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Ultrasonographical and Doppler Detection of Urinary Tract Disorder in Cats

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Abstract Many forms of urinary tract disorder could occur in cats, that difficult in differentiation between them, so that, this study was conducted to detect the Ultrasonographical and doppler finding of urinary tract disorders in cats. Study include 49 cats suffer from urinary system diseases, and other 10 cats being clinically normal consider as control group. Examination include percutaneous ultrasound scanning of both kidneys and ureters and urinary bladder. From results the common changes appeared in the renal pelvis 43 (87.75%), bladder 28 (57.14%), bladder and renal pelvis 25 (51.02%), different types of urinary system disorders happen in cats, include bladder deposits in 3 cats (6.12%), cystitis in 23 cats (46.93%), and pyelonephritis in 37 cats (75.51%). Combined cystitis and renal pelvis were found in 35 cats (71.42%), while hydronephrosis was found in 22 cats (44.89%). No significant differences were found in the Doppler examination of diseased cats compared to healthy cats in the following values: left renal resistance index, blood flow velocity, first systolic velocity, and second systolic velocity for both the right and left kidneys. The study found various urinary tract disorders and the most common of which was renal pelvic inflammation, and ultrasound and doppler scanning consider easy noninvasive technique to detect urinary tract diseases in cats

Key words: *Ultrasound, Doppler, urinary disorder, cats*

Introduction Ultrasound is a non-invasive diagnostic procedure characterized by ease of use, low cost, accurate diagnosis, timeliness, painlessness, and lack of side effects. It is commonly used as a diagnostic technique in human and veterinary medicine to examine various body systems, including the urinary system in cats. It is also used as an additional test for other diagnostic methods (1). Ultrasound uses frequencies that exceed the human hearing threshold, as the human ear can perceive sounds in the range of 20–20,000 Hz. Ultrasound used in medical imaging uses frequencies between 2–12 MHz, which is much higher than the human ear can hear. (2) Ultrasound scanners use probes equipped with arrays of piezoelectric crystals. When an electric charge is applied, these crystals deflect and emit vibrations, transmitting ultrasound waves through tissue. These echoes return to the probe and are converted into electrical signals that are transmitted to the system's computer, producing the ultrasound image. (3)

In cats and small dogs, it is preferable to use a probe with a frequency of 7.5-10 MHz. The linear probe is used to examine superficial areas, while the curved probe is used to examine deeper areas. It is preferable for the animal to be hungry during the examination, and the entire abdominal area, from the sternum to the pelvis, should be completely de-furred. It is recommended to use a gel or alcohol to ensure a high-resolution image. It is preferable for the animal to be placed in a lateral or dorsal position during the examination, either using a sedative or restraining an assistant (4; 5).

The bladder is located in the lower abdomen towards the tail. Its superficial location, easy accessibility, and fluid content make ultrasound imaging the best diagnostic tool for identifying bladder disorders that cannot be detected by urine examination alone (6). A full bladder is easy to image and is often oval in shape, surrounded by a smooth, clearly defined urethral wall. Normal urine is anechoic, but distortion or reflection in the bladder area interferes with the diagnosis of sediment or echogenic urine. The presence of echogenic material is shadowless and unrelated to gravity. These materials are fatty droplets naturally present in cat urine (7, 8). Ultrasound detects bladder volume, increased bladder wall thickness, urine density, sediment, stones, blood clots, and the presence of surrounding fat, lymph nodes, and tumors. It is difficult to determine the layers of the bladder because it varies depending on the degree of filling, but the normal bladder thickness in cats ranges between 1.3 and 1.7 mm , Furthermore, ultrasound can detect Congenital malformations (9), tumors, ureteral obstruction (10), urethral obstruction (11), bladder rupture echogenicity of urine sediment, hydronephrosis (12), renal pelvis dilatation (13), acute and chronic renal failure, renal pelvis dilatation and echogenicity of perivesical fat. (14).

