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Morphometric Study on the Developing Kidneys of the Prenatal Dromedary (*Camelus dromedarius*)

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Abstract

A morphometric study was carried out on the developing kidneys of forty (40) apparently normal fetal dromedary, one-humped camel (*Camelus dromedarius*) sampled at the Metropolitan abattoir, Maiduguri, Nigeria. The fetuses were obtained from the four prenatal developmental phases of the dromedary: 2 – 4 months, 4 – 7 months, 7 – 10 months and 10 – 13 months. The renal length and diameter showed significant progressive increase in sizes ($p<0.005$ to 0.001), so were the renal cortical and medullary lengths ($p<0.001$). The absolute mean weights of the prenatal kidneys showed significant increase across the growth periods ($p<0.001$). These progressive increases in absolute mean renal weights were without corresponding increases in the relative mean renal weights known with organ system establishment in mammals. Thus, the dromedary was concluded to have a unique pattern of kidney development.

KEYWORDS
Dromedary, foetus, kidney, left, prenatal, right

INTRODUCTION

Camel is the most distinctive of domestic animals; the hump and the long, curved neck are its most noticeable feature. Another striking feature is the presence of the peculiar horny pads on the elbow, stifle, and chest. Camel is an important source of meat, milk and hides in several countries and there is an increase interest in its meat and milk products (Skidmore, 2005).

Camels have several adaptation mechanisms that help them to survive successfully in dry and arid climates in which there is shortage of water and high environmental temperature. For survival in desert environment, camels have anatomical, physiological, and behavioral adaptation mechanisms. The nature of skin coat, eye, nostril and lips, large body size and long height and large foot pads are among the anatomical adaptations. Physiologically, water conservation ability, the unique features of blood, thermoregulation, and efficient digestion and metabolism contribute for their survival. The feeding, drinking, thermal and sexual behavior of camels also plays a major role in succeeding their existence in the desert environment (Soliman, 2015; Abu-Samra, 2017).

The kidney is an important organ involved in the removal of unwanted nitrogenous substances, excess water, and relative maintenance of osmotic concentration of the blood (Salehi and Morovati, 2012). With the changing scenario of camel management, investigations into the adaptation of camel are important (Kataria *et al*., 2007), also, a good emphasis on the prenatal development of the kidney is desirable. The morphology of the developing camel kidney is scarcely documented. Therefore, this study was aimed to evaluate the gross pattern of the kidney growth during the prenatal life of the camel.

MATERIALS AND METHODS

Animal and study design

The study was approved by the Animal Use and Ethics Committee of the University of Maiduguri (FVM/UNIMAID/AUEC/2022.001). In an adoption of earlier categorization by Jaji *et al*. (2011), the dromedary gestation period (of 13 months) was categorized into four (I-IV) phases for this study. The work was carried out from January to March 2022 at the Maiduguri Met-

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ropolitan Abattoir, Maiduguri, Nigeria. A total of 10 pairs of developing kidneys from 10 apparently normal foetuses from each phase of gestation of dromedary cows were studied. The developing dromedary kidneys were obtained after humane bleeding to death of dromedary cows.

Morphometrics

The insitu topography of the developing kidneys were noted before excising them from the foetal carcasses. Following excision, the morphology of the developing kidneys was noted then, their weights (in grams, g) and dimensions (in centimeters, cm) were measured, using a Harvard trip weighing balance (Citizen® with 0.1 g – 100 kg range) and butterfly® measuring tape (0.1-150 cm) and thread respectively. The following parameters were measured in the right and left kidneys, as adopted from Sarma and Ahmed (2007) with slight modifications: the absolute and relative weights, lengths, diameters, renal cortical and medullary thickness.

Statistical analysis

The data was analyzed using statistical software GraphPad Prism version 5.00 for Windows. The data was expressed as mean ± standard deviation. Differences between group means across the phases of development were analyzed by one way Analysis of Variance with Turkey's Post hoc test. Differences were statistically significant when $p < 0.05$.

