Introduction

Ultrasound of the upper urinary tract in veterinary medicine is a routine procedure which can provide anatomic information regarding size, location, shape and internal architecture of the kidneys. Ultrasonography made it possible to obtain data from healthy animals and it is used to establish the standards of renal measurements including length, height and width (Jarretta, et al, 2004; Rossi, et al, 2012). Ultrasonographic examination of the kidneys has been described for horses, cattle, dogs, cats and ewes. It has been used to diagnose renal calculi and cysts, renal neoplasia, hydronephrosis and cystitis (Braun, et al, 1992).

While ultrasound has been utilized sufficiently to determine fetal numbers and gestational age it can also yield important clinical information within the chest, bladder, liver and kidneys (Scott, 2013).

Ultrasonography has become increasingly important for physiological and clinical examination of the kidneys. It potentiates the clinical examination and clinic-pathological analysis by providing additional information on renal disease (Floeck, 2007). Many renal disorders are associated with changes in kidney size; therefore, in patients with chronic problems, such as recurrent urinary tract infection, vesicoureteric reflux, or a neurogenic bladder, renal growth is monitored. Renal length is the most commonly used quantitative measure of renal size for comparison with established standards (Kadioglue, 2010). To evaluate abnormalities in renal size, knowledge of standardized values for normal renal dimensions is essential as it shows variability in the values of normal renal size (Raza, et al, 2011). Clinical diseases of the urinary system is uncommon in goats and despite the low prevalence of clinical renal diseases, pathological lesions of

the kidneys are not uncommon in goats at slaughter (Smith and Sherman, 2009). Ultrasonography of the kidneys helps to detect changes in size, location and pathological condition such as hydronephrosis, nephritis and renal tumors (Vosough and Mozaffari, 2009).

Ultrasound has several advantages over other diagnostic imaging modalities. It provides excellent anatomical informations of the kidney. In comparison with radiographic contrast studies; it is non-invasive with no radiation hazards. It does not expose the patient to iodinated intravenous substances which could be nephrotoxic, allergic and may be life-threatening.

It can offer more information than radiography especially in the presence of emaciation, peritoneal and retroperitoneal effusions and impaired renal functions. It is also used to guide invasive procedures such as fine-needle biopsy, percutaneous pyelocentesis, and antegrade pyelography.

Despite its crucial rule in diagnosis, it has several limitations because it is operator dependent; also it provides limited assessment of renal function unlike computed tomography (CT) or intravenous pyelography (Nobel and Brown, 2004).

Ultrasound is a non invasive, non-time consuming, accurate and practical method for evaluation of the kidney. The objectives of the study were to determine normal measurements of the kidney in Saanen goats in Sudan.

Chapter one

Literature review

1.1. Goats

According to the Food and Agriculture Organization (FAO) of the United Nations, an estimated 837.2 million goats in the world (smith and Sherman, 2009), There is about 95.8% of this population in the developing countries. Goats are managed under every unimaginable producing system.

1.2. Anatomy of the kidney

Kidneys of the goat are smooth, elliptically bean shaped and located retroperitoneally in the abdomen. They are 6-7 cm in length. The location of the right kidney is fixed in the dorsal abdomen at the level of vertebrae T_{13}-L_3. The left kidney is located more caudally at L_4-L_5 (Smith and Sherman, 2009).

1.3. Physiology of the kidney

The kidney serve multiple functions, including water and electrolytes balance, nutrient conservation, maintenance of normal blood pH levels and regulation of nitrogenous wastes, also it has an endocrine function. It stimulates erythropoesis, regulate calcium and phosphorous metabolism (Smith and Sherman, 2009; Abdelatif, et al, 2013). It is an important organ for maintaining calcium homeostasis (Wisloff, et al, 2003).

1.4. Indications for scanning the kidneys

There are many indications of scanning the kidneys; Polydipsia, Polyuria, vomition of unknown cause, acute abdominal pain, palpable organ abnormalities, blood and urine profile abnormalities.

1.5. Renal pathological conditions diagnosed by ultrasound

A number of disorders of the kidney can be diagnosed using ultrasound technique. It includes nephritis, pyelonephritis, polycystic renal disease, renal calculi, ureteral dilatation, renal infarcts, renal trauma and calcifications, renal cysts, abscess and hydronephrosis (Ozturk and Demirkan, 2005).

1.6. Sonographic views of the kidney

Two views for complete scanning of the kidney a sagittal view (fig. 1) and a transverse view (fig. 2).

