not relapsed	239	64.7%

closely related factor, offering water at adjusted times per day favoured the obstructive condition compared to free access to water. Records revealed lower percentage of relapsed cases admitted after the first obstruction and successful catheterisation.

Regarding physical clinical examination, respiratory and pulse rates were significantly ($P \leq 0.001$) increased in cases with obstructive FLUTD compared to apparently healthy tomcats along with significant ($P \leq 0.001$) decrease in rectal temperature (Table 3).

Ultrasonographic findings in cases with obstructive FLUTD showed presence of bladder stones with distal acoustic shadow in one case. Also, presence of thick urinary bladder wall in a case with chronic cystitis resulted from relapsed obstruction. Abnormal architecture and varying degrees of dilatation of renal pelvis and inflammatory response of renal parenchyma were detected as a result of hydronephrosis in cases with complete urethral obstruction. Radiographic results showed the presence of urinary bladder stones in a case of complete urethral obstruction with a large plug (Fig. 2).

The most substantial findings from haematological examination (Table 3) included significantly ($P \leq 0.001$) increased PCV, WBCs counts and absolute neutrophil counts. There was significant decrea-

Table 3. Physical, haematobiochemical and some urinary parameters (mean±SEM) in tomcats suffering from obstructive FLUTD

Parameter	Group	Control group (n=20)	Obstructive FLUTD group (n=60)
Physical parameters	Respiratory rate (min^{-1})	43.6±0.99	61±1.23***
	Pulse rate (min^{-1})	148.1±1.24	175±2.04***
	Rectal temperature (°C)	38.5±0.05	37.3±0.13***
Haematological parameters	PCV (L/L)	0.396±0.01	0.416±0.00***
	Hb (g/L)	106.3±3.22	109.7±2.00
	RBCs count (×10^{12}/L)	8.22±0.18	8.53±0.14
	MCV (fL)	48.4±0.74	49.5±0.81
	MCH (fmol/cell)	0.80±0.01	0.80±0.01
	MCHC (g/L)	267.4±5.38	263±4.32
	WBCs count (×10^9/L)	11.8±0.27	15.34±0.38***
	Absolute neutrophils (×10^9/L)	8.18±0.34	12.54±0.38***
	Absolute lymphocytes (×10^9/L)	3.01±0.18	2.24±0.06***
	Absolute monocytes (×10^9/L)	0.57±0.01	0.45±0.01***
	Absolute eosinophils (×10^9/L)	0.12±0.01	0.108±0.01
	Absolute basophils (×10^9/L)	–	–
Blood biochemical parameters	BUN (mmol/L)	10.6±0.36	24.9±0.83***
	Creatinine (μmol/L)	128.2±6.71	776.3±34.56***
	Sodium (mmol/L)	154.3±1.06	159.1±1.09**
	Potassium (mmol/L)	4.9±0.10	5.7±0.07***
Urine analysis	Urine pH	6.79±0.07	6.85±0.11
	Urine specific gravity	1.071±0.002	1.022±0.00***

*** P≤0.001 between groups.

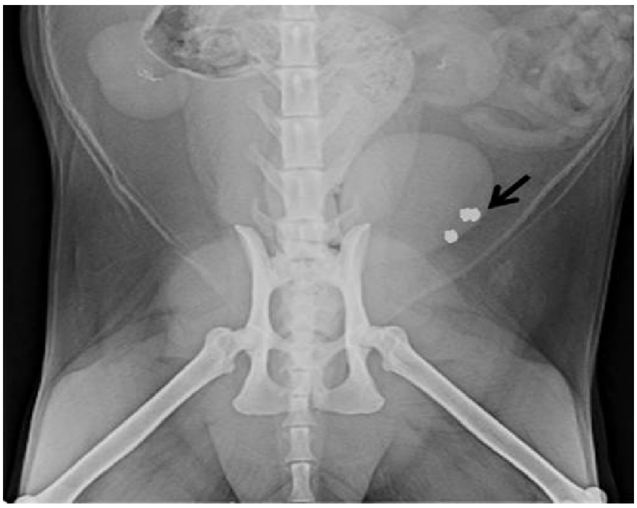

Fig. 2. Radiographic findings in cases with obstructive FLUTD showing two radiopaque cystic plugs (arrow) attached to bladder wall.

