# Feline urinary system affections – diagnostic imaging

P. Saranya[1], G. Kamalakar[2*], N.V.V. Harikrishna[3], B. Chandra Prasad[4]

[1]Dept. of Veterinary Surgery and Radiology, [2]Dept. of Veterinary Clinical Complex, [4]Dept. of Veterinary Gynaecology and Obstetrics, NTRCVSC, Gannavaram, Krishna dt; [3]Dept. of Veterinary Surgery and Radiology, College of Veterinary Science, Garividi, Vizianagaram dt. Andhra Pradesh
*Corresponding author email: drkamal1vet@gmail.com

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## Abstract

A comprehensive radiographic and ultrasonographic study was undertaken to evaluate various urinary system affections in cats presented with signs of stranguria, haematuria, pollakiuria, *etc*. to the Dept. of Veterinary Surgery and Radiology, NTRCVSC, Gannavaram. Abdominal radiography (lateral and ventro-dorsal view) could diagnose nephromegaly, severely distended urinary bladder, calculi in bladder or tip of urethra or urethral plugs. Pneumocystography was performed to diagnose a blood clot embedding two small calculi in it. Trans-abdominal ultrasonography was performed to evaluate various disorders of urinary system and recorded myriad conditions like hydronephrosis, renal cyst, pyelonephritis, renal capsular oedema, thickened renal capsule, indistinct cortico medullary junction, cystic calculi, cystitis, sludge in bladder, blood clots, thickened bladder wall and oedema of bladder wall. Pole to pole kidney length and width at renal pelvis of kidney was measured sonographically and radiographically on day 0, 7$^{th}$ and 14$^{th}$day post treatment. Significantly higher initial kidney measurements were recorded, which gradually declined to normalcy by day 14$^{th}$.

**Key words:** Cats, urinary system affections, radiography, ultrasonography

# Introduction

Cats are recent passion in public now a days and their diseases also became reported popularly. Many a times mere clinical examination can lead to correct diagnosis (Kamalakar et al 2019) but it is always preferable to use modern imaging techniques for diagnosis of affections of internal organs. Urinary system affections were the predominant amongst them (Udainiy et al., 2018, Saranya et al., 2022). The most important prerequisite for successful treatment of urinary system affections in cats is prompt diagnosis and imaging plays a pivotal in diagnosis. Plain radiography accompanied by contrast radiography techniques for urinary system i.e., cystogram, excretory urogram was a definitive method for diagnosing urinary pathologies like presence of radiolucent calculi, hydronephrosis, cystitis, tumors, ruptures, *etc*. (Tipisca et al., 2014).

B - mode ultrasonography was the modality of choice to visualize the feline urinary tract and considered to be complementary to radiography (Walter et al., 1988). Ultrasonography was indicated on observing symptoms like anuria, haematuria, stranguria; findings of small or enlarged or irregular kidneys on abdominal palpation; presence of azotemia or abnormal urinalysis results and to examine the damage to the urinary tract in trauma cases (Griffin, 2020). A comprehensive study was conducted to record various urinary system affections diagnosed by both radiography and ultrasonography in cats.

# Materials and Methods

The present work was carried out at Department of Veterinary Surgery and Radiology and Dept. of Veterinary Clinical Complex, NTR College of Veterinary Science, Gannavaram, Andhra Pradesh. The cats presented between May, 2022 and December, 2022 with complaints related to urinary system formed the material for this study.

Cats presented with signs like anuria, stranguria, haematuria and distended urinary bladder similar to obstructive urolithiasis/ feline lower urinary tract disease (FLUTD) were subjected to radiography and ultrasonography. The cats were restrained in right/ left lateral recumbency (Fig. 1) or supine position (Fig. 2) to obtain lateral and ventro-dorsal views respectively.For this purpose, Siemen's 500 mA X-Ray machine was employed and processed using Computed Radiography (Care Stream).Non – cooperative cats were anaesthetized using inj. ketamine hydrochloride @ 15-25 mg/kg BW IM and inj. midazolam @ 0.2 mg/kg BW IM. Pneumocystography was performed in cats suspected of having radiolucent calculi or tumours of bladder wall or blood clots in bladder by injecting room air in to catheterized urinary bladder (Fig. 3).

