



Computed Tomography and Gross Anatomy of the Pelvis of the Barki Male Goat (*Capra hircus*)

Manal A. Seif, Ashraf A. Karkoura, Raafat M. El Bakary, Mohamed A.M. Alsafy, Mohamed A. Abumandour

Anatomy and Embryology department, Faculty of Veterinary Medicine, Alexandria University, Egypt

ABSTRACT

Key words:

Goat, Pelvis, CT, 3-D CT images

Correspondence to:

Manal Seif,
Manalamir312@yahoo.com

The current study aimed to provide a detailed anatomic reference to the pelvis of the Barki male goat by using the cross- anatomical sections and computed tomography scans. Moreover, the internal and external pelvic measurements were recorded. Ten adult Barki male goats were used. The topography of pelvic organs was described in details through many CT images interpreted by cadaver cross- sections. Transverse and sagittal CT scans were used to investigate the male accessory sex glands. The paired ampulla of ductus deferens, the paired vesicular glands, and the paired bulbourethral glands were investigated. Except the prostate gland was not detected because of it has only disseminated part surrounding the pelvic urethra (embedded in pelvic urethral wall). The internal and external pelvic diameters on a Barki male goat skeleton and the computed tomography are recorded. It could be concluded that the CT scan has a great value in veterinary field as it can be used to evaluate the male goat productive performance through examination of the male goat accessory sex glands.

1. INTRODUCTION

In Egypt, goats are an important source of meat and they are distributed across the country, especially in the Nile valley and delta and with lower concentration in the northwestern coast region and at oases as noted by (Galal et al., 2005). The Egyptian goat breeds, especially the Baladi breed with a wider distribution across the Nile valley and delta, has high genetic variability (Agha et al., 2008).

Computed tomography(CT) is particularly useful method for looking at the complex bony structures such as the skull, spine or joints in the anatomy tutorial in Egypt, as well as in the other Arabic countries becomes essential to follow the international steps and to prepare the students to the clinical stage of veterinary study (Saber, 2008). CT has a potential advantage over routine radiography. CT provides soft tissue differentiation, no superimposition

of overlying structures, CT cross-sectional images not only used to diagnose abnormalities, but also to quantify the severity of these abnormalities (Hathcock and Stickle, 1993; Abuzaid, 1995, and Sandrasegaran et al., 2007). CT is an imaging technique that gives us an opportunity to review cross sections of the body in live animal (Shojaei et al., 2012). CT is now perceived as central to the diagnosis and clinical management of many cases (Goh et al., 2005).

There is a little references on the topography CT of the pelvis of male goats, so our work is focus on the study of the anatomical CT topographical position of the pelvic organs to provide surgeons, clinicians and veterinary student with a huge of information they are need to complete their work in a good manner. (Afolayan et al., 2006) The accuracy of functions used to predict live weight or growth characteristics from

live animal measurements is of immense financial contribution to livestock production enterprise

The purpose of this study was to provide an anatomic reference to the normal topography of the pelvis in buck by using CT and cross sectional anatomy.

2. MATERIALS AND METHODS

Animals

Ten apparently physiologically healthy Barki male goat weighted about 25–30kg and aged between 8-12 months were used in our work and the animals must be free from any pelvic abnormalities.

Computed tomography scans

Two bucks were used for CT scan after physical examination and were euthanized by using lethal dose to combination of Ketamine hydrate and xylazine. The buck cadaver were taken freshly to the CT center lab within two hours and applied in the sternal recumbence position. The CT scans (bone window) were taken by Toshiba Asteion machine at 120 K.V and 200 M.A to examine male pelvis and musculatures of the pelvis wall, The section thickness was 0.5 cm part interval in both transverse and sagittal sections from the level of the last lumbar vertebra to the 4th caudal vertebra.

The images were photographed and compared with anatomic sections to help in identification of the structures that situated from the level of the last lumbar vertebra and the fourth caudal vertebra

Cross sectional anatomy of the pelvis

Two bucks were used for male pelvis examination and muscles via cross-anatomical sections after physical examination and were euthanized by using lethal dose to combination of Ketamine hydrate and xylazine. The cadavers were placed in the freezer in sternal recumbency position. Frozen cadavers placed on a table with saw and transverse section will be cut 4 cm slice interval. The slices numbered and photographed to be compared with CT scan images.

Pelvic bony skeleton

One buck was killed by bleeding through the common carotid artery, after that the cadaver is buried under the ground for at least 6 months then get the bony skeleton for showing the bony prominence.

