Vet.Med.J.,Giza. Vol.53, No.3. (2005): 789-807.

ULTRASONOGRAPHIC AND ANGIOGRAPHIC ANATOMY OF THE NORMAL GOAT TESTIS

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Received: 11.6.2005.
Accepted: 5. 7. 2005.

SUMMARY

The current work was carried out on 8 adult clinically healthy male goats obtained from the Fac. of Vet. Med., Suez Canal University, Ismailia.
The study aimed to provide a guide for the anatomic and systemic evaluation of the caprine testicles by ultrasonographic and angiographic techniques which may help in the assessment of the anatomical morphology of the testis and testicular artery.

Brightness mode (B-mode) ultrasonography was performed with 5 MHz linear transducer for studying the echo-pattern of the testis, color Doppler flow mapping and spectral wave form of the testicular vasculature.

In vitro, testicular angiographical and histological studies were done to exclude any pathological deformities.

The obtained various vascular parameters (peak systolic velocity, end diastolic velocity, pulsatility index, resistance index and systolic/ diastolic ratio) were measured and tabulated .

INTRODUCTION

It is well known that the scrotal tunics and the testicular vessels have an important effect on the thermo-regulatory mechanism of the testis, essential for its efficient function. Moreover, studying of the vascularization of the organs has proved to be extremely beneficial in the interpretation of certain physiological and pathological events that may happen (El- Gaafary & Aly, 1977). Consequently,the gross anatomy , histology of the mammalian testis ,its arterial supply and venous drainage had received the attention of many investigators as Dellmann and Brown, 1987 in domestic animals; Ghoshal, Koch and Popesko

(1981) and Schummer, Wilkens, Vollmerhaus and Habermehl(1981) in small ruminants ; Nawar, El-Gaafary, El-Shafey and Aly (1975), El-Gaafary & Aly (1977), and Fahmy, Shahin, Kandil and Mostaffa (1981) in camel-bulls; El- Guedawy, Kandil, Fahmy, Shahin and Zaki (1981) and Shahin, Kandil, El -Sakhawy and Moussa (1982) in buffalo- bulls; Borthakur and Dhingera (1979) in Indian buffalo; Noor El-Din, Ramadan, Ebada and El-Guiziry (1986) in dogs; Shively (1987) and Dyce, Sack and Wensing (2002) in domestic animals as well as in man (El-Shahat, 2002).

However, recent techniques have been used in the field of veterinary clinical practice, among which are the ultrasonographic methods that have been newly applied to study the organs before deciding either a surgical or medical treatment could be taken (Goddard,1995).

Moreover, recent studies have also indicated that high resolution 2-D imaging coupled with color Doppler mapping is a simple reliable non-invasive technique, which provides anatomic, morphologic and physiologic data. It also demonstrates vessel potency, areas of stenosis, branching and flow direction information. The 2-D imaging also provides morphologic information which have been available only to pathologists after surgical intervention (Pinheiro, Jain and Nanda, 1993). However, nothing was found in the available literatures about the ultrasonography of the testis and testicular artery in goat.

Therefore, the present work aimed to clarify the ultrasonographic picture of the goat testis as well as to determine the anatomy of the testicular artery by angiographic and color Doppler techniques which may be useful in the assessment of the morphology of these structures. This also may be necessary for further understanding of some surgical and pathological problems occurring in such gland as well as may be of clinical application in andrological aspects.

MATERIAL AND METHODS

This work was conducted on eight adult clinically healthy bucks obtained from the farm of the Fac. of Vet. Med. , Suez Canal Univ. (Ismailia).

The animals were intramuscularly injected with xylazine hydrochloride (3 mg/ Kg body weight) and placed in a lateral recumbency. The transducer as well as the intact scrotal wall were smeared with a contact aqueous gel* (ultrasound transmission gel) as a coupling agent for proper contrast between the transducer and the examined area. Saggital scanning was then conducted by brightness mode (B-mode) with Acuson 128x P5 Computed Sonography System** equipped with 5

*Aquasonic100, Parker laboratories Inc. Orange, N.J.

**Acuson Computed Sonography, Acuson Corporation, 1220 Charleston road mountain view, California 94039-7393

MHz ultrasound linear transducer for studying the echo-pattern of both testicles of each animal, color Doppler flow mapping and spectral wave forms of the normal testicular vasculature.

Saggital (longitudinal) images were obtained by applying the transducer with its longitudinal axis parallel to the longitudinal axis of the examined testis (Goddard, 1995; Said and Bailery, 1996). The normal angle of beam was 35° .

Thenafter, the animals were slaughtered, well bled and an abdominal incision was made.The abdominal aorta was then cannulated just before the emergence of the testicular arteries and the vessels were flushed with physiological saline. Four animals were injected with a radio- opaque material (red lead oxide suspended in vegetable turpentine oil , 1: 1 weight : volume), under suitable hand pressure till increased resistance was felt. Angiography was then performed to identify the branching pattern of the testicular artery (at 70 Kv, 10 MAs and 90 Cm FFD).

For microscopic examination, specimens were taken from the testicles of three of the remaining animals , fixed in 10% neutral buffered formalin, dehydrated in ascending grades of ethyl alcohol (70-100%), then cleared with xylene. Paraffin-embedded tissues were sectioned at 5 microns thick and stained with Haematoxylin and eosin (Bancroft and Cook, 1984).

Longitudinal and transverse sections of the exposed testicles of the last remaining animal were taken and photographed to show the gross internal testicular structure.

RESULTS

Saggital testicular scanning was done by real time B-mode scanner using 5 MHz linear ultrasound transducer which was applied through the scrotum while the animals were placed in a lateral recumbency.

The echo- pattern of the testis appeared complex with marked distinction in echo-intensity between the parenchyma and the fibrous elements of the testis. The testicular parenchyma was predominately homogenous and hypoechoic (Figs.1/2, 2/6 and 3/4), while hyperechoic areas represented the mediastinum testis in the center of the testicle (Figs. 1/3, 2/8 and 3/1), tunica albuginea and the scrotal septum (Figs.1/1&4, 2/9 and 3/3).

Ultrasound scans when made through the intact scrotal wall could not differentiate the tunica albuginea testis from the scrotal wall.

The ultrasonographic testicular diameter (measured between its lateral and medial surfaces), when scanning was conducted through the scrotal wall was measured as 36.0mm ± 0.84, without significant difference between the right and left testicles. Such measurement included the scrotal wall as well as the scrotal septum.

The pars funicularis of the testicular artery started after passing from the external inguinal ring of the inguinal canal. Angiographical study revealed that, such segment of the testicular artery showed a marked convoluted course (Fig.4/1). It presented numerous coils which increased greatly distally towards the head extremity of the testis. This highly tortuous segment of the testicular artery was surrounded by the pampiniform plexus of the testicular vein (Fig.2/3).

