



Histoarchitecture of kidney in cross-bred male calves

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Abstract

The kidneys are the essential organ in domestic animals performing major functions namely ultrafiltration, excretion, electrolyte balance, blood pressure and pH regulation and reabsorption of glucose and amino acids. The aim of the study was to investigate the histoarchitecture of the kidneys in cross-bred male calves. Both left and right kidneys were collected from six numbers of apparently healthy male calves (eight months to one year old) immediately after slaughter. The gross appearance of the kidneys were analysed and small pieces of kidney were fixed in 10% neutral buffered formalin and processed for normal tissue processing. 4-5 micron thick sections were cut and stained with Haematoxylin and Eosin staining technique. Cattle kidneys were lobulated and consisted of thin capsule, outer cortex and inner medulla. The cortex contained glomerulus, Bowman's capsule, proximal convoluted tubule and distal convoluted tubules. The glomerulus were found darkly stained, compacted with parietal and visceral layer of Bowman's capsule and were lined by simple squamous epithelium. The medulla consisted of straight collecting tubules, loop of Henle and calyces.

Keywords: Calves, kidney, histology, cortex, medulla

Cattle are domesticated herbivorous mammals of the Bovidae family. The kidneys are the essential organ in domestic animals performing major functions namely ultrafiltration, excretion, electrolyte balance, blood pressure and pH regulation and reabsorption of glucose and aminoacids (Gaschen et al., 2000).

In all domestic animals, both kidneys are retroperitoneal and located in sublumbar region. The right kidney is slightly more cranial than the left kidney. Kidneys of most of the mammals are bean shaped with unipolar structure. In cattle, the shape of the kidney is oval but multiple lobes were present. Pigs, large ruminants and humans have multilobular (Multipyramidal) kidney with numerous medullary pyramids and papillae. The papillae discharge into the major and minor calyces which are the extensions of the renal pelvis of unilobular kidneys (Dellmann and Brown, 1997).

The kidneys consisted of external capsule, outer cortex and inner medulla (Kuehnelt, 2003). The functional unit of the mammalian kidney is nephron which consisted of renal corpuscles, convoluted tubules, loop of Henle and collecting tubules (Dellmann and Brown, 1997).

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Materials and methods

The left and right kidneys were collected from six numbers of apparently healthy male calves (8 months to one year old) immediately after slaughter and the research was conducted at the Department of Veterinary Anatomy, Veterinary College and Research Institute, Tirunelveli from August 2025 to March 2026. The gross appearance of the kidneys were analysed and tissue samples of .05 to 1 cm thickness were collected and fixed in 10% neutral buffered formalin, and processed as per the standard procedure and 4-5 micron thick sections for prepared and stained with Haematoxylin and Eosin staining technique (Luna, 1968). The slides were observed with a light microscope. The images were captured using Lynx Trinocular microscope with imaging system software.

Results and discussion

The kidneys of calves appeared pale brown in colour, oval in shape and were located in the sublumbar region. In contrast to the above observation, the kidneys of adult cattle were reddish brown in colour (Ishaya et al, 2021) which indicated the development of the organ. The kidneys were multilobulated with grooves filled with minimum amount of fat between the lobes whereas in adult cattle, it was filled with more amount of fat (Ishaya et al, 2021) which indicated the storage of fat in the visceral organ is more in adult animals life. The longitudinal section of the kidney showed superficial thin capsule, outer pale cortex and inner dark medulla.

Capsule

The capsule of both the kidney appeared thin with two clear layers. Capsule thickness may vary with species. In camels, the renal capsule is relatively thick, which may represent a morphological adaptation associated with the functional demands placed on the kidneys under arid desert conditions (Al-Salami, 1992). The outer layer of the capsule consisted of dense irregular type of connective tissue while the inner layer contained smooth muscle fibres intermixed with the loose connective tissue. These findings were in line with the results of cows, sheep and goat (Bacha and Bacha, 2000). The prominent thickness of the renal capsule in camels suggests that its structural characteristics are influenced by environmental factors, particularly high ambient temperatures, limited water availability, and dietary conditions (Abdalla and Abdalla, 1979).

