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ULTRASONOGRAPHIC IMAGING OF THE URINARY TRACT PRE AND POST EXPERIMENTAL URETHRAL OBSTRUCTION IN BUCKS

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ABSTRACT

The purpose of this study is to throw a light on the validity of ultrasonographic examination of urinary tract pre and post urethral obstruction in Egyptian mixed breed non castrated bucks (male goats).Nine bucks were subjected to direct penile ligation at the distal bend of the sigmoid flexure after surgical exposure of the penis to induce urethral obstruction and subsequent urine retention. Clinical and ultrasonographic examinations were carried out immediately pre experimental urethral obstruction and continued periodically every 12 hrs, throughout 48 hrs. post experimental urethral obstruction. The Ultrasonographic appearance and measurements of urinary tract compartments were assessed and compared at different examination positions using linear array endorectal probe (7.5-2.6 MHZ) and convex array general purpose probe (6-2.6 MHZ). Both kidneys were visualized ultrasonographically through transabdominal approach and the bladder was visualized through transabdominal and transrectal approaches in all bucks. Both of them revealed normal architexture, echogenicity and dimensions before ligation. The course of the urethra in the pelvis and in the penis was not imaged in any of the bucks before ligation. There were significant increase in kidneys and bladder dimensions after urethral obstruction. The proximal portion of the pelvic urethra was visualized clearly in all bucks 24 hrs. Post urethral ligation. The course of the ureters was not visualized ultrasonographically by means of the transrectal or transbdominal approaches pre-and post experimental urethral obstruction. It could be concluded that using of ultrasonography is considered a good clinical diagnostic tool for examination of the urinary tract in bucks affected with urine retention.

Key words, ultrasonographic examination, kidneys, urinary bladder, urinary tract, bucks.

INTRODUCTION

Ultrasonography offers a non invasive method for diagnosis of urolithiasis, localization of urethral calculi, as well as diagnosis of renal cysts, renal neoplasia, hydronephrosis, cystitis, bladder diverticula and obstruction of the lower urinary tract, dilated urethra, urethritis and rupture of the urethra or the urinary bladder **(Konde *et al.,* 1985; Penninck *et al.*, 1986; Juzwiak *et al.*, 1988 and Braun *et al.*, 1992).**In ruminants, ultrasound was used in examination of the upper urinary tract as the kidney blood flow and renal function in cows **(Braun *et al.*, 1992 and Loretti *et al.*, 2003)** as well as in diagnosis of urethral dilatation in calf **(Geccelep and Alkan 2000 and Magda, 2006)**. Ruptured urinary bladder with leakage of urine into the abdominal cavity is usually diagnosed by paracentesis **(Cartee *et al*., 1980; Walker and Vaughan 1980).** However, abdominocentesis was not diagnostic for the rupture of the urinary bladder because in many cases free urine in the abdominal cavity was visible via ultrasound and the urinary bladder was intact **(Magda, 2006).** This is of importance in decision making of laparotomy as the urinary bladder in ruminants usually seal with fibrin or omentum in three to five days after rupture if it kept empty **(Walker and Hull, 1984).** Ultrasonographic examination of the urinary tract can provide much useful information during the initial on-farm examination **(Scott, 2000).** The urethra in the region of the internal urethral orifice could be visualized clearly. Meanwhile, its course in the pelvis and penis could not be imaged ultrasonographically **(Braun *et al.*, 1992).** All examinations of the bladder and urethra transrectally were performed on standing rams **(Braun et al., 1992).** The most common urinary tract disease in rams is obstructive urolithiasis. Usefulness of ultrasonography for diagnosis of urolithiasis in sheep and goats has been noted by **Monoghan and Boy (1990).** But in depth studies had not been performed. Ultrasonography is not a routine diagnostic procedure in bucks with urinary tract disease.

MATERIALS AND METHODS

This study aimed to present reference values for quantitative analysis of the kidneys, ureters, and urethra pre and post urethral obstruction in adult Egyptian mixed breed bucks using ultrasonography.

