J. Appl. Anim. Res. 36 (2009) : 195-198

Some Histological and Physiological Features of Avian Kidney

A. Nabipour, E. Alishahi, M. Asadian

Department of Anatomical Sciences
School of Veterinary Medicine
Ferdowsi University of Mashhad
Mashhad, 91775-1793, Iran

(Received February 23, 2009; accepted August 21, 2009)

Abstract

Nabipour, A., Alishahi, E. and Asadian, M. 2009. Some histological and physiological features of avian kidney. J. Appl. Anim. Res., 36: 195-198.

The detailed histology of the kidney was studied in rock dove, collared dove and owl (3 each). Each kidney consisted of a caudal, a middle and a cranial division. The cortex made up the vast majority of the kidney with only a small portion as medulla. They were arranged in cones of different lengths, which were distributed randomly within the kidney. Medullary nephron tubules were arranged in a sequential manner in all birds. Thick and thin limbs of Henle were separated by the collecting ducts. Histological and features of each component of nephron have been discussed.

Key words: Bird, kidney, histology, cortex, medulla.

Introduction

Many detailed studies have been published on the histology of the mammalian kidney but comparatively few have been of the avian kidney. The nephron is the functional unit of kidney and varies greatly in structure amongst different vertebrates. Birds and mammals produce hyperosmotic urine due to the presence of a loop of Henle.

In birds, most nephrons do not contain a loop of Henle and are referred to as loopless nephrons. In mammals, all nephrons contain a loop of Henle, but some are long and some are short (Reece, 2004). The ability to conserve ions and/or water may be correlated with the structure of the nephron. The major aim of this study was to examine the histological structure of the kidney in rock dove, collared dove and owl. Also, physiological importance of each component of nephron will be discussed.

Materials and Methods

Rock dove *(Columba Livia)*, collared dove *(Streptopelia decaota)* and owl *(Athene noctua)* (3 each) were killed with an intraperitoneal injection of barbiturate, their kidneys were dissected free of synsacrum. The birds and kidneys were weighed. The overall length from the cranial pole to the caudal pole of each kidney and its mean width were measured. Left and right kidneys were measured separately. The kidneys were placed in 10% neutral buffered formalin, through a series of graded alcohols, chloroform and eventually into paraffin wax. The transverse serial sections were taken at 6 µm thickness. The sections

Corresponding author: Telefax: 0098 511 8763852;
E-mail: nabipour@ferdowsi.um.ac.ir or gnabipour@gmail.com

J. Appl. Anim. Res. 0971-2119/2009/$10.00

were stained with haematoxylin and eosin (H & E), periodic acid-Schiff (PAS) and alcian blue (AL). The latter stain was necessary to distinguish cortical collecting tubules, whose lumen stains blue due to the presence of mucus from distal tubules (Nicolson and Worswick, 1990).

Results and Discussion

The kidneys from the studied birds were very similar in external morphology. Each kidney consisted of three divisions, a large caudal, a small middle and a cranial division somewhat larger than the middle division (Fig. 1). They extended from the caudal margin of the lungs to the caudal end of the synsacrum. The dorsal half of the kidney laid embedded deeply in the synsacral fossae. These weighed 6% of the body mass in Rock dove and Collared dove and 8% in owl. These measured 27 X 10, 21 X 7 and 25 X 7mm, respectively, in the three birds.

Histologically, the kidneys of all studied birds consisted of two zones, the cortex and medulla. The cortex made up the vast area of the kidney with only a small portion being medulla. The cortex and the medulla were arranged in cones of different lengths, which were distributed randomly within the kidney. This feature is similar to other species. It would appear that the avian medullary cones are structurally similar (analogous) to the outer medulla of mammal kidneys (Casotti *et al.,* 2000).

The majority of nephrons were without a loop of Henle and were restricted entirely to the cortex. The proximal tubule fomed into a thin descending limb of Henle at the corticomedullary boundary and descended into the medulla.