The combination of ultrasonography and Doppler mode allows for the assessment and detection of hemodynamic changes that may affect renal function. The resistivity index (RI) and pulsatility index (PI), calculated from systolic and diastolic velocity values obtained from the wave spectrum, represent the resistance of the vascular wall to blood flow during organ perfusion. These indices have been used to evaluate renal perfusion in humans and animals and to determine the degree of intrarenal damage. There are no generally accepted normal values for the resistivity index and pulsatility index in feline urinary tract diseases. The resistivity index and pulsatility index are accurate indirect indicators of the degree of vascular stenosis, which can help in the evaluation of urinary tract diseases in cats and dogs (15).

Doppler technology is used in both human and veterinary medicine to assess the blood supply to the kidneys by assessing blood flow velocity, systolic and diastolic velocities, pulsatility index, and renal artery resistance index. It can detect renal artery stenosis, thrombosis, kidney inflammation, and vascular resistance, among other things. In human medicine, an increase in the resistance index and pulse index indicates the severity and duration of high blood pressure (16).

The resistance index is also considered an indicator of kidney dysfunction, especially in patients suffering from chronic kidney disease. These are indicators of vascular resistance. When resistance increases due to vascular obstruction or narrowing, diastolic blood flow decreases more than systolic blood flow, leading to a greater decrease in end-diastolic velocity compared to maximum systolic velocity, and thus both indicators rise. In veterinary medicine, it is used to detect kidney disease, especially when there is increased echogenicity of the renal cortex. A relationship has been found between their increase and increased creatinine and urea levels in the blood of cats with kidney disease. In normal cats, the resistance index should not exceed 0.70 (17).

In Iraq many researches were done about diseases in cat, about parasites infestation (18, 19, 20, 21), bacterial infection (22, 23) viral diseases (24), or as model (25) for medical study although many felid studies in Mosul try to detect the benefit of using ultrasound to confirm clinical diagnosis of the diseases in animals (26, 27, 28, 29, 30), there are little practical researches about using laparoscope (31) ultrasound (32) in detecting urinary tract diseases in cats, To the researcher's knowledge, no research has been conducted on the use of ultrasound and doppler in diagnosing urinary tract disorders in cats in Iraq. Therefore, this research was conducted to detect urinary tract diseases and describe the associated changes.

Materials and methods:

Ethical approval:

Study was ethically permitted by the Institutional Animal Care and Use Committee of the College of Veterinary Medicine, University of Mosul, UM.VET.2024.048. on 9-7-2024

Animals of study:

The study included examining 240 local cats in different areas of Nineveh and Kirkuk governorates, 49 of which showed symptoms of systemic disorders, and 10 clinically healthy cats were chosen as a control group, with ages ranging from 1 to 5 years.

Ultrasound and Doppler examination method:

Cats were examined under control and gently immobilized in the lateral recumbent position for kidney examination and dorsal recumbent for bladder examination, The lumbar region after the ribs on either side of the spine and the abdominal area were shaved using a clipper. The area was then sprayed with alcohol to remove the natural fat present on the skin. Gel was often used to fill the air gaps between the skin and the probe for clearer

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images. A Chison portable ultrasound machine with a small convex probe at frequencies of 4.5–8.0 MHz was used. The depth and focus settings were set at the same values for all cats used in the study to ensure uniform imaging conditions and accurate comparison between samples. The kidneys were examined longitudinally and transversely, the bladder was examined, and measurements were taken directly from the device (Figures 1, 2, 3, 4)

Figure 1: Transcutaneous kidney ultrasound examination of cats

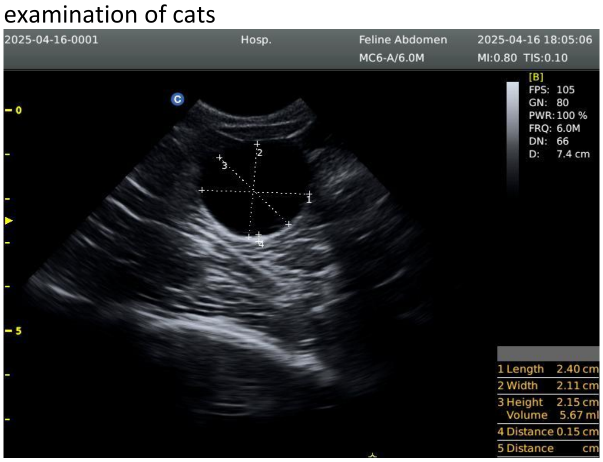

Figure 2: A normal cat's bladder examined transcutaneously using a 6.5 MHz probe.