The experimental work was carried out on nine apparently healthy balady non castrated male goats (bucks), aging 1.5 to 2 years and weighing 20-35 Kgs belonging to Department of Surgery, Faculty of Veterinary Medicine, Alexandria University.

All bucks were subjected to direct penile ligation with sterile silk No.2 at the distal bend of the sigmoid flexure after surgical exposure of the penis to induce urethral obstruction and subsequent urine retention (**Fig., 1**). Clinical and ultrasonographic examinations were carried out immediately pre experimental urethral obstruction and continued periodically every 12 hrs, through out 48 hrs, post experimental urethral obstruction.

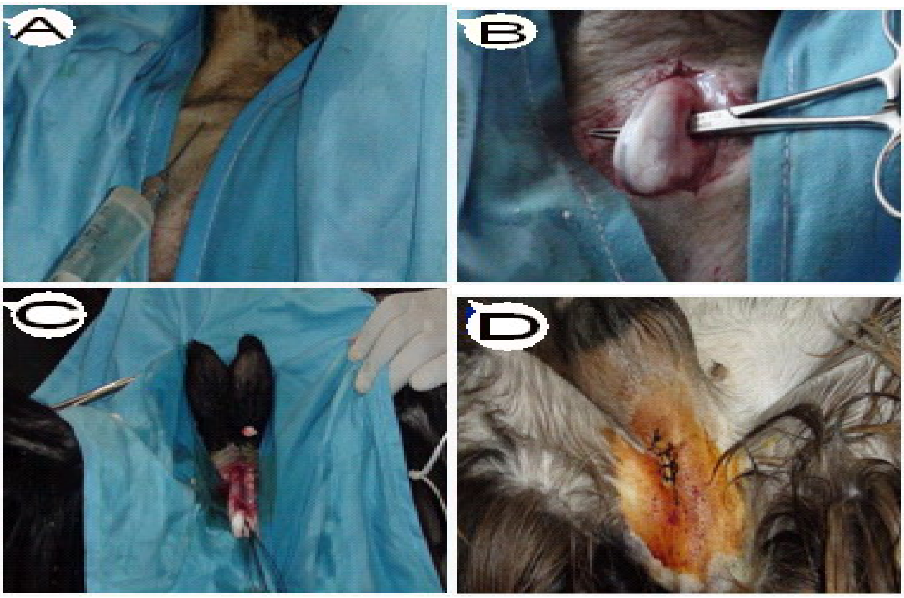

Fig. (1): showing penile exposure and ligation: Local infiltration analgesia(A), surgical exposure of the penis at the distal bend of the sigmoid flexure(B), Ligation of the penis using silk(C), and skin closure using silk(D).

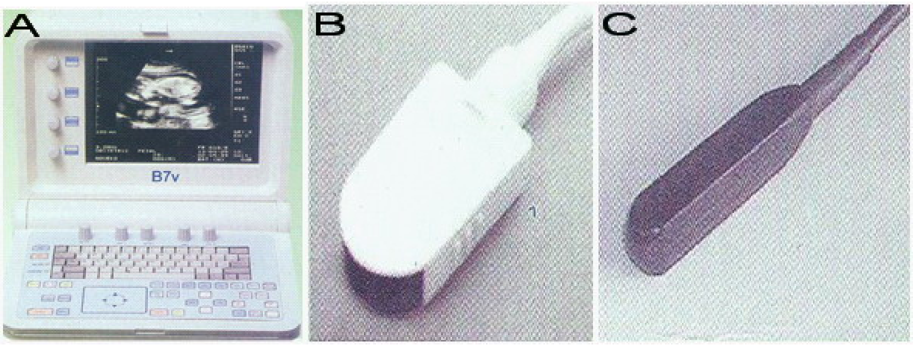

Fig. (2): B7v veterinary multipurpose ultrasound scanner (A), AM063 convex general purpose 6- 2.6 MHZ probe (B) and AM102 linear endorectal 7.5-2.6 MHZ probe (C).