The pars marginalis of the goat testicular artery began at the head extremity of the testis (Fig.4/2). It dipped under the tunica albuginea and extended along the attached (epididymal) border of the testis in a slightly flexuous course just medial to the epididymis (Figs.5/7 & 6/3) toward the tail extremity of the testis. At about 1cm. proximal to the tail extremity, it bifurcated into two unequal terminal branches; medial and lateral (Fig.4/3&4) which ran on the respective surfaces of the testis embedded in the tunica albuginea. The medial testicular branch (Figs.4/3 & 5/8). was directed towards the medial testicular surface and redivided into two nearly parallel rami that ran, toward the tail extremity of the testis, in a spiral manner, turned around the tail extremity and proceeded upward along the free (cranial) border of the testis towards its head extremity. These two rami provided a large number of fine collateral twigs which ramified on the medial surface of the testis. The lateral testicular branch (Figs. 4/4& 5/9) was much smaller than the preceding one. It passed in an undulating manner into the lateral surface of the testis and also gave off a number of collateral branches to such testicular surface .

Both the medial and lateral terminal testicular branches also detached fine secondary and tertiary rami, which formed a sort of a dense network of fine vessels deep to the tunica albuginea. Such vessels supplied the parenchyma of the gland as the proper testicular arteries (Fig.4/5).

Color Doppler imaging of the normal caprine testicle demonstrated the mapping of the testicular vasculature (funicular part, marginal part and proper testicular arteries). The tracing of the target vessels was guided by the use of color flow mapping (Figs. 7 & 8).

The normal funicular part of the testicular artery was displayed as a positive wave form with a high frequency systolic phase and a continuous diastolic flow component (Fig.9). While the marginal and proper testicular arteries had a gradual reduction in the systolic peak velocity with a slight increase in spectral broadening (Figs.10& 11).

The peak systolic velocity, end diastolic velocity,

Table (1): Showing the various parameters of the funicular, marginal and proper parts of the testicular artery of both testicles in goat.

Parameter / Part of the testicular artery	Right testicular artery						Left testicular artery					
	MAX (m/s)	MIN (m/s)	TAMX (m/s)	PI± S.E.	RI± S.E.	S/D± S.E.	MAX (m/s)	MIN (m/s)	TAMX (m/s)	PI± S.E.	RI± S.E.	S/D± S.E.
Funicular part (FP)	0.23	0.13	0.14	0.71± 0.06	0.43± 0.02	1.77± 0.15	0.25	0.14	0.14	0.79± 0.05	0.44± 0.06	1.79± 0.17
Marginal part (MTA)	0.13	0.08	0.08	0.63± 0.04	0.38± 0.02	1.63± 0.09	0.122	0.08	0.07	0.57± 0.04	0.37± 0.02	1.50± 0.07
Proper testicular artery (PTA)	0.17	0.11	0.10	0.60± 0.05	0.35± 0.02	1.55± 0.08	0.16	0.11	0.10	0.55± 0.04	0.31± 0.01	1.45± 0.06

MAX= Peak systolic velocity
MIN= End diastolic velocity
TAMX= Time average maximum velocity
PI= Pulsatility index
RI= Resistance index
S/D= Systolic/diastolic ratio
S.E.= Standard error
Results are mean ± S.E.

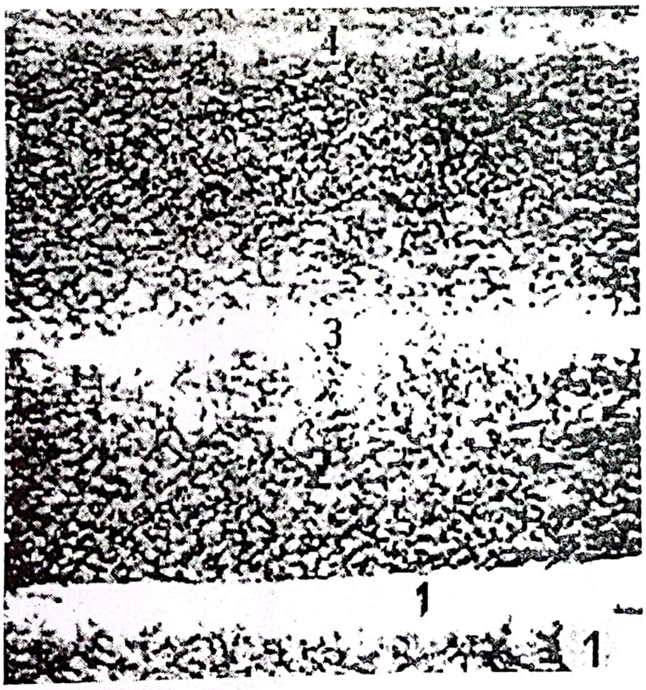

Fig.(1): A saggital ultrasound scan of the normal goat testis through the scrotal wall showing:

1- Scrotal wall and Tunica albuginea of testis.

2- Testicular parenchyma.

3- Mediastinum testis.

4- Scrotal septum.

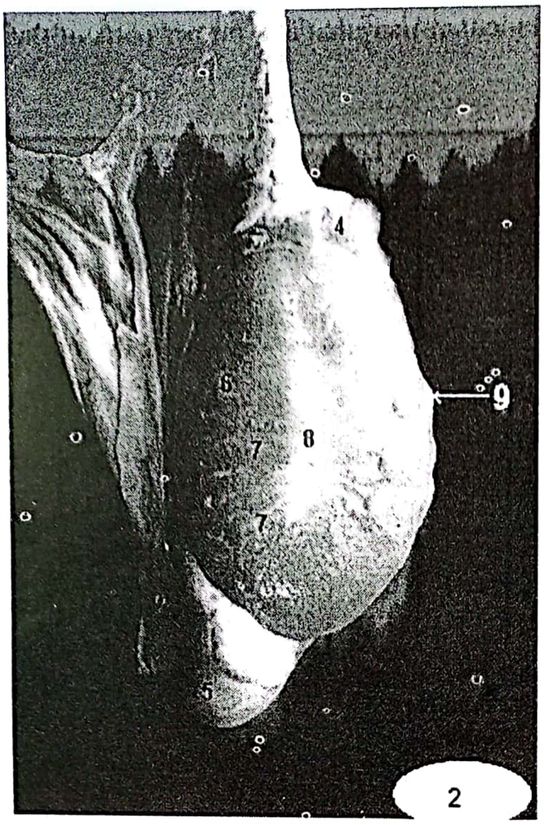

Fig. (2): A photograph of a longitudinal section of the testis of an adult goat:

1- Ductus deferens.

2- Tunica vaginalis visceralis.

3- Pampiniform plexus of the testicular vein surrounding the testicular artery.

4- Head of the epididymis.

5- Tail of the epididymis.

6- Testicular parenchyma.

7--Connective tissue septa.

8- Mediastinum testis.

