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*Afr. J. Biomed. Res. Vol.16 (January 2013); 31 - 37*

*Full Length Research Paper*

# Prenatal Development of the Kidney of One-Humped Camel (*Camelus dromedarius*) – A Histomorphometric Study

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**ABSTRACT**

This study aimed at investigating the prenatal development of the kidney of the camel using standard histomorphometric methods. In the experiment, fifteen *Camelus dromedarius* foetuses obtained from Sokoto metropolitan abattoir at different gestational ages were used for the study. The fetuses were weighed and grouped according to their gestational ages which were estimated using their crown-vertebral-rump length. Five foetuses belong to first trimester, seven foetuses in the second trimester and three foetuses belong to third trimester. In all foetuses the kidneys were bean-shaped with smooth external surface and thick fibrous capsule which becomes thicker with advancement of gestational age. Well-developed ureters and distinct renal pelvis were evident at all stages of development. In each gestational age, values of the weight, length, width and volume of the kidney were determined. In addition the periodic differentiation of the cortex and medulla; their significance in relation to the renal histodiffrentiation was discussed. Histological sections showed evidence of collecting duct system that are numerous and extensively coiled in the cortex and medulla of the third trimester kidneys. This is an indication of the ability of the kidney to concentrate urine, in accordance with the counter-current mechanism of the kidney collecting system. It was suggested that the kidneys of the camel possess the anatomical features for the production of hypertonic urine owing with the adaptive behavior of desert animals. Thick capsule that increases in thickness was also noticed in the kidneys.

**Keywords**: Histomorphometry, Camel, Kidney, Prenatal development, Northern Nigeria.

## INTRODUCTION

The one-humped Dromedary (*Camelus dromedarius*) and the two-humped Bactrian (*Camelus bactrianus*) camels are among the largest mammalian species, adapted to the desert with its high temperatures and extreme desiccation (Kohler-Rollefson, 1993). Camelids have been known to be capable of withstanding harsh conditions characteristic of the semi-arid and arid regions because of their peculiar physiologic and morphologic features (Garba *et al.*, 1992). Development of sophisticated physiological adaptations for coping with high temperature, feed and water scarcity in the dry and rough habitat of the camel are seen. These adaptations seem to depend on its ability to tolerate severe dehydration and to economise the meagre water

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*Date Received: August, 2012*
*Date Accepted: December, 2012*

***Abstracted by:***
*Bioline International, African Journals online (AJOL), Index Copernicus, African Index Medicus (WHO), Excerpta medica (EMBASE), CAB Abstracts, SCOPUS, Global Health Abstracts, Asian Science Index, Index Veterinarius, , African Journals online*

availability (MacFarlene *et al.*, 1963). During the last century, specific investigations have highlighted the mechanisms governing such adaptation (Schmidt-Nielsen, 1964; MacFarlene, 1968; Gauthier-Pilters and Dagg, 1981) including anatomical and physiological peculiarities.

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 *et al.*, 2012). Sperber (1994) was one of the first to note that certain features involving renal anatomy in different mammals vary with the aridity of the habitat. Numerous textbooks of anatomy and histology (Fawcett and Raviola, 1994; Eurell *et al.*, 2006; Dyce *et al.*, 1995; Sisson, 1975) have described the anatomy and histology of the adult kidney of domestic animals, and also research studies that investigated kidney development and morphology. The morphometric observations on the kidney of camel (*Camelus dromedarius*) (Abdalla & Abdalla, 1979), one horned rhinoceros (Talukdar *et al.*, 2003), biometrical study of the kidney of buffalo (Malik *et al.*, 1978), morphometric study on kidney of African rat fetus (Onyeanusi *et al.*, 2006) and measurement of renal dimension (Moorthy and Venugopal, 2001). With the changing scenario of camel management, investigations into the adaptation of camel is important (Kataria *et al.*, 2007), with good emphasis on the prenatal development of the kidney is considerable.

