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Experimental Ureteric Obstruction and Hydronephrosis in dogs: Clinical Assessment, Ultrasonographical and Hematological Findings

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ABSTRACT

The present experimental study was carried out on 12 apparently healthy dogs divided into two groups (6 dogs for each). Complete unilateral ureteral obstruction was performed in group A and bilateral partial obstruction was performed in group B. all dogs were evaluated clinically, hematobiochemically and ultrasonographically for one month post obstruction. Signs of depression, anorexia and loss of weight were observed in both groups. Animals in group A regained their appetite and activity with time. A significant increase in SUN and creatinine was observed in group A. Ultrasonographic examination showed marked increase in kidney length and width with decreased thickness of cortex and medulla in both groups. It could be concluded that bilateral partial obstruction of the ureter resulted in significant hematobiochemical changes and prolonged clinical signs than unilateral complete ureteral obstruction.

1. INTRODUCTION

The urinary system is intricate and has the main function of body homeostasis safeguarding, by controlling volume of fluids within body, electrolyte balance and urine transmission outside body. The kidneys, intricate and vital organs responsible for filtering waste products and maintaining fluid and electrolyte balance, are highly susceptible to the deleterious effects of urine accumulation (Thotakura and Anjum, 2023). The ureter, the safe passage in which urine travels from kidney to urinary bladder, protects renal parenchyma from distally generated backflow and back pressure, by its elasticity and adaptation to diuresis amount (Gomes-Blanco, et al., 2016). When normal urine flow is obstructed or disrupted, the renal pelvis and calyces become distended with urine, resulting in the condition termed hydronephrosis. The physiological response to obstruction is not confined solely to anatomical factors; it encompasses a spectrum of potential etiologies ranging from congenital abnormalities to acquire obstructions arising from urinary stones, tumors, or inflammatory processes (Thotakura and Anjum, 2023).

Ureteral obstruction may manifest as partial or complete obstruction, determining whether urine can transverse the point of blockage. The extent of obstruction dedicates the degree of hydrostatic pressure elevation exerted upstream of blockage site, extending to the proximal ureter, renal pelvis, and renal parenchyma. This augmented pressure induces passive dilation of the proximal ureter and renal pelvis, occasionally resulting in marked expansion of these structures (Fink et al., 1980).
The dog in acute hydronephrosis typically presents with sudden and severe clinical signs, including intense pain, abdominal discomfort, vomiting, and potentially life-threatening systemic disturbances. The rapid development of symptoms necessitates prompt diagnosis and intervention to alleviate the obstruction and relieve the associated pain (Rimer et al., 2022). On the other side, chronic hydronephrosis refers to a prolonged state of renal accumulation within the renal pelvis and calyces due to a persistent or recurrent obstruction. This prolonged structure allows the renal structures to adapt to the increased pressure, potentially leading to gradual renal parenchymal damage, loss of functional

nephrons, and compromised renal function (Thotakura and Anjum, 2023). Diagnosis of hydronephrosis relies on a combination of clinical signs, the laboratory assessments (blood tests and urine analysis) and imaging studies (ultrasound and radiography) that play a key role in visualizing the extent of hydronephrosis, assessing renal parenchyma and determining the underlying cause (Rimer et al., 2022; Bowen et al., 2023). The primary benefit of ultrasonography over radiography is that it is not hampered by the presence of ingesta, abdominal fluid, or absence of retroperitoneal fat. It is quicker and noninvasive, and it can offer a better evaluation of the internal architecture of the renal parenchyma. It can also be carried out without regard to renal function. There is no need for ionising radiation or contrast media and makes it possible to evaluate nearby structures (Kealy and McAllister, 2005). The management of hydronephrosis centers on rapid relief of the obstruction and restoration of normal urine flow. Surgical intervention may be necessary to remove obstruction promptly, addressing underlying cause, managing pain, and providing supportive care are essential components of treatment (Chávez-Iñiguez, et al., 2020). This experimental investigation aims to evaluate the clinical, ultrasonographical and hematological findings following an experimental ureteric obstruction in dogs.

