

RESEARCH ARTICLE

MORPHOMETRICS OF HEART OF THE FOETAL DROMEDARY

Alhaji Zubair Jaji¹, Ibrahim Alhaji Girgiri^{2*}, Shaibu Mohammed Atabo³, Baba Gana Gambo², Adamu Saleh Saidu⁴, Faruku Da'u⁵, Ahmed Yahaya²

¹Department of Veterinary Anatomy,
Faculty of Veterinary Medicine,
University of Ilorin, Kwara State,
Nigeria

²Department of Veterinary Anatomy,
Faculty of Veterinary Medicine,
University of Maiduguri, Maiduguri,
Borno State, Nigeria.

³Department of Veterinary Anatomy,
Faculty of Veterinary Medicine, Bayero
University, Kano, Nigeria

⁴Department of Veterinary Public
Health and Preventive Medicine,
University of Maiduguri, Maiduguri,
Borno State, Nigeria

⁵Department of Veterinary Services,
Ministry of Agriculture and Natural
Resources, Kano, Kano State, Nigeria

***Corresponding author:**

Dr. Ibrahim Alhaji Girgiri
Department of Veterinary Anatomy,
Faculty of Veterinary Medicine,
University of Maiduguri, Borno State,
Nigeria

Phone: +234 7035108133

ORCID: 0000-0002-606-9953

Email: ibrahimgirgiri@unimaid.edu.ng

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ABSTRACT

The present study provides an anatomical account of the morphometry of heart of prenatal camel. For this purpose, 15 normal fresh hearts were randomly obtained from different fetuses collected from Maiduguri central abattoir. The fetuses were divided into three different growth periods i.e., first (2-4 months), second (4 -7 months), and third (7-10 months) based on their body weight and crown-rump length. The prenatal dromedary heart was grossly observed to be coned-like with flattened base and nearly sharp apex. The subepicardial blood vessels showed corresponding development with each quarter of the pregnancy. The heart weight showed no significant increase during the second growth period ($p>0.05$), while an extremely significant increases ($p<0.001$) were observed during the third growth period. The dimension of the prenatal dromedary heart presented a significant increase ($p<0.05$) during the second growth period, while an extremely significant increase ($p<0.001$) was observed during the third growth period in all the fetuses. This increase indicates that there was more embryogenesis of the heart during the third growth period of the prenatal dromedary. It was concluded that the length of posterior border base to apex of prenatal dromedary is higher in length than anterior border base.

Keywords: Dromedary, foetal, heart, grooves, morphometry

INTRODUCTION

The heart is the muscular central organ of the blood-vascular system, that pumps blood by rhythmic contractions through the blood vessels (Dyce et al. 2017). It is mainly comprised of the heart muscle that forms a sac divided into four chambers consisting of the right and left atrium and ventricle (Konig et al., 2004). The two atria and ventricles are separated by an internal septum, but the atrium and ventricle of each side communicate through a large opening (Dyce et al., 2017). The right side of the heart pumps deoxygenated blood to the lungs for oxygenation, whereas the left side delivers oxygenated blood for systemic circulation (Pasquini et al., 1999). This cardiovascular function is altered during fetal life by a shunt system of foramen ovale and ductus arteriosus that closes shortly before or immediately after birth (Hyttel et al., 2009). The heart is fairly variable among domestic species, but generally resembles a pointed, bilaterally flattened cone enclosed by the pericardium (Schummer et al., 1981). There are various disorders and congenital defects affecting the heart of camel (Tharwat et al., 2012) and diagnosis presents rather a challenging task due to the absence of clinical signs (Aref et al., 2024). Heart diseases manifest as changes in size and weight in proportion to its severity (Queiroz et al., 2018). In camels, diagnosis usually occurs in slaughterhouses, or happens by chance during a post-mortem examination (Fowler, 2010). There is rarely published data regarding the standard dimensions of the fetal dromedary heart. Sarwad and Anas (2010) reported on the morphometry of some splanchnic organs, including the heart in dromedary camel calves. Recently, Aref et al. (2024) reported on normal cardiac dimension of the heart of adult camel by magnetic resonance imaging and topographic anatomy. This study aims to add new knowledge of the developmental anatomy of the heart with focus on the morphometry of the heart, with the hope that will benefit science and practitioners.