Most available reports on renal anatomy were entirely concerned with adult structures of the kidney, thus there is paucity of information about the prenatal development of camel kidney in this area. In this research, gross changes, morphometric changes and histological differentiation involved in the development of the kidney in one-humped camel will be described. The study will also add to the existing information on the morphometric analysis in camels. Therefore this investigation was carried out to reveal and evaluate the pattern of the kidney growth during prenatal life in camel (*Camelus dromedarius)* foetuses..

## MATERIALS AND METHODS

The study was carried out on 15 foetuses of the one-humped camel collected from the metropolitan abattoir, Sokoto at different gestational ages. The collected foetuses were then taken to the Veterinary Anatomy laboratory of Usmanu Danfodiyo University; where the weight and age of the foetus were determined. The foetal body weight was measured using electrical (digital) weighing balance for the smaller foetuses and compression spring balance (AT-1422), size C-1, sensitivity of 20kg X 50g in Kilogram for the bigger foetuses. The approximate age of the foetuses was estimated by using the formula adopted by El-wishy *et al.*, (1981) using Crown Vertebral Rump Length (CVRL). Based on this, samples were divided into 3 main groups as

- 1st trimester = below 130 days
- 2nd trimester = 131- 260 days
- 3rd trimester = 261 - 390 days

The foetuses were then placed on a dorsal recumbency and a mid-line incision was made, starting from the xiphoid cartilage and extending to the pubic symphysis. The peritoneum was reflected and the intestine displaced to gain access to the reproductive organs. The organs were examined in situand exteriorised. The length, weight, and width of each kidney were measured using ruler and thread, weighing balance, and vernier callipers, respectively. The length was taken from the cranial pole to the caudal pole along the longitudinal axis while the width was taken from the median fossa (hilus) to the lateral edge of the hilus. The Volume of each kidney was determined by water displacement technique (Archimedes principle). The organs were weighed using an electronic weighing (Mettler® balance P1210, Mettler Instruments AG, Switzerland) with a sensitivity of 0.01 g. The data obtained were expressed as mean ± standard error of the mean (mean ± SEM).

$1cm^2$ thick of sample from each the medulla and cortex was collected and fixed in 10% formalin solution. After fixation was achieved, the tissue sample was processed for paraffin blocks preparation. The sections of 5µm were subjected to haematoxylin and eosin for routine morphology (Luiz and Jose, 2005). The standard sections were examined under light microscope and micrographs taken using Sony digital camera(x5) with 12.1 mega pixel.

## RESULTS

A total of fifteen camel foetuses were used and grouped into first, second and third trimesters comprising of five, seven and three foetuses respectively as shown in Table 1. In all stages of development, the kidneys were found to be irregularly elongated and reddish-brown in colour. Both kidneys were bean-shaped, having a smooth surface and covered by a thin fibro-muscular capsule (which tend to become whiter with the advancement of gestational age) as shown in Plate B.

The kidneys were located below the transverse processes of lumbar vertebrae on each side, with the right kidney being more cranial in all camel foetuses as shown in plate A. At the hilus of each kidney adipose tissue were found.

**Table 1:**
The Mean CRVL, Mean Weight and Sex of the camel foetuses at various trimesters of age

| Trimester | Mean CRVL (cm±SEM) | Sex | | Mean Weight (g±SEM) |
|---|---|---|---|---|
| | | M | F | |
| 1st | 15.30±1.74 | 3 | 2 | 68±21.49 |
| 2nd | 40.42±5.35 | 3 | 4 | 1990±733.17 |
| 3rd | 93.00±1.52 | 2 | 1 | 11600±378.59 |
| **Total** | | **8** | **7** | |