2 . MATERIALS AND METHODS

2.1 . Animals:

Following approval by the Institutional Animal Use and Care Committee of the Faculty of Veterinary Medicine, Alexandria University (AU-IAUCC) and in accordance with the institutional ethical guidelines for the care and use of laboratory animals, all experiments and procedures were carried out in the department of Surgery. The present investigation included a total number of 12 mongrel apparently healthy dogs aged 2 – 5 years and weighed 18 – 35 kg. The dogs were divided into 2 groups; group A (6 dogs) was subjected to complete unilateral ligation of the left ureter and group B (6 dogs) which were subjected to partial bilateral ligation of both ureters.

2.2. Animal preparation and anesthesia

All dogs were subjected to physical examination to detect their fitness for the study. After fasting for 12 hours, dogs were pre-medicated with 2% xylazine Hcl (Xylaject, ADWIA, Egypt) as 1 mg/kg. IM. Then, the dogs were positioned in dorsal recumbency, and the ventral abdomen was prepared for aseptic surgery. General anesthesia was then conducted with 5 mg/kg of Ketamine Hcl (Ketamax-50, Troikaa Pharmaceuticals Ltd., India).

2.3. Surgical operation:

The urinary bladder was approached through a caudal abdominal midline (female) and para midline (male) incisions. The urinary bladder was carefully extracted through the incision and surrounded by a wet laparotomy pad. Stay suture was placed in the bladder apex, for its retraction. The ureter was then bluntly dissected from the surroundings and ligated about 1 cm far from the bladder using silk 2/0 for complete unilateral ureteric ligation. (Fig., 1 A&B)

In partial bilateral cases after dissecting the ureter, silk was wrapped around it and the metal rode was positioned within the wrap parallel to the ureter using fingers and then the silk was ligated around the ureter and rode together (Fig., 1 C). The column was finally withdrawn carefully leaving a loose ligation around the ureter (Fig., 1 D). The same steps were taken for the other ureter. Stay suture of the bladder was then removed and the bladder was washed and moistened with saline and returned to its normal position inside abdominal cavity. Abdominal muscles were sutured using vicryl 2 / 0 in simple continuous pattern and skin was sutured using silk 2 / 0 in simple interrupted pattern.

2 . 3 . Clinical examination

The clinical symptoms were recorded during the period from the 1st to 28th days after unilateral and bilateral ureteral ligation including temperature, body weight and any other symptoms appeared on the animal.

2 . 4 . Ultrasonographic imaging

Ultrasonographic imaging was performed weekly till the 4th week using the scanner A real time B – mode and M – mode linear array ultrasound scanner. Ultrasonographic examination of kidneys was performed according to the method described by Barr (1992**)**. Animals were positioned in lateral recumbency. The transducer was positioned in the last 2 right intercostal spaces to visualize the right kidney and behind the last left rib to visualize the left kidney.

2 . 5 . Hematological evaluation

The blood samples were collected from cephalic vein in a test tube containing anticoagulant for hematological analysis including RBCs count, Hb concentration (g/dl) and hematocrit. Other samples were collected in plain tubes without anticoagulant to obtain serum. The coagulated blood was stored in room temperature for an hour then kept in refrigerator for 2 hours. After this it was centrifuged at 1500 rpm for 10 minutes. The serum was stored in a sterile clean vials at - 20 degree cellisious for biochemical analysis determination of serum urea nitrogen (SUN), creatinine, calcium, inorganic phosphorus, chloride, sodium and potassium (mg/dl). (Fawcett and Scott, 1960, Bohoun,1962, Schonfeld and Lowellen,1964, Teitz, 1970, Henry et al., 1974). The samples were collected before and at 1st, 2nd, 3rd and 4th weeks post ligation.

2. 6 . Statistical analysis

All values were expressed as mean ± SE. The data were analyzed using the general linear model of SAS (1996), while the difference between means was detected by ANOVA and Duncun's multiple range test.