9- Tunica albuginea.

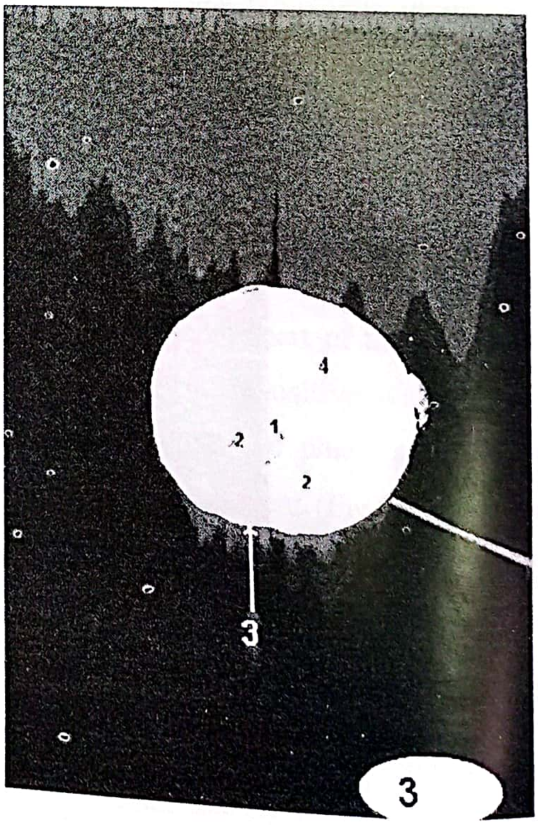

Fig. (3): A photograph of a transverse section of the testis of an adult goat:

1- Mediastinum testis.

2-Connective tissue septa.

3-Tunica albuginea .

4-Testicular parenchyma.

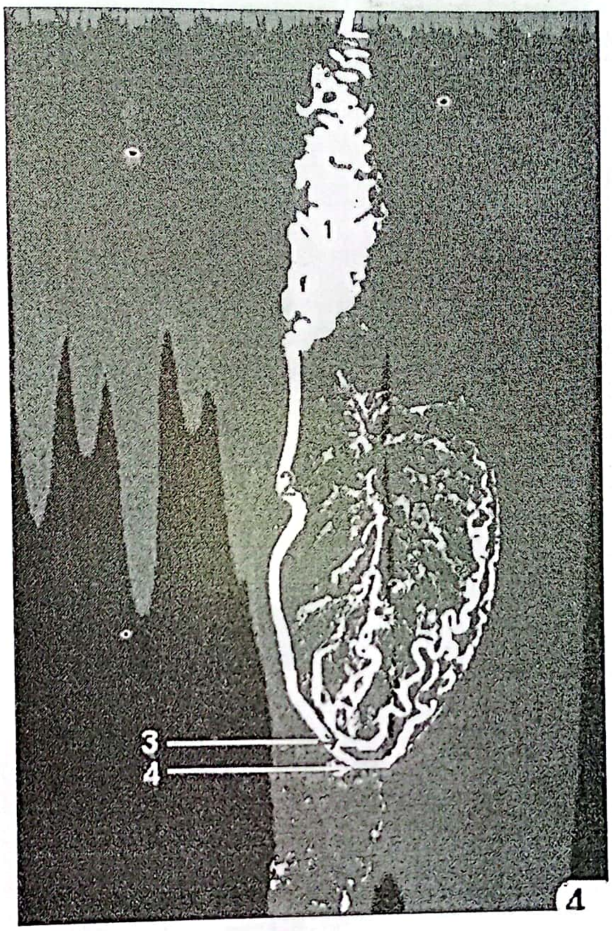

Fig. (4): A testicular arterial radiograph (medio-lateral view) of an adult goat.

Notice: 1-Funicular part of the testicular artery.

2-Marginal part of the testicular artery.

3- Medial testicular branch of(2).

4- Lateral testicular branch of(2).

5- Proper testicular arteries.

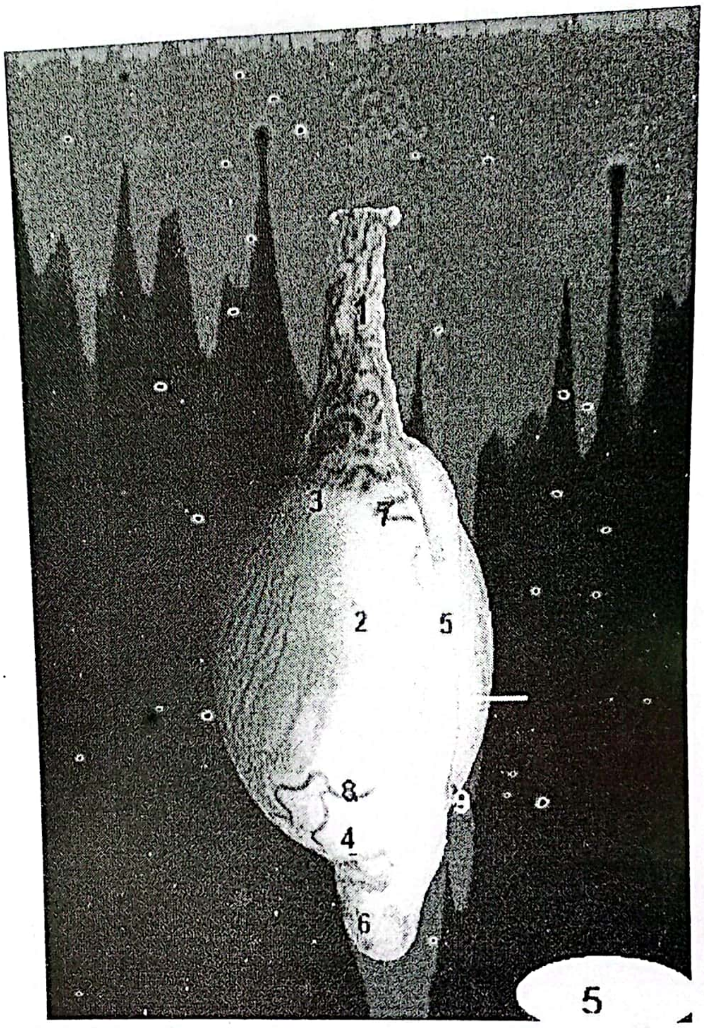

Fig. (5): A photograph of the caudo-medial aspect of the right testis of a goat showing:

1- Testicular artery surrounded by the pampiniform plexus of the testicular vein (seen through the vaginal tunic).

2- Testis covered by the visceral vaginal tunic.

3-Head extremity (Extremitas capitata) of testis.

4- Tail extremity (Extremitas caudata) of testis.

5- Body of the epididymis.

6- Tail of the epididymis.

7- Marginal part of the testicular artery.

8- Medial branch of (7).

9- Lateral branch of (7).