RESULTS

Gross features

The kidneys were retroperitoneally located below the lumbar transverse processes throughout the dromedary developmental phases. In the third phase, the kidneys were observed to be closer to the lumbar transverse processes than in the earlier phases. Grossly, the right and left kidneys were bean-shaped, firm, soft and smooth, with no external lobulations throughout the developmental period. The kidneys were pale during the first phase and turned slightly brown during the last phase. The dorsal surface was rounded and the ventral surface concave. The renal hilus were oriented directly medially and the renal pelvises were evident centrally right from the first developmental phase and became more distinct in the second, and extensive in the third and fourth. In all the four phases, the medulla was observed gradually becoming larger than the cortex with a demarcating line at the third and fourth phases (Figs. 1 to 8). The pyramids were unipyramidal.

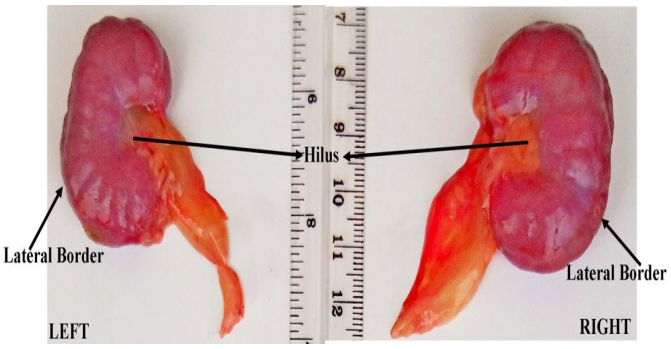

Fig. 1. A lateral view of the left and right developing kidneys of a 1st phase old (2 – 4 months) camel fetus showing the Adrenal gland (AG), Hilus and lateral borders.

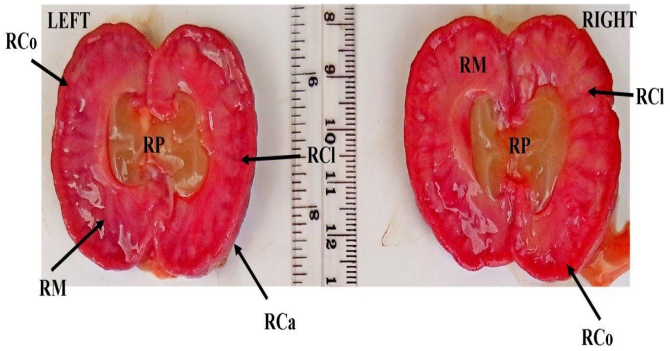

Fig. 2. A longitudinal section of the left and right developing kidneys of a 2 – 4 months old (1st phase) camel fetus showing the Renal capsule (RCa), Renal cortex (RCo), Renal medulla (RM), Renal column (RCl) and Renal pelvis (RP).

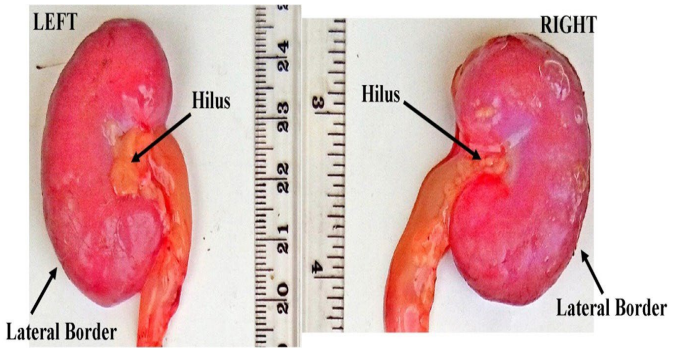

Fig. 3. A lateral view of the left and right developing kidneys of a 4-7 months old (2nd phase) camel fetus showing the Adrenal gland (AG), Hilus and lateral borders.