Pelvic measurements

Five barki male goats were used for internal measurement that include, the pelvic axis was the distance from the pelvic inlet and the pelvic outlet, this line shows inclination ventrocaudally. The transverse diameter measured the greatest width of the pelvic, dorsal to the psoas tubercle. The vertical diameter calculated by measuring the distance from the cranial end of the pelvic symphysis to the sacrum vertebra. The conjugate diameter measured the distance from the sacral promontory to the cranial end of the pelvic symphysis. The external measurements were the inter-tubercoral diameter that measured by the distance between both lateral borders of the tuber coxae. The lateral tuber ischi was the distance between the lateral tuberosity of both ischiatic tuberosities, the medial tuberischi that measured by the distance between the medial tuberosity of both ischiatic tuberosities and the rump length was the distance between the anterior part of tuber coxae and the caudal tuberosity of the ischiatic tuberosity.

The nomenclature used in these work is adapted to Nomina anatomica Veterinaria (2012).

3. RESULTS

Computed tomography scans obtained excellent bone window images of the bone of pelvis and soft tissue architecture of pelvic content, CT images with the most closely corresponding cross sections and sagittal sections of barki buck were selected.

Cross sectional anatomy and computed tomography of the male pelvis

At the level of the 3rd sacral vertebra

In cross-anatomical sections, the rectum was filled with fecal pellets (Fig. 1A\2) it was located dorsally to the vesicular gland (fig.1A\ 3) which appear as a cluster of grapes, the ampulla of ductus deferens (Fig.1A\4) and the neck of the urinary bladder (Fig. 1A\5). Both testicles are appeared (Fig.1A\14).

In the CT scan image, the rectum was appeared with a part of low density and another with moderate density circular (Fig.1B\2), the neck of the urinary bladder was low density (Fig.1B\5) and the right and left testis appeared with a moderate density (Fig. 1B\14).

At the level of 5th sacral vertebra

In cross anatomical sections, the rectum (Fig.1C\2) was filled with fecal pellets and located dorsally to the urinary bladder (Fig.1C\5), the disseminated prostate (Fig.1C\16) was appeared obviously surrounded by the pelvic urethra wall (Fig.

1C\15) which present ventral to the urinary bladder at the pubic symphysis (Fig.1C\6). The root of the penis was also obviously appeared (Fig.1C\17).

In CT scan images, the rectum (Fig.1D\2) was appeared with low-density part and filled with fecal matter. The, pelvic urethra (Fig. 1D\15) was appeared with low-density part. The prostate cannot be detected and the urinary bladder (Fig.1 D\5) was appeared as low density part and located dorsally to the pelvic symphysis (Fig.1D\6) and the root of the penis was appeared low to moderate density part (Fig.1D\17).

At the level of the 3rd caudal vertebra

In cross-anatomical section, the anal canal (Fig. 1E\20) was appeared. The bulbo urethral glands or Cowper's glands (Fig.1E\23) appear similar to the size of the walnut, located dorsal to the pelvic urethra (Fig.1E\15), the both right, and left ischiatic tuberosities (Fig.1E\21) was appeared on both sides, ending by the ischiatic arch (Fig.1E\22) and the root of the penis (Fig.1 E\17) appeared ventrally.

In CT scan images, the anal canal (Fig.1F\20) was` appeared with its lumen with presence of a fecal pellets inside it. The pelvic urethra (Fig.1 F\15) was low density in appearance and located dorsally to the ischiatic arch (Fig. 1F\22). The right and left ischiatic tuberosities (Fig.1 F\21) were present. The root of the penis (Fig.1 F\17) was appeared low to moderate density.

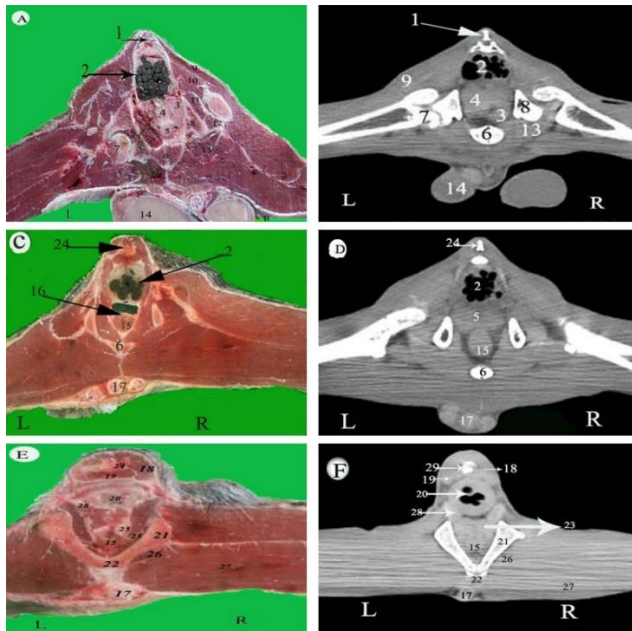


Figure (1): computed tomography (bone window) and cross sections of the male goat pelvis. (A)-Cross anatomical section at the level of the 3rd sacral vertebra, (B)-Transversal C.T scan at the level of the 3rd sacral vertebra,