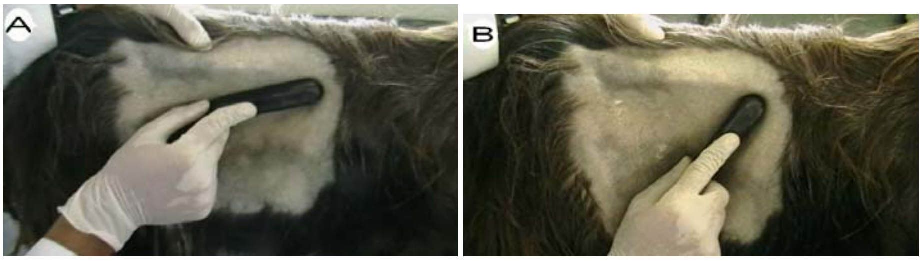

Fig. (3): Showing Examination position in the right side for sagital imaging of the right kidney (Note the transducer is slightly oblique) (A); for transverse section of right kidney (note the linear transducer at the right angle to the longitudinal axis of kidney) (B).

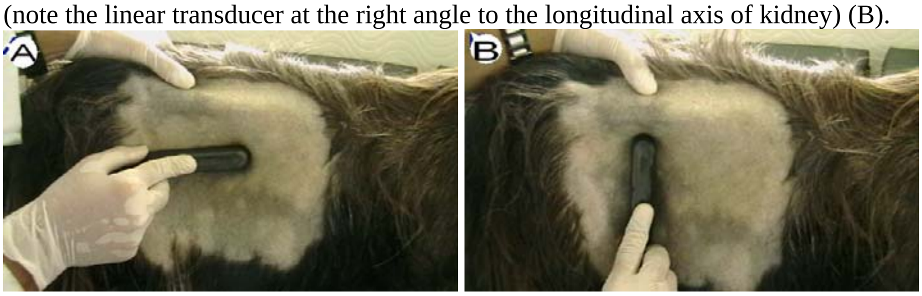

Fig. (4): Showing Examination position in the right side for longitudinal imaging of the left kidney (A); for transverse imaging of the left kidney (B).

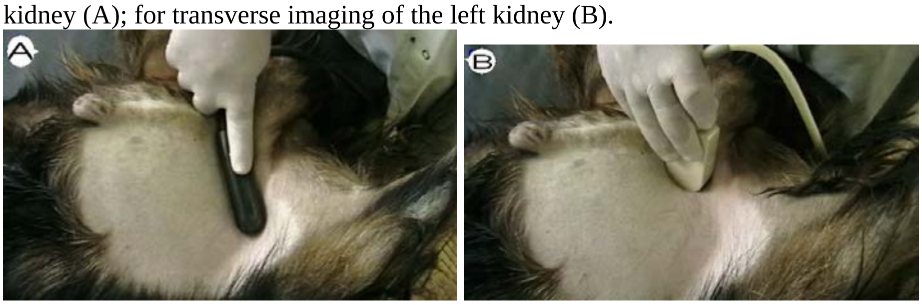

Fig. (5): Showing Examination position at the right inguinal region immediately cranial to the pelvis for examination of the urinary bladder and caudal abdomen using linear array endorectal probe (A);convex array general purpose probe (B).(note Head of the animal to right).

Clinical examination was carried out by observation of animals and recording any behavioural or clinical changes. Area of skin under examination was routinely prepared. An ultrasound gel was liberally applied to the wet skin to ensure good contact. Ultrasonographic examination was carried out using veterinary multipurpose ultrasound Scanner B7v Noveko Medical equipment Lachine, Quebec, Canada H81C4 (**Fig., 2**). Sonographic examination was performed according to the technique described by **Braun*, et al.,* (1992)**. Diagnostic images of the abdomen and bladder were obtained using linear array endorectal probe (7.5-2.6 MHZ) and convex array general purpose probe (6-2.6 MHZ) connected to a real time, B-mode ultrasound machine. Scans were recorded using a thermal printer.