**Table 2**:
The Mean ±SEM of biometrical parameters of right and left kidneys in relation to stages of development

| Age of the foetus | 1st trimester | 2nd Trimester | 3rd trimester |
|---|---|---|---|
| **Sample size** | 5 | 7 | 3 |
| **Mean Weight(g)** | | | |
| Right Kidney | 0.48±0.19 | 8.44±4.56 | 49.13±2.11 |
| Left Kidney | 0.48±0.19 | 8.71±4.55 | 50.33±1.42 |
| **Mean Length(cm)** | | | |
| Right Kidney | 1.34±0.16 | 3.11±0.58 | 6.90±0.10 |
| Left Kidney | 1.32±0.12 | 3.04±0.55 | 7.06±0.08 |
| **Mean Width** | | | |
| Right Kidney | 0.80±0.08 | 1.77±0.30 | 3.53±0.12 |
| Left Kidney | 0.78±0.09 | 1.7±0.26 | 3.70±0.05 |
| **Mean Volume (ml)** | | | |
| Right Kidney | 0.40±0.07 | 4.21±1.27 | 12.4±0.31 |
| Left Kidney | 0.41±0.09 | 4.39±1.27 | 12.6±0.31 |

Biometrical parameters were shown to be increasing with advancement of gestational age as shown in Table 2. The mean weight, mean length, mean width and mean volume of the right and left kidneys were determined as shown in table 2.

Histological observation shows that the camel kidney appeared to have the two zones of cortex and medulla right from 1st trimester as shown in figures 1-6. The development of renal tissues were found to be in succession, from the stage of mesenchyme cells, developing glomerulus and finally to fully developed glomerulus with advancement of gestational age among the three groups as shown in figures 1-6. The duct system also followed the same trend of development from immature to matured duct system.


**Plate A:**
Dissected first trimester camel foetus showing the location of foetal kidneys insitu (Black arrows).

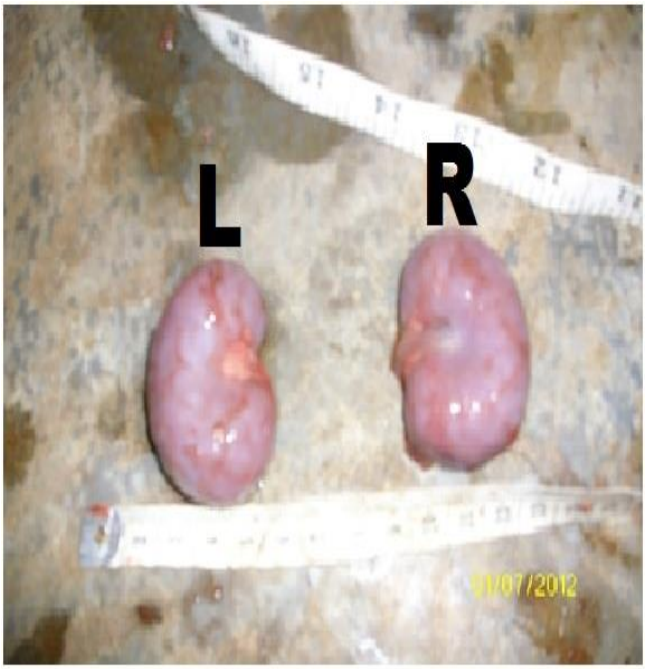


Plate B:
Camel foetal kidneys showing smooth external appearance and bean-shaped right kidney (R) & left kidney (L)

The cortex at first trimester revealed numerous mesenchymal cells and connective tissue with few developing glomerulus (Fig 1). At second trimester few

fully developed glomerulus were found, moderate number of mesenchyme cells and immature developing duct system (Fig 2). Numerous developed glomerulus and matured duct system with moderate developing glomerulus and connective tissue were seen at third trimester. There was extensive coiling of the duct system at the cortex of the kidney (Fig 3).

