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Ultrasonography of the urinary tract in dogs and cats: Clinical investigations and prevalence

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ABSTRACT

The aim of this study was to investigate the different forms of urinary tract affections in dogs and cats by using ultrasonography. The present study was carried out on 118 clinical cases (27 dogs and 91 cats) of both sexes (90 males and 28 females) and different ages (ranged from one to 14 years old) suffered from urinary tract affections. The recorded cases were urolithiasis (n= 42), chronic cystitis (n= 41), hemorrhagic cystitis (n= 20), uroabdomen (n= 4), polycystic kidney (n= 8), renal abscess (n= 1), renal mass (n= 1), and urinary bladder mass (n= 1). The results revealed that in cats, urolithiasis represented the highest percentage among recorded cases (34.00%), followed by chronic cystitis (30.70%), with minor prevalence of renal mass, renal abscess, and urinary bladder mass (1.09% each). Whereas in dogs, the highest percentage of cases were chronic cystitis (48.10%), followed by urolithiasis (40.70%), with minor prevalence of uroabdomen (3.70%). The ultrasonographic investigations revealed that urolithiasis appeared as a hyperechoic structure with a distal acoustic shadowing, while the key feature for the chronic cystitis was the notable thick and corrugated urinary bladder wall. The present study concluded that ultrasonography was beneficial for the diagnosis of the different clinical affections of urinary tract in dogs and cats.

1. INTRODUCTION

Urinary tract diseases are frequently examined with ultrasound compared with other diagnostic modalities because it can be done quickly, cheaply, and with good contrast resolution (Robotti and Lanfranchi, 2013). However, differentiating between some incidental findings and pathological changes can be challenging (Griffin, 2020b). Renal neoplasms, polycystic kidney, renal abscess, cystic urolithiasis, cystitis, bladder neoplasms and bladder rupture are routinely encountered in the pet's clinical practice and could be diagnosed using ultrasonography (Debruyn et al., 2012 ; Griffin, 2020b).

Polycystic kidney is recorded mainly in Persian and Persian crossbred cats (Paepe et al., 2012). The loss in Kidney function gradually develops with time when occurring continuous growth of the cysts (Griffin, 2020a). Renal abscess includes both perirenal and intrarenal abscesses (Faucher et al., 2017). Cortical or corticomedullary intrarenal abscesses are usually implanted inside the renal capsule. Staphylococcus aureus skin infections can induce renal cortical abscess (Patterson and Andriole, 1987). Renal neoplasms exhibit variable echogenicity; hyperechoic, isoechoic, hypoechoic, homogeneous, and heterogenous (Hecht and Henry, 2011).

Cystic urolithiasis is a crystal growth inside the urinary bladder (UB), which sometimes completely fill the cavity (Rana *et al.*, 2022). The ultrasonographic examination usually shows a hyperechoic structure with distal acoustic shadow (Griffin, 2020a). Acute or mild cystitis might not be detected by ultrasound but UB wall in chronic cystitis, may be reduced in echogenicity (Griffin, 2020b). Hemorrhagic cystitis is an inflammation of the UB that induces mucosal hemorrhage. The main reasons of hemorrhagic cystitis include infection, trauma, bleeding problems or tumors (Léveillé, 1998; Manikandan et al., 2010).The disease is characterized by frequent, painful, and bloody urine (Ukwueze, 2015).The most frequent bladder neoplasm is the transitional cell carcinoma (Mannion, 2008). Diagnosis of UB neoplasia can be achieved well with abdominal ultrasonography (Biller *et al.*, 1990).

In addition to the above-mentioned cases, uroabdomen is an important urinary tract affection, which is defined as an accumulation of urine inside the abdominal cavity, caused either by damage to the kidney, ureter or the lower urinary tract (Grimes et al., 2018). It is frequently caused by trauma, long time urinary tract blockage, rough urinary catheterization, and neoplasia. In ultrasound, UB rupture is characterized by free abdominal fluid and urinary bladder wall defect (Suresh *et al.*, 2020).

The aim of the present study was to record and evaluate the ultrasonographic imaging of different urinary tract affections in dogs and cats and interpretate its relationship with some other diagnostic tools.