A. Sonographic examinations of normal goat's kidneys:

Visualization of the right kidney was carried out after routine preparation of skin overlying the right sublumbar fossa. The transducer was placed behind the last rib high on the paralumbar fossa (**fig., 3**). The transducer was held in oblique and vertical position for longitudinal and transverse sections, respectively **(Fig., 3, A&B).** Visualization of the left kidney longitudinally was carried out by placing the transducer over the middle of the paralumbar fossa, parallel to the lumbar vertebrae (**fig., 4**). Both linear array endorectal probe (7.5-2.6 MHZ) and convex array general purpose probe (6-2.6 MHZ) were used to obtain numerous ultrasonograms of the kidney in both transverse and longitudinal sections. The echogenicities of renal cortex, medullary pyramids and renal sinus were assessed and compared. Measurements included renal length according to **Braun *et al.*, (1992)** and width as shown in **Figs., (6 & 7).**

B. Ultrasonographic examination of the normal bladder and caudal abdomen:

Ultrasonographic examination of the bladder transrectally was undertaken in the standing animal using linear array endorectal probe which introduced into the rectum with the beam directed ventrally after application of ultrasound gel on its scanning surface. The diameters of the bladder were determined, the bladder wall, bladder contents and internal urethral orifice were visualized. The pelvic part of the urethra was also examined.

Visualization of the urinary bladder and caudal abdomen transabdominally was made in standing and in dorsal recumbent positions. Linear array endorectal probe and convex array general purpose probe were used at the right inguinal region immediately cranial to the pelvis. The transducer head was firmly held at right angle against the abdominal wall (**Fig., 5**). A convex array general purpose probe and linear array transducer were used to examine the penile part of the urethra in standing bucks. The transducer was placed between the thighs to visualize the urethra in the area of the sigmoid flexure. The transducer was moved in an attempt to obtain an image of the urethra longitudinally and transversely. Statistical analysis was performed according to ***SAS (1996).***

RESULTS

Clinical examination

During the forty eight hours post experimental urethral ligation, all bucks had signs of abdominal pain and urinary obstruction, Complaints listed in order of frequency, were anuria, depression, anorexia, teeth grinding, colic, vocalization, and collapsing to knees.

Ultrasonographic examination

A) Examination positions :

A.1. Kidneys:

A good sonogram of the right kidney was obtained by placing the linear probe at the last right intercostal space vertically in standing position. The right kidney was visualized longitudinally when the transducer was held slightly oblique, Transverse section was visualized when the transducer was held vertically parallel to the last rib. Sonographic examination of the left kidney was difficult than the right one. Occasionally, a good sonogram of the left kidney was obtained transrectally (**Fig., 8**).

A.2. Ureters, bladder and urethra:

The ventral part of the full bladder was visualized using the convex general purpose transducer (6-2.6 MHz) via the inguinal region with the beam aimed dorsomedially in standing position. Whereas the partially full bladder was visualized only in dorsal recumbency **(Fig., 9).** A good sonogram of the urinary bladder was obtained through trans abdominal scanning after 24 hours of experimental urethral obstruction, using either (7.5-2.6 MHZ) linear array endorectal probe or convex array general purpose probe (6-2.6 MHZ).