(C) - Cross anatomical section at the level of the 5th sacral vertebra, (D) - Transversal C.T scan at the level of the 5th sacral vertebra, (E) - Cross anatomical section at the level of the 3rd caudal vertebra, (F) - Transversal C.T scan at the level of the 3rd caudal vertebra. 1- 3rd sacral vertebra, 2- Rectum, 3-Vesicular gland, 4-Ampulla of ductus deference, 5-Neck of urinary bladder, 6- Pelvic symphysis, 7- Head of femur, 8- Right ilium shaft, 9- Superficial gluteal muscle, 10- Middle gluteal muscle, 11- Accessory gluteal muscle, 12- Deep gluteal muscle, 13- Ilio psoas muscle, 14- Testis, 15- Pelvic urethra, 16- Prostata, 17-Penis,18- Right sacrocaudalis dorsalis lateralis muscle, 19- Right sacrocaudalis ventralis medialis and lateralis muscle, 20- Anal canal, 21- Right ischiatic tuberosity, 22- Ischiatic arch, 23- Bulbo urethral gland, 24- 5th sacral vertebra, 25- Internal obturator muscle, 26- External obturator muscle,27- Right adductor muscle,28- Muscle sphincter ani internus and externus, 29- 3rd caudal vertebrae.

Computed tomography and sagittal section of the male goat pelvis

In sagittal section, the rectum appeared dorsally with low-density part and another moderate density one, and filled with fecal matter (Fig.2\1). The vesicular gland (Fig.2\2) was appeared with low density, the pelvic urethra (Fig.2\5) was located dorsal to the ischiatic bone (Fig.2\6) reaching to its end then the penile urethra appear (Fig.2\7) with low density. The bulbourethral gland (Fig.2\4) was appeared with low to moderate density.

Part of rumen with its content (Fig.2\R) was appeared on sagittal section on sternal recumbency position of the buck.

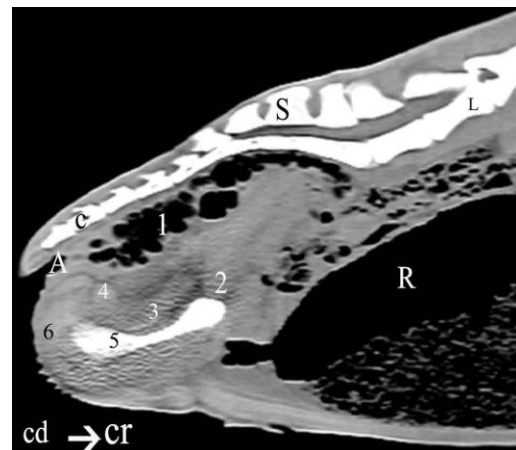


Figure (2) Sagittal computed tomography scan (bone window) of the male goat pelvis. 1-Rectum, 2- Vesicular gland, 3-pelvic urethra, 4- bulbourethral gland, 5-ischium bone, 6- Penile urethra, L-Lumbar vertebrae, S-Sacral vertebrae, C-Caudal vertebrae, A-Anal opening, R-rumen.

Pelvic measurements

Internal pelvis measurements by 3-D reconstruction CT Images and bony skeleton.

Five internal diameters can be measured inside the pelvic skeleton of the male goat.

The pelvic axis, the transverse diameter (diameter transversa) (Fig.2/ T), the vertical diameter (diameter verticalis) (Fig.2/ V), we found that it cut the middle of the body of the 2nd sacral vertebrae, the conjugate diameter (diameter conjugate) (Fig.2/ C). Between the vertical diameter (diameter verticalis) and the conjugate diameter (diameter conjugate), there is an angle that resemble the inclinatio pelvis line (Fig.2/ PL) and it reach to 12°.