2. MATERIAL AND METHODS

2.1. Animals:

The present study was carried out on 118 clinical cases of dogs and cats (27 dogs and 91 cats). These animals were of

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both sexes (90 males and 28 females) and different ages (from one to 14 years old) through the period from 2021 – 2023 (Table 1). These cases were admitted to Benha Veterinary Teaching Hospital as well as another 9- private clinics at Qalubia, Gharbia, and Cairo governorates. All cases were diagnosed based on case history, clinical examination, and ultrasonography. The diagnosis of some cases sometimes was confirmed by radiographical examination, and/or some other laboratory diagnostic methods such as hematological and biochemical examination. The research protocol was approved by the Ethical Committee for Institutional Animal Use and Care of the Faculty of Veterinary Medicine, Benha University with the approval number (BUFVTM 18-01-23).

Table 1 Number and incidence rate of each affection, species, sex, and age of the examined dogs, and cats with urinary tract affections.

Affections	Number and incidence rate	Species		Sex		Age
		Dog	Cat	Male	Female	
Polycystic kidney disease	8 (6.70)	-	8 (8.70%)	4	4	3-10 Y.
Renal abscess	1 (0.84%)	-	1 (1.09%)	-	1	8 Y.
Renal mass	1 (0.84%)	-	1 (1.09%)	-	1	4 y.
Urolithiasis	42 (35.60%)	11 (40.70%)	31 (34.00%)	29	13	1-14 Y.
Chronic cystitis	41 (34.70%)	13 (48.10%)	28 (30.70%)	34	7	9 M-12Y.
Hemorrhagic cystitis	20 (16.90%)	2 (7.40%)	18 (19.70%)	19	1	1.5-7 Y.
Urinary bladder mass	1 (0.84%)	-	1 (1.09%)	-	1	11 Y.
Uroabdomen						
Ruptured urethra	2 (1.70%)	-	2 (2.20%)	2	-	2 & 7 Y.
Ruptured urinary bladder	2 (1.70%)	1 (3.70%)	1 (1.09%)	2	-	3 & 13Y.
Total number	118 (100%)	27 (100%)	91 (100%)	90	28	1-14 Y.

2.2. Ultrasonography:

Ultrasonography was done by using portable ultrasound machines (CHISON Eco 3 expert, China, 2016), (EDAN DUOS 60, China, 2021). Different types of probes were used including high frequency (7.5–10 MHz) linear, convex, and micro-convex transducers. All animals were examined in lateral and dorsal recumbency. Sedation was used in nervous animals. Examinations of urinary system by ultrasonography was performed via lateral and ventral abdominal approaches according to Mannion (2008); Griffin (2020a&b).

2.3. Radiography:

X ray machines used were (Digital X ray, PIXXGEN Corporation, COREA, 2021) (Model GT-SF 50BY Mobile medical X ray machine, 2016) (CR-FUJIFILM Corporation, JAPAN, 2018). Survey and negative contrast radiography were performed in 11 cases through lateral and ventro-dorsal views, whenever indicated. Survey radiography was performed on 10 animals. Negative contrast cystography was performed in only one case through evacuation of urine by urethral catheter then injection of air (40 ml) into the urinary bladder by syringe followed by capturing the X ray film.

2.4. Urine analysis and hematological and biochemical examination:

Urine samples in some urinary tract affections were collected either by hand pressure on urinary bladder in caudal abdomen or by catheterization or by cystocentesis. The urine samples were examined physically, chemically, microscopically, as well as microbiologically.

Hematological examination was done by Vet Scan HM5 hematology analyzer, Hungary, 2020. The biochemical examination was done by FUJIFILM Dri-chem Nx 500i.

2.5. Surgical interference:

2.5.1. Anesthesia:

Injectable general anesthesia by xylazine ketamine mixture IM or IV at a dose 1-3 mg/kg b. wt. for xylaject® (ADWIA, Egypt) as a premedication and 5-10 mg/kg b. wt. for ketamine ®, (sigmatec, Egypt) as a general anesthetic. Maintenance of anesthesia was performed whenever indicated by propofol® (B. Braun Melsungen AG, Germany) at a dose 3-6 mg/kg b. wt. slowly IV.

2.5.2. Surgical technique:

Perineal urethrostomy was performed according to Nye and Luther (2018). Cystotomy was performed according to Nikousefat et al., (2018). Urethral catheterization was performed according to Lulich and Osborne (2011).

3. RESULTS

3.1. Polycystic kidney disease:

Polycystic kidney disease (PKD) was diagnosed in eight Persian cats above 3 years old (4 females and 4 males) with a weight range from 2-4 kg. Cases of PKD were introduced with a history of anorexia and emaciation. All cases were incidental findings and pure Persian. Palpation of the abdomen indicates enlarged, non-painful both kidneys. Ultrasonographic examination showed multiple (2-8 cysts), small, medium, and large sized anechoic structures in both kidneys (Figs. 1a&b).