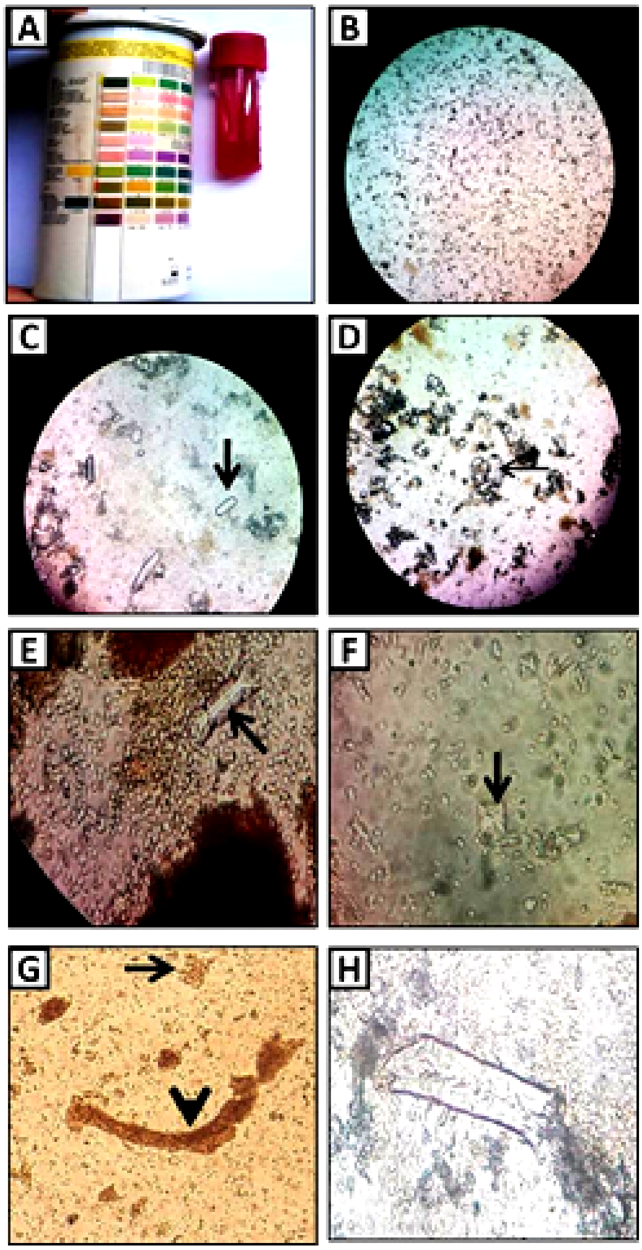

Fig. 3. Different findings of urinalysis and sediment examination: **A**. urine strip analysis; **B**. struvite crystals (4×); **C, D**. struvite crystals (10×); **E**. alkaline phosphate type struvite crystal. **F**. calcium oxalate crystal (envelope-like); **G**. red blood cell (arrow) and RBCs cast (arrowhead); **H**. epithelial cast in cases of FLUTD.

ses ($P \leq 0.001$) for absolute counts of both lymphocytes and monocytes in cases with obstructive FLUTD. The other haematological parameters showed insignificant variations towards control healthy group. Regarding biochemical evaluation for cases with obstructive FLUTD, results showed significant ($P \leq 0.001$) increase in serum BUN, creatinine and potassium levels while this increase was less significant ($P \leq 0.01$) for serum sodium. In terms of urine analysis, physical criteria of urine in such cases showed reddish to brownish foul smelling urine with blood clots and parts of plug (Fig. 1C). After centrifugation, dipstick analysis using urine strip test showed marked increase in leukocytes, positive sign for haematuria and traces of protein, glucose, urobilinogen and bilirubin (Fig. 3A). Statistical analysis of urine pH and specific gravity data revealed significant ($P \leq 0.001$) decrease for the latter but no significant change in urine pH. Microscopic examination of urine sediment in cases with obstructive FLUTD showed multiple findings including numerous struvite crystals which were main finding in all cases (Fig. 3B–E). Also, calcium oxalate crystals were detected in some cases (Fig. 3F) while most of cases showed amorphous phosphate crystals (Fig. 3G). Cellular cast was detected as a result of degenerative changes in renal tubules (Fig. 3G). Renal cast was detected in few serious cases (Fig. 3H). Urine culture of cases with obstructive FLUTD showed the presence of *Staphylococcus* spp. and *E. coli* infection in most cases.

Concerning the anatomical findings (Table 4, Fig. 4), the tomcat urethra was commonly divided into two main parts; the pelvic and penile urethra. The pelvic urethral parts were the preprostatic, prostatic, membranous (postprostatic) and the isthmus urethrae. The most susceptible parts of urethra for obstructions occur at the prostatic and the membranous urethra, isthmus urethrae and the penile urethra. The prostatic urethra (Fig. 4/6) was surrounded dorsally by the prostate gland and the pelvic symphysis was found ventrally which favoured the occurrence of obstruction forming a hindrance to the applied urinary catheters during emergency catheterization. The membranous (postprostatic) urethra (Fig. 4/7) was a short segment of urethra in-between the body of prostate gland and the root of penis, just caudal to the bulbourethral glands. The location of this part between the two glands led to slowdown of urine flow at this area, so more intensive precipitation of salts and occurrence of obstructions were possible at this part of urethra. The isthmus urethrae (urethral isthmus) (Fig. 4/11) was the narrow part between the two bulbourethral glands at the ischial arch, and the penile urethra (Fig. 4/12) was the part of urethra inside the penis; very narrow and short.