Arrow indicates the testicular bursa

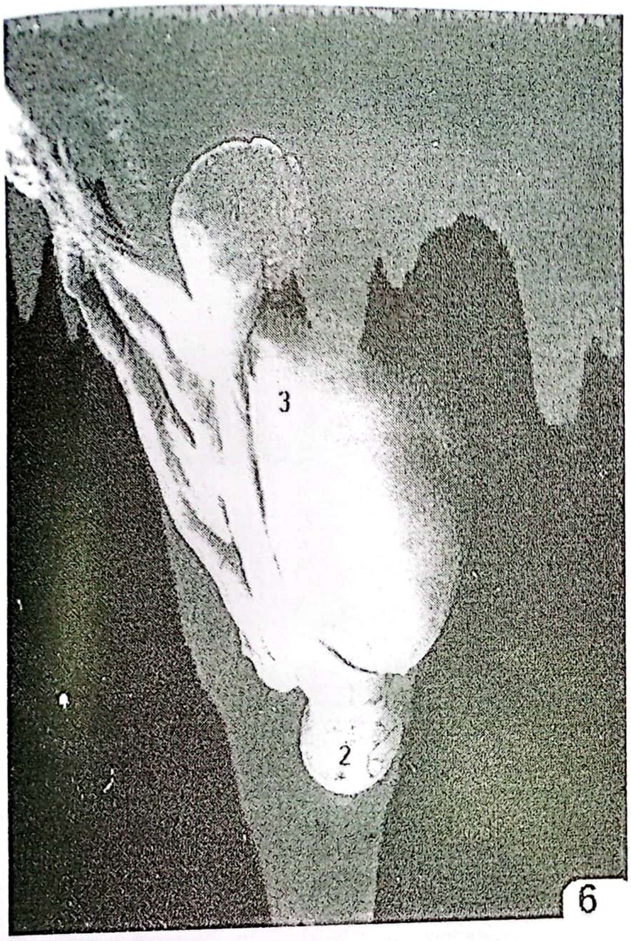

Fig.(6): A photograph of the left testis of an adult goat left testis showing the beginning of the marginal part of the testicular artery at the head extremity of the testis.

1- Head of the epididymis (reflected).

2- Tail of the epididymis.

3- Marginal part of the testicular artery (injected with red led oxide).

Fig.(7): A photograph showing color Doppler mapping of the funicular part of the testicular artery.

FP: Funicular part of the testicular artery surrounded by the pampini form plexus of the testicular vein.

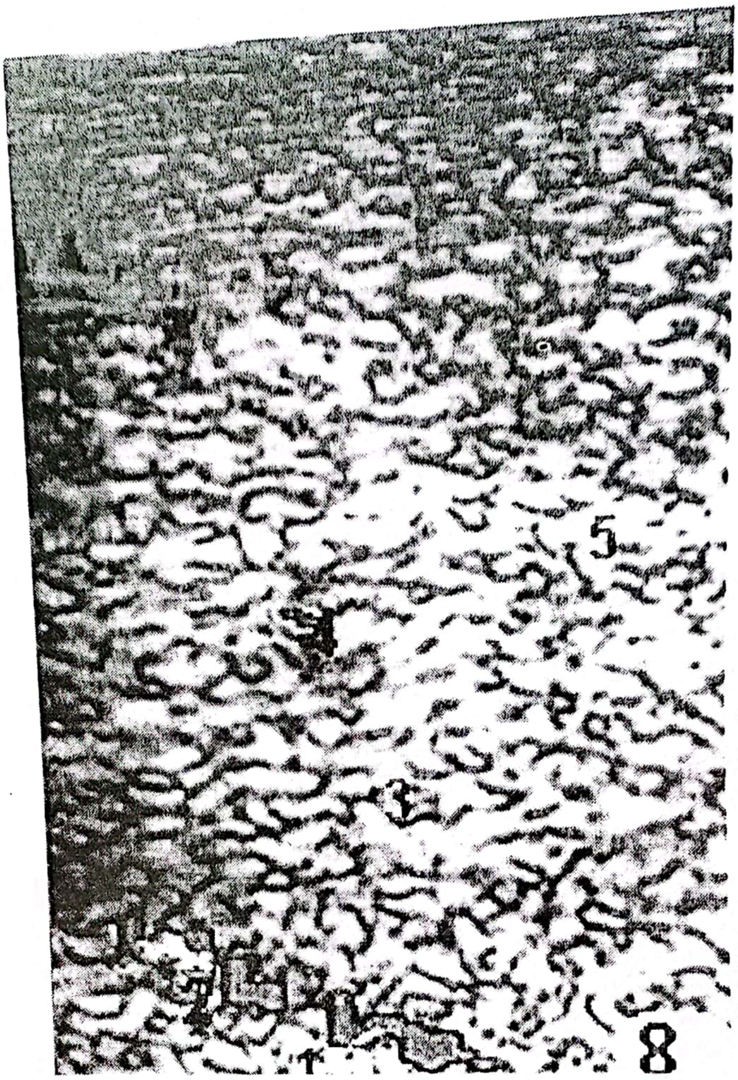

Fig. (8): A photograph showing color Doppler mapping of the marginal and proper parts of the testicular artery

1-Tunica albuginea of testis.

2-Marginal part of the testicular artery.

3-Testicular parenchyma.

4-Proper testicular artery.

5-Mediastinum testis.

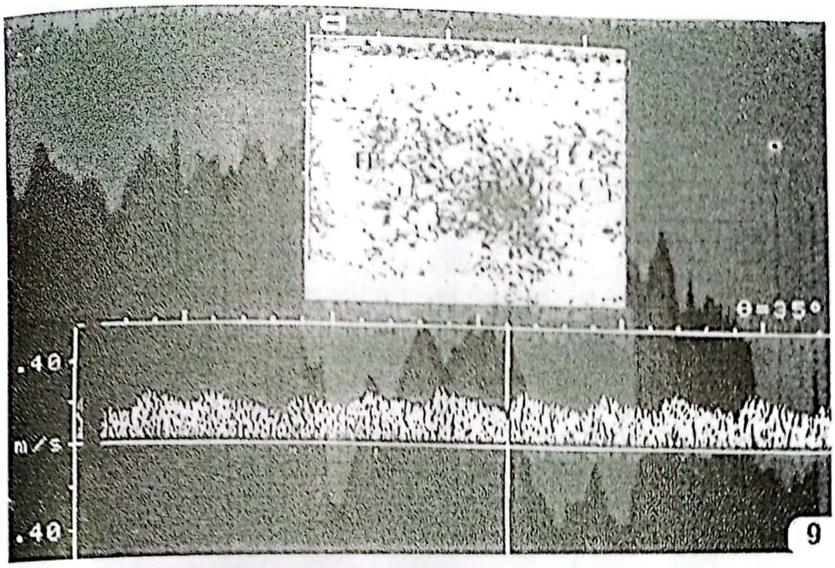

Fig.(9):
A photograph showing the spectral wave form of the funicular part **(FP)** of the testicular artery.