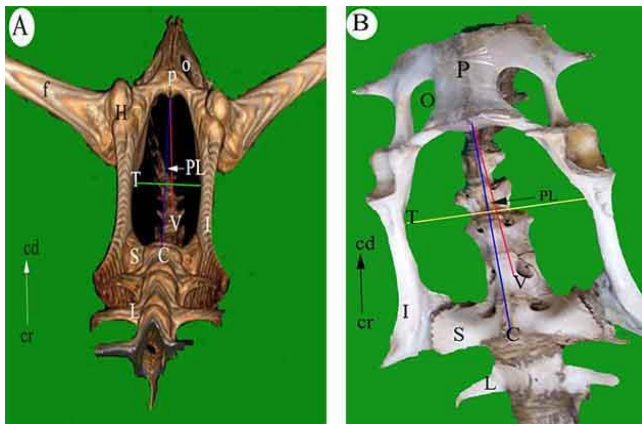


Figure (3): Internal pelvis measurement on 3-D image and on buck skeleton in ventral view (A &B): (T) Transverse diameter, (V) Vertical diameter, (C) Conjugate diameter, (P) Pelvic inclination, L-Lumbar vertebrae, I-Ilium, S-Sacral vertebrae, f-femur bone, p-pelvic symphysis, O-Obturator foramen.

Table (1): Internal pelvis measurement

	Transverse diameter	Vertical diameter	Conjugate diameter	Pelvic angle
Mean value	8.8	8.1	9.8	13°

The mean value of the internal pelvis diameter can be shown in **table (1)**, the mean value of the transverse diameter is 8.8cm, the mean value of the vertical diameter is 8.1cm, the mean value of the conjugate diameter is 9.8cm and the mean value to the pelvic inclination angle is 13°.

The external pelvis measurements by 3D. Images and bony skeleton

In the studied animals, the external measurements were; the inter-tuber coxal diameter (Fig. 3\A1), the lateral tuber ischi (Fig. 3\A4), the medial tuber ischi (Fig. 3\B5) and the rump length (Fig. 3\A3).

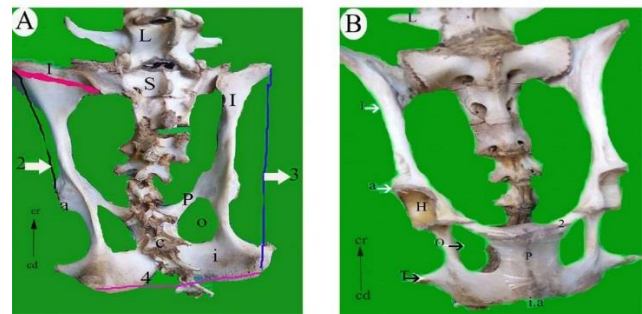


Figure (4): External pelvic measurements in 3D images (A &B). 1- the distance from tuber coxae to sacral tuberosity, 2- the distance from tuber coxae to hip joint, 3- the distance from tuber coxae to ischial tuberosity, 4- Lateral tuber ischium, 5- Medial tuber ischium, f-femur bone, H- site of articulation between acetabulum and head of femur forming the hip joint, L-Lumbar vertebrae, s-sacral vertebrae, c-caudal vertebrae, p-pubic symphysis, o-obturator foramen, I-Ilium, i- ischium, a- acetabulum.

Table (2): Mean value of the external pelvis measurements

	Median tuber ischii	Lateral tuber ischii	From Tuber coxae to Ischiatic tuberosity.	From Tuber coxae to Sacral tuberosity.	From Pin to Tail.	From Tuber coxae to Hip joint	From Tuber coxae to Tail
Mean value	1.96 cm	8.12 cm	18.5 cm	6.36 cm	6.74 cm	13.36 cm	17.65 cm

The mean value of the external pelvis diameter can be shown in table (2). The mean value of median tuber ischii diameter was 1.96 cm. The mean value of lateral tuber ischii diameter was 8.12 cm. The mean value of the distance from tuber coxae to ischiatic tuberosity was 18.5cm. The mean value to the distance

between tuber coxae to sacral tuberosity is 6.36cm. The mean value of the distance from pin to tail was 6.74cm, the mean value of the distance from tuber coxae to the hip joint was 13.36cm and the mean value of the distance from tuber coxae to the tail was 17.65cm.

4. DISCUSSION

The male goat was euthanized until death then transported freshly to the CT scan lab and placed on sternal recumbency position to clarify all the pelvic internal organs of the buck on a CT scan.

Our work revealed that the male goat glandulae genitales accessoriae include the ampullae which attached to vas deference, the glandulae vesicularis, the prostate and the glandulae bulbourethralis, similar findings recorded by North (2004) in goats. Whereas Budras et al., (2007) in dog found that there is only the prostate gland present.

