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A review about: Anatomical and Histological Studies of Rabbit's kidney

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***Abstract*— The present study was conducted to focusing the light on the anatomical and histological picture of the kidney of the rabbit, for this purpose the report recorded that the anatomical findings which was the kidney large relatively firm, retroperitoneal, reddish brown in color and unilobular with bean-shaped surrounded by a tough fibrous capsule with abundant amount of per-renal fat tissue. The right kidney was between the 11th and 12th intercostal space and the second lumbar vertebrae while left kidney localized between the 2nd and 4th lumbar vertebrae.**

The right and the left renal arteries supply kidneys of the rabbit that originated from the related side of the abdominal aorta, they were entering the hilus of the kidney.

Histologically were reported that the kidney of rabbit surrounded by a thin fibrous capsule and consists of darker, granular and highly vascular outer cortex which had the renal corpuscles and inner medulla which was slightly thick and less vascular that had the tubules of the nephrons .

The functional unit of the kidney called nephron and each nephron consists of renal corpuscle, proximal convoluted tubule, loop of Helene, distal convoluted tubule, collecting tubule and collecting duct.

The sections extend from the capsule to the medulla showing variations in distribution of renal corpuscles, otherwise the straight tubules of the nephrons and the collecting ducts continue from the cortex into the medulla.

***Keywords* — Kidney, Rabbits.**

INTRODUCTION

Rabbits are selected for traits that are considered economically important. A purebred rabbit is one that has the characteristics defined by a breed registry and purebreds are expected to pass those traits on to their offspring with a high degree of predictability. Crossbreeding has been used to develop new lines of rabbits that are now considered purebreds because they have a set of traits that are consistently passed on and a breed registry has been established (1).

The rabbit is an attractive model for kidney transplantation research, in view of its docility, convenient size, easy maintenance, low cost, and renal anatomical and functional similarity to human kidneys. We were further attracted to the rabbit kidney transplant model due to the overwhelming use of this model in studies (2), so the aim of this report was to focusing the light on the anatomical and histological picture of the rabbit's kidney.

Literatures review

From time immemorial, man has depended on animals for his survival, either as food (cattle, sheep, pigs, poultry etc.) or for competition and companionship (horse, dog, cat, parrots etc.). As he knew more about his surroundings he extended this dependence to acquisition of knowledge, dating back to the days of the great physician Galen (129-200 AD) who used animals to demonstrate that arteries contained blood and not air. We have come a long way since then and specially bred laboratory animals consisting of mice, rats, hamsters, guinea pigs, rabbits, cats, dogs, monkeys, higher farm animals and a variety of birds and other lower forms are now integral part of biomedical research (3).

Human biology is very much like that of many other animals that is why results from animal experiments apply to people. Most laboratory animals have the same set of organs - heart, lungs, liver and so on which work in the same way as they do in humane. There are seven major areas of medicine and biology where animals for experiments need to be used (3).

The morphological variation in various structures of living organisms (animals and plants kingdom) is a common observable fact. There are a great number of experiments where laboratory animals like rabbit are using worldwide. Different articles described widespread details attention to the body structure and organ systems (4).

The rabbit is a widely distributed animal species, commonly used in the laboratory and for economical purposes. It is a model for numerous medical experiments and is extensively used in teaching, especially in fields where laboratory techniques are performed (5).

Rabbits are used in human and veterinary medicine as experimental animals. Most medical instruments are also applied to humans after being tested generally on some animal (6, 7). On the other hand rabbits are widely kept as pets and their importance as veterinary patients continues to grow with specific requests for imaging (8).

The principle function of urinary system is conservation of water and electrolyte homeostasis and the second major function of this system is the excretion of many toxic metabolic waste products particularly the urea and creatine (9).

The kidneys are a complex organs play important role in removal of unwanted nitrogenous substances, excess water and relative maintenance of osmotic concentration of the blood (10, 11).

The kidney is a major component of the urinary system, which maintains body homeostasis through filtration, active and passive absorption, and secretion. The final product of the filtration processes is urine which contains eliminated waste metabolic products. The kidneys are equally involved in the regulations of fluid and electrolyte balance, blood pressure and erythropoiesis (9).

It is now well understood that the kidney morphology changes based on the functional status and condition of the organ. A thorough understanding of the complex structure of the mammalian kidney provides a basis for comprehending the multitude of functional characteristics of this organ in both healthy and disease states. Renal structural alterations are closely related to their functional alterations and renal histopathological analysis is indispensable to investigate kidney related diseases as well as kidney failure. To make a correct interpretation of histopathological observations in laboratory experiments, a clear understanding of normal histological features of laboratory animals is very important (12).