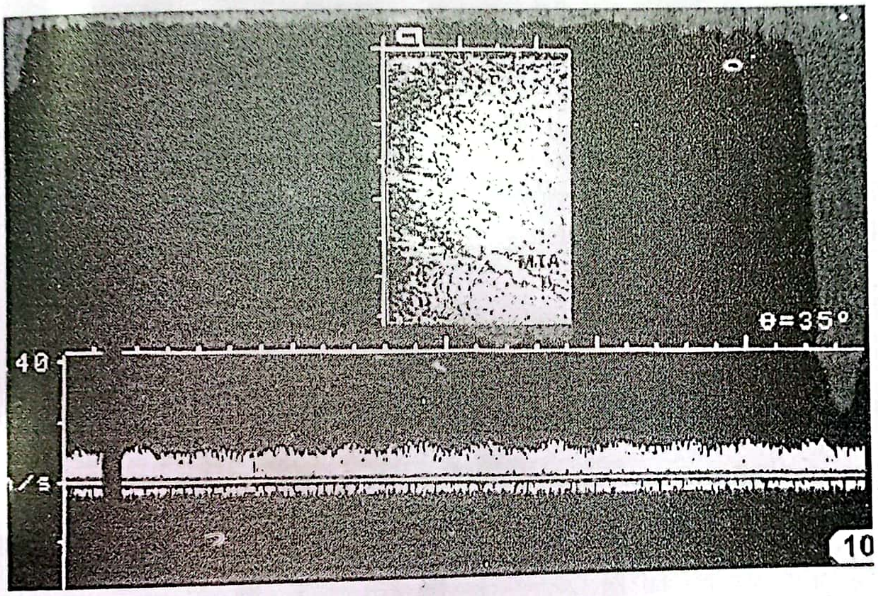

Fig.(10):
A photograph showing the spectral wave form of the marginal part of the testicular artery. **(MTA).**

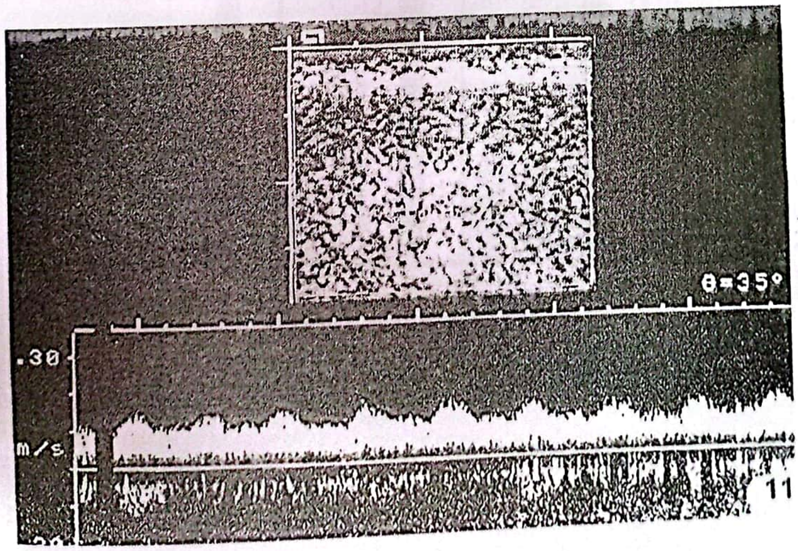

Fig.(11): A photograph showing the spectral wave form of the proper testicular artery (PTA).

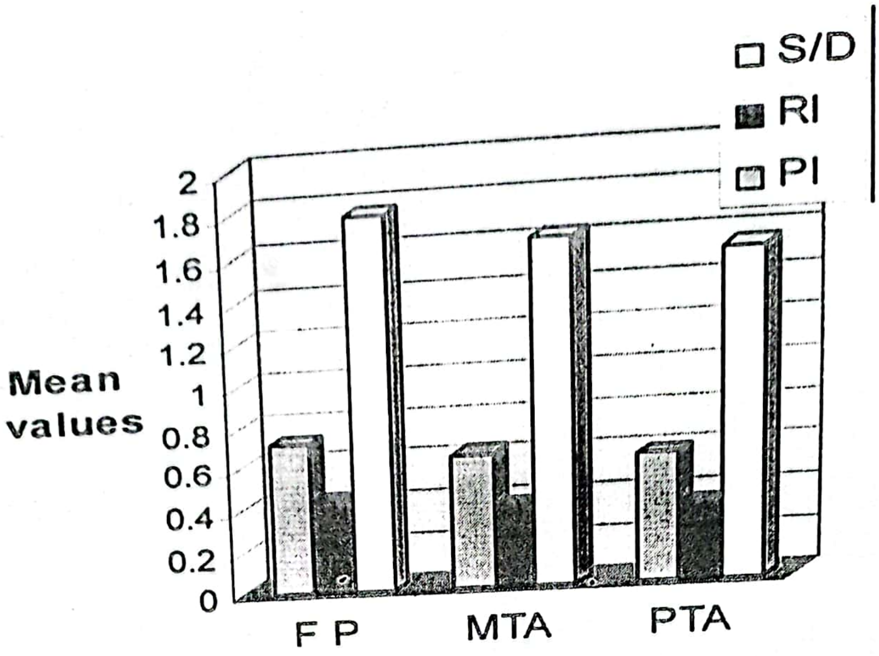

Fig. (12): Mean values of the **PI, RI** and **S/D** of the funicular , marginal and proper parts of the right testicular artery in goat.

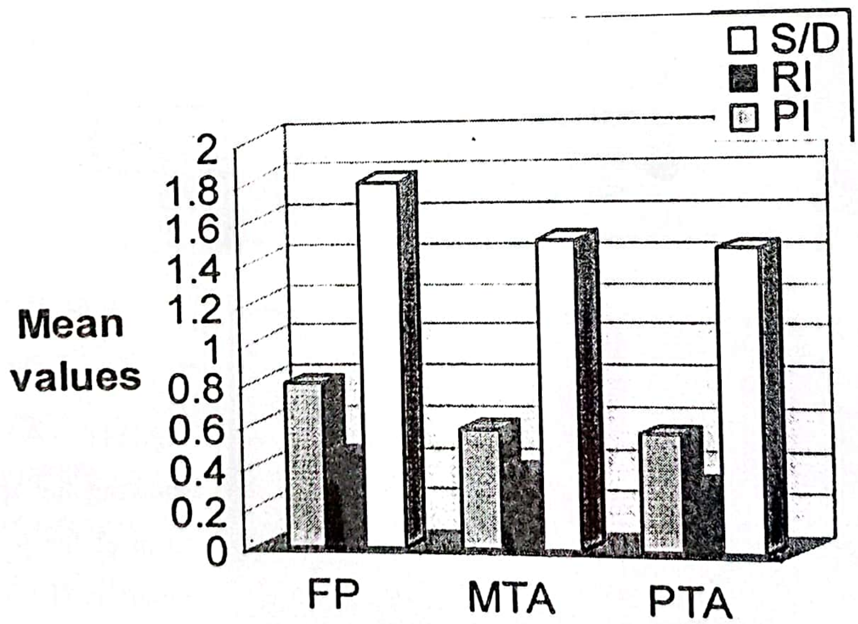

Fig. (13): Mean values of the **PI, RI** and **S/D** of the funicular , marginal and proper parts of the left testicular artery in goat