Cortex

The cortex of the kidney consisted of renal or Malpighian corpuscles, convoluted tubule and cortical loop of Henle. Some portions of medulla dip into the cortex and reached upto the capsule forming medullary rays and rest of the portions formed cortical labyrinth (Fig. 1). The medullary rays consisted of cortical collecting

ducts, cortical thick ascending limb of Henle and proximal straight tubule. The cortical labyrinth consisted of renal or Malpighian corpuscle and convoluted tubules namely proximal and distal convoluted tubules. The observations were in relation with the studies of all domestic animals (Dellmann and Brown, 1997). The distribution of renal corpuscle varied in the cortex of calves. The proportion of renal corpuscle was more in the midcortical region than in the subcapsular and juxtamedullary region which aligns with adult cattle (Al-Janabi, 2024).

Medulla

The medulla of the kidneys of the male calves consisted of maximum proportion of collecting duct and straight tubules and minimum proportion of convoluted tubules as reported in adult cattle (Ishaya et al., 2021) which could be differentiated by the lining epithelium with simple cuboidal as convoluted tubules and simple squamous as collecting ducts (Fig. 2). The medullary portion appeared as multiple conical structures and was commonly called as medullary pyramids. The apex of the pyramid contained renal papillae and base contacted renal cortex. The renal papillae opened into calyx as seen in kidneys of other domestic animals (Dellmann and Brown, 1997).

Nephron

Renal corpuscle

Renal corpuscle was formed by Bowman's capsule which was a double layered cup-like arrangement and glomerulus, a tuft of capillaries which was enclosed within the Bowman's capsule. The two layers of Bowman's capsule were outer parietal layer of simple squamous epithelium and inner visceral layer of simple squamous epithelium. The Bowman's space was located with the parietal and visceral layer of Bowman's capsule. These results align with the reports of Bankir and Farman (1973) in rabbits and Al-Janabi (2024) in local cows of Iraq. Mesangial cells were found intermingled with glomerular capillaries. Urinary pole of Bowman's capsule continued as proximal convoluted tubules (Fig. 3). The glomerulus consisted of tuft of capillaries which arose from afferent arteriole and conveyed through efferent arteriole and were located at the urinary pole. The glomerulus appeared darkly stained in blue colour with intermingling of mesangial cells which appeared with round nucleus in contrast to simple squamous cells of endothelium. According to the location of renal corpuscle within the cortex, the renal corpuscles were differentiated into cortical, midcortical and juxtamedullary renal corpuscles. Among these three, midcortical renal corpuscle was found maximum and cortical and juxtamedullary renal corpuscle was found in minimum proportion. PAS positive reaction was noticed with the glomerulus, parietal layer of Bowman's capsule, brush border structure of PCT and Basement membrane of PCT and DCT (Fig. 4)

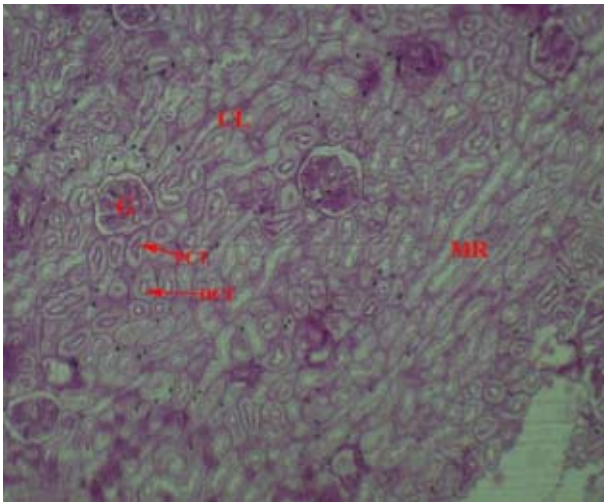


Fig. 1: Photomicrograph of eight month-old calf kidney showing cortical labyrinth (CL) and Medullary ray (MR) in the renal cortex G – Glomerulus PCT – Proximal Convoluted tubule DCT – Distal Convoluted tubule H & E X 100

