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DIAGNOSTIC IMAGING OF URINE RETENTION AND SUBSEQUENT HYDRONEPHROSIS IN GOAT.

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A B S T R A C T

Healthy male goats (n=20); aged from 8 months to 4 years and weighing from 15 to 25 kg were divided into four equal groups. Group A (Control animals), group B (animals operated for induction of urine retention via urethral legation), group C (animals operated for induction of urine retention via bilateral ureteral legation) and group D (animals operated for induction of urine retention via unilateral ureteral legation). Clinical observations, blood urea and creatinine analysis and ultrasonographic, radiographic and computed tomography (CT) examinations were performed for each group before and after induction of urine retention. Ultrasonographically, Hydronephrosis was classified into functional dilatation (recorded slightly in the opposite non legated kidney in case of unilateral ureteral legation), dilatation with stasis (as a result of urine stasis), mild hydronephrosis (as result of back pressure of the urine on renal parenchyma) and severe-advanced hydronephrosis (due to advanced continuous back pressure over long period). The four stages were recorded in case of unilateral ureteral legation while in cases of urethral and bilateral ureteral legation severe advanced hydronephrosis wasn't recorded. It was found that, urine retention in group B and C was very dangerous which characterized by rapidly onset and seriously developed renal and blood alterations with to threat the animal life. The present study provide Thorough knowledge of the cross sectional anatomy aided to achieve accurate interpretation of ultrasonography and CT, hence establish reference standards for normal urinary tract organ's size, position and structure and compare it with the abnormal conditions.

KEY WORDS: Computed Tomography, Hydronephrosis, Ruminants, Ultrasonography

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1. INTRODUCTION

Small ruminant are hardy, highly prolific animals [34]. They are important in the production of meat, milk and skin; moreover their productivity may be threatened by urogenital abnormalities [15, 17]. Early diagnosis of any pathological condition is the first step towards the effective treatment of any diseased animals. Diagnostic Ultrasonography and radiography are considered as an integral part of all the methods available for early diagnosis [2]. Radiography and Ultrasonography complement each other in the diagnosis of renal diseases [6, 12, 13, 19, 24, 25, 31, 24]. They provide additional information to that obtained by physical examination and laboratory analysis [1]. Major advantage of ultrasound over radiography is that it is not hampered by the lack of retroperitoneal fat or the presence abdominal fluid or ingesta. It is non-invasive, faster; it has the ability to provide superior assessment of internal renal parenchyma architecture. In addition, it can be performed independent of renal function. It requires no ionizing radiation or contrast medium and it enables the assessment of neighboring structures [5, 12, 19, 21, 38]. Radiology (Excretory urography) remains an essential tool for the assessment and evaluation of the renal pelvis and ureter (collecting system) [8, 12, 18, 19] as it is the most sensitive method for detecting subtle pelvic and ureteral dilation [21, 28]. CT eliminates superimposition of structures and dramatically improves resolution [10], CT has begun to compete with radiology and ultrasound for evaluation of certain urinary tract conditions [33].