The real time B – mode trans-abdominal ultrasonographic examination was performed using an ultrasonography machine (Prosound α6, Aloka Trinitron Medical Technology Pvt. Ltd) 5.0 to 7.5 MHz curvilinear transducer. Both kidneys, ureter, urinary bladder and urethra were examined and lesions present if any, were noted.The cats were treated accordingly and the outcome was evaluated by radiography and ultrasonography on the day of presentation and $7^{th}$ and $14^{th}$ post operative day.

# Results and Discussion

A total of 91 cats presented and 21 cats were diagnosed with urinary system affections among which nephromegaly (Fig. 4) observed in seven cats (33.33%). In four cats (19.04%), hydronephrosis was detected which was characterized by increased opacity of kidneys along with distended urinary bladder (Fig. 5). In 20 out of 21 cats, the urinary bladder was distended severely because of obstructive urolithiasis and or feline lower urinary tract disease (FLUTD) which showed gas filled colon with faecal impaction.

Mineral concretions or calculi were found in cranial poles of both kidneys in one cat (Fig. 6) (4.8%). Two cats (9.52%) had cystoliths in which large sized radio opaque solitary cystolith (Fig. 7) was found in one cat and the other cat with two radio-opaque small sized cystoliths which was confirmed by pneumocystography (Fig. 8). Three cats (14.3%) were diagnosed with urethral plugs which were lodged at the penile urethra (Fig. 9).

The mean ± SE values of length and width of right kidney recorded on day 0and 14 were significantly declined from 4.43 ± 0.22 cm to 3.90 ± 0.2 cm and 2.79 ± 0.18 cmto 2.41 ± 0.16 cm respectively. Similarly, the length and width of left kidney (cm) significantly decreased from 4.40 ± 0.2 to 3.87 ± 0.17 and from 2.87 ± 0.21 to 2.43 ± 0.2 respectively from day 0 to day 14. Enlargement of kidneys was almost symmetrical.From the above results, it was found that the cats with urinary system affections had acute nephromegaly on the day of presentation which was gradually normalized by day 14 after treatment.

## Radiographic evaluation

Fig. 1: Photograph showing placement of cat over cassette for lateral view of abdomen

Fig. 2: Photograph showing placement of cat over cassette for ventro-dorsal view of abdomen**.**

**Fig. 3**: Photograph showing infusion of room air into catheterized urinary bladder of cat placed in lateral recumbency

**Table 1**: Mean ± SE values of measurements of kidneys compared to 2nd lumbar vertebral body (L2) based on radiography

| S. N. | Parameter | | $L_2$ | Day 0 (N =21) | Day 7 (N = 17) | Day 14 (N = 15) |
|---|---|---|---|---|---|---|
| 1 | Right kidney | Width (cm)** | 1.63 ± 0.06 | 2.79±0.18$^{c}$ | 2.57±0.17$^{b}$ | 2.41±0.16$^{a}$ |
| | | Length (cm)** | | 4.43±0.22$^{c}$ | 4.17±0.22$^{b}$ | 3.90±0.2$^{a}$ |
| 2 | Left kidney | Width (cm)** | | 2.87±0.21$^{c}$ | 2.63±0.21$^{b}$ | 2.43±0.2$^{a}$ |
| | | Length (cm)** | | 4.40±0.2$^{c}$ | 4.13±0.19$^{b}$ | 3.87±0.17$^{a}$ |