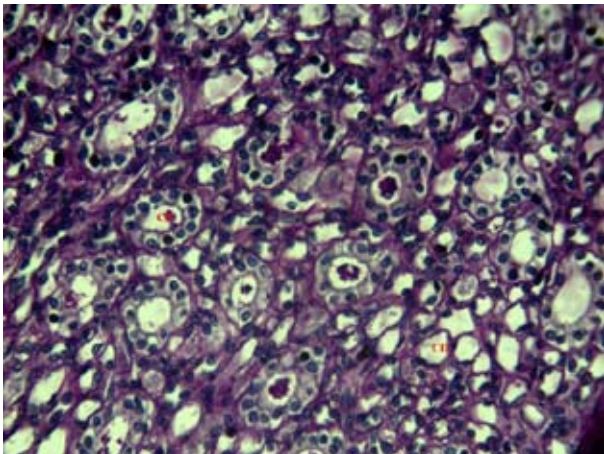


Fig. 2: Photomicrograph of nine month-old calf kidney showing convoluted tubules (CT) and collecting ducts (CD) in the renal medulla. H & E X 400

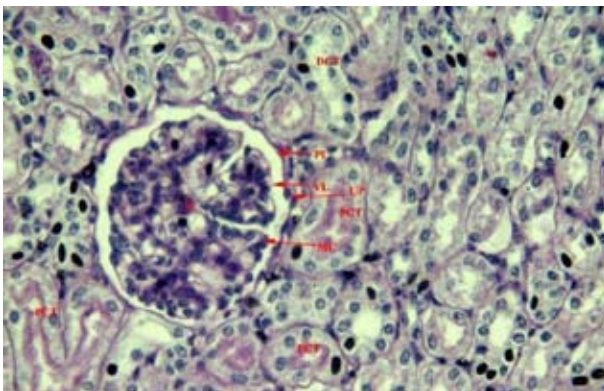


Fig. 3: Photomicrograph of eight month-old calf kidney showing Glomerulus (G), Proximal convoluted tubule (PCT) and Distal convoluted tubule (DCT) PL – Parietal layer of Bowman's capsule VL – Visceral layer of Bowman's capsule MC – Mesangial cells H & E X 400

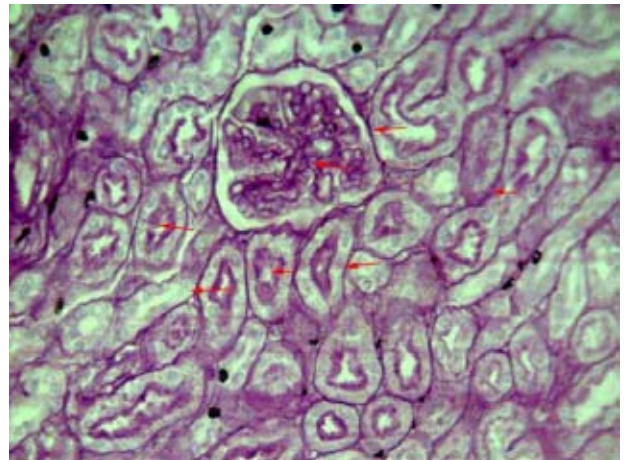


Fig. 4: Photomicrograph of one year-old calf kidney showing PAS positive reaction (arrow) inside glomerulus, brush border of PCT and basement membrane of PCT and DCT. H & E X 400

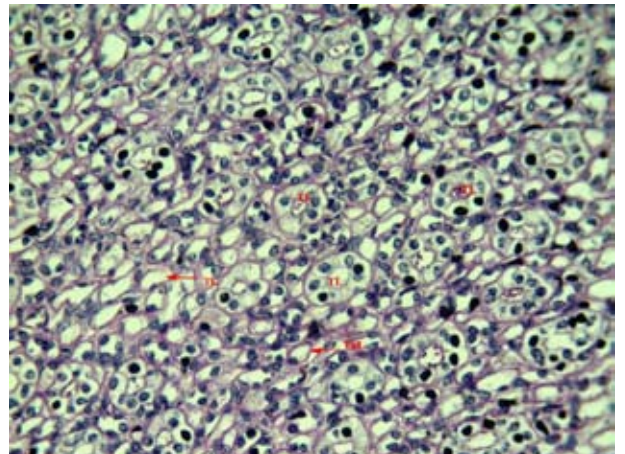


Fig. 5: Photomicrograph of 11 month-old calf kidney showing thick limb of Henle (TL) and Thin limb of Henle (TnL) in the renal medulla. H & E X 400