Urine retention is one of the most common life-threatening affection of the small ruminant. Anurea, dysurea, strangurea, abdominal pain and off food are the most common clinical signs. Physical examinations reveal elevated respiratory and pulse rates and normal temperature [30]. On palpation of the perineal region urethral pulsation could be felt and on palpation of the caudal ventral abdomen distended urinary bladder could be felt in case of urine retention due to urethral obstruction [32]. Hydronephrosis means dilatation of the renal outflow tract as a result of partial or complete obstruction of the urinary outflow (one ureter, two ureters or urethra). Urine continued to be formed resulting into progressive dilatation of the outflow tract and the increased pressure causes progressive atrophy of the renal parenchyma till the kidney become a large fluid filled sac and urine formation ceases [21, 22]. Hydronephrosis can be classified into four categories (functional dilatation, dilatation with stasis, mild hydronephrosis and advanced hydronephrosis) [13]. The most common clinical signs of hydronephrosis include anorexia and depression. Physical examination revealed markedly pale mucous membranes and mild dehydration. Striking findings on the serum biochemical analyses included elevated blood urea nitrogen and creatinine [31]. The hydronephrotic kidney was examined by using 5 MHz linear array transducer [9]. There is no separation of the dense echo collection in the region of the renal sinus or collecting system in ultrasonographic examination of normal goat kidney [8]. The hydronephrotic kidney was identified in sagittal plane by dilatation renal pelvis which represented by an enlarged anechoic fluid filled center of the kidney with the renal capsule clearly identified as a hyperechoic line [30]. The transverse plane reveal hypoechoic -v-shaped dilated renal pelvis surrounding the renal crest, and a dilated ureter extending medially may be seen [19, 31]. In long standing cases only a thin rim of renal tissue remains (parenchymal atrophy) with several echogenic linear bands extending from the hilus toward the capsule representing vessels and associated fibrous tissue [21]. On intravenous urography varying degrees of parenchymal opacification are seen depending upon how much of the kidney is still functioning. If urine is still excreted, the kidney will appear as a large opacified mass with distention of the ureter proximal to the obstruction site [22]. Due to marked peri-nephric fat and the retroperitoneal location, both kidneys were easily recognized by CT. The renal CT on transverse scans appears oval near the renal poles and sickle shaped in the hilur region with smooth external boundaries. The renal parenchyma appears homogenous [14].

Our study aims to throw a light on the validity of ultrasonographic and radiographic examinations of experimentally induced partial and complete urine retention and hydro-nephrosis in comparison with normal urinary tract examinations and established criteria for the diagnosis of partial and complete urine retention via ultrasonography and radiography.

2. MATERIALS AND METHODS

2.1. *Animals and experimental design*

The present study was conducted on 20 clinically healthy bucks ranged in age from 8 months to 4 years, weighing from 15 to 25 Kg and were divided equally into 4 groups. All animals were operated for

experimental induction of urine retention as following.
Group A: sham-operated male goats.
Group B: subjected to directed urethral legation at the distal end of the sigmoid flexure after surgical exposure of the penis according to Ghanem et al. [16]
Group C: subjected to legation of both ureters using silk No.1 at one cm above its junction with the bladder.
Group D: subjected to legation of the left ureter at the same level as in group (C).
All goats were observed for clinical, creatinine and blood urea levels, radiography and ultrasonography changes before and 12, 24, 36 and 48 hours after surgical interference in group B and C. Group D was observed before and each 5 days post the first 48 hours (7th d., 12th d. and 17th d.)..

2.2. *Ultrasonographic examination*:
Ultrasonographic examination was performed by 5 MHz sector probes using mobile ultrasound machine (LOGIQ TM 180 GE Medical system) [3].

2.3. *Radiographic examination*:

Radiographic examination (intravenous pyelography) was performed by using 100 KV and 80 mA X- ray machine (Mobile Simply HP), 80 cm FFD, 55 kV and 4.5 mA. High volume prolonged or drip infusion technique with abdominal compression by using of Urographin® (Tri-iodinated contrast medium; Iodine 76 %; Schering Co., USA) at a dose of 1200 mg iodine/kg b.wt. mixed with glucose 5% (*v/v*) for intravenous pyelography (22).

2.4. *Computed tomography*:
Computed tomography (CT) was performed for all goats of the group D before and after induction of urine retention and hydronephrosis. CT was performed at 120 kV and 250 mA by using Asteion -CXR Multi-slice CT scanner. Continuous transverse series of CT scan were obtained every 1 cm thickness. After finishing CT imaging, the animals were kept in deep freezer at -15 °C with sternal position and sectioned in transverse plans in slices of 1 cm thickness with high speed electric band saw and photographed. The CT images were matched with the corresponding sections at the same levels and plans and selected for their identity.

2.5. *Statistical analysis*
The results were expressed as mean (±S.E.) and statistical significance was evaluated by T-test using SPSS (version 10.0). Values were considered statistically significant when $p < 0.05$.