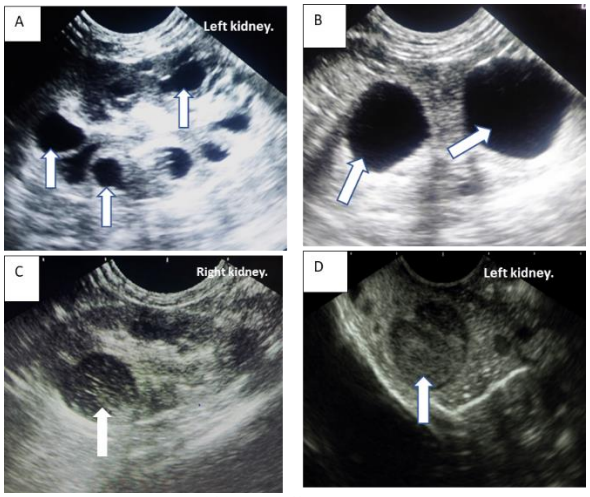

Fig. 1 Ultrasound images of kidney affections in cats. A. Polycystic kidney disease (PKD) (eight, different size renal cysts with anechoic content in the left kidney- arrows). B. PKD (two large size renal cysts with anechoic content in the right kidney - arrows). C. Renal cortical abscess (unilateral circumscribed hypoechoic structure in the right renal cortex - arrow). D. Renal mass (enlarged left kidney with hypoechoic mass, loss of corticomedullary distinction and loss of kidney architecture-arrow).

3.2. Renal abscess:
Renal cortical abscess was diagnosed in one female 8 years old cat. Fever with a painful palpation to the right kidney are the main signs. Ultrasonographic examination showed presence of a unilateral hypoechoic structure in the right renal cortex (Fig. 1c). Treatment by LEVOFLOX 250 mg tab (5 mg/kg. b. wt./1 month). The follow up through telephone conversation for one month revealed disappearance of the clinical signs.

3.3. Renal mass:
One female 8 years old cat was admitted with a history of anorexia, vomiting, hematuria, dehydration, and emaciation. By palpation, the left kidney was enlarged in size. Ultrasonographic examination showed enlarged right kidney with hypoechoic mass, loss of corticomedullary distinction, and loss of kidney architecture (Fig. 1d).

3.4. Urolithiasis
Urolithiasis was diagnosed in 42 animals (31 cat and 11 dog) (29 males and 13 females), with an age 1-14 Y. Cases of urolithiasis were presented with a history of anuria or oliguria (bloody or bloodless) and painful urination. UB palpation revealed hard structure inside UB in only one case. Ultrasonography of these cases showed either single or multiple, small, medium, or large sized hyperechoic curve linear structure in the dependent portion of the urinary bladder (UB) which moves by agitation, with distal acoustic shadowing (Figs. 2a&b). Survey radiography in six cases showed radio-opaque calculi inside UB vary in size and number (Figs. 2c&b). The laboratory values in 2 cases of UB calculi with urine retention showed a significant increase of BUN and urea. Calculus analysis of three cases revealed that 2 calcium oxalate calculi (2 cases), and triple phosphate calculus (one case). Microscopical examination of urine for seven cases showed (3) calcium oxalate, (which have acidic pH by urine strip test), and (3) triple phosphate, (which have alkaline pH by urine strip test), and (1) uric acid crystal. Surgical intervention was successfully performed in four cases (cystotomy in 3 cases (2 dogs and one cat) and perineal urethrostomy in one cat). The other examined 38 cases responded well to medicinal treatment and catheterization.

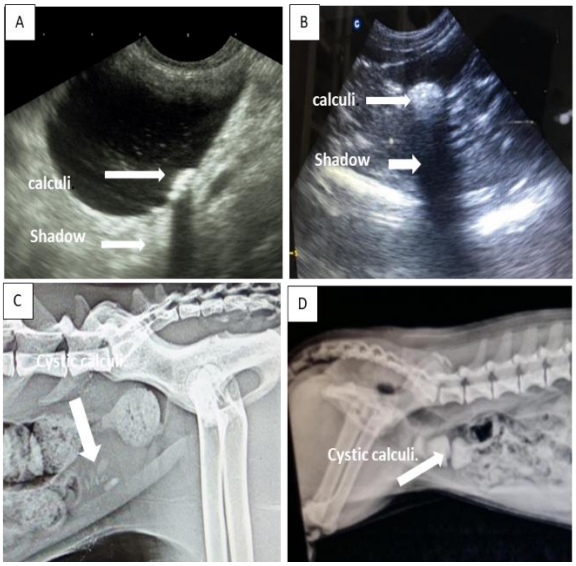

Fig. 2 Ultrasound images & lateral survey X-ray images of a male dog and tom cat with cystic calculi. A&B. Ultrasound images showing hyper-echoic calculi with distal acoustic shadowing. C&D. Lateral survey X-ray images showing multiple, different size, and radio-opaque cystic calculi (arrows).