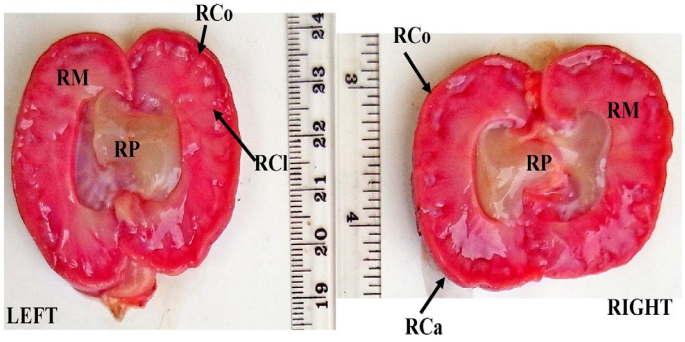

Fig. 4. A longitudinal section of the left and right developing kidneys of a 4-7 months old (2nd phase) camel fetus showing the Renal capsule (RCa), Renal cortex (RCo), Renal medulla (RM), Renal column (RCl) and Renal pelvis (RP).

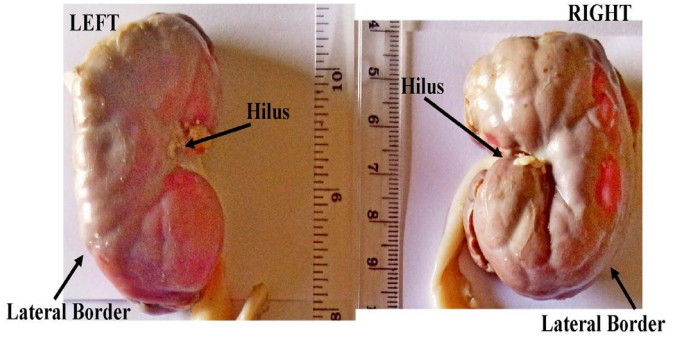

Fig. 5. A lateral view of the left and right developing kidneys of a 7 – 10 months old (3rd phase) camel fetus showing the Adrenal gland (AG), Hilus and lateral borders.

Weights

The absolute weights of the right and left developing kidneys in the studied dromedary fetuses were 8.92±0.52 g and 8.80±0.59 g respectively during the first growth period. Most of

Table 1. Morphometrics and weights of foetal dromedaries and their kidneys

Dimensions (Mean±S.D)	Prenatal Growth Phases (n = 10 per phase)			
	1st Phase 2 – 4 months	2nd Phase 4-7 months	3rd Phase 7 – 10 months	4th Phase 10 – 13 months
Foetal Crown-Rump Length (cm)	44.0±9.7	67.07.4^{c}	85.0±4.0^{c}	100.7±4.9^{c}
Foetal Body Weight (kg)	3.4±1.4	8.0±2.2^{c}	12.5±1.9^{c}	17.5±3.5^{c}
Absolute Renal Weights (g)				
Right	8.92±0.52	20.73±2.20^{c}	45.71±4.61^{c}	53.40±3.12^{c}
Left	8.80±0.59	21.04±3.47	46.26 ±4.69^{c}	52.56±3.59^{c}
Relative Renal Weight (Left and Right Renal Weights to Body Weight) %	0.52	0.52	0.74	0.61
Renal Lengths (cm)				
Right	3.32±0.28	4.82±0.35^{c}	6.37±0.41^{c}	6.91±0.39^{c}
Left	3.40±0.28	4.94±0.27^{c}	6.53±0.35^{c}	6.92±0.36^{c}
Renal Diameters (cm)				
Right	2.54±0.19	3.42±0.26^{b}	4.73±0.28^{c}	6.16±0.65^{c}
Left	2.40±0.13	3.21±0.20^{c}	4.57±0.20^{c}	5.20±0.37^{c}
Renal Cortical Thickness (cm)				
Right	0.25±0.02	0.29±0.02	0.60±0.04^{c}	0.66±0.03^{c}
Left	0.20±0.02	0.30±0.03^{c}	0.57±0.05^{c}	0.62±0.03^{c}
Renal Medullary Thickness (cm)				
Right	0.78±0.02	1.00±0.06^{c}	1.57±0.02^{c}	2.01±0.03^{c}
Left	0.80±0.04	1.04±0.01^{c}	1.38±0.05^{c}	1.81±0.05^{c}

^{b} = Very significant ($p < 0.005$), ^{c} = Extremely significant ($p < 0.001$), n = Number of observations

them showed extremely significant changes along the four developmental phases ($p < 0.001$), so were the fetal crown-rump lengths and body weights. There were no commensurate changes in their relative renal weight, as shown in Table 1.