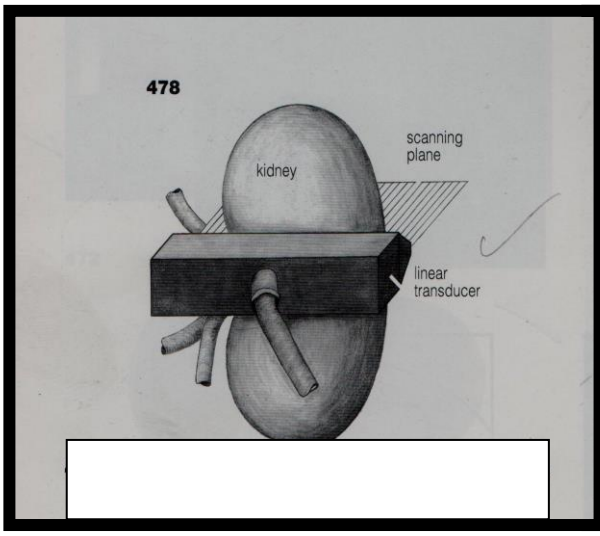

Fig. 1. Transverse view

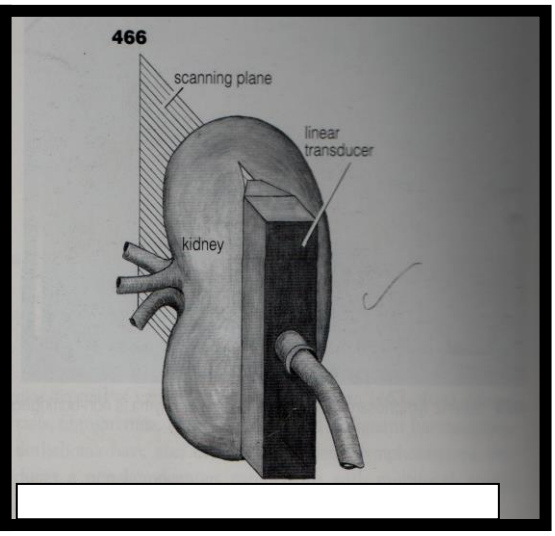

Fig. 2. Sagittal view

Chapter two

Material and methods

2.1. Animals

Thirty clinically healthy female Saanen goats were involved in the study. Their ages were between (6 months-8 year) and had body score of 2-4.They were fed roughages and concentrate with free access to water and mineral block supplements. Clinical examination, blood and biochemical profiles were done before ultrasound examination. Breeders and owners of Saanen goats were requested to present their goats for the examination. The study was carried out at Veterinary Teaching Hospital, College of Veterinary Medicine, Sudan University of Science and Technology (SUST).

2.2. Methods

2.2.1. Clinical examination of the animals

Body temperature, pulse and respiratory rates were taken from all animals according to (Kelly, 1984) Body score of animals were also taken using the method described by (Koyuncu and Altincekic, 2012)

2.2.2. Complete blood count (CBC)

Blood samples were obtained from the animals by vein puncture from the external jugular vein; 5 ml of blood were collected into EDTA tubes. Total white blood cells, total erythrocytes count, packed cell volume and hemoglobin analysis were done using the manual methods according to (Weiss and Wardrop 2010).

2.2.3. Renal function test (RFT)

5 ml of blood were collected into heparinized tubes. The samples were centrifuged at 3000\RPM for collection of plasma. The blood plasma was stored at -20°C. Urea, creatinine, uric acid, sodium and potassium analysis were done using digitalized machine **(Bio system 360, Spain).**

2.2.4. Ultrasound

2.2.4.1. Animal preparation

Animals were put off food for 12 hours to avoid accumulation of gases in the gastrointestinal tract. Area of scanning which extends from the 10^{th} intercostal space to the region immediately caudal to the last rib was clipped and shaved carefully using manual clipper (Supermax, UK).

2.2.4.2. Ultrasound technique

Ultrasonography of the kidney was performed on non-sedated animals using real-time scanner (Pie Medical Easote Machine, The Netherland) equipped with dual frequency (3.5-5) MHz convex probe. Liberal amount of ultrasonic gel (Aquasonic-turkey) was applied to the area prior to the scanning. Both kidneys were scanned and measured from the right flank while the animals were on the standing position. The examination was carried as described previously for sheep (Schefer, 1991; Braun, et al., 1992b) and goats (Steininger, 2009). Only one view was taken; longitudinal view with the transducer held parallel to the longitudinal axis of the organ (Steininger and Braun, 2011). The 10^{th} to 12^{th} intercostal spaces on the right flank was clipped and shaved carefully.