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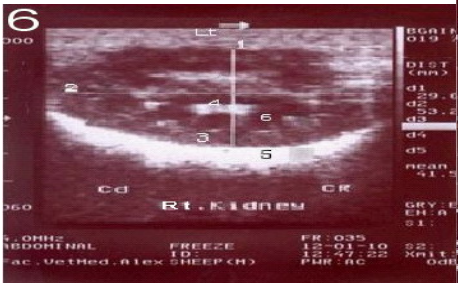
B) Ultrasonographic findings of urinary tract (pre urethral obstruction):

B.1. Kidneys:

Both kidneys were visualized before ligation and revealed normal architexture echogenicity and dimensions. The surface was smooth. The centrally located, hyperechogenic renal sinus was easily distinguished from the surrounding hypoechogenic renal cortex and medulla. Ultrasonographically, the renal medulla consisted of anechoic, circular, medullary pyramids (**Fig., 6**).The renal cortex appeared uniformly gray and was less echogenic than the renal sinus and bright hypoechoic than the surrounding tissues. The renal hilus was always visualized in the transverse image of the kidney (**Fig., 7**).

Means and standard errors of the normal kidney and bladder measurements are illustrated in **Table (1**)



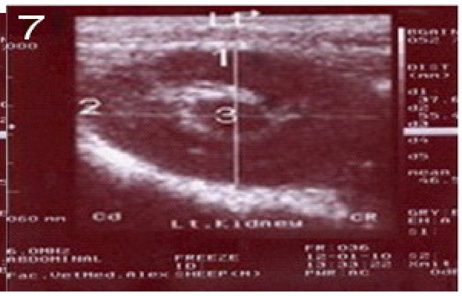


Fig . (6): Showing ultrasonogram of a longitudinal section through the right kidney. 1= width of the kidney; 2= length of the kidney; 3 = renal cortex; 4 = renal sinus; 6= renal parenchyma; Lt= lateral abdominal of the wall; Cr = cranial and Cd = caudal.

Fig. (7): Showing ultrasonogram of a transverse section through the left kidney . 1= depth of the kidney; 2 = width of the kidney; 3 = renal sinus; Lt= lateral abdominal wall;; Cr = cranial and Cd = caudal.

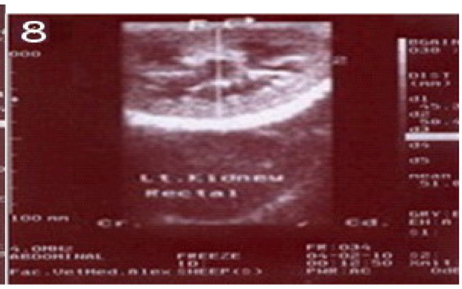


Fig. (8): Showing ultrasonogram of a longitudinal section through the left kidney using linear array endorectal probe transrectally at (4 MHZ).

Fig. (9): Showing ultrasonogram of a normal animal showing a partially distenteded urinary bladder filled with an echoic fluid with regular hyperechoic walls using convex array general purpose probe trans abdominally at (4 MHZ).

Fig. (10): Ultrasonogram in a buck 24 hours after urethral ligation showing a distenteded urinary bladder filled with an echoic fluid with 2 borders of the bladder wall appear only using linear array endorectal probe trans rectally at (4 MHZ).

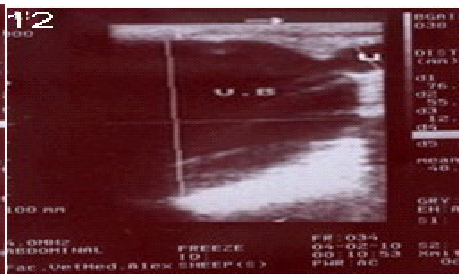
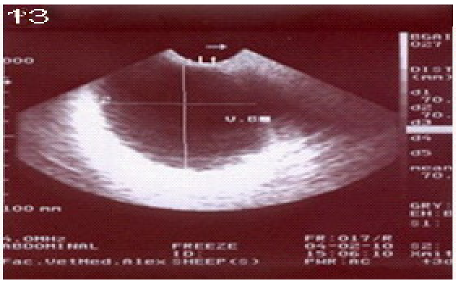


Fig. (11): Ultrasonogram of a buck 24 hours after urethral ligation showing a distenteded urinary bladder filled with an echoic fluid. 2 borders of the bladder wall appeared only using linear array endorectal probe transrectally at (4 MHZ).