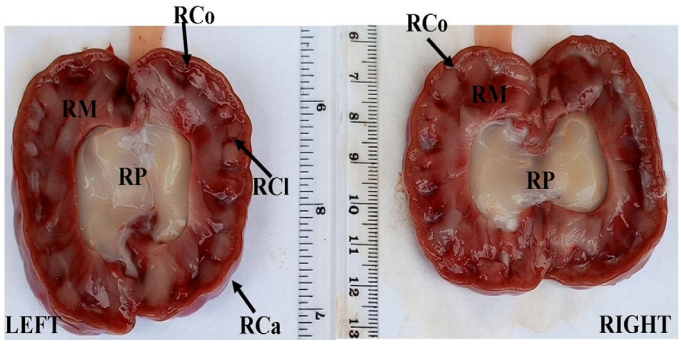

Fig. 6. A longitudinal section of the left and right developing kidneys of a 7 – 10 months old (3rd phase) camel fetus showing the Renal capsule (RCa), Renal cortex (RCo), Renal medulla (RM), Renal column (RCl) and Renal pelvis (RP).

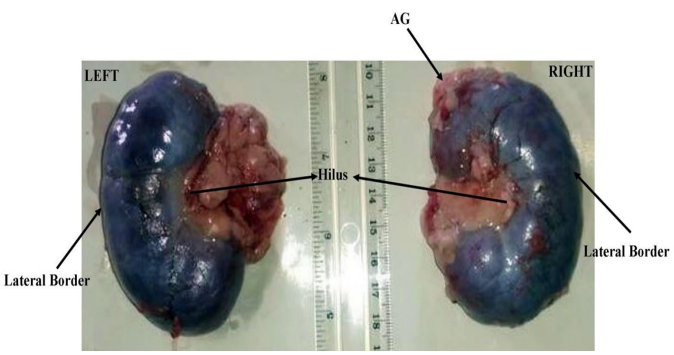

Fig. 7. A lateral view of the left and right developing kidneys of a 10 – 13 months old (4th phase) camel fetus showing the Adrenal gland (AG), Hilus and lateral borders.

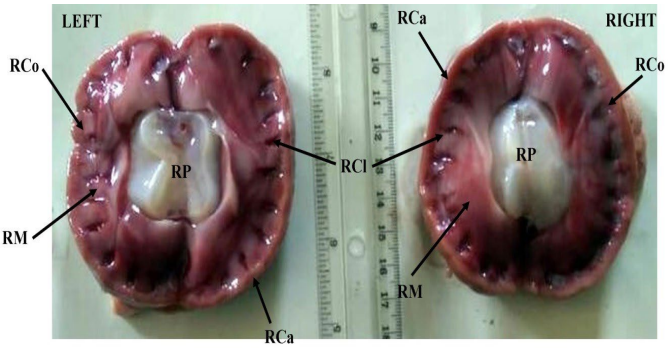

Fig. 8. A longitudinal section of the left and right developing kidneys of a 10 – 13 months old (4th phase) camel fetus showing the Renal capsule (RCa), Renal cortex (RCo), Renal medulla (RM), Renal column (RCl) and Renal pelvis (RP).

Morphometry

Lengths of the right and left kidneys

The lengths of the right and left kidneys of the dromedary fetus were 3.32±0.28 cm and 3.40 ±0.28 cm respectively during the first developmental phase. They showed extremely significant changes along the four developmental phases ($p < 0.001$), as shown in Table 1.