3.5. Chronic cystitis
Chronic cystitis was recorded in 41 animals (28 cats and 13 dogs) (34 males and 7 females) aged 9 months to 12 years. Chronic cystitis cases were recorded with the history of frequent painful urination. Ultrasonography showed UB wall thickening (ranged between 2.0 to 6.7 mm), and echogenic urine UB. Follow up of a 4-years-old Persian non castrated tom cat for 11 days, revealed a very thick (6.68 mm) and corrugated UB wall on admission, and UB wall thickness was markedly decreased on day 11 (2.70 mm) without corrugation (Figs. 3a&b). Radiographic examination of chronic cystitis cases by survey radiography and negative contrast cystogram showed thick wall of UB (Figs. 3c&d). Neutrophilia and leukocytosis were recorded in two cases.

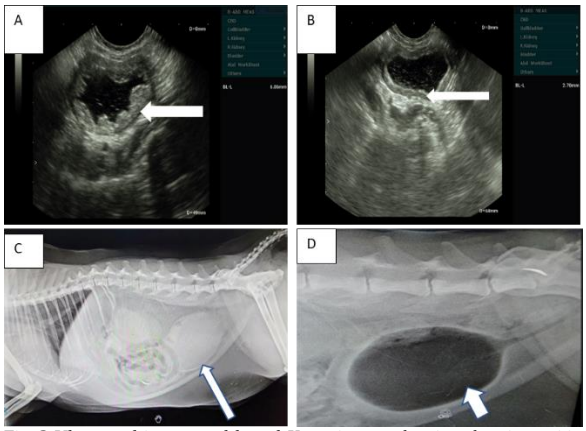

Fig. 3 Ultrasound images and lateral X-ray images showing chronic cystitis in a four-year-old Persian tom cat. A. Ultrasound image at zero day, the wall of UB (arrow) is thick (6.68mm) and corrugated. B. Ultrasound image on day 11, UB wall thickness was markedly decreased (2.70 mm) without corrugation - arrow). C. Lateral plain X-ray image showed thick wall of UB (arrow) and distension of UB which extend to the level of 4th lumber vertebrae. D. Lateral negative contrast X-ray image showed thick wall of UB - arrow.

3.6. Hemorrhagic cystitis (n:20).
Hemorrhagic cystitis was diagnosed in 20 animals (18 cats and 2 dogs) (19 males and one female). These cases were presented with a history of bloody urine (with or without urine retention) with difficult and painful urination. Urine retention cases showed distended UB (Fig. 4a). Ultrasonography showed echogenic mobile non shadowing structure which move by agitation (Fig. 4b) or diffuse turbid echogenic urine (Fig. 4c). Survey radiography for one case showed distended UB (Fig. 4d). Urine culture for two cases revealed proteus and staph aureus. Antibiotic sensitivity tests were done for the same 2 cases and showed sensitivity to amoxicillin and clavulanic acid. Cystotomy was performed for one case which did not respond to medicinal treatment and catheterization (Fig. 4e). Medical treatment and catheterization were performed for 19 cases. Catheterization detected bloody urine (Fig. 4f).

3.7. Urinary bladder mass:
Urinary bladder (UB) mass was detected in an 11-year-old female Persian cat with a history of taking long periods during urination and cough. Ultrasonographic examination showed presence of hypoechoic mass originated in ventral wall of UB that wasn't detached from the wall by agitation (Fig. 5a). Radiographic examination showed multiple masses in the lung (Fig. 5b). Surgery was not performed upon the request of the owner.