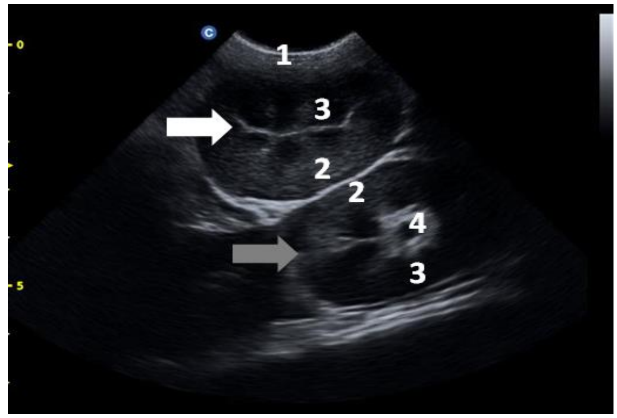

Figure 3: Right (white arrow) and left (grey arrow) kidneys of a cat examined by transcutaneous ultrasound using a 6.5 MHz probe, abdominal wall (1), cortex (2), medulla (3), renal pelvis (4)

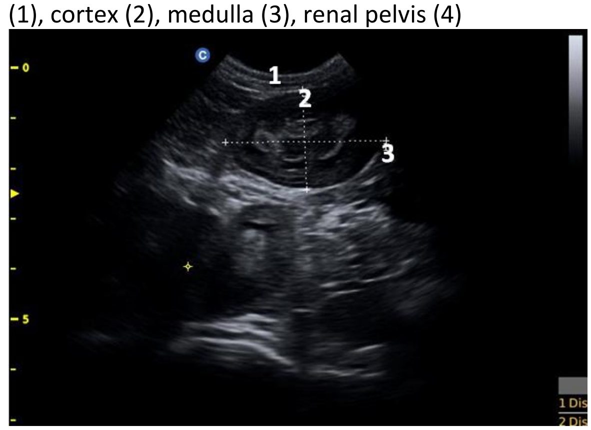

Figure 4: Ultrasound examination of the kidney using a 6.5 MHz probe, showing the method of taking measurements: abdominal wall (1), length (2), width (3).

The examination was performed using pulsed wave Doppler mode after identifying the main renal artery in each kidney using B mode, and setting the measurement angle to 60 degrees to ensure accurate blood velocity measurement. The waveform was recorded to evaluate the regularity of flow for three consecutive pulses, recording the peak systolic velocity (VS1), the diastolic pulse velocity (VS2), and the flowing blood velocity (VD), and determining the resistance index (RI) for each kidney, Figure (5).

Data set as means and standard deviations and the statistical comparison were done using Paired sample T test SPSS version 23 to detect the significant differences between the two groups, values rate significant were $p \leq 0.05$.

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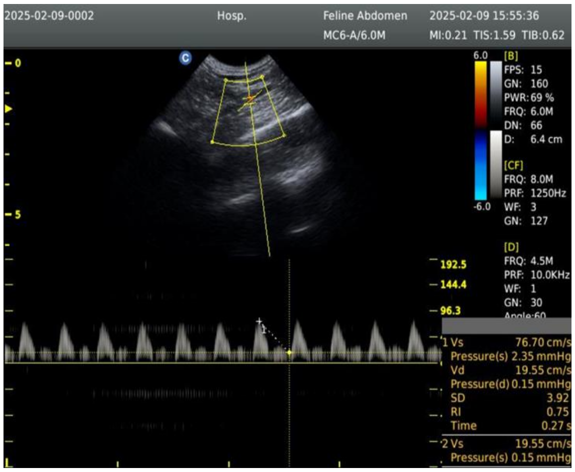

Figure 5: Using Doppler technology in kidney examination

Results

From the results of the ultrasound examination, it was shown that the sites of abnormal changes were most in the renal pelvis, with 43 and a percentage of 87.75%, followed by the bladder. Out of a total of 49 infected cats, 28 were in the bladder, with a percentage of 57.14%. The lowest results were in the bladder and renal pelvis, with 25 cats, with a percentage of 51.02%, as shown in (Table 1).