**Table 2**: Mean ± SE values of Ultrasonographic measurements of kidney:

| S. No | Parameter | | Day 0 | Day 7 | Day 14 |
|---|---|---|---|---|---|
| 1. | Right kidney | Width (cm)* | 2.56±0.12$^{c}$ | 2.45±0.11$^{b}$ | 2.37±0.12$^{a}$ |
| | | Length (cm)** | 4.57±0.20$^{c}$ | 4.41±0.18$^{b}$ | 4.16±0.19$^{a}$ |
| | | Cortex (cm)** | 0.58±0.04$^{a}$ | 0.67±0.03$^{b}$ | 0.73±0.04$^{c}$ |
| | | Medulla (cm)** | 1.29±0.12$^{b}$ | 1.21±0.09$^{b}$ | 1.07±0.08$^{a}$ |
| 2. | Left kidney | Width (cm)** | 2.57±0.11$^{b}$ | 2.53±0.11$^{b}$ | 2.41±0.11$^{a}$ |
| | | Length (cm)** | 4.45±0.15$^{c}$ | 4.31±0.13$^{b}$ | 4.15±0.13$^{a}$ |
| | | Cortex (cm)** | 0.61±0.04$^{a}$ | 0.71±0.03$^{b}$ | 0.75±0.03$^{b}$ |
| | | Medulla (cm)* | 1.33±0.10$^{b}$ | 1.21±0.1$^{a}$ | 1.94±0.87$^{ab}$ |
| 3. | Urinary bladder wall thickness (cm)** | | 0.38±0.03$^{c}$ | 0.28±0.02$^{b}$ | 0.21±0.01$^{a}$ |

**highly significant difference at 1% level of significance (p<0.01) Means with different superscripts differ significantly within a row

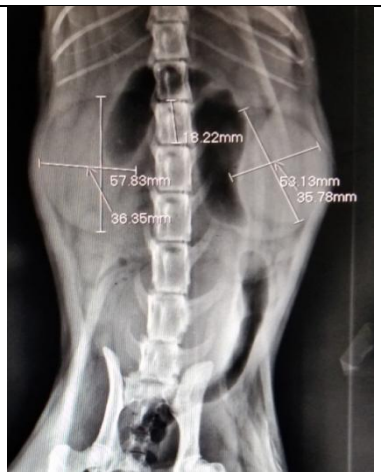


Fig. 4: Skiagram showing bilateral nephromegaly and partially distended urinary bladder.

Fig. 5: Skiagram showing increased opacity of both kidneys suggesting hydronephrosis, distended urinary bladder along with gas in colon

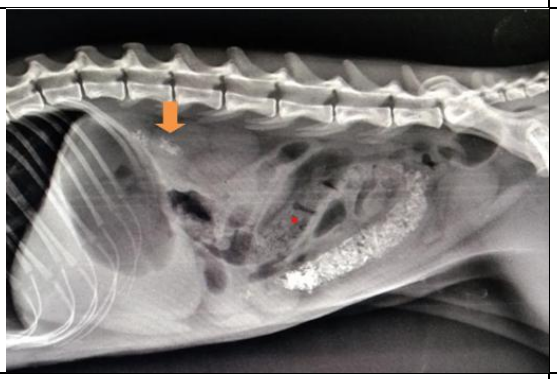

Fig. 6: Skiagram showing mineral concretions at the cranial poles of both kidneys.