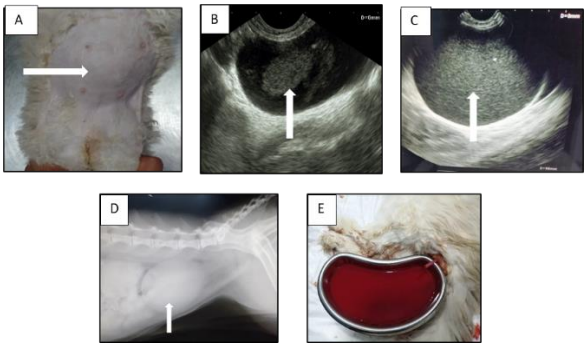

Fig. 4 Hemorrhagic cystitis in tom cat. A. Distended UB (arrow) in 4 years old tom cat. B. Ultrasound image showing echogenic, mobile, and non-shadowing blood clot in the lumen of UB (arrow) of a 2-year-old tom cat. C. Ultrasound image showing turbid (echogenic) urine inside the UB (arrow) of a 2-year-old tom cat. D. Lateral X-ray image showing very distended urinary bladder (arrow) in a 1.5-year-old tom cat. E. Bloody urine by catheterization of the same cat figure 4-c.

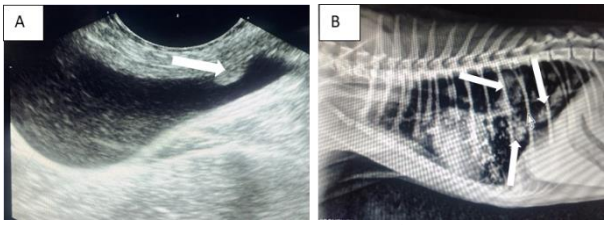

Fig. 5 Urinary bladder mass in an 11-year-old female Persian cat. A. Ultrasonographic examination of UB shows presence of hypoechoic mass (arrow) originated from ventral wall, and by agitation not detached from the wall. B. Lateral radiography in the same cat shows diffuse radiopaque lung nodules (arrows

3.8. Uroabdomen:

Four cases of uroabdomen were diagnosed (1 dog, and 3 cats). All cases were males (Two UB ruptures, and two urethral ruptures) with history of complete urine retention, abdominal distension, off food, recumbency and shivering. Subnormal temperature (36 °C) was detected in only one case. Fluctuated swelling around testicle was recorded in one case that was associated with urethral rupture. Abdominocentesis showed uriniferous odor. The ultrasonographic examination in case of UB rupture showed the presence of free anechoic abdominal fluid and defect in the wall of UB which appeared in all views (Fig. 6a). Injection of saline through catheter during ultrasonographic examination showed movement of fluid from urinary bladder through the defect into the abdominal cavity, but urethral rupture ultrasonography showed presence of free anechoic abdominal fluid between liver lobes and kidney and visible hepatic lobes (Fig. 6b). Lateral radiographic examination in one case showed loss of abdominal details (Fig. 6c).

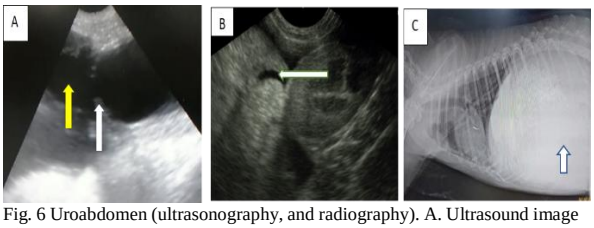

Fig. 6 Uroabdomen (ultrasonography, and radiography). A. Ultrasound image of UB rupture during retrograde injection of normal saline into the UB through catheter in 13 years old male griffon dog shows free abdominal anechoic abdominal fluid (green arrow) passing through UB wall defect (white arrow). B. Ultrasound image of a 2-year-old Persian tom cat demonstrates free fluid anechoic fluid between liver lobes and kidney with visible hepatic lobes (arrow). C. Lateral X-ray image of the same dog in figure 6-a shows loss of abdominal details (arrow).

4. DISCUSSION

All the recorded PKD cases in this study were incidentally in Persian cats of more than three years old. PKD appeared as incidental finding and the sensitivity of ultrasound for feline PKD increases with age and reaches 91% at 9 months (Bonazzi et al., 2007; d'Anjou and Penninck, 2015). The reported ultrasonographic findings of PKD showed multiple, thin-walled ovoid structures of different sizes with anechoic content in both kidneys. This was in agreement with that reported by Elgazzar et al. (2021).

In this study, renal abscess was recorded in only one case and appeared as a unilateral circumscribed hypoechoic structure in the renal cortex. This result agreed with Debruyn et al. (2012), who stated that renal abscess is a rare cause of focal renal disease. Ultrasonographic features comes in the same line as that observed by others (Debruyn et al., 2012 ; Faucher et al., 2017).