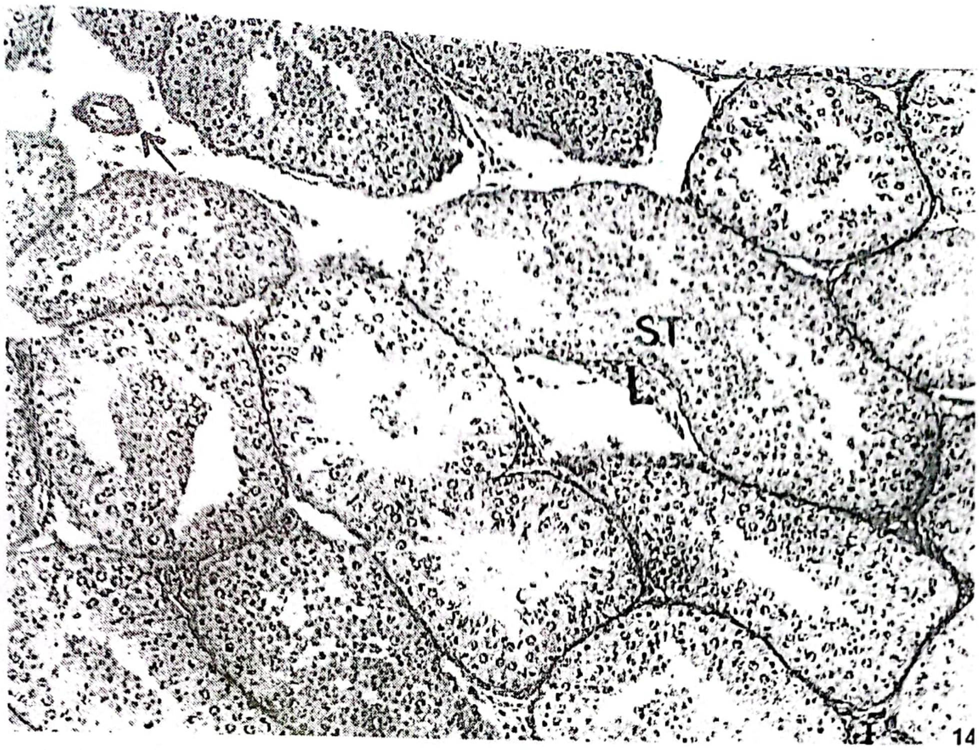

Fig. (14): A photomicrograph of a transverse section in the testis of an adult goat showing the normal appearance of both seminiferous tubules **(ST)** , Leydig cells **(L)** and branches of the testicular artery (arrow). (Hx. & E. X100)

Fig.(15): A photomicrograph of a transverse section in the testis of an adult goat showing the branches of the testicular artery (arrows) in the mediastinum testis (MT). (H&E; X100).

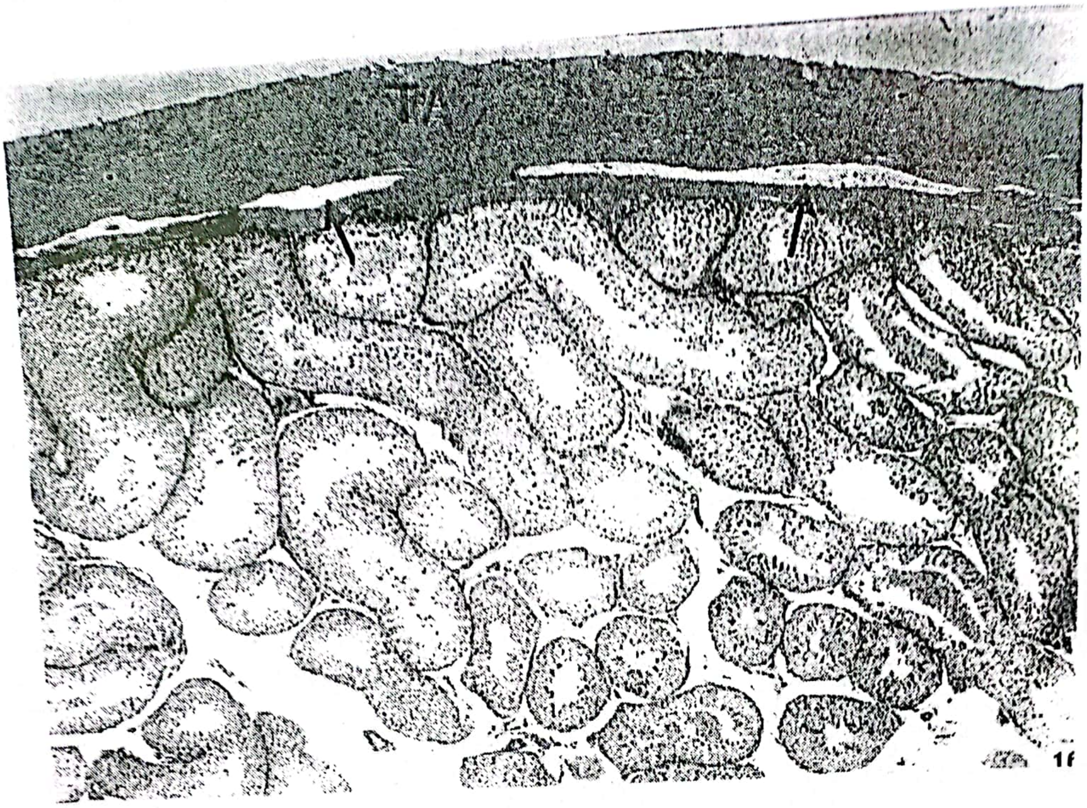

Fig. (16): A photomicrograph of a transverse section in the testis of an adult goat showing the branches of the testicular artery (arrows) penetrating the tunica albuginea **(TA)**. (Hx. & E.; X40)

pulsatility index, resistance index, and systolic / diastolic ratio of each of the examined parts of the right and left testicular arteries were measured and statistically tabulated (table1 and Figs. 12 & 13).