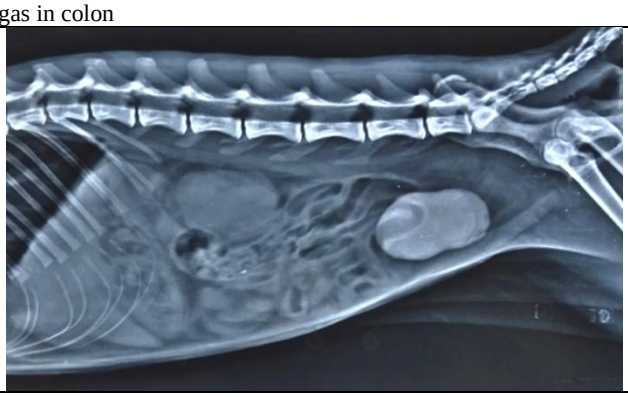

Fig. 7: Skiagram showing solitary large radio opaque cystolith in a queen cat

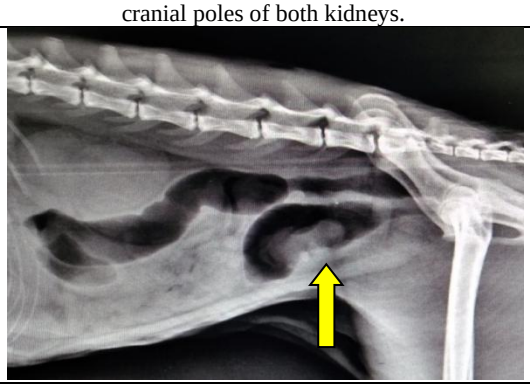

Fig. 8: Skiagram showing mass within the bladder lumen along with two cystoliths diagnosed by Pneumocystography (yellow arrow)

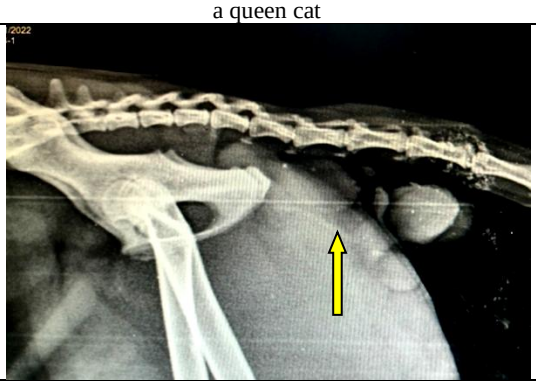

Fig. 9: Skiagram showing radio opaque urethral plugs at the tip of penile urethra (lateral abdomen).

Plain radiography enables diagnosis of some kidney disorders like nephromegaly and nephrolithiasis apart from identifying the topography of urinary system like shape, size and opacity (Temizsoylu et al., 2006). In the present study, nephromegaly was observed in some of the cats characterized by increased size of kidneys when measured corresponding to height of second lumbar vertebra in ventro-dorsal view (Feeney and Johnston, 2002). However, Martinez et al. (2022) assessed the kidney length with length of 5$^{th}$ lumbar and 6$^{th}$ lumbar vertebral bodies based on radiography and ultrasonography. The lengths and widths of the kidneys that were recorded in the present study were almost identical to that reported by Feeney and Johnston (2002). Hydronephrotic kidney appeared more opaque, slightly increased in size and rounded in shape.

Fig. 10: Ultrasonogram showing hydronephrosis. Note the dilated renal calyces with anechoic fluid

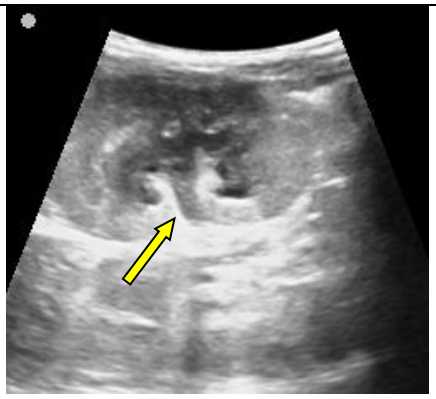

Fig. 11: Ultrasonogram showing pyelonephritis,dilated renal pelvis and hyperechoic pelvis wall (sagittal view).

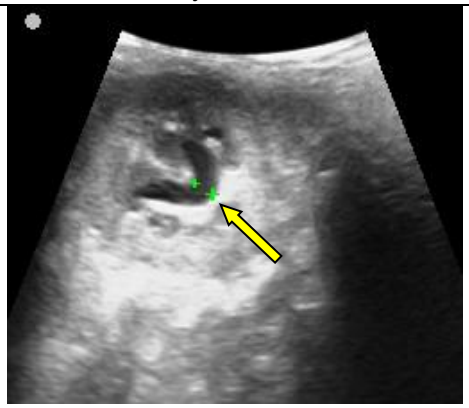

Fig. 12: Ultrasonogram showing pyelonephritis, dilated renal pelvis and hyperechoic pelvis wall (cross sectional view).