In this study, the ultrasonographic findings in case of renal mass demonstrated an enlarged kidney together with a hypoechoic mass, loss of corticomedullary differentiation, and loss of kidney architecture. This result agrees with Torad et al. (2005), who stated that renal neoplasia often causes renomegaly with displacement of the normal contour. Moreover, Taylor et *al.,* (2014) added that disappearance of the corticomedullary distinction, renomegaly, renal deformity, and the presence of a single or several hypoechoic nodules or masses in one or both kidneys are all ultrasonographic indicators of lymphoma.

Urolithiasis in this study was the most common urinary affection (42 out of 118 cases, 35.6%). These cases were mainly recorded in UB. Male cases were more than females. Similar finding was also reported by Hunprasit et al. (2019). The ultrasonography findings in urolithiasis cases were the presence of hyperechoic curve linear structure, with distal acoustic shadowing. The same results previously recorded by Griffin, (2020a). Lateral radiographic examination of different animals with cystic calculi confirmed the ultrasonographic examination and showed single or multiple radio-opaque cystic calculi of variable size. Similar findings were recorded by Torad et al., (2005). Urolithiasis ultrasound was confirmed by cystotomy after removal of calculi.

Chronic cystitis appeared ultrasonographically as a thick, corrugated UB wall with echogenic urine. Plain radiography and negative contrast cystography revealed a thick UB wall with distended UB that extended up to the level of 4th lumber vertebrae, This results agrees with that reported by Torad et al., (2005) ; Warren-Smith and Lamb, (2012) and Elgazzar et al.,(2021).

In hemorrhagic cystitis, echogenic and mobile structures which settle to the dependent portion without distal acoustic shadowing were detected. Injection of normal saline inside UB during ultrasonographic examination was performed to exclude neoplastic masses originating from the UB wall. Plain radiography showed distended urinary bladder which might be attributed to urethral obstruction by blood clot causing urine retention. Urine culture revealed the presence of staph aureus and proteus. These findings agrees with earlier studies (Ukwueze, 2015 ; Parry and Mahoney, 2019). Ultrasonographic diagnosis of hemorrhagic cystitis was confirmed by urethral catheterization and / or during cystotomy that confirmed presence of blood clot inside UB. Surgery are usually performed in these cases after failure of medical treatment (Baronciani et al., 1995).

Ultrasonography in a case of urinary bladder mass showed echogenic polypoid bulk originated from the wall of the urinary bladder at the level of its apex. The mass was fixed in its position and not moved by agitation of the transducer or by repeated examination after 7 days and not associated with distal acoustic shadowing. Lateral radiography showed radio-opaque nodules distributed throughout the lung tissue. Unfortunately, the owner refused performing needle biopsy or surgery to confirm the diagnosis. However, the case was suspected to be urinary bladder neoplasm with pulmonary metastasis. Similar findings were detected in urinary bladder neoplasia (Nyland et al., 1995 ; Léveillé, 1998 ; Heather M. Wilson et al., 2007 ; Holland and Hudson, 2020). Pulmonary adenocarcinoma appeared radiographically as multiple diffuse circumscribed mass dispersed in lung tissue (Koblik, 1986).

Uroabdomen was detected ultrasonographically in dogs and cats as free anechoic abdominal fluid and defect in wall of urinary bladder which appeared in all views. Catheterization, and injection of saline during ultrasonographic examination confirmed the diagnosis and showed movement of fluid through the urinary bladder defect into the peritoneal cavity. These findings are in agreement with that reported in earlier studies (Mannion, 2008; Colopy and Bjorling, 2015; Suresh et al., 2020). In case of UB rupture ultrasonographic examination showed free anechoic abdominal fluid between hepatic lobules and the kidney with visible hepatic lobes. This was in agreement with Hudson and Hamilton (2017), who stated that liver lobes cannot be easily distinguished unless separated by peritoneal effusion. Diagnosis was confirmed through abdominocentesis and lateral radiographic examination that revealed loss of abdominal details due to free abdominal fluids. These findings matched with that recoded by Muhammad *et al.* (2015) and Parry and Mahoney (2019).

5. CONCLUSIONS

Ultrasonography plays a vital role and provides important information in diagnosis of urinary tract affections in dogs and cats. Ultrasonography is easily accessible, unexpansive and allows real-time procedures to be performed. However, other additional diagnostic methods sometimes are essential to confirm the diagnosis.

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