Fig. (12): Showing ultrasonogram of a distenteded urinary bladder filled with an echoic fluid. Urethra in the region of the internal urethral orifice in a buck 36 hours post urethral ligation using linear array endorectal probe transrectally (4 MHZ).



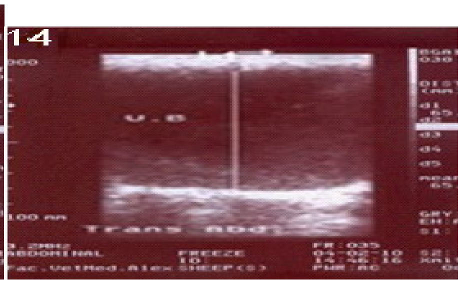


Fig. (13): Showing ultrasonogram a distenteded urinary bladder filled with an echoic fluid with regular hyperechoic walls in a buck 36 hours post urethral ligation using convex array general purpose probe trans abdominally at (4 MHZ).

Fig. (14): Showing ultrasonogram in a buck 48 hours after urethral ligation showing a distenteded urinary bladder filled with an echoic fluid with 2 borders of the bladder wall appear only using linear array endorectal probe trans rectally at (3.2MHZ).

B.2. Ureters, bladder and urethra:

The course of the ureters was not visualized ultrasonographically in any of the bucks by means of the transrectal or transbdominal approaches. The bladder was ultrasonographically visualized in all bucks. The contents of the bladder appeared hypoechogenic and the bladder wall was uniform in thickness and smoothly demarcated (**Fig., 10**). The mean diameter of the normal bladder in 9 bucks is 45.90±8.12 mm. The bladder located in the intrapelvic position with a round to ovoid appearance. The bladder wall appeared with two distinct thin hyperechoic lines separated by a hypoechoic layer when the ultrasound beam was perpendicular to the surface of the bladder (**fig., 10**). The urethra in the region of the internal urethral orifice was visualized clearly in 3 bucks (**Fig., 12**). The course of the urethra in the pelvis and in the penis was not imaged ultrasonographically in any of the bucks.

C) Ultrasonographic findings of urinary tract (post urethral obstruction):

C.1. Kidneys:

There was significant increase in right kidney length and width. The highest increase was obtained after 12 hrs and 24 hrs for width and length, respectively (**Tab., 1** and **fig., 15**). There was significant increase in left kidney length and width. The highest increase was obtained after 36 and 24 hrs for width and length respectively (**Tab., 1** and **fig., 15**). Renal pelvis and medullary pyramids appeared hypoechoic to nearly anechoic and dilated than cortex (**Fig., 7**).

C.2. Ureters, bladder and urethra:

There was significant increase in bladder dimensions 48 hours after urethral obstruction. This increase began after 12 hrs and continued with gradual increase till the end of the experiment (**Tab., 1** and **fig., 15**). After 24 hours from urethral ligation only one complete bladder dimension (length or width) was possible to be measured **(Fig., 11).** An equal changes in the bladder diameters (an increase in the longitudinal diameter faced with a decrease in the vertical one and vice versa) was noticed.

The urethra in the region of the internal urethral orifice was visualized clearly in all bucks 24 hrs. Post urethral ligation. The diameter of the urethra in this area measured 12.3 ± 0.55mm (**Fig. 12).**

Table (1): Showing ultrasonographic measurments for kidneys and urinary bladder pre and post urethral ligation.