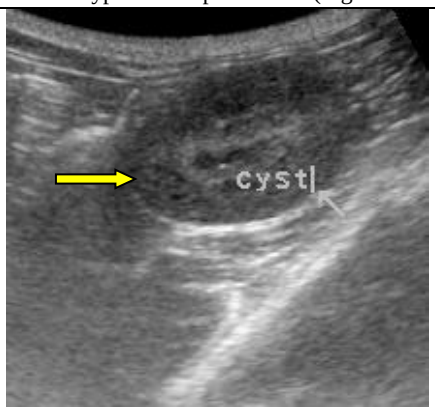


Fig. 13: Ultrasonogram showing multiple small, anechoic spaces in the cortex (yellow arrow), thickened cortico-medullary junction

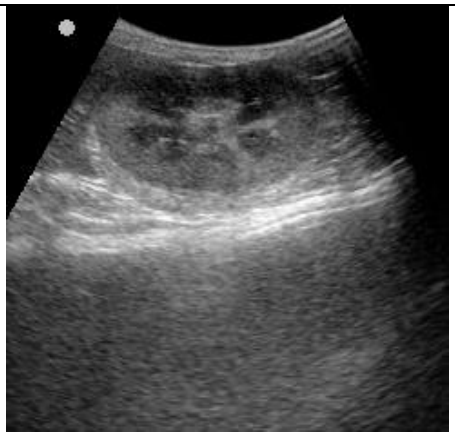

Fig. 14: Ultrasonogram showing sub-capsular edema and haemorrhages; thickened renal capsule

Fig. 15: Ultrasonogram showing solitary large calculus showing acoustic shadowing in the urinary bladder

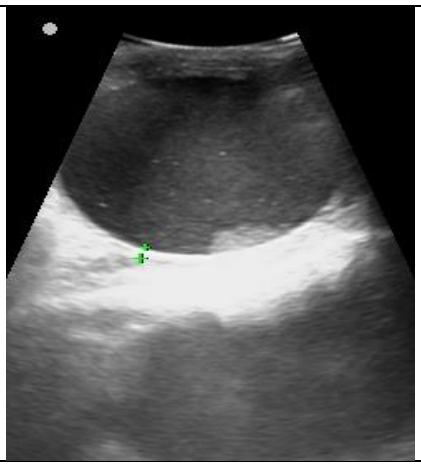

Fig. 16: Ultrasonogram showing thickened bladder wall along with sludge

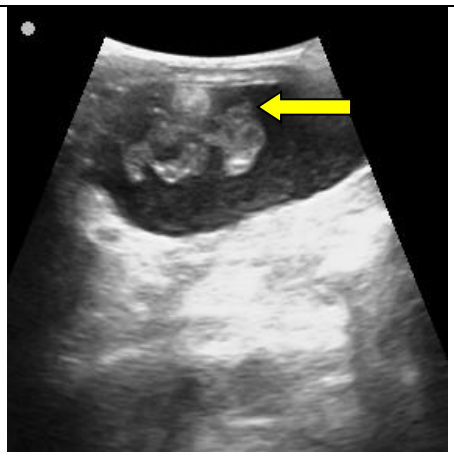

Fig. 17: Ultrasonogram showing mixed echogenic blood clot in the urinary bladder along with hyperechoeic calculi with no acoustic shadowing

Fig. 18: Ultrasonogram showing floating mixed echogenic blood clot/ polyp in urinary bladder and thickened bladder wall

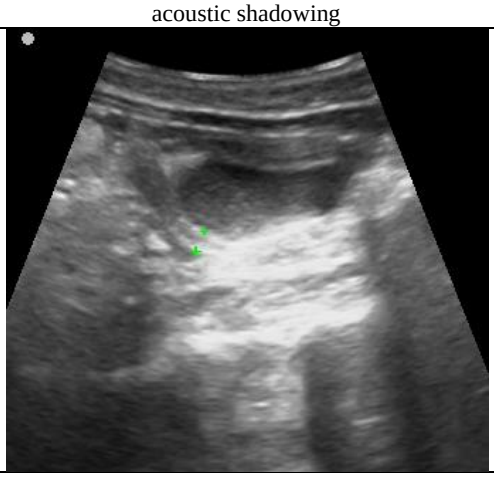

Fig.19: Ultrasonogram showing thickened bladder wall along with bladder wall edema. Note thin hypoechoic line in the bladder wall layers