MATERIAL AND METHODS

The studies involved 15 apparently normal fresh hearts of one-humped camel fetuses obtained from Maiduguri central abattoir over a period of six months. The fetuses were divided according to four periods of development based on their body weight (BW) and crown-rump length (CRL) measurement, as described previously (Jaji et al., 2011). Thus, they were divided into 2 – 4, 4 – 7, 7 – 10, and 10 – 13 months growth periods. Fetal hearts from the first three growth periods (1st, 2nd and 3rd) were immediately weighed and fixed in 10% buffered formalin for 48 hours. Then, the hearts were reweighed and the following parameters were measured:

- i. Length of anterior border base to the apex
- ii. Length of posterior border base to the apex
- iii. Circumference at the coronary grooves
- iv. Distance between the right coronary grooves to the apex
- v. Distance between the left coronary grooves to the apex

The whole-body weight (kg) of each fetus was determined using (spring platform scale), whereas electronic precision balance (METRA TL – 300) was used to weigh the heart (g). The hearts were carefully removed from the thoracic cavity with the aid of scalpel, and the surrounding pericardial tissue was freed from the heart using thumb forceps. Measuring tape (Butterfly brand) and thread were used to measure the crown-rump length of the fetuses and all the aforementioned heart parameters.

Statistical analysis

The fetal heart dimensions at different phases of prenatal growth were presented as means $\pm$ SD in the Table. The differences across the phases were further analyzed using ANOVA test and Duncan's follow-up test at a 95% confidence level using statistical software GraphPad Prism version 5.00 for Windows.

RESULTS

In the prenatal dromedaries the heart was reddish – brown in color. It occupied the greater part of the middle mediastinal space. Its shape was irregular and somewhat flattened cone. It was attached to its base by the vena cavae, otherwise entirely free within the fibrous sac pericardium. It was asymmetrical in position. The long axis (from the middle of the base to the apex) was directed ventrally and caudally. The hearts presented an apex, base, two surfaces and two borders. The base was directed dorsally, and its highest part laid approximately at the junction of the dorsal and middle thirds of the dorsoventral diameter of the thorax. It was formed by the right and left atria; the cranial and caudal vanae cavae and the pulmonary veins entered through the base. The apex laid centrally, dorsal to the sternum. The caudal (left) border was much shorter and nearly vertical. The surfaces, atrial (right, diaphragmatic) and auricular (left, sternocostal) were convex and marked by grooves, which indicated the division of the heart into four chambers. The coronary groove, partly

filled with adipose tissue, divided the atria from the ventricles at the base of the heart, two atria dorsally and two ventricles ventrally (Figure 1). The camel heart at the second quarter of pregnancy at left auricular presentation showed the convex cranial border belonging to the right ventricle. The coronary groove was much developed at the second quarter, clearly separating the right from the left ventricle. The paraconal interventricular branch of the left coronary artery and left ventricular branches emanating from the circumflex branches, and the intermediate groove that runs at the margin of the left ventricle were all discernable (Figure 2,3), At the fourth quarter, the subepicardial distribution of adipose tissue was wider, covering much of the surface of the right ventricle and the interventricular groove up to the apex of the heart. The conically shaped conus arteriosus at the proximal portion of the right ventricle and the pulmonary trunk were conspicuous. The branch of the great cardiac vein accompanying the paraconal interventricular branch can be seen at the fat-filled cardiac groove (Figure 4).