Diameters of the right and left kidneys

The diameters of the right and left developing kidneys in the studied dromedary fetuses were 2.54±0.19 cm and 2.4±0.13 cm respectively during the first developmental phase. They showed extremely significant changes along the four developmental phases ($p < 0.001$), as shown in table 1.

Renal Cortical Thickness

The cortical lengths of the right and left kidneys of the dromedary fetus were 0.25 ± 0.02 cm and 0.20±0.02 cm respectively during the first growth periods. They showed extremely significant changes along the four developmental phases ($p < 0.001$), as shown in table 1.

Renal Medullary Thickness

The medullary lengths of the right and left kidneys of the dromedary fetus, were 0.78±0.02 cm and 0.80±0.04 cm respectively during the first growth periods. They showed extremely significant changes along the four developmental phases ($p < 0.001$), as shown in Table 1.

DISCUSSION

This study documented the kidneys of the developing dromedary as being retroperitoneally located below the lumbar transverse processes throughout the prenatal developmental period. By the third phase they were observed to be symmetrically adhered to the fatty tissues around the first three lumbar transverse processes. Khan *et al*. (2003) reported that the right and left kidneys shifted rostrad with the advancement of age in goat, the authors added that the kidneys were attaching to the posterior extremity of the adrenal gland at the respective sides in the foetus of the crossbred pig.

The developing dromedary kidneys were bean-shaped, firm, soft and smooth, with no external lobulations throughout the developmental phases. A similar observation was made by Khan *et al*. (2003) on the kidneys of sheep and goats during the 1.5 – 2 months of gestation period.

Just like the fetal crown-rump length and weight, the absolute weights of the right and left developing dromedary kidneys showed extremely significant increase from the second growth period up to full-term. Jaji *et al*. (2011) reported that the body weight of dromedary fetuses showed extreme significant growth in the second quarter of gestation. However, there were no corresponding increases in relative weights of the kidneys. This is inconsistent with normal organ-system development in mammals, as established by Ouajd and Kamel (2009).

The length and diameters of the right and left developing dromedary kidneys sampled showed significant increase from the second growth phase to full term. Sarma and Ahmed (2007) in a study on the morphogenesis of kidney in cross bred pig reported that kidney growth is more in the left kidney. A similar feat was only observed in the measured renal lengths of this present study. Sarma and Ahmed (2007) went further to observe a greater embryogenesis of both kidneys in the early stages of development in crossbred pigs. In addition to that, this study also recorded rapid increase in kidney size at the third and fourth phases of development. Similar findings were also reported in foetus of goats (Malik, 1992).

In this present study, a trend in growth length was observed in the left kidney indicating a better sequence of growth in length phase in the left kidneys as compared to the right one. This trend of growth was in accordance with the findings of Ouajd and Kamel (2009) who reported that variable growth and structural diversities at different stages of development of an organ is a normal phenomenon for accommodating and molding of the organ.

The cortical and medullary lengths of the right and left developing dromedary kidneys sampled in the present study showed significant growth across the developmental phases Sarma and Ahmed (2007) however reported that there was no significant variation in measurements of the thickness of the medulla that was evident between the right and left kidneys in all age groups indicating negligible bilateral variation in this aspect between both kidneys during foetal growth of the cross bred pig. No significant difference was also observed between the measurements of the thickness of the medulla of the right and left kidneys presently sampled.

CONCLUSION

Almost all the dimensions significantly increase during the third and fourth growth periods indicating a greater embryogenesis of the prenatal dromedary at these stages. There are progressive increases in absolute mean renal weights without corresponding increases in the relative mean renal weights. This is inconsistent with the pattern of organ system established in mammals.

It is recommended that the study should be followed to its logical conclusion by extending it to histological and histochemical studies aimed at studying the histogenesis of the dromedary kidneys. This will enable a complete understand mechanisms of the prenatal development of the dromedary kidneys.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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