This was due to the fluid accumulation in kidneys consequent to obstructive FLUTD (Bovens, 2011). Plain radiography was sufficient to diagnose the large solitary calculus in one cat as it appeared radio opaque with distinct margins (Temizsoylu et al., 2006). But in another cat, in which cystotomy was performed, though the calculi were radio opaque, they were concealed inside a blood clot. This could not be diagnosed on a plain radiograph. Hence, pneumocystography was performed to diagnose the structure with soft tissue opacity and two small calculi within it. Else, the pneumocystography was carried out to diagnose transitional cell carcinoma of bladder, radiolucent calculi, bladder wall abnormalities, *etc*. (Feeney and Johnston, 2002). Severely distended bladder was noticed with cranial displacement of intestines which was also observed by Gokulakrishnan and Meena (2020). 14.3 per cent of the cats under the study had urethral plugs lodged at the penile urethra. On the contrary, Abdel - Saeed et al. (2021) observed two radio opaque cystic plugs in case of complete urethral obstruction.

In the present study, mild nephromegaly was noticed in most of the cats as reported by Ebrahim et al. (2019). However, renal length and width could be influenced by several factors such as age, gender, neutering status and body weight which was justified by presence of larger sized kidneys in males and intact cats compared to females and neutered cats and also decreased kidney size as age advances as stated by Seyrek - Intas and Kramer (2008).

The real time B – mode trans-abdominal ultrasonographic examination was performed in all cats under study. This aided in confirmatory diagnosis when there was conspicuous sign of only distended bladder in radiography with no evidence of other abnormalities of urinary system. Increased radio opacity of kidneys was also correlated with ultrasonography and sludge which was not evident in radiography was visualized in this technique.

Lesions of kidneys detected including mild hydronephrosis marked by the dilated renal pelvis, indistinct cortico-medullary junction and dilated renal calyces (Fig. 10), pyelonephritis (Fig. 11&12), renal cysts characterized by anechoic spaces in the cortex (Fig. 13), sub capsular edema and hyperechoic thickened renal capsule (Fig. 14). These findings were correlated with vomitions and azotemia which indicated renal injury.

Length and width of kidneys, thickness of cortex and medulla were measured in sagittal plane as described by Debruyn et al. (2013). Corresponding to the radiographic findings, the length and width of kidneys showed significant reduction in size from the day of presentation to day 14$^{th}$ (Table 2). For right kidney, cortical thickness and total medullary width were 0.58 ± 0.04 cm and 1.29 ± 0.12 cm respectively making the cortico-medullary ratio 0.89 ± 0.17 on the day of presentation. By day 14, the values gradually changed to 0.67 ± 0.04 cm and 1.07 ± 0.08 cm and the ratio was 1.14 ± 0.2. For left kidney, the cortical thickness and total medullary width were 0.61 ± 0.04 cm and 1.33 ± 0.10 cm respectively making the cortico-medullary ratio 0.91 ± 0.11. By day 14, the ratio changed to 1.15 ± 0.18.

The urinary bladder wall thickness initially was 0.38 ± 0.03 cm which declined to 0.21 ± 0.01 cm on day 14 with high significant difference ($p < 0.01$). In case of pyelonephritis and hydronephrosis, the renal pelvic diameter reached up to 5.2 mm. Sonography of urinary bladder showed variety of lesions in bladder wall, urine and its contents. Some specific findings like solitary hyperechoic cystic calculus with acoustic shadowing (Fig. 15) and cystitis along with sludge were observed (Fig. 16). In a case of haemorrhagic cystitis, a mass like blood clot was observed along with two cystoliths embedded in the clot without producing any acoustic shadowing was observed (Fig. 17). Further, suspected polypoid cystitis/ blood clot (Fig. 18), edematous urinary bladder wall and hyperechoic urethral wall (Fig. 19) were also identified.