Time	No.	Width (mm)		Length(mm)		Urinary bladder diameter (mm)
		Right kidney	Left kidney	Right kidney	Left kidney	
		Mean± Std. Error	Mean± Std. Error	Mean± Std. Error	Mean± Std. Error	Mean± Std. Error
Control (12 hours pre ligation)	9	Da 31.07±0.40	Da 32.77±1.64	Cb 52.43±0.46	Ca 53.87±0.82	E 45.90±8.12
12 hours	9	Aa 47.54±6.89	Cb 36.37±0.34	Bb 54.87±1.28	Ba 56.17±0.57	D 82.09±3.41
24 hours	9	Ca 37.27±1.18	Ca 38.70±0.97	Aa 60.16±1.37	Aa 59.30±0.44	C 88.91±4.08
36 hours	9	Bb 39.40±0.82	Aa 44.00±1.17	Ab 57.83±0.35	Aa 59.03±0.43	B 91.72±5.71
48 hours	9	Bb 39.00±1.15	Ba 41.53±1.37	Aa 58.43±0.49	Aa 58.84±0.26	A 94.34±4.07

Capital letters within the same column indicated that means are significantly different at ($P < 0.01$).Small letters within the same row indicated that means within are significantly different at ($P < 0.01$).

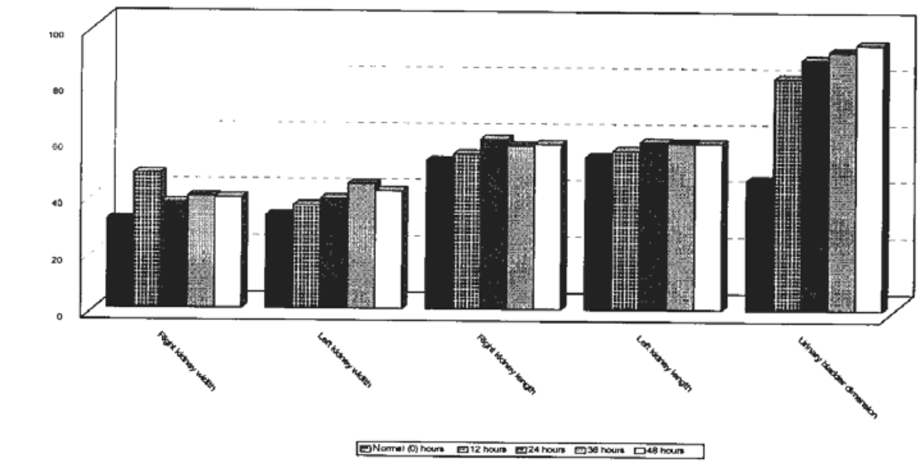


Fig. (15): A histogram showing ultrasonographic measurements of kidneys and urinary bladder pre and post urethral obstruction.

DISCUSSION

Ultrsonography provides more useful information through a non invasive diagnostic technique. Ultrasonographic appearance of male caprine urinary tract with some anatomic variables was assessed quantitatively in this study. It was indicated that the kidneys can be visualized ultrasonographically from the body surface, the bladder and the proximal portion of the urethra can be imaged transrectally, however, the normal ureters could not be observed ultrasonographically.

Scanning position of the kidneys affect image quality and appearance of detailed structures,In this study, the left kidney was also imaged transrectaly, and this may be due to its caudal position than the right one and ventrolateral direction of the endorectal probe to left side. The right and left kidneys were scanned from the right side of abdomen, resembling the same results of **Braun *et al.* (1992); El-Khodary (2000)** and **El-Shahawy (2008)**. Meanwhile, **Abou Zaid (1995)** imaged the left kidney from the left side with pressure on the transducer. That may be attributed to the full rumen pushing of the left kidney towards right abdominal wall. Scanning of the right kidney longitudinally just caudal to the last rib required slightly oblique transducer holding because the longitudinal axis of the right kidney did not lie horizontally in most cases. This attributed to shadowing of the rib interrupt the continuity of the longitudinal section **(El-Khodary, 2000 and El-Shahawy, 2008)**. It can be imaged using sector array general purpose probe (6-2.6 MHZ). The concave nature of the right sublumbar fossa precludes the use of linear array endorectal transducer (7.5-2.6 MHZ). Difficult Sonographic examination of the left kidney than the right one may be due to the free mobility of the left kidney at the retroperitoneal space in standing position.