Table 1: Location of abnormalities in the urinary system using ultrasound

No	Changes site	Frequency (N=49)	%
1	Renal pelvis	٤٣	87.75
2	Bladder	٢٨	57.14
3	Bladder and renal pelvis	٢٥	51.02

It was found that the types of abnormal qualitative changes in the bladder were 3 cats suffering from the presence of deposits at a rate of 6.12%, 10 cats suffering from increased echogenicity of the contents at a rate of 20.40%, 16 cats suffering from irregularity of the wall at a rate of 32.65%, 21 cats suffering from wall thickening at a rate of 42.85%, while 23 cats were suffering from increased echogenicity of the wall at a rate of 46.93%, as shown in (Table 2), figure (6,7,8,9).

Table 2: Types of abnormal qualitative changes in the bladder using ultrasound

no	Location of abnormality	Frequency (N=49)	%
1	Presence of deposits	٣	6.122
2	Increased echogenicity	١٠	20.40
3	Wall irregularity	١٦	32.65
4	Wall thickening	٢١	42.85
5	Increased echogenicity	٢٣	46.93

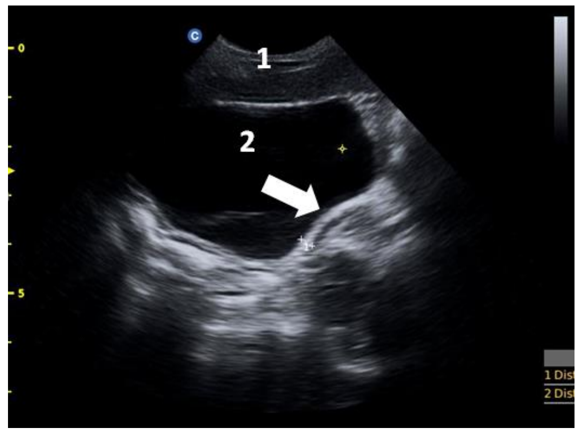

Figure 6: Ultrasound of a cat's bladder examined transcutaneously using a 6.5 MHz probe, abdominal wall (1), bladder containing black anechoic urine (2), bladder wall thickening (white arrow).

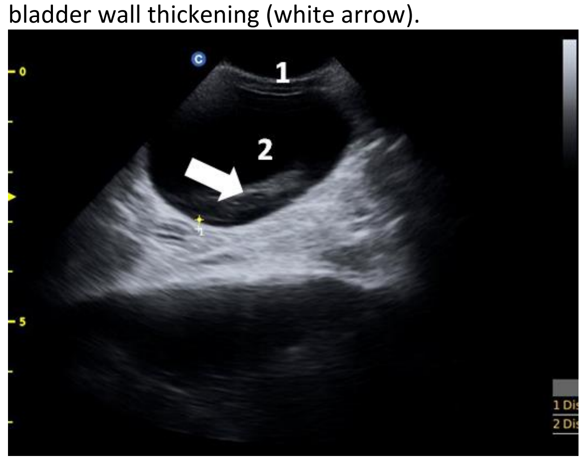

Figure 7: Ultrasound of the bladder of a cat examined through the skin using a 6.5 MHz probe, abdominal wall (1), bladder containing black anechoic urine (2), white sediment representing a collection of inflammatory cells or sand (white arrow).

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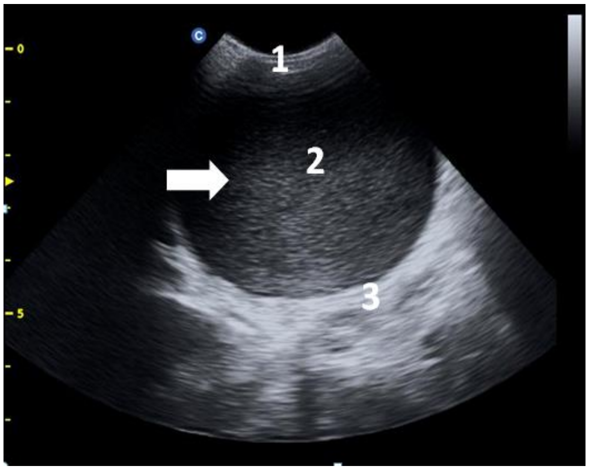

Figure 8: Ultrasound of a cat's bladder examined transcutaneously using a 6.5 MHz probe, abdominal wall (1), bladder (2), bladder wall (3) presence of echogenic inflammatory fluids and grayish color resembling a snowstorm (white arrow).