3. RESULTS

All operated animals suffered from urine retention showed signs of dysuria or stranguria, depression, tenesmus and apparent abdominal pain. Physical examination revealed normal temperature, elevated respiratory and pulse rates, pale to mucous membranes and ruminal atony. Urethral pulsation could be felt easily on rectal palpation of the urethra and distended urinary bladder was palpated manually on the posterior part of the ventral abdomen and anterior to the pelvic inlet from both sides in cases of urethral legation. Different results of clinical examination in all groups were recorded in table 1. Hydronephrosis results from outflow obstruction of the ureter or urethra. Obstruction eventually destroys renal function because of elevated backpressure leading to progressive parenchymal atrophy and urine stasis and accumulation within the kidney till it become like fluid filled sac. Ultrasonographically, hydronephrosis was classified into functional dilatation (recorded in the opposite non legated kidney in case of unilateral urete leg.), dilatation with stasis (due to urine stasis), mild hydronephrosis (due to of back pressure of urine on renal parenchyma) and sever advanced hydronephrosis (due to continuous back pressure over long period).

The four stages were recorded in case of unilateral ureter legation while in cases of urethral and bilateral ureter legation advanced hydronephrosis wasn't recorded due to short time experiment as more time will threaten the animal life.

Sagittal ultrasonography plane revealed that the normal kidney was smoothly contoured oval shape; the renal capsule appeared as very fine hyperechoic line around the kidney and was not clearly demonstrated from the perirenal fat at either pole.

Table 1 Clinical observation in experimental induction of urine retention and hydronephrosis.

Clinical signs	Before legation	After legation			
		Urethral leg.	Bilateral ureteral leg.	Unilateral ureteral leg.	
				1st week	2nd week
Temperature (°C)	38.7±0.2	39.9±0.2	40.4±0.2	39.7±0.1	38.7±0.1
Respiration (n/min.)	25.6±1.6	36.8±2.3	38.8±0.6	35.8±0.1	27.4±0.9
Pulse (n/min.)	80.60±3.40	110.00±3.5	125.8±1.80	98.98±2.50	87.80±0.70
Rumen movements (n/2 min.)	1-2	0	0	0	1
Mucous membrane color	Rosy	pale	pale	pale	Pale
Urethral pulsation	Absent	Present	Absent	Absent	Absent
Abdominal pain	Absent	Present	Present	Less severe.	Not obvious
Appetite	no change	off food	off food	off food	no change
Animal death	0	1 (After 60 hrs.)	1 (After 36 hrs.)	0	0

leg. =legation.

Table 2 Ultrasonographic measurement of kidneys and urinary bladder in experimental induction of urine retention and hydronephrosis with urethral legation.

Time in relation to legation	Right kidney measurements (mm)			Left kidney measurements (mm)			Urinary bladder measurements (mm)	
	Length	Depth	Width	Length	Depth	Width	UB diameter	Wall thickness
Before	46.6±0.4	25.8±0.7	30.0±0.6	48.6±0.2	27.2±1.1	32.8±0.5	28.78±2.9	1.85±0.04
12 hrs.	49.6±0.6*	29.0±1.0*	32.8±0.5*	52.4±1.0*	32±1.8*	35.6±0.6*	51.28±0.83	1.46±0.12*
24 hrs.	55.4±0.7*	31.2±1.3	37.6±0.9*	57.2±0.7*	36.2±2	42.6±1.6*	68.78±0.27	1.09±0.08*
36 hrs.	58.0±2.2	32.8±1.8	38.6±0.8	61.2±1.8	38±1.5	43.2±2.1	72.8±0.53*	0.92±0.06
48 hrs.	59.2±3.0	33.6±2.2	38.6±0.4	62.0±3.0	38.6±1.6	43.4±2.4	73.66±0.29*	0.79±0.07

*= significant at $P \leq 0.05$

Table 3 Ultrasonographic measurement of kidneys and urinary bladder in experimental induction of urine retention and hydronephrosis with bilateral ureteral legation.