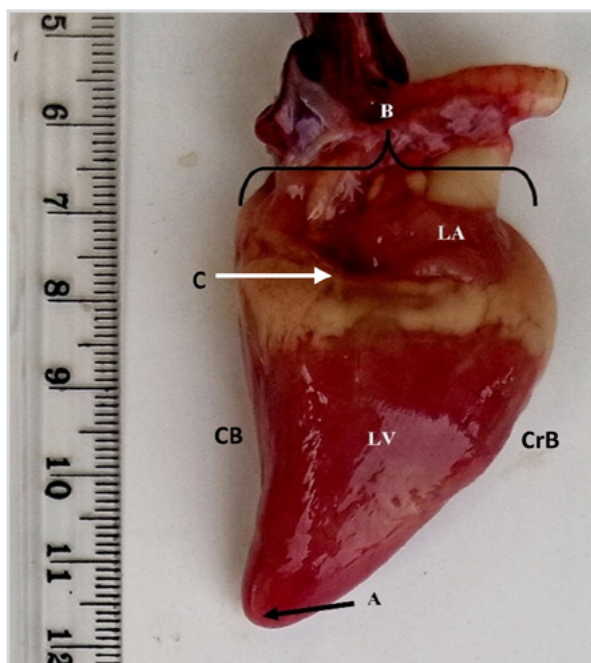
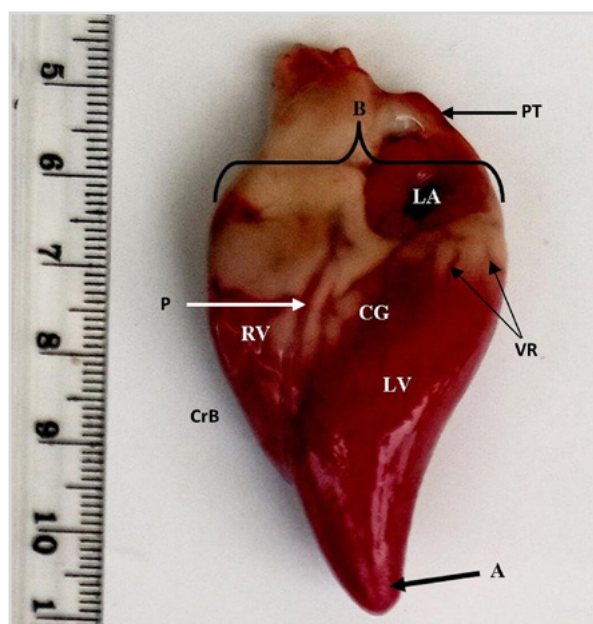
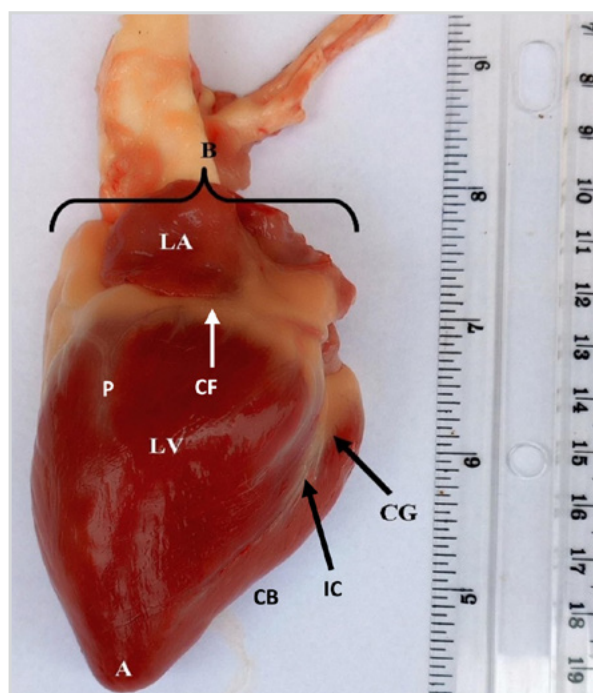


Figure 1

(Left view) A one-humped camel fetal heart of a 1st quarter pregnancy, showing the Base (B), Left Atrium (LA), Fat-filled Coronary Sulcus (C), Left Ventricle (LV), Apex (A), Cranial Border (CrB) and Caudal Border (CB)

**Figure 2**

(Left auricular view) A one-humped camel fetal heart of a 2nd quarter pregnancy, showing the Base (B), Pulmonary Trunk (PT), Left Atrium (LA), Ventricular Rami of Coronary artery (VR), Left Ventricle (LV), Coronary Groove (CG), Paraconal Interventricular Branch of Left Coronary Artery (P), Right Ventricle (RV), Cranial Border (CrB), and Apex (A)

**Figure 3**

(Left auricular view) A one-humped camel fetal heart of a 3rd quarter pregnancy, showing the Base (B), Left Atrium (LA), Circumflex Branch of Left Coronary Artery (CF), Paraconal Interventricular Branch (P), Left Ventricle (LV), Coronary Groove (CG), Intermediate Branch of Circumflex Branch of Left Coronary Artery (IC), Caudal Border (CB) and Apex (A)