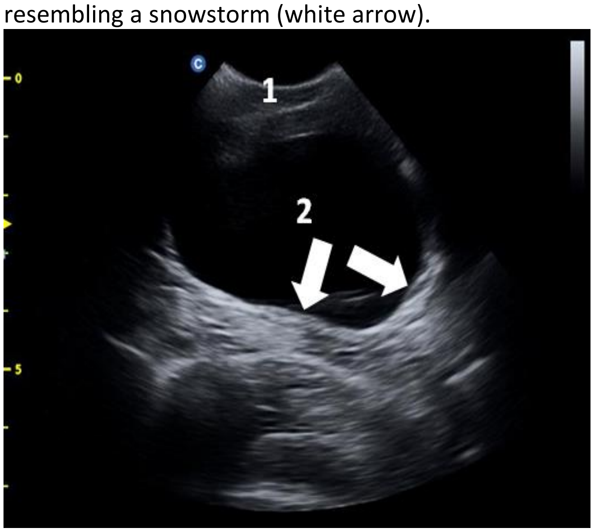

Figure 9: Ultrasound of a cat's bladder examined transcutaneously using a 6.5 MHz probe, abdominal wall (1), bladder containing anechoic black urine (2), bladder wall irregularity (white arrow)

The results of the study using ultrasound showed that there are types of urinary system disorders in cats, as 3 cats were suffering from bladder deposits at a rate of 6.12%, 23 cats were suffering from cystitis at a rate of 46.93%, and 37 cats were suffering from renal pelvis inflammation at a rate of 75.51%, while inflammation of the bladder and renal pelvis was present together in 35 cats at a rate of 71.42%, while hydronephrosis appeared in 22 cats at a rate of 44.89%, as shown in Table (4)

Table 4: Types of urinary tract disorders in cats using ultrasound

No	Types of disorders	Frequency (N=49)	%
1	Bladder deposits	٣	6.12
2	Cystitis	٢٣	46.93
3	Pyelonephritis	٣٧	75.51
4	Cystitis and renal pelvis	٣٥	71.42
5	Hydronephrosis	٢٢	44.89

While the results of the kidney examination using ultrasound showed the types of qualitative changes, which are as follows: the disappearance of the distinction between the cortex and the medulla in the left kidney in 29 cats, at a rate of 59.18%, while in the right kidney in 28 cats, at a rate of 57.14%, while the echo of the renal pelvis was increased in the left kidney in 37 cats, at a rate of 75.51%, and the right kidney in 35 cats, at a rate of 71.42%. As for hydronephrosis, it was in the left kidney in 20 cats, at a rate of 40.81%, while in the right kidney in 22 cats, at a rate of 44.89%, as in Table (5) and Figure (10, 11, 12)

Table 5: Types of abnormal qualitative changes in the kidneys using ultrasound

No	Type of changes	Side of changes	Frequency (n=49)	%
1	Loss of distinction between cortex and medulla	Left	٢٩	59.18
		Right	٢٨	57.14
2	Increased echogenicity of the renal pelvis	Left	٣٧	75.51
		Right	٣٥	71.42
3	Hydronephrosis	Left	٢٠	40.81
		Right	٢٢	44.89