Time in relation to legation (hrs.)	Right kidney measurements (mm)			Left kidney measurements (mm)		
	Length	Depth	Length	Depth	Length	Depth
Before	51.4±1.4	25.8±0. 7	29.6±0.8	49.8±0.7	27.2±1.1	32.8±0.5
12	56.2±1.2*	30.6±1.1 *	36.6±0.5	56.2±0.7 *	34.6±1.6 *	38.2±0.4
24	68.0±1.4*	35.8±0.9 *	42.8±0.7 *	66.0±1.1	40.0±1.4	44.8±1.3 *
36	76.0±1.5 *	39.2±0.9 *	45.8±0.4	67.4±5.6 *	42.8±1.1	47.8±1.1
48	81.6±1.0 *	42.0±0.8 *	46.2±1.8	73.2±1.4	46.0±1.1	49.2±2.0

*= significant at $P \leq 0.05$

The renal medulla consisted of anechoic, circular, area interrupted by bright echogenic lines representing the recesses and interlobar arteries that gave the appearance of the typical medullary pyramids. The cortex had uniform finely granular hypoechoic pattern. The cortico-medullary junction was curved lines slightly more echogenic than the cortex due to the presence of the arcuate arteries (Fig.1-A). In the transverse plane, the renal parenchyma shaped like a horseshoe; the renal pelvis appeared as hyperechoic double -v- shape structure; renal sinus was high echogenic due to the presence of the adipose tissue, renal vessels and ureter; the renal crest appeared anechoic, rounded and embraced by the echogenic renal sinus and two limbs of peri-pelvic fat. The ureters could not be observed (Fig. 1-B). The urinary bladder was appeared as pear shaped anechoic structure in front of the pelvic cavity circumscribed by a thin echogenic wall. Underneath it there was an area of enhancement (Fig.2-A). The mild hydronephrotic kidney was identified ultrasonographically in sagittal plane by dilatated renal pelvis which represented by an enlarged anechoic fluid filled center of the kidney with the renal capsule clearly identified as a hyperechoic line (Fig. 1-B), while the transverse plane reveal anechoic. V-shaped dilated renal pelvis surrounding the renal crest and anechoic dilated ureter extending medially (Fig. 1-A).

Table 4 Ultrasonographic measurement of left kidney in experimental induction of urine retention and hydronephrosis with unilateral ureteral legation.

kidney measurements (mm)	Time in relation to ligation (days)						
	Before	1	3	6	9	12	15
Length	52.30±0.25	52.60±0.21	55.30±0.27	56.60±0.26	58.10±0.22	60.80±0.25	62.40±0.27
Width	38.00±0.12	38.30±0.11	39.60±0.21	40.10±0.25	41.10±0.23	42.30±0.24	43.20±0.24
Depth	28.90±0.11	28.60±0.11	29.10±0.11	29.00±0.11	30.40±0.09	32.10±0.07	33.00±0.10

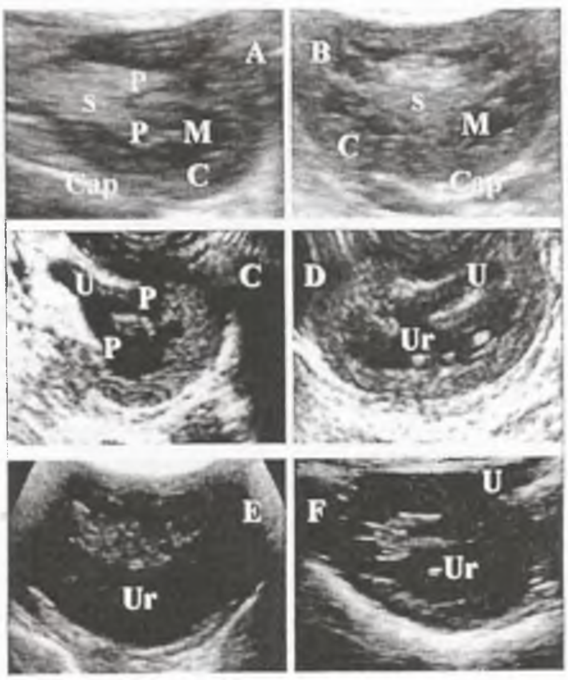

Fig. 1 Ultrasonography examination of normal kidney (Transverse section (A) & Sagittal section (B)), mild hydronephrotic kidney (Transverse section (C) & Sagittal section (D)) and sever advanced hydronephrotic kidney (Transverse section (E) & Sagittal section (F)). S= renal sinus, P = renal pelvis, M =renal medulla, C = renal cortex, Cap = renal capsule, U = ureter & Ur = urine.