Within the cortex, most nephron tubules were distributed randomly, except for the glomeruli which occurred most commonly in the peripheral cortex and the majority of distal tubules which were clustered around the intralobular vein (Fig. 4).

The renal corpuscle consisted of an outer Bowman's capsule separated by Bowman's space from a centrally located glomerulus. The glomeruli consisted of tightly packed central core of mesangial cells, surrounded by capillary loops (Fig. 2).

The proximal and distal tubules consisted of a cuboidal epithelium (Fig. 2, 3, 4). The luminal surface area of the proximal tubule was enhanced by a thick layer of microvilli forming a brush border (Fig. 2, 4, 5). Wide intercellular spaces coupled with extensive cell membrane infolding in proximal tubule are a

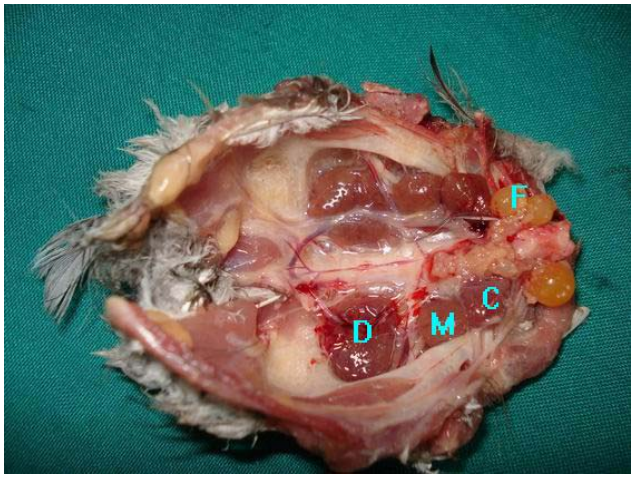

Fig. 1. Ventral view of the kidneys of a female rock dove. Cranial division (C); middle division (M); caudal division (D); follicle (F).

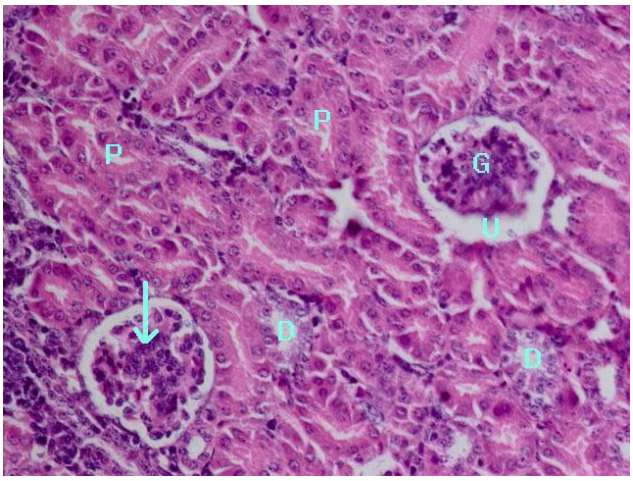

Fig. 2. Photomicrograph of the kidney of collared dove, showing glomerulus (G); proximal tubule (P); distal tubule (D); urinary space (U); mesangial cells (arrow) (H & E × 640).

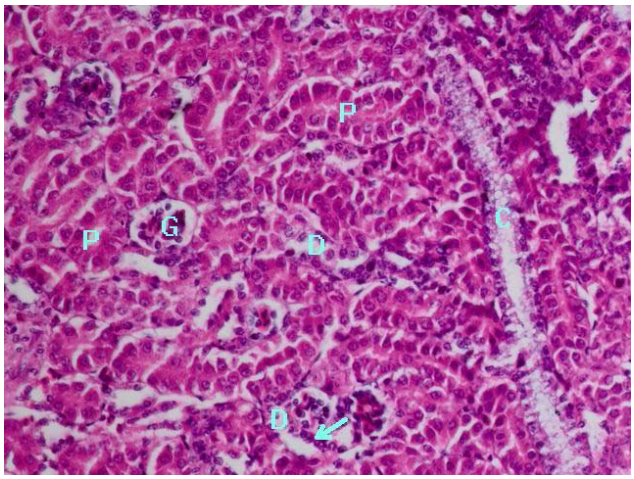

Fig. 3. Photomicrograph of the kidney of rock dove. Proximal tubule (P); distal tubule (D); cortical collecting tubule (C); macula densa (arrow) (H & E × 640).