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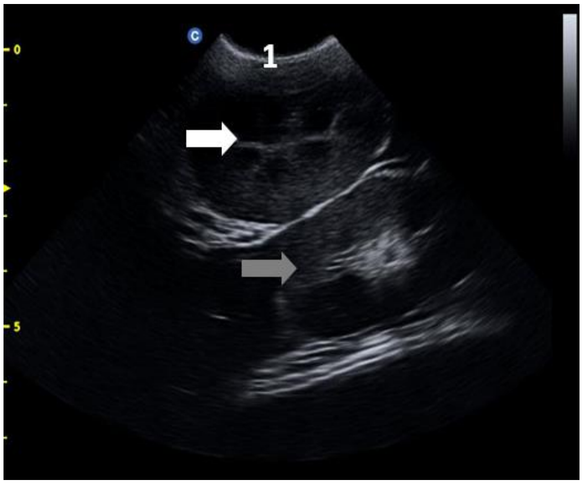

Figure 10: Kidneys of a cat examined by transcutaneous ultrasound using a 6.5 MHz probe, abdominal wall (1), undifferentiated right kidney white arrow) and undifferentiated left kidney (grey arrow).

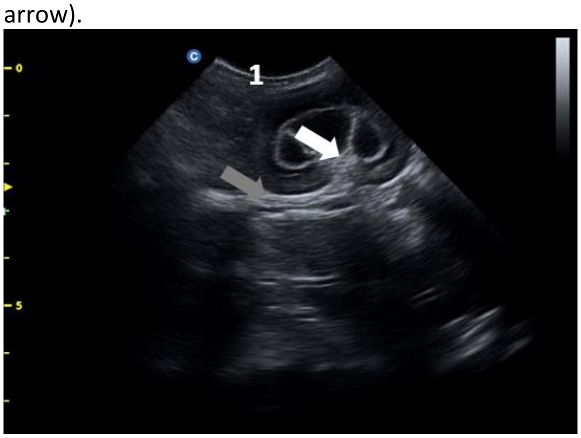

Figure 11: Kidney of a cat examined by transcutaneous ultrasound using a 6.5 MHz probe, showing inflammation of the renal pelvis and ureter, abdominal wall (1), increased echogenicity of the renal pelvis (white arrow), thickening of the ureter and its presence of white echogenic material (grey arrow).

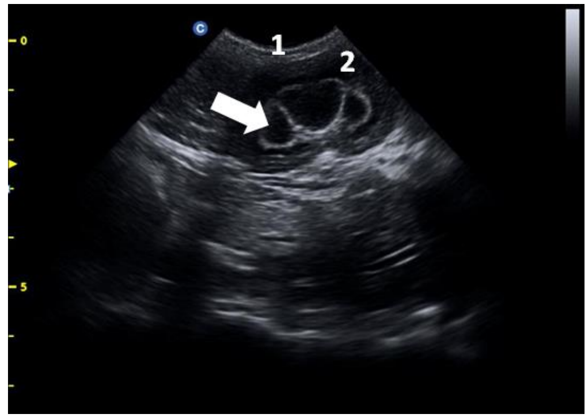

Figure 12: Kidney of a cat examined by transcutaneous ultrasound using a 6.5 MHz probe, showing hydronephrosis, abdominal wall (1), cortex (2), and fluid collection in the kidney (white arrow).

The results of the Doppler examination showed that there was no significant difference between the kidneys in diseased cats compared to healthy cats in each of the following values: the resistance index in the left kidney, blood flow velocity centimeter/second (cm/s), first systolic velocity cm/s, and second systolic velocity cm/s for both the right and left kidneys. Table (6) Figure (13)

Table 6: Changes in the kidneys using doppler examination

Examination		Mean ± Standard Error		P
Right Kidney		Normal (3)	Diseased (12)	
1	Left Renal Resistance Index	± ٦٠ ٠,٠٥	± ٠,٥٠ ٠,٠٣	٠,٨
2	Blood Flow Velocity cm/s	٥٨,١٥ ٦,٠١±	± ٥٢,١٣ ٦,٠١	٠,٩
3	First Systolic Velocity cm/s	± ٢٧,٦٧ ٢,٦	± ٢٤,٦٤ ٢,٦	٠,٨
4	Second Systolic Velocity	± ٢٤,٦ ٢,٢	٧,٤ ± ١٣,٨	٠,٢
Left Kidney		Normal (2)	Diseased (8)	
1	Right Renal Resistance Index	± ٠,٠٥ ٠,٥٠	± ٠,٥٤ ٠,٠٥	٠,٥
2	Blood Flow Velocity	± ٠,٨ ٣٠,٨	± ٢٥,٤ ٢,٥١	٠,٢
3	First Systolic Velocity	٨,٣ ±٦٠,٩	± ٥٩,٠٢ ٥,٦	٠,٤