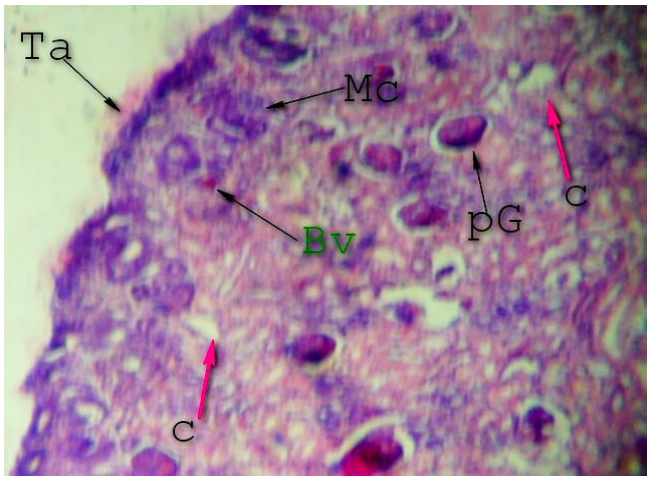


**Fig. 1:**
Photomicrograph of Camel kidney (cortex) at 1st Trimester showing developing glomerulus (pG), connective tissue (C), blood vessels (Bv), tunica adventitia (Ta) and mesenchyme cells (Mc) H&E x200.


**Fig. 2:**
Photomicrograph of Camel kidney (cortex) at 2nd Trimester showing glomerulus (G), connective tissue (cT), developing collecting ducts (Pd), kidney capsule (C) and mesenchyme cells (Mc) H&E x200.

The medulla in the camel kidney at first trimester shows only various types of connective tissue (collagen, reticular and elastic) fibers and mesenchyme cells (Fig 4). At second trimester the medulla was found to have numerous developing collecting ducts, few developed collecting ducts and few mesenchyme cells (Fig 5). Developed collecting ducts were predominant in the medulla at third trimester with few mesenchyme cells (Fig 6).

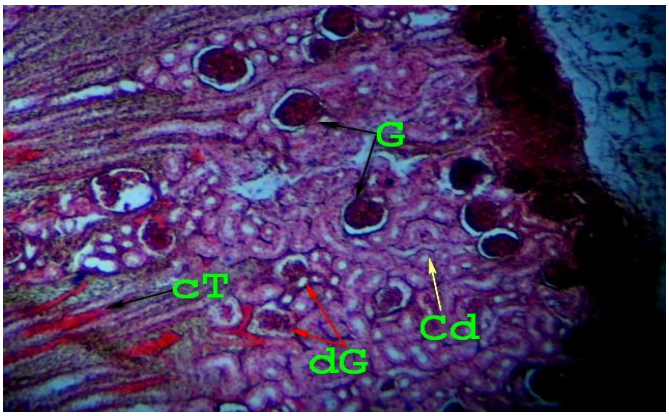


**Fig. 3:**
Photomicrograph of Camel kidney (cortex) at 3rd Trimester showing developed glomerulus (G), developing glomerulus (dG), connective tissue (cT) and developing collecting ducts (Cd). H&E x 200.

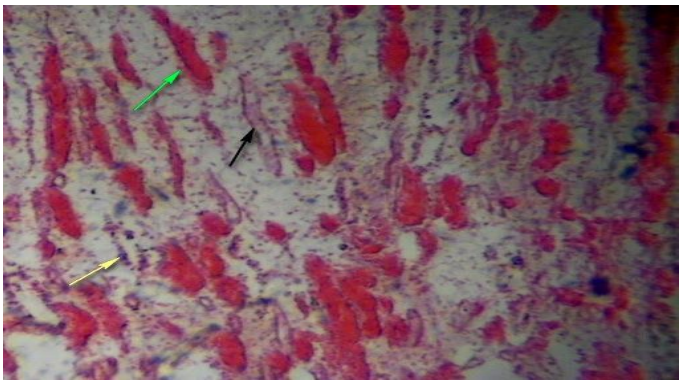

**Fig. 4**
Photomicrograph of Camel kidney (medulla) at 1st Trimester showing connective tissues collagen (green arrow), reticular (black arrow), elastic (blue arrow) and mesenchyme cells (yellow arrows) H&E x200.