Fig 2 Ultrasonography examination of nearly empty urinary bladder (A), fully distended urinary bladder in transverse section (B) and in sagittal section shows the anterior part of pelvic urethra (arrow) (C). (UB=Urinary Bladder).

In long standing cases only a thin rim of renal tissue remains (parenchymal atrophy) with incomplete disappearance of renal fat echogenicity and obviously distended ureter (Fig. 1-C& 1-D). The fully distended urinary bladder appeared as large anechoic sac with thin stretched echogenic wall and distal enhancement, the first part of pelvic urethra was seen distended in sagittal plane (Fig.2-B and C). In group (B) and (C), the main ultrasonographic changes of the renal tissue were represented by enlarged and more rounded kidney with marked dilatation of the ureter, pelvis and collecting recesses (mild hydronephrosis). In group (D) mild hydronephrosis was detected 7 days post legation while 17 days post-legation, the kidneys appear as anechoic sac filled with urine and obviously distended anechoic ureter (advanced hydronephrosis) with Slight dilatation of medullary pyramids of the right non legated Kidney (functional dilatation). Ultrasonography measurements of kidneys and UB before and after urethral, bilateral ureteral and unilateral ureteral legation recorded in table 2-4.

Radiographically (IVP) (intravenous pyelography), the normal kidney appeared just after the end of infusion as homogenously opacified organ, bean shaped in ventro-dorsal projection to oval in lateral projection with smooth regular outline. The urinary bladders appear strong radiopaque oval structure within the pelvic cavity. The hydronephrotic kidney didn't appear in the radiographs taken immediately after the end of infusion and appeared in the following radiographs within 5-10 minutes as enlarged, rounded, faint and less radiopaque than the other kidney in case of unilateral ureteral legation. The ureter of the affected kidney wasn't visualized due to masking by bowel filled with superimposed ingesta. The urinary bladders appear as large rounded less radioque structure extended to the abdominal cavity in case of urethral obstruction (Fig. 3).

Computed tomography (CT), the normal kidney appeared ovoid, sharply demarcated with homogenous renal parenchyma. The right kidney viewed in cross sections taken at 1st and 2nd lumbar vertebraes, the left kidney has variable directions and in this study it was viewed in cross sections taken at 4th and 5th lumbar vertebrae. There was no sharp demarcation between cortex and medulla although the cortex was slightly denser than the medulla. The -v- shaped renal pelvis and the proximal ureters of both kidneys can be observed and their resolution is clearly enhanced after administration of contrast material.

The proximal ureters was seen as high dense tubular structure emerging at the renal hilus and as round structure in cross sections taken between the two kidneys and the urinary bladder (Fig.4-A&B). The urinary bladder was scanned within the pelvic cavity as nearly empty ovoid sharply demarcated high dense structure. At more caudal section of the neck of the bladder was detected as small circle of same density (Fig.4-C&D).

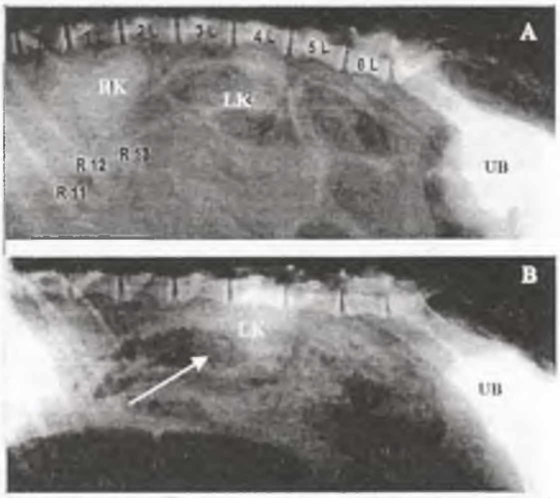

Fig 3 Lateral radiographic pictures (A&B); shows normal kidneys (A) (right kidney (RK), left kidney (LK) & urinary bladder (UB)) and the hydronephrotic kidney (B-arrow).