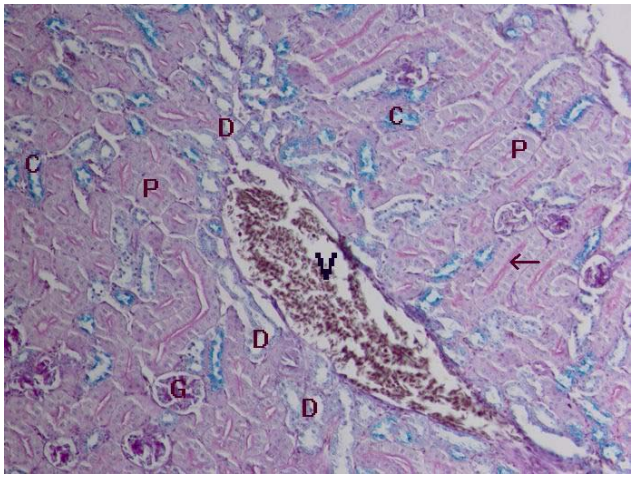

Fig. 4. Photomicrograph of the kidney of collared dove, showing the concentric arrangement of distal tubule (D) around the intralobular vein (V). Proximal tubule (P); brush border (arrow); cortical collecting tubule (C); glomerulus (G) (PAS-Al × 320).

characteristic of cells that have a high ion and water reabsorption capacity (Cunningham and Klein, 2007). The avian proximal tubule absorbs about 70 of the filtered volume of water, which depends on active reabsorption (Reece, 2004). In the avian nephron, absorption of sodium chloride from the distal tubule may, in some instance, proceed without water reabsorption, further increasing the concentration gradient along the length of the nephron tubule and thus allowing water to be reabsorbed distally along the nephron at the medullary collecting ducts (Casotti, 2001).

The cortical collecting tubule consisted of a cuboidal epithelium. The cytoplasm of each cell contained a basal nucleus and

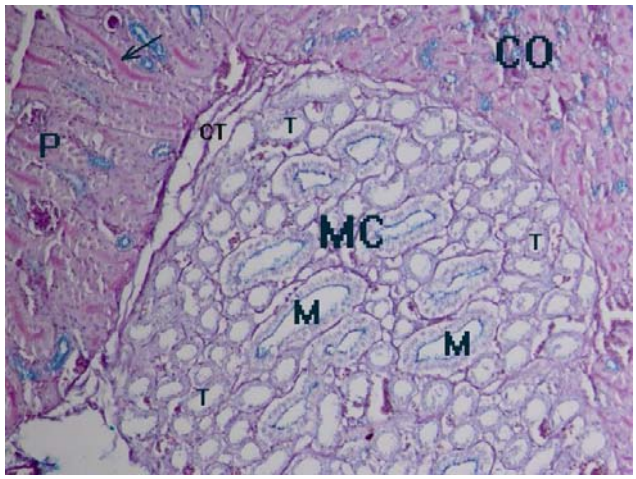

Fig. 5. Photomicrograph of the kidney of owl in transverse section. Cortex (CO); medullary cone (MC); thick limb of Henle (T); proximal tubule (P); brush border (arrow) (PAS-AL × 320).