The length of the kidney (the distance between the cranial and caudal poles, measured in the longitudinal plane) was measured on longitudinal images. On the same plane the width (distance between the medial and lateral aspects), cortex and medulla were also measured. The echogenicity of the kidney were normal and the cortico-medullary demarcation was obvious.

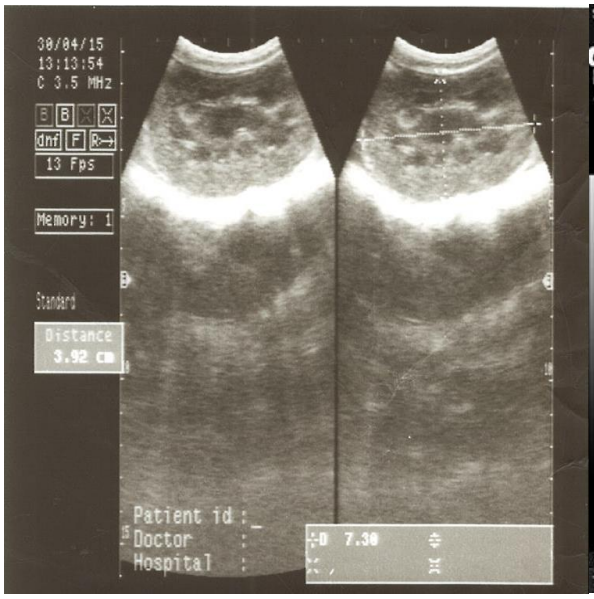

Fig. 3. Saanen kidney

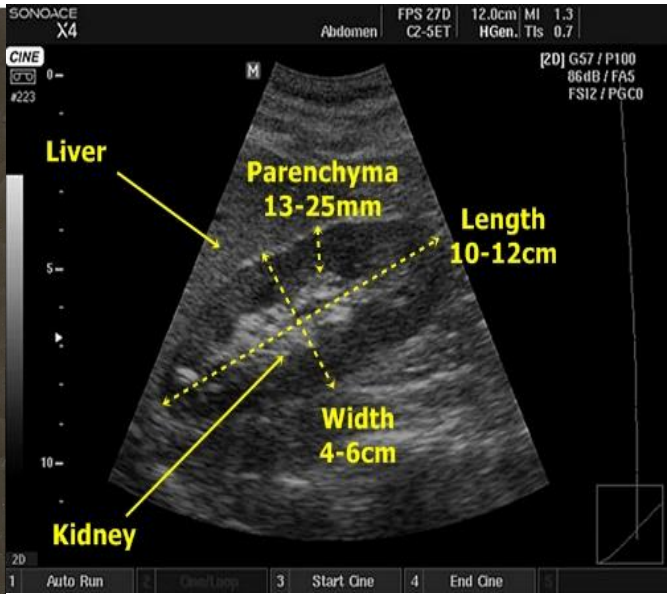

Fig.4. Human kidney

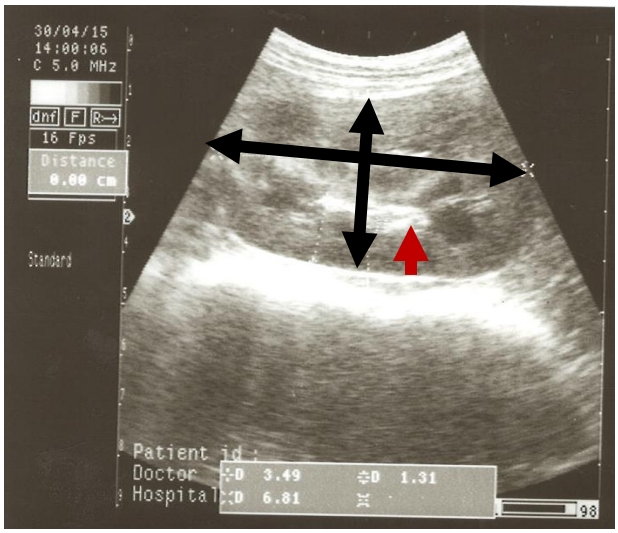

Fig.3. length and width of Saanen kidney

Chapter three

Results

3.1. Clinical examination

Clinical examination of the animals revealed normal temperature, pulse and respiratory rate in all animals.