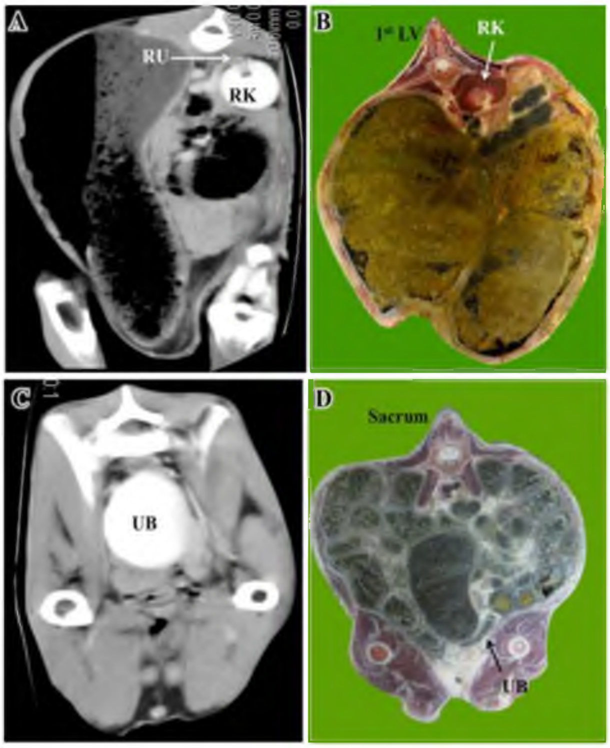

Fig. 4 CT (A&C) in relation to cross sectional anatomy (B&D) at corresponding levels o f goat abdomen, shows normal right kidney (RK), normal rig h t ure te r (RU) and urinary bladdrer

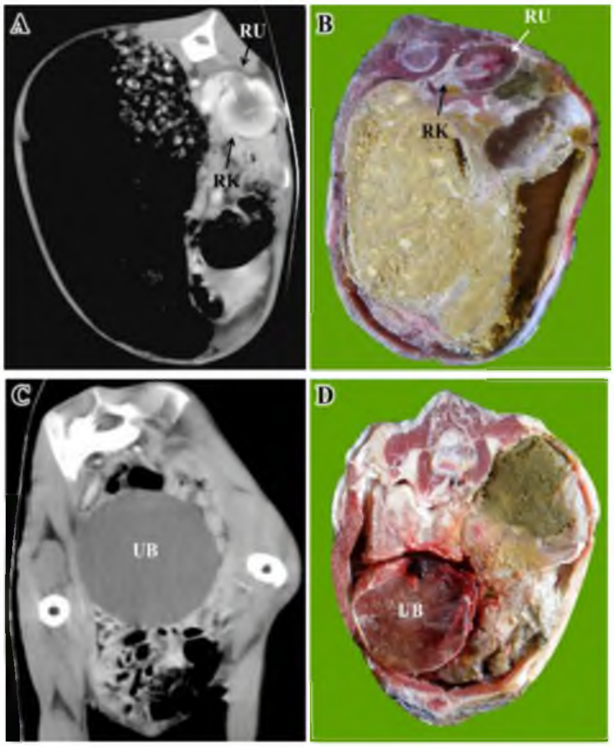

Fig. 5 CT (A&C) in relation to cross sectional anatomy (B&D) at corresponding levels o f goat abdomen show hydronephrotic right kidney (RK), dilated right ureter (RU) and urinary bladder (UB) after induced urine retention and subsequent hydronephrosis.

Table 5 Creatinine and urea levels before and after different stages of experiments.

Time in l elation to legation	Creatinine			Urea		
	Urethral. Leg.	Bilateral Ureteral leg	Unilateral Ureteral leg.	Urethral. Leg.	Bilateral Ureteral leg.	Unilateral Ureteral leg.
Before	0.90±0.10	0.73±0.02	1.02±0.10	32.20±1.98	28.2± 1.77	31.Oil.8
12 h	1.01±0.10	1.09±0.04	1.44±0.10*	59.40±1.80	37.2±3.18	35.6il.6
24 h	1.81±0.10	1.86±0.07	1.76±0.10	72.60±1.50*	55.6±4.84*	40.4il.9
36 h	2.12±0.10*	2.29±0.14*	2.05±0.10	78.80±1.40	73.40±5.55	46.2±1.8
48 h	2.41±0.10*	2.60±0.13	2.06±0.10	97.20±0.90	107.00±9.43	46.6il.9
7 d	-	-	2.61±0.6	-	-	45.0i2.3
12 d	-	-	1.95*0.11	-	-	44.4i2.0
17 d	-	-	1.75±0.10	-	-	43.4i2.0