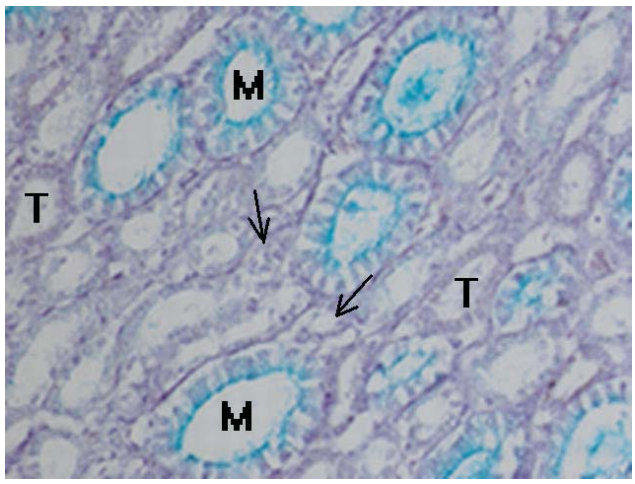

Fig. 6. Photomicrograph of the medullary cone in the kidney of collared dove, showing the arrangement of tubules within the cone. Thick limb of Henle (T); medullary collecting ducts (M); thin limb of Henle (arrows); connective tissue sheath (CT) (PAS-Al × 640).

mucopolysaccharide in the cytoplasm of the cell. The mucopolysaccharide stained positive with Alcian blue and PAS (Fig. 4, 5). As with the distal tubules, the cortical collecting tubules also play a role in producing concentrated urine by reabsorbing water from the tubular lumen. In addition, they are also known to secrete mucin, which may aid in eliminating uric acid from the kidney (Casotti, 2001).

Medullary nephron tubules were arranged in a sequential manner. Thick and thin limbs of Henle were separated by the collecting ducts. Thick limbs were restricted to the periphery of the medullary cone and surrounded a ring of collecting ducts, which in turn surrounded a few number of thin limbs. The thin and thick limbs consisted of simple cuboidal epithelium (Fig. 5, 6). The countercurrent multiplier mechanism operates between the descending and ascending limbs of Henle via recycling of a single solute (NaC) with no water accompaniment, forming an osmotic gradient along the medullary cone (Nishimura, 2008).

The cortical collecting duct continued into the medulla as the medullary collecting duct. The medullary collecting duct consisted of a proximal segment and a distal papillary duct which consisted of a columnar epithelium. The cytoplasm of each cell contained a basal nucleus and mucopolysaccharide (Fig. 5, 6). Role of the medullary collecting duct is reabsorption of water and possibly some sodium from the tubule (Casotti and Braun, 2000). Possible differences in the urinary concentrating ability of species from different zones may be the result of differences in the proportion of cortex and medulla. Previous studies have demonstrated that arid zone birds have a high volume of renal medulla than mesic zone birds (Casotti, 2001).

Acknowledgement

The authors wish to express their appreciation to Research Council of the Ferdowsi University of Mashhad for financial support (Grant No. 797). They also wish to Mr. Pouradibi for his technical assistance.

References

Casotti, G. 2001. Effects of season on kidney morphology in house sparrows. J. Exp. Biol., 204: 1201-1206.

Casotti, G., Lindberg, K.K. and Braun, E.J. 2000. Functional morphology of the avian medullary cone. Amer. J. Physiol. Regulatory Integrative Comp. Physiol., 279: R1722-R1730.

Casotti, G. and Braun, E.J. 2000. Renal anatomy in sparrows from different environments. J. Morphol., 243: 283-291.

Cunningham, J.G. and Klein, B.G. 2007. *Textbook of Veterinary Physiology*. Saunders, St. Louis, PP: 537-564.

Nicolson, S.W. and Worswick, P.V. 1990. Sodium and potassium concentrations in floral nectars in relation to foraging by honeybees. South African J. Zool., 25: 93-96.

Nishimura, H. 2008. Urine concentration and avian aquaporin water channels. Pflugers Arch., 456: 755-768.

Reece, W.O. 2004. *Dukes' Physiology of Domestic Animals*. Twelfth Edition, Cornell University Press, Ithaca, PP: 107-113.