3.2. Complete Blood Count (CBC)

CBC revealed that total red blood cells count, white blood cells count, hemoglobin concentration and packed cell volume are within the normal range as presented in table 1

Table 1. Complete blood count

Parameter	No. of animals	Minimum	Maximum	Mean ± SD
T.R.B.Cs x10^6c/cum	30	6.82	15.19	11.61± 2.31
T.W.B.Csx1000c/cum	30	6.00	18.00	11.20±2.90
HB g/dl	30	8.20	12.40	9.8±1.3
PCV %	30	22.00	38.20	30±5.1

3.3. Renal Function Test (RFT)

Blood urea, creatinine, uric acid, sodium and potassium were found to be within the reference values as they are presented in table 2.

Table (2) renal function test

Parameter	No. of animals	Minimum	Maximum	Mean ±SD
Urea mg/dl	30	17.00	28.00	23±2.66
Creatinine mg/dl	30	0.50	1.30	0.85±0.21
Uric acid mg/dl	30	0.50	1.50	0.9±0.25
Sodium mmol/L	30	133.90	154	146± 4.7
Potassium mmol/L	30	3.5	5.70	4.62±0.53

3.4. Ultrasonographic measurements of the kidneys

Nomograms of renal length, width, cortex and medulla were established. The right kidney could be seen from the right side and it was positioned with its longitudinal axis parallel to the vertebrae in all animals. The left kidney could be seen from the right side caudally to the ribs in 28 goats. In one goat it was seen immediately caudally to the right kidney and in one goat it couldn't be located until the animal was put on the left lateral recumbency.

The left kidney was positioned with its longitudinal axis parallel to the vertebrae in all animals. The kidneys had a smooth surface and were mobile with synchrony with respiratory movements. The maximum length of the kidney was seen in longitudinal views in a sagittal plane. Measurements of the length, width, cortex and medulla of both kidneys were shown in table 3.

Table (3): measurements of the length, width, cortex and medulla of the kidney

measurements / Kidney	No. of animals	Length ± SD(cm)	Width ±SD(cm)	Cortex diameter ±SD (cm)	Medulla diameter ±SD (cm)
Right kidney	30	7.0±0.64	3.8±0.49	1.03±0.31	1.75±0.32
Left kidney	30	6.9±0.63	3.80±0.84	1.00±0.32	1.8±0.38

No differences in measurements were found between the left and right kidney.

Chapter four

Discussion

Renal ultrasound is one of several imaging modalities in the evaluation of patients with acute renal disorders; it provides excellent anatomical informations without exposure to radiation hazards; however it is limited in its assessment of renal function (Nobel and Brown 2004). The present study constitutes a genuine attempt in the country to measure the normal size of the kidneys in female Saanen goats under Sudan condition. The right and left kidneys could be seen from the right side and were positioned with their longitudinal axes parallel to the vertebrae in almost all animals. The urinary tract of the goats was examined using the methods described for sheep (Braun et al., 1992) and goats (Steininger, 2009).

In our study the length, width, cortex and medullary diameter for the right kidney were found to be 7.0±0.64, 3.8±0.49, 1.03±0.31 and 1.75±0.32 respectively. For the left kidney we found that the length, width, cortex and medulla were 6.9±0.63, 3.80±0.84, 1.00±0.32 and 1.8±0.38 respectively.

Steininger and Braun (2012) measured the kidney size in 29 female Saanen goats; they reported that the length of the right kidney was found to be 8.0±0.67 cm and the left kidney was 8.40±0.64.this is not in accordance with our findings, however the breed is the same as our study but other factors could influence the measurements. They found that both kidneys had similar dimensions, and this is in accordance with our study that no differences were found between both kidneys.

Vosough and Mozaffari (2009) measured the length, width, cortex and medulla of both kidneys in 10 female Raiini goat; they found that the length, width, cortex and medullary diameter for the right kidney were 4.45, 3.00, 0.87

and 2.66 respectively. For the left kidney, the length, width, cortex and medullary diameter were found to be 4.37, 2.98, 0.82 and 2.54 cm respectively. This is not similar to our study and it could be due to breed differences.