Table 4. Average length (cm) of different anatomical parts of tomcat's urethra

Name of the part	Average length (cm)
Preprostatic urethra	3.30 ± 0.11
Prostatic urethra	0.99 ± 0.03
Membranous urethra	2.15 ± 0.14
Isthmus urethrae	1.05 ± 0.10
Penile urethra	3.13 ± 0.15

DISCUSSION

Obstructive FLUTD is considered the most prominent urinary problem among tomcats in Egypt, The present study recorded an occurrence of 82% for obstructive FLUTD in tomcats which give conclusive information that this disease repre-

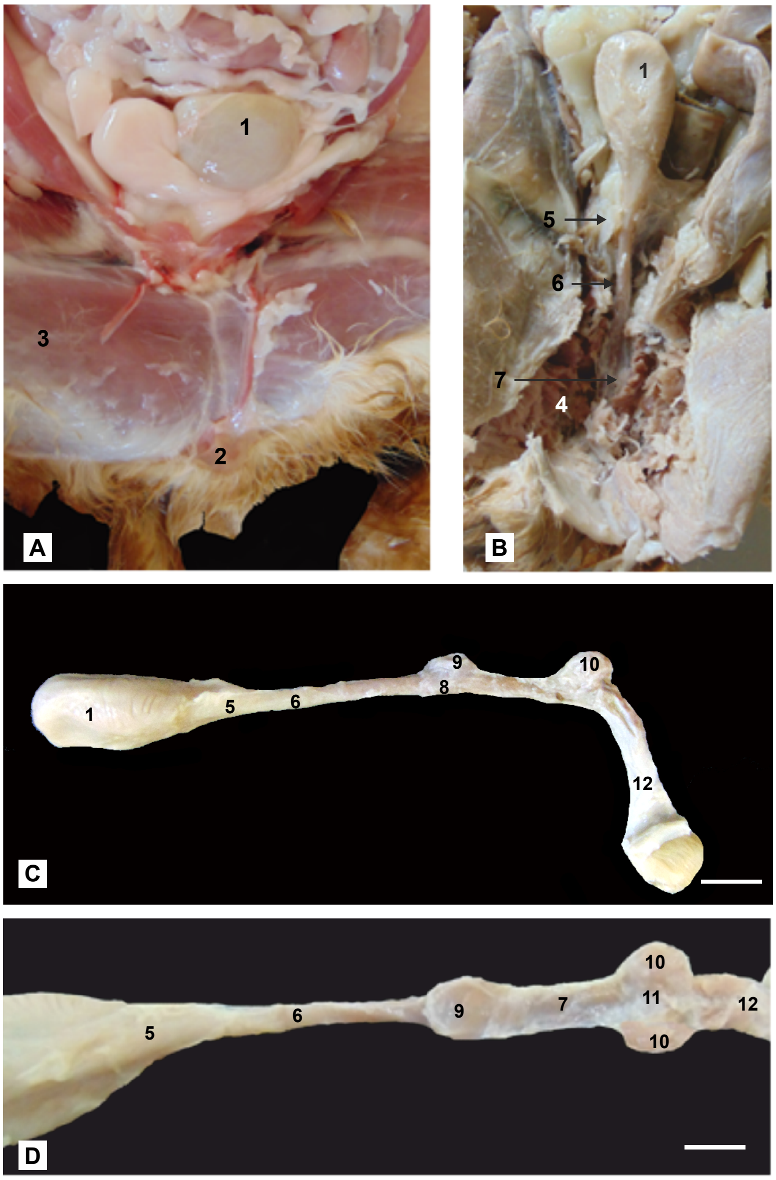

Fig. 4. A. Photograph showing the ventral view of the tomcat pelvis (fresh specimen); **B.** Partial removal of the pelvic symphysis and surrounding bones to show the urethra above them; **C.** A photograph showing the separated urinary bladder and attached genital tract of tomcat (lateral view) (bar= 2 cm); **D.** A photograph viewing the magnified genital tract of tomcat (dorsal view) (bar=1 cm). 1. Urinary bladder; 2. Tomcat genitalia; 3. Pelvic limb; 4. Removed pelvic symphysis; 5. Bladder neck; 6. Preprostatic urethra; 7. Membranous urethra; 8. Prostatic urethra; 9. Prostate gland; 10. Bulbourethral gland; 11. Isthmus urethrae; 12. Penile urethra.