3 . RESULTS

3 . 1 . Complete unilateral obstruction

3 . 1 . 1 . Clinical findings

All dogs refused food consumption during the first 2 days post-operative then they have returned gradually to their normal appetite. During the second week ligated kidney was painful, firm, and larger than normal in palpation. Animals were dull in appearance and loss weight. Urinary incontinence was the most notable clinical sign. After the 2nd week, the body condition got better gradually, appetite has returned to normal toward the end of study, but palpated kidney has remained painful till the last day of the study. Water consumption has also been increased. Body temperature was significantly increased at the 2nd week then decreased again to become around the baseline value, while body weight showed non-significant decrease all over the observation period (Table, 1).

3 . 1 . 2 . hematological evaluation

There was a non-significant decrease in RBCs count till the 3rd week followed by a significant decrease at the 4th week. HB showed a significant decrease in the 1st and 4th weeks 4th week. Hematocrit showed non-significant changes till the 4th week (Table, 2).

3 . 1. 3 . serum analysis

Serum urea nitrogen was increased insignificantly at the first 3 weeks then increased significantly toward the end of the study but still within the physiological limits. Creatinine was increased non-significantly till the end of the study. The serum levels of Ca, Ph, Mg, Na and Cl showed insignificant changes throughout this study. Potassium level showed a significant increase in the 1st week (Table, 3).

3 . 1 . 4 . Ulrtasonographic findings

The left kidney revealed a significant increase in kidney length, width and sinus length and width from the 1st week. The medullary and cortical thicknesses showed non-significant changes (Table, 4 and Fig., 2).

3 . 2 . partial bilateral obstruction

3 . 2 . 1 . clinical findings

The dogs lost appetite for 2 days post-operative then appetite increased gradually but not returned to normal. The animals were dull throughout the whole study period, activity was low, and they were reluctant to move. Abdominal pain was an obvious clinical sign and constipation has appeared during the 2nd week and remained till the study end. Body temperature was significantly increased at the 2nd week, body weight decreased significantly till the end of the study (Table, 5).

3.2.2. hematological evaluation

There were non-significant changes of HB, RBcs and hematocrit till the end of the study (Table, 6).

3.2.3. serum analysis

SUN and creatinine showed significant increase till the end of experiment and never returned to the baseline value. There was a significant decrease of potassium from the 2nd to the 4th week and significant increase of serum calcium at the 2nd and 3rd week with no significant changes in other serum electrolytes (Table, 7).

3.2.4. ulrtasonographic findings

Significant changes in length and width of kidney and in sinus width and length till the end of 4th week. The renal cortex and medulla thickness were significantly decreased till the 4th week (Table, 8 and Fig., 3).

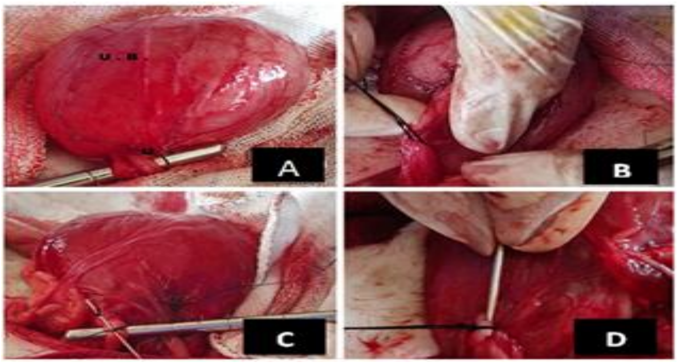

Fig. 1. The ligation of ureters (A) Identification and blunt dissection of ureter near the urinary bladder. (B) Complete ureteric ligation using silk no. 2 near the urinary bladder in group A. (C) Partial ureteric ligation using metallic stent in group B . (D) Removal of metallic stent for induction of partial ureteric obstruction. U, ureter; UB, urinary bladder; 1, metallic stent.