Rossi, et al (2012) measured the renal length, cortex and medullary diameter in different group of ages in Saanen female goats. Comparison with these results could not be performed because of grouping the animals into ages. Braun, et al (1992) measured the length and width of the normal adult white alpine rams, they reported that the length and width of the right kidney were 8.2±0.3 and 4.8±0.3 cm respectively. For the left kidney they found the length and width were 8.4±0.3 and 4.7±0.3 cm respectively. Khan, et al (2003) measured the kidneys in Pakistan female goats at slaughter houses. They found that the length and width of the right kidney were as follows: 6.18± 2.3 and 3.24±0.39, for the left kidney 6.32±0.38 and 3.19±0.36. This is also not in accordance with our study and again it could be due to breed differences. Due to the scare date concerning measurements of kidney; comparisons were not possible and further research should be done to evaluate the normal measurements in all breeds of goat and sheep.

Chapter five

References

Abdellatif, A. M., Alsayed, S. A. and Hassan, Y. M. (2013). Effects of uninephroctomy on morphological and histological measurements of the ruminant kidney in goats (Capra hircus) model. Journal of Physiology and Pharmacology Advances (3): 94-102.

Braun, U., Schefer, U. and Fohn, J. (1992). Urinary tract ultrasonography in normal rams and in rams with obstructive urolithiasis. Canadian veterinary journal, 33: 654-659.

FAO (2007) Livestock Units. In: Resources stat module of FAOSTAT, Food and Agricultural Organization of the United Nations, Rome

Floeck, M (2007). Sonographic application in the diagnosis of pyelonephritis in cattle. Veterinary Radiology and Ultrasound, 48, 74-77

Jarretta, G., Bombonato, P. and Guimares, M. (2004). Renal ultrasonographic evaluation in the oncilla (Leopardus Tigrinus). Journal of Zoo and Wildlife Medicine, 35, 3: 356-360.

Kadioglue, A. (2010). Renal measurements, including length, paranchymal thickness, and medullary pyramid thickness, in healthy children: What are the normative ultrasound values? AJR Am J Roentgenol, 194 (2):509-515.

Kelly, W.R. (1984). Veterinary clinical diagnosis, 3rd edition, Bailliere Tindall, 1st Anne's road, Eastbourne, East Sussex B N 21 3UN.

Khan, H., Rind, M., Ahmed, R., Ahmed, N. and Shah, G. (2003). Gross anatomical study on normal kidneys of adult goat, journal of animal and veterinary advance, 2 (9), 539-541.

Koyuncu, M. and Altincekic, S. (2013). Importance of body condition score in dairy goats. Macedonian journal of animal science, 3(2): 167-173.

Nobel, V. and Brown, D. (2004). Renal Ultrasound, Emergency medicine clinics of North America, 22, 641-659.

Ozturk, S. and Demirkan, I. (2005). Transrectal ultrasonographic examination of the urinary system in Holstein cows, Turkish journal of veterinary and animal science. 29: 263-267.

Raza, M., Hameed, A and khan, M. (2011). Ultrasonographic assessment of renal size and its correlation with body mass index in adults without known renal disease. J Ayub Med Coll Abbottabad, 23, (3): 64-68.

Rossi, R.S., Bombonato, P.P., Piva, F.M. and Gregory, L. (2012). Avaliação da morfometria renal através do método ultrassonográ_ico de fêmeas caprinas (Capra hircus) normais da raça Saanen. Pesq Vet. Bras. 32: (2), 165-173 abstract.

Scott, P. (2013). Transabdominal ultrasonographic examination of 26 sheep with suspected urinary tract disease. Journal of Veterinary Science and Medical Diagnosis, (2-1): 1-5.

Smith, M. and Sherman, D. (2009). Goat Medicine, 2nd ed., Wiley-Blackwell, 2121 state avenue, Ames, Iowa 50014-8300, USA.

Steininger, K and Braun, U (2012). Ultrasonography of the urinary tract in female Saanen goats, Schweizer Archiv für Tierheilkunde, 154, 67-74. (Abstract)

Vosough, D. and Mozaffari, A. A. (2009). Evaluation of normal ultrasonographic findings of kidneys in Rainii goat. Iranian Journal of Veterinary Surgery. 4, (1-2), 59-65.

Weiss, D. J. and Wardrop, K. J. (2010). Schalm's Veterinary Hematology, 6th ed. Willey-Blackwell.

Wisloff, H., Flaoyen, A., Ottesen, N and Hovig, T. (2003). Narthecium ossifragum (L.) Huds. Causes kidney damage in goats: Morphologic and functional effects, Veterinary pathology, 40, 317-327.