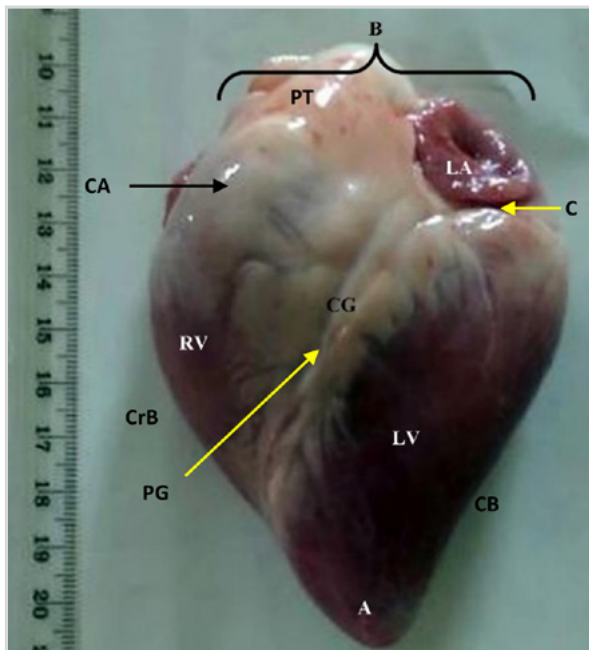


Figure 4

(Left auricular view) A one-humped camel fetal heart of a 4th quarter pregnancy, showing the Base (B), Pulmonary Trunk (PT), Left Auricle (LA), Conus Arteriosus (CA), Circumflex Groove (C), Fat-filled Coronary Groove (CG), Right Ventricle (RV), Left Ventricle (LV), Paraconal Interventricular Branch of Left Coronary and Great Cardiac Vein (PG), Cranial Border (CrB), Caudal Border (CB), and Apex (A)

Biometry of heart of foetal dromedary

The weight of heart of camel foetus

The weight of the heart of the dromedary foetus was 13.52 ± 8.74 g during the first growth period. It showed a level of significance increase along the four prenatal growth periods, as shown in Table 1.

The length of anterior border base to apex of heart of camel foetus

The length of the anterior border base to the apex of the heart of the dromedary foetus was 3.94 ± 0.78 cm during the first growth period. It showed the levels of significant increase along the four prenatal growth periods, as shown in Table 1.

The length of posterior border base to apex of heart of camel foetus

The length of posterior border base to apex of the heart of camel foetus was 3.5 ± 0.91 cm during the first growth period. It showed a level of significance

increase along the four prenatal growth periods, as shown in Table 1.

The circumference at coronary grooves of heart of camel foetus

The circumference at coronary grooves of heart of camel foetus was 7.71 ± 0.80 cm during the growth period. It showed the levels of significant increase along the four prenatal growth periods, as shown in Table 1.

The distance between right and left coronary grooves to apex of heart of camel foetus

The distance between right and left coronary grooves to apex of the heart of camel foetus were 3.32 ± 0.65 cm and 3.4 ± 0.49 cm, respectively during the first growth period. The showed levels of significant increases along the four prenatal growth periods are shown in Table 1.

Table 1 Morphometrics of heart of foetal dromedary

Heart Dimensions (Mean±SD)	Prenatal Growth Period (n=6 per phase)			
	1st Period	2nd Period	3rd Period	4th Period
Weight (g)	13.52±1.74	29.44±3.28***	69.39±7.04***	77.73±6.72
Length of anterior border base to apex (cm)	3.94±0.28	5.45±0.34***	6.87±0.45***	7.51±0.33*
Length of posterior border base to apex (cm)	3.58±0.41	5.38±0.49***	7.13±0.55***	8.63±0.44***
Circumference at coronary groove (cm)	7.71±0.70	11.32±0.74***	15.17±1.04***	17.44±0.1.31**
Distance between right coronary groove to apex (cm)	3.32±0.40	5.04±0.50***	6.63±0.70***	7.70±0.37**
Distance between left coronary groove to apex (cm)	3.46±0.29	4.98±0.43***	6.63±0.70***	8.37.37±0.61***

* = significant (p<0.05), ** = significant (p<0.005), *** = significant (p<0.001), n = Number of observations

DISCUSSION AND CONCLUSION

The prenatal dromedary heart was observed to have occupied the greater part of the middle mediastinal space, having an irregular, somewhat flattened cone shape and attached base by the great vessels, but otherwise entirely asymmetrical in position, common to most domestic mammals. The wedge-shaped sternum, particularly in ungulates, which is bilaterally flattened influences the position of the heart of the domestic mammals within the thoracic cage (Schummer et al., 1981).