Ultrasonography was performed for confirmatory diagnosis of any soft tissue abnormalities as a support to the radiography. Kidneys were sonographed both in longitudinal and transverse planes for measuring and to identify the pathologies of kidney (Debruyn et al., 2013). Hydronephrosis characterized by the dilated renal calyces, renal pelvis and altered cortico-medullary junction associated with nephromegaly was observed in some cats which were in accordance with the findings of Udainiya et al. (2018) and Abdel – Saeed et al. (2021). This condition was due to backflow of urine because of urethral obstruction (Abdel - Saeed et al., 2021). Hypoechoeic subcapsular thickening was noticed as an incidental finding in some cases. The condition with presence of this finding along with nephromegaly, pyelectasia, increased cortical echogenicity, presence of hypoechoeic masses and nodules was diagnosed as renal lymphosarcoma (Valdes – Martinez et al., 2007) but no such tumours or nodules were observed in the present study. Pyelectasia was observed in cats under heavy fluid therapy or pyelonephritis (Delaney and Dennison, 2010). Similarly, the completely filled urinary bladder would have caused the backflow of urine and thus the dilated the renal calyces and pelvis. In the present study, ovoid shaped anechoeic renal cysts were observed in the cortex of kidney and were mostly the incidental findings (Nyland and Mattoon, 2015; Beck and Lavelle, 2001) and familial in origin (Nivy et al., 2015).

Very few reports were available pertaining to kidney measurements but, no work was on record indicating measurements in pathological conditions. The cortical and medullary thicknesses were above the levels described by Park et al. (2008) and below the levels indicated by Walter et al. (1988). Majority of the cases were having acute hydronephrosis and hence the medullary width was higher initially and as the condition was improvised, the values declined gradually correspondingly increasing the cortical thickness.

In one cat, a solitary hyperechoeic calculus was observed with distal acoustic shadowing which was similar to the findings of Ebrahim et al. (2019) and Abdel - Saeed et al. (2021). Contrarily, acoustic shadowing was absent in another case of cystic calculi as they were masked by the huge polypoid pedunculated floating structure in bladder which was found to be a blood clot. Hence, cystotomy was carried out to retrieve clot and cystic calculi. But, Young et al. (2021) infused tissue plasminogen activator intravesically to dissolve the clot. Another cat was also having a mixed echogenic polypoid structure in bladder, but was not reported for surgery. These mixed echoeic structures in bladder were of similar structure to that of pseudomembranous cystitis (Puccinelli et al., 2021). The ratio of cortex to medulla in all three cat breeds was 0.93 ± 0.43, 0.91 ± 0.26 and 0.88 ± 0.31 respectively. Similar findings were also observed by Martinez et al. (2022). Severely distended urinary bladder with hyperechoeic thickened wall suggestive of cystitis was observed in the present study as reported by Udainiya et al. (2018) and Gokulakrishnan and Meena (2020). In some cases, under the study, hypoechoeic thickened bladder wall suggestive of chronic cystitis was observed which was similar to that of Ebrahim et al. (2019) which could be the result of prolonged obstruction (Abdel - Saeed et al., 2021). Few hyperechoeic non shadowing foci which could be blood clots or sludge were observed in some cases of the present study as observed by Gokulakrishnan and Meena (2020). Hyperechoeic urethral walls were observed in a case of present study which might be due to inflammation of urethra. Mild variations in the kidney measurement values in radiography and ultrasonography might be due to positional alterations during radiography and or improper plane of renal sonation.

**Conclusion**

Studies on urinary system affections in cats are rare in India. Radiography and ultrasonography of the urinary tract has provided a very good insight in diagnosis of different clinical conditions. The effects caused by FLUTD are acute only, hence, except nephromegaly many extreme alterations in parenchyma were not observed in kidneys.

**Conflict of interest**

We declare that we do not have any conflict of interest.

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