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4	Second Systolic Velocity	30.8 ± 0.8	± ٤١,٣٦ ٢٧,٠٢	٠,٣

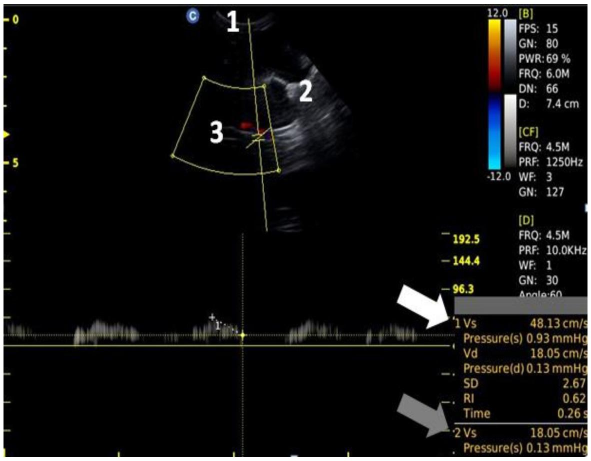

Figure 13: Doppler examination of the kidney, abdominal wall (1), kidney (2), Doppler examination area (3), first systolic velocity (white arrow), second systolic velocity (grey arrow)

Discussion:

The results of abnormal qualitative changes in the bladder using ultrasound showed a clear significant difference between the healthy group of cats and the affected group of cats, represented by increased bladder wall echogenicity, increased bladder wall thickness, irregularity of the bladder wall, and the presence of deposits. These results were similar to those found by several studies (33, 34).

This is due to the infiltration of inflammatory cells and bleeding in the layers of the bladder wall or due to pressure inside the bladder wall resulting from its excessive expansion during urinary retention, as a tear in the bladder wall occurs and bleeding occurs (34) and poor blood supply with the presence of areas of necrosis or ulceration on the bladder wall (35). The sediment may also be blood, bacteria, crystal gas, (36).

This study also recorded an increase in the echogenicity of the bladder contents, similar to the results of (15), The presence of high or low echogenic materials of different sizes indicates the presence of a blood clot, inflammatory cells, cellular debris, and fat droplets, or the presence of a tumor (8, 37) stated that an increase in the echogenicity of the bladder contents is not always an indication of an infection or active bacterial content, especially since cat urine contains fat droplets that increase the echogenicity of the urine and are not considered a pathological condition. Also, when the specific gravity of the urine decreases, the urine appears anechoic. An increase in urine echogenicity is not considered an indication of an infection, especially in cats suffering from kidney failure. The results of the current study also showed increased echogenicity of the surrounding bladder fat, which is associated with cystitis. The results were similar to those of (11) stated that the use of ultrasound in the evaluation of cystitis is very effective, acute and minor injuries may be difficult to detect with ultrasound, while severe and chronic injuries may lead to the appearance of these changes.

The results of the study on the qualitative examination of the kidneys using ultrasound showed that the renal cortex of the healthy cats group has moderate and equal echogenicity compared to the liver and spleen, and its shape is granular in texture, while the medulla is anechoic and separated by echo lines or intervals (cavities or pockets), thus making it easy to differentiate between the cortex and medulla in healthy cats, and this result was similar to the results of (38).

The results of the current study also showed a significant difference between the two study groups, including the loss of differentiation of the cortex and medulla in sick cats. This result was similar to what was reached by (38, 39, 40), that the loss of differentiation of the cortex and medulla occurs as a result of degenerative changes that occur in the kidney tissue as a result of inflammation and fibrosis or as a result of the presence of a tumor, fatty deposits, bleeding, abscess (37, 38) or as a result of infection with infectious peritonitis in cats (41, 42) found that the changes that occur in the kidney tissue have a direct effect on the echo of the kidney. Increased cortical echogenicity is often accompanied by increased medullary echogenicity, making it difficult to differentiate between the cortex and medulla (3). A subtle change in cortical echogenicity can be observed on ultrasound, which helps in early diagnosis of diseases, as well as detecting chronic diseases that are not accompanied by clinical symptoms (43). Although it is difficult to differentiate between increased echogenicity in the renal cortex of healthy and diseased cats, other changes such as changes in shape, size, borders, and internal texture may help in the correct assessment (42).