The systolic/diastolic (S/D) ratio of such parts of the testicular artery was measured by dividing its peak systolic velocity by the end diastolic velocity. It was 1.77 ± 0.15 (right testis) and 1.79 ± 0.17 (left testis) for the funicular part; 1.63 ± 0.09 (right testis) and 1.50 ± 0.07 (left testis) for the marginal part, whereas for the proper testicular artery, the S/D ratio was 1.55 ± 0.08 (right testis) and 1.45 ± 0.06 (left testis). The resistance index was measured as follows :

The pulsatility index was measured as follows:

$$\frac{\text{MAX - MIN}}{\text{MAX}}$$

Microscopical observations revealed normal structure of the testis without any pathological deformities either in the seminiferous tubules or interstitial tissue(Fig.14). It was also seen that the testicular blood vessels were free from plaques and arteriosclerosis(Figs. 15 & 16).

DISCUSSION

Testicular anatomy that can be discriminated on ultrasonographic images through the scrotal wall and has been used in testicular evaluation in the goat includes the testicular parenchyma, mediastinum testis and the scrotal septum. In this respect, B- mode ultrasonography, as a reliable non- invasive method, had also been widely used in scrotal and testicular evaluation in rams (Cartee, Rumph, Abu-Zaid and Carson, 1990; Agunbah, Tafirei, Mudense and Shumba, 1995) , boars (Cartee, Powe, Gray, Hudson and Kuhlers, 1980), bulls (Cartee, Gray, Powe, Hudson and Whitesides, 1989), and man (Miskin & Bain , 1974 and Miskin , Buckspan and Bain, 1976).

The present work had revealed that the caprine testes when sonographically visualized in a saggital plane appeared as homogenous hypoechoic structure representing the parenchyma. The scrotal wall, mediastinum testis and scrotal septum appeared as hyperechoic areas. Similar observations were also provided by Cartee et al. (1980) in boars; Cartee et al. (1989) in beef bulls; Cartee et al. (1990) and Agunbah et al. (1995) in rams as well as by Boyd (2001) in dogs.

The diameter of goat testicles recorded in the present study was 36.0mm ± 0.084 as measured sonographically through the intact scrotum. Moreover, there was no significant difference between both testicles. Such a result confirmed that was reported by Cartee et al . (1990) in rams. In this aspect, the authors added that there was a significant difference between the physical and ultrasonographic measurements of the ram testicular circumference and diameter when scanning was conducted through the scrotal wall. The authors also stated that there was no significant difference between the physical and ultrasonographic measurements of the testicular diameter when performed on the exposed testicle. In bulls, Cartee et al. (1989) had reported that there was no significant difference between the ultrasonographic measurements of the diameter through the intact scrotum and that measured physically on the exposed testicles . However, the variations reported in the different studies might be due to the different number of animals used, the different equipment calipers, or due to species differences.

According to El- Gaafary & Aly (1977); Harrington, Schaure and Gilbert (1996); Amer, El-Haggar, Mostafa, Fayez, Roia and Salem (2000); Asala, Chaudhary, Masumbuko and Bidmos (2001) and El-Shahat (2002), a comprehensive knowledge of the patterns of the testicular artery termination is essential to understand the role played by testicular vessels in the thermoregulatory mechanism of the testes essential for their efficient function, and also to define the areas of poor vascular anastomosis to be used for testicular biopsies. Also, circulatory disturbances in animals may cause testicular inflammation, followed usually by degeneration and then fibrosis (Shively, 1987). In this respect, the current study revealed that the funicular part of the testicular artery was highly convoluted till it reached the testis. A similar result was also found by (El-Gaafary & Aly (1977) in camel- bulls; Borthakur & Dhingra (1979) in buffalo - bulls and Noor El- Din et al. (1986) in dogs. Moreover, Nawar et al. (1975) in camel- bulls and Shahin et al. (1982) in buffalo- bulls stated that contractions of the longitudinally arranged smooth muscle fibers in the tunica media of the testicular artery were responsible for the convolutions of the artery and slowing blood flow, thus allowing the preheating and precooling mechanisms to be effectively performed (El- Gaafay & Aly, 1977). However, in man , the testicular artery passed down to the testis either in an almost straight course in 84% of the cases or in variable convoluted courses in the remaining 16% (Williams, Berry, Collins , Dyson, Dussek, Ferguson and Bannister, 1995 and El-Shahat, 2002), though Heider (1980), reported that the testicular artery descended straight without convolution in all cases.

Regarding the marginal part of the testicular artery in the goat, it was revealed that it had a slightly wavy course along the epididymal (caudal) border of the testis just medial to the epididymis. Similar findings were observed by Noor El- Din et al. (1986) in dogs, whereas in buffalo - bulls (Borthakur & Dhingra, 1979) and in camel-bulls (El-Gaafary & Aly, 1977), such segment of the testicular artery proceeded under the epididymis. The marginal part of the testicular artery, as declared in the current study, was divided into two main unequal terminal branches (medial and lateral) before reaching the tail extremity of the testis, the findings which were in a line with those observed by Williams et al., (1995) in man; Borthakur & Dhingra (1979) in buffalo-bulls and El-Gaafary & Aly (1977) in camel - bulls. The latter authors also added that beside the medial & lateral branches, the marginal testicular artery of camel detached 1- 6 small accessory testicular arteries that are distributed mainly on the lateral surface of the testis and played a role in supplying its parenchyma.

In this respect, Harrison (1949), in the horse, and Noor El-Din et al. (1986), in the dog, recorded that the main artery detached its branches after turning round the tail extremity of the testis. However, such variations in the site of arborizations of the marginal testicular artery perhaps, may be due to species differences.

The vertical direction of the goat testicles beside the upward undulating manner of both medial and lateral branches of the marginal part of the testicular artery might reduce the blood flow velocity into the testis. Thus, assisting in the homogenous thermal and hormonal distribution within the testicular parenchyma.

The arborizations of the lateral testicular branch on the lateral surface of the goat testicle were comparatively less than those of the medial branch. Therefore, the lateral testicular surface, in view of the present study, was suggested to be the preferable site for testicular biopsies in order to obtain sperm extraction. This was in contrary with that reported by El- Gaafary & Aly (1977), who said that the medial surface of the camel testis would be the best site for biopsies.

Although many authors had extensively described the anatomy of the testicular artery, regarding its origin, course, branching and termination, yet, nothing was found in the available literatures about the color flow mapping of the testicular vasculature. However, on using color Doppler imaging technique in the recent work, the testicular vascular flow mapping could be easily traced up to the proper testicular vessel. Moreover, detection of blood flow in the intratesticular arteries may be helpful to exclude occlusion of the ipsilateral main stem (Barrie, Evans and Bell, 1979).

Various normal parameters of the testicular artery obtained in the present investigation must be known to the clinicians in order to compare them with the obtained data of the diseased cases. However, among animals, neither normal nor abnormal parameters were available at hand in this scope.