sents a major sum of all urinary system problems. This finding comes in the same context with data of Westropp *et al.* (2005) and Kojrys *et al.* (2017) who revealed that urethral obstruction was the second most common cause of FLUTD. There is more than one risk factor favouring the occurrence of FLUTD. The present work elucidated that occurrence was more common in Persian tomcats, those from two to three years of age, especially intact. Free access to feed especially in winter months predisposed to the condition. These factors agreed with those outlined by Kim *et al.* (2017). Dry food with watering adjusted times per day was the most prominent record associated FLUTD in tomcats. Jones (1997) and Gerber (2008) findings were similar to those in the present study. Also, Kojrys *et al.* (2017) revealed that more than 60% of tomcats with obstructive FLUTD were kept on dry food.

Regarding physical examination, the present study demonstrated significantly ($P \leq 0.001$) increased respiratory and pulse rates among diseased cases and decreased rectal temperature in same cases. Severe abdominal pain, ischuria and haematuria were recorded, in agreement with data of Gerber *et al*. (2005) and Dorsch *et al.* (2014).

Heematological parameters were severely affected in tomcats with obstructive FLUTD compared with apparently healthy tomcats. Significantly ($P \leq 0.001$) increased PCV, WBCs and neutrophil counts indicated haemoconcentration, dehydration and severe inflammation. The same findings were recorded by Tariq *et al.* (2014). Both lymphocytes and monocytes were significantly ($P \leq 0.1$) decreased in diseased cases.

Most prominent serum biochemical findings in diseased cases comprised significantly ($P \leq 0.001$) elevated BUN and creatinine levels comparably to other results (George & Grauer, 2016). Significant ($P \leq 0.01$) increase in serum sodium level in diseased cases may be attributed to the increased absorptive capacity by renal tubules as sodium is very important for extracellular fluid status of the body. Serum potassium level showed significant ($P \leq 0.001$) increase in diseased cases in line with other studies (Gerber, 2008; George & Grauer, 2016) as there was abnormal hyperkalaemia resulting from decreased water intake which is life-threatening.

Data concerning urine specific gravity in the present study revealed significant ($P \leq 0.001$) decrease in cases with obstructive FLUTD compared with apparently healthy tomcats. The most convincing explanation of this decrease is the damage of renal tubular cells. This result agreed to some extent with that of George & Grauer (2016) who recorded urine specific gravity higher than 1.040 for such cases. The present work revealed the presence of struvite crystals in urine sediment in most samples of diseased cases, similarly to previous findings showing struvite crystals as the major cause for urethral obstruction in tomcats (Kruger *et al.*, 2009; Costa, 2011). Culture of diseased tomcats urine samples confirmed the presence of *Staphylococcus spp.* and *E. coli* in most cultured samples as also shown by Eggertsdottir *et al.* (2007) and Lund *et al.* (2014). The pH of urine in cats with FLUTD is very often alkaline, but in our investigation this was not confirmed as the increase in pH was not significant.

Regarding diagnostic imaging findings, radiography showed radiopaque cystic plug formation. Ultrasonographic findings confirmed the presence of cystic plug as hyper-echogenic material with distal acoustic shadow. Also, increased thickness of urinary bladder wall was indicative for cystitis. These findings agreed with those of Bovens (2011).

The anatomical findings for the very narrow and much shorter feline penile urethra compared to that of the dog were in agreement with data of Baker & Davidson (2015). The urethral lumen was located in close vicinity confirming findings of Dimitrov & Toneva (2006).

The canine prostate completely surrounded the urethra. In contrast, the bilobed feline prostate was positioned above the urethra (Fletcher, 2012). The feline prostate is very small and found only dorsally, also the prostatic urethra is short, similar to the observations of Barsanti (1995) & Baker and Davidson (2015). The present observations were in a line with those of Fletcher (2012) who found out that the postprostatic urethra in the cat ran from the body of the prostate gland to the root of the penis where paired bulbourethral glands were present.

CONCLUSION

The present study threw light on the diagnostic evaluation and epidemiology of the obstructive feline lower urinary tract disease among tomcats. The condition was the most prevalent urinary problem among tomcats in Egypt. It was more prevalent in Persian breed, 2–3 years old age intact tomcats that kept mostly on dry food with occasional access to water. This affection occurred more in winter months and especially when there is aggression and stress between tomcats. The anatomical analysis of the urethral anatomy of tomcats revealed that the most susceptible parts of urethra for obstructions were at the prostatic and the membranous urethra, isthmus urethrae and the penile urethra. During catheterisation, the tomcat should be placed in dorsoventral position, with the penis extended backward and slightly upward which is *sine qua non* for successive catheterisation as the first normal anatomical hindrance includes the presence of isthmus urethrae in relation to the ischial arch ventrally.

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