In some cases, cats are healthy and there is no change in kidney function, but an increase in cortical

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echo is observed. This condition occurs as a result of several factors, such as older cats, pregnant women, neutered males, or the accumulation of fat on the renal cortex, as a result of the activity of sex hormones, the thickness of the patient's body, and ultrasound settings (44, 45)

The current study also showed the presence of dilatation and increased echogenicity of the renal pelvis as a result of hydronephrosis. These results were similar to those of (38, 40). The increase in renal pelvis dilatation depends on the duration and severity of the obstruction. Therefore, if the retention is not severe, the ureter and pelvis may not be significantly dilated in cats (48). The renal pelvis may dilate as a result of the accumulation of cell debris, blood clots, tumors, and stones, leading to a defect in renal pelvic filling. Nephritis may be present even before any change appears on ultrasound (37).

The results of the study regarding the dimensions of the kidneys showed that the average length/centimeters of the kidney in healthy cats was (3.39 ± 0.01) cm left, (3.32 ± 0.1) cm right. The average width was (2.04 ± 0.07) cm left, (2.13 ± 0.12) cm right and within the limits of the average kidney lengths mentioned in previous studies (34, 47), (3_4.3), the results of this study differed from (48, 44) as they found that the right kidney is longer than the left kidney, the difference may be due to the fact that the left kidney is more mobile (49, 47) did not find a significant difference between Kidney lengths Kidney dimensions may vary depending on gender, age, neutering status, and weight (44; 48) and found that males have larger kidneys than females. They also found that neutered cats have smaller kidneys than unneutered cats (50). Weight is due to the accumulation of retroperitoneal fat, which affects the accurate determination of kidney dimensions (49).

This study recorded the average thickness of the left cortex (0.39 ± 0.02) cm, the right (0.43 ± 0.03) cm, and differed from the results of previous studies (48) The dimensions may vary depending on the imaging position, imaging level, or imaging angle or may be affected by age (49) as a result of organ immaturity. stated that a decrease in the thickness of the cortex indicates a loss of kidney function due to the presence of glomeruli in the cortex area (51). It is also used to monitor the stages of kidney failure development (52) who stated that there is no correlation between the thickness of the cortex and kidney failure. Determining Kidney dimensions are clinically important for detecting kidney disorders or failure and are important for diagnosis and treatment (50). Kidney failure leads to kidney atrophy, while acute kidney failure leads to kidney enlargement. It is important to determine the cortical thickness to determine the extent of kidney failure. Low glomerular filtration rate is considered more important than length and width, which are considered an important and early indicator. They are even used to monitor disease progression in human medicine (52, 53).

The results of the study using Doppler technology showed that the resistance index (RI), blood flow velocity, and the first and second systolic velocities (centimeters/second) of the renal artery were within normal limits, and no significant differences were recorded between diseased and healthy cats. This result was contradicted by (15) and (54), as their study revealed significant differences between diseased and healthy cats. This result may be due to the small sample size used in the study, as it was difficult to conduct a Doppler examination for all study cases. The diversity of cases within the study, which included upper and lower urinary tract injuries of varying degrees of severity, may not cause clear changes in renal hemodynamics or a direct impact on the blood vessels within the kidney. It may also be due to the use of the renal artery, which is a large artery compared to the arcuate arteries used in previous studies, which explains the emergence of this result (55, 56). There is no clear scientific consensus on the normal values of the resistance index in cats, but based on the results of previous studies, both in humans and cats, it was found that the normal index should not exceed 0.70 (57, 58).

Conclusions:

Ultrasound provide easy and excellent technique for accurate detection of urinary tract disorder in cats. Results of the Doppler of this study can consider as references for cats in Iraq.

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Conflict of interest:

Authors declare that no any conflicts of interest

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