CT examination of the hydronephrotic kidney revealed that the kidney was more rounded, horse-shoe shape; the right kidney extended to scanned in cross sections taken from 13th thoracic and 3ld lumbar vertebrae, and the left kidney was extended to scanned in cross sections taken from 3rd lumbar vertebrae to 6th lumbar vertebrae. The cortexes appeared as thin low dense band on renal periphery, while the medulla appeared less dense than that in normal kidney due to urine accumulation and less saturation by urographine.

The double -v- shape renal pelvis and the two ureters of both kidneys were obviously dilated and dense (Fig.5-A&B). The urinary bladder was scanned as dilated sharply demarcated slight dense structure extended to the abdominal cavity and could be scanned with the left kidney at the same level (6th lumbar vertebrae) Fig.5-C&D). At more caudal section, the neck of the bladder was detected as dilated circular structure of same density.

Urea level significantly increases at 24hrs post legation in group (B), at 24hrs post legation in group (C) and show non-significant changes in group (D). Creatinine level significantly increase at 36 hrs post legation in group (B), at 36 and 48 hrs post legation in group (C) and at one day post legation in group (D), table 5.

4. DISCUSSION

Small ruminants with a tentative diagnosis of urine retention, all parts of the urinary system should be subjected to thorough ultrasonographic examinations, serum examination (serum urea and creatinine levels) and clinical observations [30]. Thoroughly ultrasonographic examination of each part of the urinary tract was recommended to confirm the diagnosis and evaluate degree of damage caused by urinary obstruction [3, 4]. In our study, the urinary bladder appeared as rounded anechoic sac bounded by uniformly thin echogenic wall. The shape of the urinary bladder changed with degree of distention as the empty bladder has a smoothly undulant contour while the distended bladder due to complete or incomplete urine retention became pear to rounded shape with distal acoustic enhancement and could be scanned at posterior abdominal wall [3, 25, 39].The hydronephrotic kidney appeared as an enlarged anechoic fluid filled center of the kidney with clearly identified hyperechoic renal capsule as the normal structures of renal pelvis and walls of the renal recesses could not be imaged sonographically unless in cases of hydronephrosis due to urinary stasis [4, 28, 37]. During ultrasonographic examination the course of the ureters could not be visualized in any animals either by means of the transrectal or transabdominal approaches due to the anatomical position of ureters which located retroperitoneally at the dorsal wall of the abdominal cavity that couldn't be accessed [11].The nephrogram phase, at which obtain the best visualization of the normal kidneys in radiographic picture due to presence of the contrast agent in the renal capillaries, was best demonstrated immediately just after end of infusion of contrast material when the kidneys appear more opaque [35, 23, and 36]. But in case of hydronephrosis, the nephrogram phase delayed and could be demonstrated 5-10 minutes later due to delayed excretion of the contrast material by the impaired kidney which appear as faint more round enlarged structure with thin hyperechoic periphery band represents renal cortex. The ureter was not demonstrated, this might be attributed to masking or obscuring of the ureter by the contents of the full GIT as a result of inadequate preparation of the animals prior to investigation because fasting might aggravate the case [22]. Regarding the blood biochemical analysis, the obtained results revealed that creatinine and urea levels were increased subsequent to experimental urinary obstruction due to sudden retention of nitrogenous waste product due to decrease urinary outflow [20].

In cases of unilateral hydronephrosis, urea and creatinine showed transient elevation in their level till 12 days post legation. Unilateral obstruction of the ureter often results in unilateral hydronephrosis without evidence of decrease renal function when the other healthy kidney maintains the renal function [7, 26].

In conclusion unilateral urinary obstruction will not cause azotemia if the contralateral kidney is functioning normally. In the meantime, bilateral upper and lower urinary tract obstructions cause progressive azotemia and hydronephrosis and ended by death due to life threatening metabolic disorders. Renal and ureteral obstruction often requires radiographic or ultrasonographic investigations for accurate diagnosis. So an early recognition and correction of urinary obstruction will help in complete restoration of renal function.

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