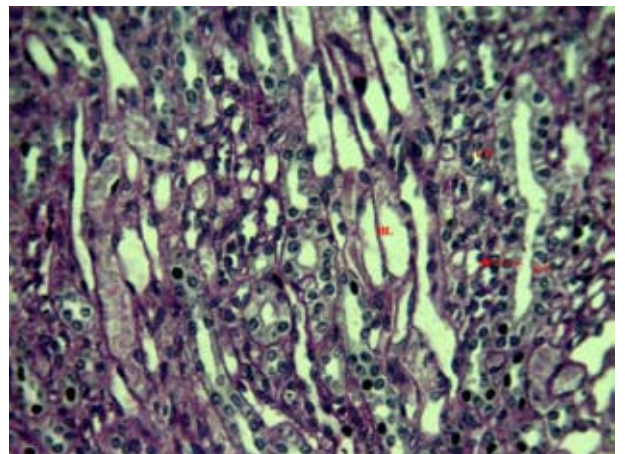


Fig. 6: Photomicrograph of 11 month-old calf kidney showing Henle's loop (HL) and collecting tubules (CT) in the renal medulla. H & E X 400

Proximal Convoluted tubule (PCT)

The proximal convoluted tubule in cross section were appeared in the renal cortex with narrow lumen, acidophilic cytoplasm and lined with simple cuboidal epithelium with round nucleus located in the centre of cytoplasm with nucleus both in mitotic and non-mitotic stages. The nucleus with mitotic stages indicates the growth of the organ. The luminal layer of the cells contained brush border which was acidophilic and prominent. The basement membrane of the proximal convoluted tubule was appeared prominent with dark acidophilic staining (Fig. 3). Similar findings were also reported in buffalo kidneys (Al-Kinanny, 2006).

Distal convoluted tubule (DCT)

The distal convoluted tubules also appeared in the renal cortex with wide lumen when compared to PCT. The DCT was lined by simple cuboidal epithelium (Fig. 3). The epithelial cells of the DCT were smaller and exhibited less acidophilic cytoplasm than those of the PCT. The DCT lumen lacked a brush border. The tubules were lined by cuboidal epithelial cells with centrally located, round nuclei and lightly acidophilic cytoplasm. The nuclei were observed in both mitotic and non-mitotic stages. During mitosis, the nuclei appeared vesicular or fragmented, whereas in the non-mitotic stage, they appeared homogeneous and dark blue. Similar result regarding the appearance of DCT was also found in domestic animals (Dellmann and Brown, 1987).

Loop of Henle

The loop of Henle consisted of thin and thick segments of the descending and ascending limbs, respectively, both of which were located in the renal medulla (Fig. 5). The thick limb was lined by simple cuboidal epithelium resting on a prominent basement membrane. Its epithelial cells had lightly acidophilic cytoplasm and centrally located oval nuclei, and the lumen was relatively wider than that of the thin limb. In contrast, the thin limb was lined by a single layer of flattened squamous epithelial cells with scant cytoplasm and spindle-shaped nuclei. Similar histological features of the loop of Henle have been described in other domestic animals (Bacha and Bacha, 2000). In contrast, fishes lack a loop of Henle (Dyce et al., 2010), which may be associated with their aquatic habitat and consequently different requirements for renal water conservation. In camels, the structural organization of the loop of Henle is associated with efficient water reabsorption and the production of concentrated urine, thereby minimizing urinary water loss and conserving body fluids which are an important adaptation to arid environments (Abdalla and Abdalla, 1979).

Collecting tubules

The collecting tubules continued from the distal

convoluted tubule and were located both in cortex and medulla. In cortex, it appeared convoluted and lined with simple cuboidal epithelium as reported in domestic animals (Dellmann and Brown, 1987). In medulla, the collecting tubules appear straight and were lined with simple low cuboidal epithelium when compared to that in cortex (Fig. 6).

Conclusion

The kidney of the present study showed the comparative anatomical features of other mammals. The excretory organ had started fully functional and attained its maximum growth about eight months of age. This study will form the basis for understanding the pathophysiology of renal system in cattle and calves.

Conflict of interest

The author declares that there is no conflict of interest.

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