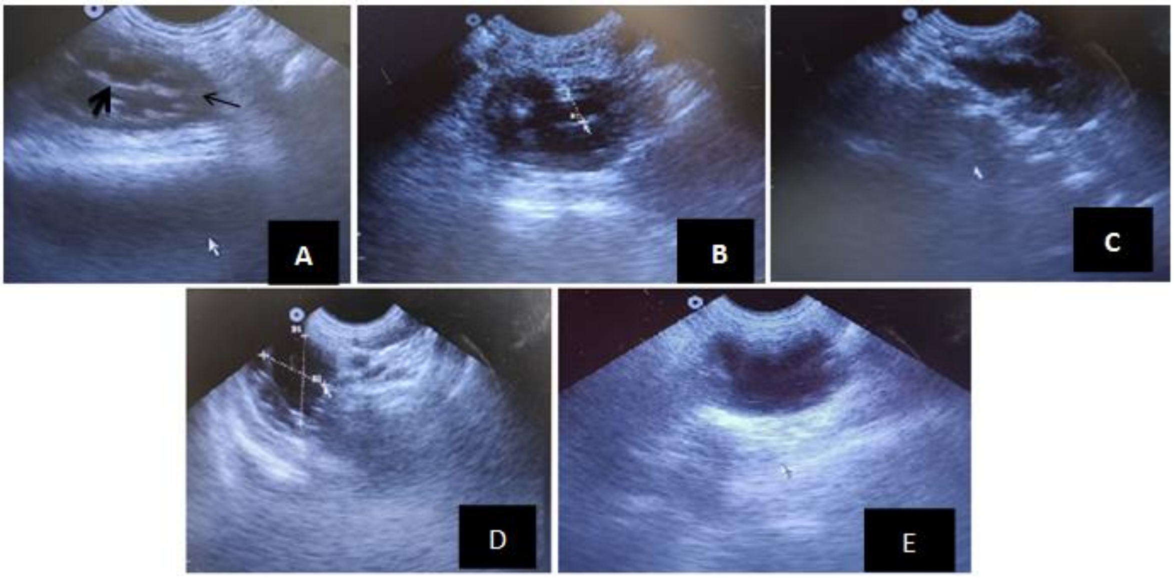

Fig. 2: ultrasonography for kidney after induction of complete unilateral ureteral ligation (group A)
(A) normal kidney before induction of hydronephrosis. (B) 7 days post ligation, kidney size has increased. (C) 14 days post ligation reveals observable dilation of renal pelvis. (D) 21 days post operation, renal parenchyma has degenerated, and renal pelvis continued to increase in size. (E) the kidney 28 days post ligation; the cortex is indistinct from medulla, hydronephrosis became clear, kidney appeared as a water sac. thin arrow: cortex, thick arrow: medulla