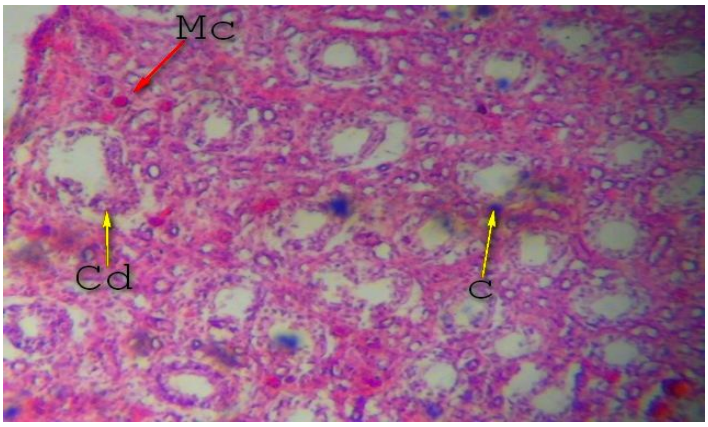


**Fig. 5**
Photomicrograph of Camel kidney (medulla) at 2nd Trimester showing developing collecting ducts (Cd), developed collecting ducts (C) and mesenchyme cells (Mc) H&E x200.

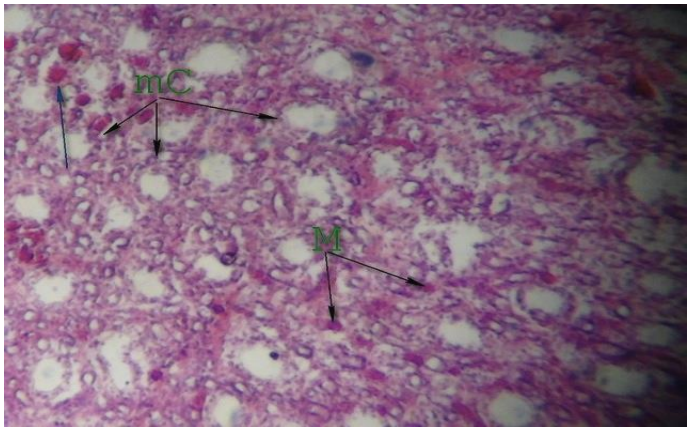


**Fig. 6**
Photomicrograph of Camel (medulla) at 3rd Trimester showing developed collecting ducts (mC) and mesenchyme cells (M) H&E x200.

## DISCUSSION

The results of this study show that the morphometric data were increasing progressively with the advancement of gestation. This is in accordance with the finding of Hena *et al.,* 2012, on pigeon and Bello *et al.*, 2012 on camel digestive tract. All kidneys were found to be irregularly elongated and reddish-brown in colour. Both kidneys are bean-shaped, having a smooth surface and covered by a thin fibro-muscular capsule. This is in accordance with the reports of Smuts and Bezuindenhout, (1987); Dyce, (1995); Abdalla *et al.,* (1974); Dowelmadina, (2012); Salehi *et al.*, (2012).

Both kidneys were located below the transverse processes of lumbar vertebrae of each side, with the right one being more cranial in all groups. Abdalla *et al.*, (1974) reported that right kidney is situated under the first three lumbar vertebrae while the left one is found under the last three lumbar vertebrae. Salehi *et al.*, (2012) also reported that the right kidneys shifted rostrally more than the left in camel embryos. Malik and Vais (1998) also reported that the right and left kidneys shifted rostral with advancement of age in ruminants. This cranial positioning of the kidneys might be due to relative variation in growth of different organs in the abdominal and pelvic cavities during various stages of embryonic development (Salehi *et al.,* 2012). Adipose tissue was found at the hilus of each kidney. Dyce, 1995 reported similar finding in ruminant, the fat sometime enough to hide the kidney completely. The fat protects against distorting pressures from neighbouring organs. Salehi *et al.,* (2012) also reported that adipose tissue surrounded the hilus and sides of the kidney.

A distinct renal pelvis with a well-developed ureter originating from the middle of the renal pelvis was found in all kidneys, similar to Salehi *et al.*, (2012) and Sarma *et al.,* (2007). This confirms the development of renal pelvis and ureter in early phase of the gestation period in *Camelus dromedarius* embryos (Salehi *et al.*, 2012). The right ureter was found to have higher length than the left one in all foetuses. Abdalla *et al.,* (1974) also reported that the right ureter of the camel is longer than the left considering the positions of the kidneys and the bladder in adult kidneys.