The course of the ureters could not be visualized ultrasonographically in any of the bucks by means of the transrectal or transbdominal approaches. **El-Shahawy (2008)** attributed this finding to their anatomical position at the dorsal wall of the abdominal cavity that couldn't be accessed. Using linear array endorectal probe and convex array general purpose probe at the right inguinal region immediately cranial to the pelvis with the beam aimed dorsomedially to visualize the ventral part of urinary bladder and caudal abdomen transabdominally in dorsal recumbent position succeeded in visualization of the urinary bladder even if it was partially full with some effort to localize the probe in such position. **Braun *et al.* (1992)** *used* the same technique in standing position that works well when the bladder is full; However, the bladder cannot always be visualized when it is only partially full.

In transverse plan, the normal kidneys appeared round shape while with longitudinal section they appeared oval or bean shape. Echointensity of renal cortex is hypoechoic, than liver and spleen. Renal medulla appeared hypoechoic than cortex to nearly anechoic. **Marchal *et al.,* (1986); Braun *et al.,* (1992); El-Khodary, (2000), and El-Shahawy (2008)** attributed this finding to histological structure of these tissue as renal medulla had higher content of water.

Renal sinus appeared more echogenic than renal cortex and mostly visualized in the transverse plane **(El-Shahawy, 2008)**.

Measuring two bladder diameters perpendicular to each others is more reliable indicator of the bladder size than one diameter because the bladder shape changes with animal movement, Meanwhile, **Braun *et al.* (1992)** measured only one bladder diameter and sometimes it was unable to be measured, as it was greater than 10 cm and therefore beyond the penetration capacity of the (5MHz) rectal transducer. This problem not appeared with the use of a multi-frequency endorectal prope (7.5-2.6

MHz).Unfortunately the two diameters of the bladder could not always be measured transrectally especially 24 hours after induction of urine retention. That is because of the walls of the distended bladder was larger than the scanning range of the linear probe (10×6 & 14×6) either transrectally or transabdominally, So that, the walls of the distended bladder could not appear completely on the monitor. This was in spite of the repeated examination at different frequencies trans rectally as changing the frequency change the depth (6, 10 and 14 cm) but not the width (6 cm) of the linear probe. In such cases, Using a convex array general purpose probe (6-2.6MHz) at the right inguinal region immediately cranial to the pelvis with the beam aimed dorsomedially transabdominally in dorsal recumbent position succeeded in visualization of the whole urinary bladder.

An equal changes in the kidney diameters (an increase in the length faced with a decrease in the width and vice versa) may be due to the fluid nature of the kidney contents that resulted in changing kidney diameters subsequently. Renal pelvis and medullary pyramids appeared hypoechoic than cortex to nearly anechoic and dilated **Braun *et al.* (1992)** attributed these sonographic appearance to the urinary stasis.

The urinary bladder is normally intrapelvic in situation. So that, its visualization in the abdomen is considered as abnormal ultrasonographic finding in bucks regardless its large size that could be measured accurately referring to urine retention raised from urinary obstructive lesion, **SCOTT (2000)** confirmed this result. Ultrasonographic examination of the urinary tract was easily and quickly performed. **Braun *et al.* (1992)** proved these results. However, it is occasionally carried out in small ruminants with urolithiasis because of the low financial value of these animals but it can be used for breeding bucks, which are valued for their blood lines.

It could be concluded that, small ruminants with a tentative diagnosis of urine retention due to obstructive urolithiasis, all parts of the urinary tract should be subjected to thorough examination. The kidneys are examined for enlargement and the renal pelvis, medullary pyramids، urethra, and ureters for dilatation. The size of the bladder and urethra should be noted and their contents are examined. Together with the clinical examination, determination of serum urea and creatinine concentrations, and abdominocentesis، ultrasonography provides a useful aid in the diagnosis of caprine urolithiasis.

It is evident from the results of this study that ultrasonography is a useful aid in confirming a clinical diagnosis of urine retention that may be caused by obstructive urolithiasis, the most common urinary tract disease in small ruminants.

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