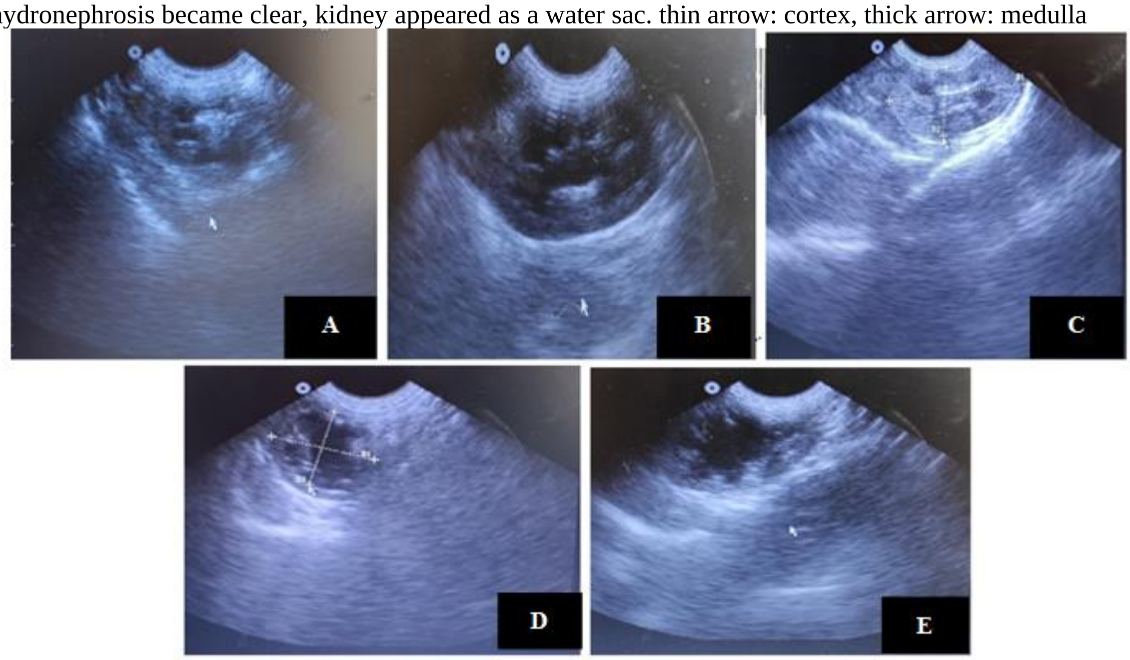

Fig. 3: ultrasonography for kidney after induction of partial bilateral ureteral ligation (group B)
(A)Normal kidney before induction of bilateral ureteral ligation. (B) kidney 7 days post ligation, slight increase in renal pelvis size . (C) kidney 14 days post ligation, (D) kidney 21 days post ligation, renal pelvis is anechoic and increasing in size was more prominent (E) 28 days post operation, hydrronephrosis became clear , renal parenchyma was degenerated and renal pelvis has consumed the most of the kidney.

Table 1 : *Comparing temperature and body weight measurements between time points in group A (n= 6).*

time	Temperature	Body weight
Baseline	38.63 ± 0.15 A	23.17 ± 1.56 A
Week 1	38.7 ± 0.04 A	22.13 ± 1.37 B
Week 2	39.55 ± 0.13 B	21.62 ± 1.33 AB
Week 3	38.72 ± 0.11 A	21.18 ± 1.3 AB
Week 4	38.53 ± 0.08 A	19.42 ± 2.22 C

Table 2: Comparing CBC parameters between time points in group A (n= 6**)**

time	HB (gm/dl)	RBCs (×10^6/ml)	Hematocrit (%)
Baseline	13.12 ± 0.85 A	5.76 ± 0.33 A	37.93 ± 2.71 A
Week 1	11.88 ± 1.61 B	5.62 ± 0.69 A	36.77 ± 3.38 A
Week 2	13.6 ± 1.52 A	5.95 ± 0.48 A	39.87 ± 3.78 A
Week 3	12.22 ± 0.83 AB	5.37 ± 0.21 A	35 ± 2.31 A
Week 4	11.3 ± 0.27 B	4.99 ± 0.11 A	33.58 ± 0.98 A

Table 3: *Comparing Renal Function Test parameters between time points in group A (n= 6).*

time	BUN	creat	Na	K	Ca	Ph	Cl
Baseline	13.85 ± 1.62 A	0.81 ± 0.08 A	142.98 ± 0.9 A	4.87 ± 0.23 AB	10.02 ± 0.15 A	4.49 ± 0.24 A	112.14 ± 2.45 A
Week 1	16.12 ± 3.86 A	1.02 ± 0.09 A	142.05 ± 0.59 A	5.18 ± 0.1 A	10.26 ± 0.39 A	5.13 ± 0.4 A	110.63 ± 0.69 A
Week 2	15.03 ± 1.62 A	0.96 ± 0.11 A	143.78 ± 1.76 A	4.56 ± 0.12 B	11.06 ± 0.69 A	4.44 ± 0.21 A	111.62 ± 1.66 A
Week 3	17.8 ± 2.51 A	0.95 ± 0.13 A	143.5 ± 0.99 A	4.81 ± 0.06 AB	10.58 ± 0.41 A	4.68 ± 0.23 A	111.85 ± 2.62 A
Week 4	24.5 ± 4.86 A	0.92 ± 0.12 A	146.32 ± 1.09 A	4.78 ± 0.16 AB	10.71 ± 0.4 A	4.66 ± 0.31 A	108.15 ± 0.86 A