The mean values of the biometric study of the right and left kidneys in all trimesters are shown in Table 1. The measurements of all parameters varied between right and left kidneys, and between all the trimesters. The values of foetal weight were found to increase significantly with advancement of gestational age. This is in accordance with Sonfada *et al.,* (2012) who observed that there was an increase in body weight across the trimesters in the foetus with advancement in pregnancy, and Anderson *et al.,* (1987) that there were obvious body weight changes in MDX mice which seem to increase with age.

The weights of left and right kidneys were found to be equal in the first trimester foetuses. Though there was no significant difference observed between the weight of the right and left kidneys in the study, there was significant difference between the left and right kidneys in both length and width in the study. The length and width values of the right kidneys were found to be greater than the left ones. The volume of the left kidneys was greater than the right one in first trimester. This finding is in contrast to the work of Salehi *et al.*, (2012). In the second and third trimesters such values of all parameters measured were found have greater values in the left kidneys than in the right ones. The lengths of the left kidneys were found to have higher values than their right counterpart in the 2nd and 3rd trimesters. Similar observations were made for the width values. The weight values of the left kidney were found significantly higher than that of the right one in the 2nd and 3rd trimester foetuses. This was in accordance with the findings of Salehi *et al.,* (2012) in camel embryos and that of Dowelmadina, 2012 in adult camels and that of Sarma *et al.,* 2007 in crossbred pig foetuses. Al-Ani (2004) reported that the larger kidney which was twice that in cattle and four times that of sheep, was possibly due to the adaptation of camel to arid desert life. Constantinesu, (2004) reported that the greatest dimension of kidney may be due to size of the animal, direction and position. Histological development of the renal tissues was also found to be variable across the three trimesters. The camel kidney present two distinguishing zones i.e cortex and medulla at first, second and third trimesters which is similar to the finding of Franco *et al.,* (2004) on llama,

guanaco and on goat. This is however in line with varying number of glomerulus and different levels of development of the duct system in the cortex and medulla of the camel kidneys at different trimesters. Stages of growth observe ranges from the level of mesenchyme cells, connective tissue proliferation, developing glomerulus, developed glomerulus, immature developing duct system and finally to matured duct system in the medulla and cortex of the kidneys. This is in line with that observed by franco *et al.*, (2004) on Llama and the observations of El-Salmi and Amri (2012) on Sudanese sheep. Histological sections showed the presence of thick capsule which becomes thicker with advancement of gestational age was noticed in the kidneys.

The cortex of the first trimester kidney was found to have numerous mesenchymal cells and connective tissues with few developing glomerulus. This is in agreement with Onarlioglu *et al.*, (1997) that observed no developed glomeruli in the kidneys where dense mesenchymal tissue take place in early stage of development in rat foetus. The number of mesenchyme cells reduced in the second trimester, together with few fully developed glomerulus and immature developing duct system.

The camel is the only domestic animal that has collecting duct system in the cortex. Numerous developed glomerulus and matured duct system with moderate developing glomerulus and connective tissue were seen at the third trimester. Extensive coiling of the tubular duct system was evident in the third trimester kidneys. This is in line with that observed by Franco *et al.*, (2004) on Llama and El-Salmi and Amri (2012) on Sudanese sheep.

The medulla of the first trimester kidney was found to have various types of connective tissue (elastic, collagen and reticular) fibers and mesenchyme cells. Numerous developing collecting ducts, few developed collecting ducts and few mesenchyme cells were seen in the second trimester. This is also in line with that observed by Franco *et al.*, (2004) on Llama and El-Salmi and Amri (2012) on Sudanese sheep. At third trimester the kidneys showed predominant developed collecting ducts and few mesenchyme cells, which showed the kidneys, were still developing. This trend of growth was in accordance with the findings of Patten and Carlson (1977), 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.

In conclution, the histological differentiation of the camel kidney is largely similar to that of sheep, goat, horse, llama, and guanaco but differs from that of the cat, dog and pig. Meanwhile, considering the histological features observed in the study, the camel kidney may become fully matured and functional at post-natal age.

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