In our study, we found that the vesicular glands were paired gland present on the right and the left side with hypodense appearance, similar finding agree with Dimitrov et al., (2011).

In sectional anatomy, we found that the glandulae vesicularis were a paired lobulated gland present on cranio dorsal aspect of the vesicae urinaria and look like a cluster of grapes. it can be easily note that the left glandulae vesicularis is enlarged and higher than the right one, similar finding obtained by Archana et al., (2009) in buck, Gofur (2015) in buck and also agree with that obtained by Dyce et al., (2010) in ruminant and Hathcock et al., (1993).

The prostate gland was a single one that embedded within the pelvic urethral wall and this was different from that obtained by Schwarz and Saunders (2011) in dog who found that the prostate is a bilobed, ovoid-shaped retroperitoneal gland encircling the neck of the urinary bladder and the proximal urethra. in CT, the prostate gland was not detected because it has only disseminated part surrounding the pelvic urethra (embedded in pelvic urethral wall) without body of gland.

In sectional anatomy we found that, only the pars disseminate part present that found in pelvic urethra and surrounded by urethral masculine. Similar finding obtained by Getty (1975) in ruminant, Garrett (1988) in goats, Frandson et al., (2009) in ruminants and Gofur (2015) in buck, and there is a little difference from that obtained by Archana et al., (2012) in goats who mentioned that the corpus prostata present in some gaddi goats.

Also there was a difference from that obtained by Dyce et al. (2010) who found that in ruminant there was a two part of prostate the disseminate part and the compact part. Whereas Budras et al. (2007) in dog found that the prostate consist of two parts the body

(external part) with two glandular lobes and a slight disseminate part (internal part).

The bulbourethral glands were paired found on right and left side, small in size, similar result obtained by Dimitrov (2010) in rabbit who found that the bulbourethral glands were big homogeneous soft tissue findings, situated dorsolateral against the contrast-enhanced bulbar urethra. The glands were located behind the situated cranially prostate gland at the pelvic outlet. Bulbourethral glands were visualized as soft tissue relatively hyperdense structures against the urethral and rectal walls.

In sectional anatomy, we found that, the glandula bulbourethralis was a paired gland, small in size similar to hazel nut, and lies dorsal to the pelvic urethra. It's obvious that the gland surrounded by white fibrous capsule, similar observations noted by Budras and Habel (2003), Frandson et al., (2009) in ruminants, Archana et al., (2012) in goats, Gofur (2015) in buck and Dyce et al., (2010).

Whereas Hathcock et al., (1993) and Dyce et al., (2010) added that the bulbourethral gland have watery secretion discharged into the diverticulum and flushes the urethra in advance of the main ejaculate

We measure five imaginary points on the skeleton of five male goat includes; the pelvic axis, diameter transversa, diameter conjugata, diameter verticalis and inclination pelvis angle, this measurements was similar to those taken by Getty (1975) in ruminants, with different numbers.

The pelvic external measures was similar to Silva and Noakes (1984) in ewe, which include the inter tuber coxal diameter, the lateral tuber ischii, the medial tuber ischii, the rump length and in addition to those measurements in our study, we recorded the measurement of the distance between the cranial border of tuber coxae and hip joint.

In the level of anatomical science, the both internal and external measurements considered important to other specialized persons in breeding and obstetric field. by anatomical knowledge with the bony pelvis constitutions we can provide others with the demanded diameters that needed to reproduction average judgment, because the reproduction depends on the pelvis and a good pelvis means good, strength productive life and this also means good healthy offspring with high productivity level. Coopman et al., (2003).

5. CONCLUSION

Consequently, it could be concluded that the CT scan has a great value in veterinary field as it can be used to evaluate the male goat productive performance through examination of the male goat accessory sex glands that includes the paired ampulla of vas deference, the paired vesicular glands, the prostate gland and the paired bulbourethral glands. The internal pelvic measurements take the diameters to 5th imaginary lines on the bony skeleton of a male Barki goat that include the diameter transversa, the diameter conjugate, the diameter verticalis, the pelvic axis and the pelvic inclination. The external pelvic measurements include the inter tuber coxal diameter, the lateral tuber ischii, the medial tuber ischii, the rump length can be measured externally on the back of the male goat at the pelvic area using a meter tool, and also both of internal and external pelvic diameters can be measured on a CT image and recorded. The pelvis measurements are very important because good pelvis structure helps the goat toward a comfortable productive life and the buck breeding ability depends on the strength and correctness of his pelvis.

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