Table 4: *Comparing ultrasonographic findings between time points in group A (n= 6).*

time	Kidney length	Kidney width	Sinus length	Sinus width	Cortex thickness	Medulla thickness
Baseline	4.56 ± 0.12 B	3.27 ± 0.08 B	2.05 ± 0.2 B	0.98 ± 0.23 B	0.7 ± 0.03 A	0.8 ± 0.21 A
Week 1	6.05 ± 0.22 AB	4.08 ± 0.24 AB	2.88 ± 0.29 AB	1.6 ± 0.29 AB	0.78 ± 0.03 A	0.92 ± 0.12 A
Week 2	7.58 ± 0.49 AC	4.42 ± 0.3 AB	3.08 ± 0.14 AC	1.85 ± 0.33 AB	0.78 ± 0.05 A	1.03 ± 0.15 A
Week 3	8.08 ± 0.42 C	5.12 ± 0.41 A	3.77 ± 0.21 CD	2.32 ± 0.27 A	0.72 ± 0.04 A	0.88 ± 0.08 A
Week 4	8.63 ± 0.54 C	5.18 ± 0.38 A	4.27 ± 0.18 D	2.7 ± 0.19 A	0.68 ± 0.05 A	0.88 ± 0.17 A

Table 5: *Comparing temperature and body weight measurements between time points in group B (n= 6).*

time	Temperature	Body weight
Baseline	38.5 ± 0.1 B	32 ± 0.97 A
Week 1	38.6 ± 0.06 AB	30.48 ± 0.96 B
Week 2	39.27 ± 0.11 C	29.55 ± 1 AB
Week 3	38.63 ± 0.03 AB	28.58 ± 0.86 AB
Week 4	38.88 ± 0.09 A	28.27 ± 0.93 C

Table 6: *Comparing CBC parameters between time points in group B (n= 6).*

time	HB (g/dl)	RBCs (×10^6/ml)	Hematocrit (%)
Baseline	13.77 ± 0.52 A	6.28 ± 0.51 A	40.17 ± 2.28 A
Week 1	14.97 ± 1.4 A	6.66 ± 0.87 A	43.56 ± 4.73 A
Week 2	13.35 ± 1.38 A	6.37 ± 0.74 A	40.64 ± 4.12 A
Week 3	14.25 ± 0.35 A	6.46 ± 0.38 A	41.63 ± 1.63 A
Week 4	11.83 ± 0.8 A	5.57 ± 0.53 A	35.3 ± 2.77 A

Table 7: *Comparing Renal Function Test parameters between time points in group B (n= 6).*

time	SUN	creat	Na	K	Ca	Ph	Cl
Baseline	16.97 ± 2.25 B	1.08 ± 0.1 B	143.78 ± 0.81 A	4.76 ± 0.05 B	9.99 ± 0.12 AB	3.8 ± 0.04 A	114.45 ± 0.81 A
Week 1	40.2 ± 13.26 AB	1.86 ± 0.33 AB	145.83 ± 0.6 A	4.27 ± 0.05 A	10.36 ± 0.15 AB	3.81 ± 0.31 A	113.68 ± 0.71 A
Week 2	31.57 ± 7.74 AB	1.8 ± 0.23 AB	145.77 ± 0.12 A	4.61 ± 0.07 B	10.54 ± 0.13 A	4.31 ± 0.49 A	111.53 ± 1.51 A
Week 3	36.5 ± 5.54 AB	1.81 ± 0.18 AB	147.47 ± 0.88 A	4.58 ± 0.08 B	10.3 ± 0.14 AB	4.09 ± 0.22 A	114.45 ± 0.71 A
Week 4	56.52 ± 7.43 A	2.04 ± 0.2 A	146.55 ± 2.31 A	4.66 ± 0.07 B	9.63 ± 0.39 B	4.55 ± 0.19 A	112.33 ± 2.37 A