At last, it could be said that ultrasonography of the testis and its vasculature in goat could be used as a technique in the assessment of the anatomical morphology of this gland, which might be used to detect any pathological changes in such an organ.

REFERENCES

Agunbah, G.J.; Tafirei. G., Mudensc. D. and shumba, W. (1995) : Testicular ultrasonography in rams. Und.Vet. J., 72, 829 - 834.

Amer, M.; El-Haggar, S.; Mostafa. T.; Fyez, A.; Roia, M. M. and Salem, A. (2000): Selection of viable testicular spermatozoa using phosphodiestrase inhibitors. Egypt. J. Androl. Reprod., 13 (1), 87 - 98.

Asala, S., Chaudhary S.C.; Masumbuko, K. N. and Bidmos, M. (2001): Anatomical variations in the human testicular blood vessels. Ann. Anat., 138 (6) 545-549.

Bancroft, J.D. and Cook, H.C. (1984): Manual of Histological Techniques. 1st ed., Churchill & Livingstone. Edinburgh, London, Melbourne and New York.

Barrie, W. E.; Evans, O.H. and Bell, P.R.F. (1979) : The relationship between ultrasonic pulsatility index and proximal arterial stenosis. British J. Surgery, 66, 366.

Borthakur, S. and Dhingra, L.D. (1979) : Anatomical studies on the blood vessels of the testis in Indian buffalo (Bubalus bubalis). Indian J. Anim. Sci., 49, 266- 270.

Boyd, J.S. (2001): Color Atlas of Clinical Anatomy of the Dog and Cat. 2nd ed. Mosby, London, Edinburgh, New York, St. Louis, Sydney, Toronto. P. 134.

Cartee, R.E; Powe, T.A.; Gray, B.W., Hudson, R.S. and Kuhlers, D.L. (1980) : Ultrasonographic evaluation of normal boar testicles. Am. J. Vet. Res., 47,12, 2543 - 2548.

Cartee, R.E.; Gray, B. W.; Powe, T.A. ; Hudson, R.S. and Whitesides, J. (1989) : Preliminary implications of B - mode ultrasonography of the testicles of beef bulls with normal breeding soundness examinations. Theriogenology, 31, 1149- 1157 .

Cartee, R. E.; Rumph, P.F.; Abuzaid, S. and Carson, R. (1990): Ultrasonographic examination and measurement of ram testicles. Theriogenology, 33, (4), 867 - 875.

Dellmann,H.D. and Brown, E.M. (1987) : Textbook of Veterinary Histology . 3rd ed. . Lea and Fiebiger, Philadelphia. 286-287.

Dyce, K.M.; Sack. W.O. and Wensing, C.J.G. (2002) : Textbook of Veterinary Anatomy. 3rd ed. W.B. Saunders Co., Philadelphia, London, Toronto, Montreal, Sydney, Tokyo. 679-680.

El - Gaafary, M.A.H. and Aly, A.E.A. (1977) : Anatomical studies on the arterial supply of the testis and epididymis of the dromedary camel. Assiut Vet. Med. J. , 4 (7), 12 - 23.

El-Guedawy, S.A.; Kandil, M.H.A., Fahmy Y.M.; Shahin, Y. M. and Zaki, K. (1981) : A histochemical study on the testes of Egyptian water buffalo (Bos bubalis). Vet. Med . J. , Vol. 29, No 29 , 265- 278.

El-Shahat, A. (2002) : An anatomical study of the testicular artery termination in man . Egypt J. Anat., Vol. 25 (2), 291 - 311 .

Fahmy M. F. A.; Shahin, Y. M.; Kandil, M. H. A. and Mostaffa, I. A. (1981) : Histological studies on the testis of one - humped camel (Camelus dromedarius). Vet. Med. J. , Vol. 29, No. 29, 347 - 356 .

Ghoshal, N.G.; Koch, T. and Popesko, P. (1981): The venous drainage of the domestic animals. W. B. Saunders Company. Philadelphia, London, Toronto and Sydney. Pp. 117- 119.

Goddard, P.J. (1995): Veterinary ultrasonography, CAB International, British Library.

Harrington, T.G.; Schaure, D. and Gilbert, B.R. (1996): Percutaneous testis biopsy: An alternative to open testicular biopsy in the evaluation of subfertile man. J.Urol. , 156, 16 - 47.

Harrison , R. G. (1949): The comparative anatomy of the blood supply of the mammalian testis. Proc. Zool. Soc. London , 119, 325-344.

Heider, E. A. (1980): Arterial supply of the human testis and effect of occlusion of different arteries on integrity to testicular tissue. Ph. D. Anatomy, Faculty of Medicine, Cairo University, Egypt.

Miskin, M. and Bain, S. (1974): B-mode ultrasonographic examination of the testes. J. Clin . Ultrasound . 2, 307 - 311.

Miskin, M. ; Buckspan, M. and Bain, J. (1976): Ultrasonographic examination of scrotal masses. J. Urol, 117, 185-188.

Nawar, S.M.A.; El- Gaafary, M.A. H. ; El- Shafey, S.M. and Aly, A.E.A. (1975): Micromorphological studies on the arterial supply of the testis and epididymis of one humped camel (Camelus dromedarius). Assiut Vet. Med. J. , vol. II, 67-71.

Noor- El- Din, M. A. ; Ramadan , A. G. ; Ebada, R. M. M. and El - Guiziry, H.S. (1986): The vascular pattern of the testes and epididymides in dog (Canis familiaris). Egypt. J. Histol. , 9 (2), 213 - 218.

Pinheiro, L. ; Jain, S. and Nanda , N. C. (1993): Doppler echocardiography: conventional and color Doppler evaluation of abdominal vessels. 2nd ed. , Lea & Fib. , Philadelphia, London, 357 - 364.

Said, E. M. and Bailery, M. Q. (1996 a): Methodology of ultrasonography of bovine mammary gland. Med. J. Cairo Univ. , 64 (5), 611- 617.

Schummer, A. ; Wilkens, H. ; Vollmerhaus, B. and Habermehl, K. (1981): Circulatory system, skin and skin organs of the domestic mammals. 1st ed. , New York, Verlag, Paul Parey, P. 176.

Shahin, Y. M. ; Kandil, M. H. A. ; El - Sakhawy, M. A. and Moussa, M.H.G. (1982): Micromorphological study of the arterial supply of the testis and epididymis of the buffalo in Egypt (Bos bubalis). Egypt. Vet. Med. J. Giza, Vol. 30, No. 30 , 69 - 78.

Shively, M.J. (1987): Veterinary Anatomy. Basic , Comparative and Clinical. Texas A & M Univ. Press College Station. P. 346.

Williams, P.L.; Berry, M.M.; Collins, P.; Dyson, M.; D; Dussek, J.E.; Ferguson, M.W. and Bannister, L.H. (1995): Gray's Anatomy, 38th ed., Longman, Churchill livingston, Edinburgh, 666.