The weight of the prenatal dromedary heart showed no significant increases during the second growth period. An extremely significant increase was, however, observed during the third growth period. Leinder (1996), Mohan and Prakash (1997) and Miglino and Amorim (1998) observed that the postnatal buffalo heart showed an average weight to be ranged from 1800 – 2500 g. Miller (2004) recorded the mean weight of the heart of buffaloes ranging from 5 – 7 lb. The breed, resultant size and body weight affects both absolute and relative weight of the heart. It has been stated that the significance of measurements will depend on diastolic and systolic state or whether the heart was in rigor at the time of measurement

(Schummer et al., 1981). The length of anterior border base to apex of the prenatal dromedary heart showed a very significant increase during the second growth period. An extremely significant increase was observed for the length of anterior border to the apex during the third growth periods, though Mohan and Praskash (1997), and Miller (2004) recorded a relative dearth existing on the biometrical value of the mean length buffaloes.

The length of posterior border to apex of the prenatal dromedary heart showed a very significant increase during the second growth period. An extremely significant increase was observed for the length of posterior border base to the apex during the third growth period. Report from Miller (2004) indicated the average length of posterior border base to apex of buffaloes as 13.50cm.

The circumference at the coronary grooves of prenatal dromedary heart showed a very significant increase during the second growth period. An extremely significant increase was observed for the circumference at coronary grooves during the third growth periods. According to Mohan and Prakash (1997), the circumference within the coronary groove averaged 28.95cm in buffaloes and 38.75cm in cows, while Braun et al. (1999) recorded 37cm for the buffalos’ heart.

The distance between the right and left coronary grooves to apex of prenatal dromedary heart showed a very significant increase during the second growth periods. An extremely significant increase was observed for the distance between the right and the left coronary grooves to the apex during the third growth periods. It is difficult to compare the present result regarding the right and left coronary grooves of prenatal growth periods of dromedary to the result of other workers because, to the best of our knowledge, no such kind of studies have been carried out on camel before. However, Braun et al. (1999) studied and measured the distance between the right and left coronary grooves to apex in cows and obtained average of 15 cm.

It was discovered that the length of posterior border base to apex of prenatal dromedary was longer than anterior border base. The left coronary artery gives off the paraconal interventricular branch and circumflex branch and runs caudally via the intermediate groove to give the intermediate

branch. Thus, the dromedary, like the ruminants and carnivores, is a species that possesses a left coronary type of supply.

More research is required to determine the morphometry of the internal structures of dromedary heart so as to have a record of the full term. So, also, histogenesis of the dromedary heart needs to be studied so as to have enabled the complete elucidation of the prenatal development of the dromedary heart.

CONFLICT OF INTEREST

The authors have no conflict of interest to declare.

CONTRIBUTION

Conception, Design, Supervision: AZJ; Materials, Data collection and Processing: ASS, FD; Analysis and Interpretation of the Data: AZJ, IAG; Literature Review: SMA, BGG; Writing: IAG; Critical review: AZJ, IAG, AY

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MORFOMETRIJA SRCA FETUSA JEDNOGRBE KAMILE

SAŽETAK

Ovo istraživanje pruža anatomske uvid u morfometriju srca prenatalne kamile. U tu svrhu smo randomizirali 15 svježih srca iz fetusa prikupljenih u centralnoj klaonici Maidugurija. Fetus su podijeljeni prema tri različita perioda rasta: prvi (2-4 mjeseca), drugi (4-7 mjeseci) i treći (7-10 mjeseci) na osnovu tjelesne težine i dužine krunice. Prenatalno srce dromedara je makroskopski honičnog oblika, zaravnjene baze i skoro oštrog apeksa. Subepikardijalne krvne žile su u svakom kvartalu trudnoće bile odgovarajuće razvijene. Težina srca se nije značajno povećavala u drugom periodu rasta ($p > 0.05$), dok se u trećem periodu ekstremno povećala ($p < 0.001$). Dimenzije prenatalnog srca fetusa jednogrbe kamile su u drugom periodu rasta pokazale značajno povećanje ($p < 0.05$), dok je u trećem periodu kod svih fetusa zabilježeno ekstremno povećanje ($p < 0.001$). Ovo povećanje pokazuje da je u trećem periodu rasta prenatalnih fetusa jednogrbe kamile embriogeneza najintenzivnija. Zaključak je da je dužina od posteriornog ruba baze do apeksa kod prenatalnih fetusa jednogrbe kamile veća od dužine anteriornog ruba baze.

Ključne riječi: Fetus, jednogrba kamila, morfometrija, srce, žljebovi