Table 8: *Comparing ultrasonographic findings between time points in group B (n= 6).*

time	Kidney length	Kidney width	Sinus length	Sinus width	Cortex thickness	Medulla thickness
Baseline	6.34 ± 0.2 D	3.51 ± 0.4 B	2.42 ± 0.25 B	1 ± 0.03 A	1.22 ± 0.03 C	1.73 ± 0.21 B
Week 1	7.12 ± 0.14 A	4.1 ± 0.12 AB	3.05 ± 0.18 AB	1.37 ± 0.07 A	1.07 ± 0.04 AB	1.07 ± 0.16 A
Week 2	7.98 ± 0.11 B	5.28 ± 0.19 C	3.37 ± 0.22 AC	2.37 ± 0.16 B	1.18 ± 0.04 AC	0.87 ± 0.07 A
Week 3	8.32 ± 0.16 BC	4.7 ± 0.22 AC	3.73 ± 0.2 AC	2.74 ± 0.15 BC	0.97 ± 0.02 B	1 ± 0.1 A
Week 4	8.77 ± 0.16 C	4.87 ± 0.14 AC	4.1 ± 0.24 C	2.95 ± 0.14 C	0.78 ± 0.04 D	0.87 ± 0.06 A

4. DISCUSSION

Ureteral blockage can manifest as partial or complete obstruction determining whether urine can traverse the point of blockage. The extent of obstruction dictates the degree of hydrostatic pressure elevation exerted upstream of the blockage site extending to the proximal ureter, renal pelvis and renal parenchyma. In this experimental study, clinical examination of dogs in both groups revealed dullness, decreased weight and decreased appetite, the same results was observed by El Kammar et al. 2012, Dinesh Dehmiwal et al., 2016. The active unligated kidney played a magic role to help animals return to their normal appetite and activity after ligation by compensatory mechanism Kealy and McAllister, 2000, Radiosities et al. 2003. By abdominal palpation, kidneys appeared assymetrical and hydronephrosed, firm, enlarged and painful. This also was recorded by Segev et al. 2016 which may be due to increased hydrostatic pressure within the kidney and inflammation. Urine incontinence was observed in group B which persists for one month, the same results was observed by Kanazono 2009. The ultrasound is the most trusted imaging method for researching urinary tract problems in dogs; due to its easiness, low cost and it offers outstanding resolution for contrast in real – time Robotti, Lanfranchi, 2013. Ultrasonographic findings of both groups revealed significant increase of kidney length and width, this due to urine accumulation,while the renal cortex was significantly decreased in thickness due pressure atrophy of renal tissue Bokhari et al., 2015. The augmented pressure due to obstruction induces passive dilatation of the proximal ureter and renal pelvis, occasionally resulting in marked expansion of these structures Fink et al., 1980.

RBCs and HB were decreased gradually in both groups all over the study till reach their lowest value at the 4th week, this result may refer to destruction of RBCs due to increased urea level Latimer, 2003; Bokhari et al., 2015 recorded significant reduction of RBCs and HB all over the study.

Analysis of renal function tests between the two groups unveils substantial differences in multiple parameters. Group B exhibits significantly higher levels of urea, BUN, creatinine, calcium (Ca), and Phosphate (Ph). Conversely, potassium (K) and chloride (Cl) levels are significantly lower in Group B. These findings suggest a more pronounced impact of partial bilateral ureteral ligation on renal function and electrolyte balance, while the healthy kidney in complete unilateral obstruction maintains the renal function. Kene, 1986 refers the increase in urea nitrogen and creatinine to sudden retention of nitrogenous wastes due to decrease in urinary ouflow. In line with our results, Semieka , Abd El-Ghaffar, 1997 observed preservation of renal functions for the first 15 days after unilateral complete renal ligation**.** Disturbed renal function due to bilateral ureteral obstruction was also documented by Zaid, et al., 2011. Contrary to this, azotemia, hyperphosphatemia, and hypercalcemia were reported in cates with unilateral ureteral obstruction Kyles, et al., 2005. However, Kerr, 1956 also supported our findings, showing normal functions after complete unilateral ureteral ligation.

5. CONCLUSION

This study revealed that bilateral partial ureteral obstruction resulted in more significant changes in kidney function than unilateral complete one as the contralateral kidney functioning normally and the animal regained its activity and appetite by the end of the study. Ultrasonography is considered a reliable, non-invasive and rapid diagnostic method for early prediction of severity of renal disease in dogs together with hemato-biochemical evaluation.

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