The kidney of the mammalian species had been typical bean-shaped appearance fig (1) characteristic of the unipolar mammalian kidneys according to (13).

The kidneys in rabbit are large relatively firm, reddish brown in color and single-partition (unilobular or unipyramidal) fig (2 and 3). They are localized retroperitoneally, as the right kidney is between the 11th and 12th intercostal space and the second lumbar vertebrae. The cranial pole reaches the liver under the last intercostal space and makes a mark on the caudal end of it. The caudal pole of the right kidney goes to the descending end of the duodenum. The left kidney is localized between the 2nd and 4th lumbar vertebras and remains ventro-caudally to the right (14, 15).

The anatomical features were revealed that the kidney of the rabbits was large relatively, firm, reddish brown in color fig (2) bean-shaped retro-peritoneal organ surrounded by a tough fibrous capsule located in the posterior region of the upper abdomen, one kidney on each side of the sublumbar region and surrounded by abundant amount of per-renal fat tissue and the right kidney being anterior in their location to the left kidney and nearer to the medial plan. The presence of much per-renal fat in the rabbit kidney gives it more stable external environment and act as a good insulator (16).

The right kidney was larger and heavier than left one, it was elongated, bean in shape and flattened dorsoventrally while the renal impression of caudate lobe of liver accommodates the cranial extremity of right kidney (17). Otherwise the dorsal surface was flattened and in contact chiefly with the sub-lumbar muscles and the ventral surface was more convex and related to the liver, pancreas and cecum, but the hilus lies in the middle part of the medial border which was concave and lies parallel to the caudal vena cava where the renal artery and nerve enters the organ and the renal vein and ureter leave, while the lateral border was convex. The cranial pole related directly with right adrenal gland (13).

The left kidney similar to right kidney with some differences which ventro-cranially on the descending colon and the body of the pancreas and the ventral border on jejunal loops, the left kidney being posterior in their location to the right kidney and away to the medial plan (18).

The right and the left renal arteries supply kidneys of rabbit that originate from the related side of the abdominal aorta, which give rise to the dorsal and ventral branches before entering the hilus of the kidney; the dorsal and ventral branches, respectively were divided into the interlobar, arcuate, and interlobular arteries. In some species each kidney is thought of as supplied by a single renal artery. However, some anatomic studies show that two or more renal arteries can supply a kidney. Variations in renal vascular anatomy have been important in increasing frequency of experimental renal transplantation, vascular reconstruction for congenital and acquired lesions, and abdominal aortic aneurysms (19, 20).

Histologically (21, 22) were reported that the rabbit kidney was unipapillary consists of superficial capsule, outer cortex and inner medulla fig (3). The outer cortex which is darker, granular and highly vascular; the inner medulla is slightly thick and less vascular.

In cross section of both kidneys in rabbit revealed that composed mainly of renal corpuscles fig (4), convoluted tubules and cortical loops of Henle. The sections extend from the capsule to the medulla showing variations in distribution of renal corpuscles from the superficial which has little renal corpuscles to the mid-cortical region which has more renal corpuscle and the juxtamedullary region that has less renal corpuscle than the mid cortical and cortical region, while the medullary region in cross section appeared consists of straight tubules, collecting ducts, and a special capillary network. The straight tubules of the nephrons and the collecting ducts fig (5) continue from the cortex into the medulla, they are accompanied by a capillary network (9).

The tubules in the medulla, because of their arrangement and differences in length, collectively form a number of conical structures called renal pyramids which is conical in shape and its broad base lies toward cortex while its apex called renal papillae. The apical portion of each pyramid that known as the papilla projects into a calyx which is a cup-shaped structure that represents an extension of the renal pelvis (23).

The functional unit of the kidney called nephron and each nephron consists of renal corpuscle, proximal convoluted tubule, loop of Helene, distal convoluted tubule, collecting tubule, collecting duct (24).

The renal corpuscle consists of a tuft of capillaries called the glomerulus, surrounded by a double layered cup – shaped Bowman's capsule. The afferent arteriole give rise to the capillary loops, the outer or partial layer of Bowman's capsule was simple squamous epithelium which reset on visible basement membrane. The inner or visceral layer appears as globe-like structure represented by the podocytes. Between the two layers of Bowman's capsule was the Bowman space, which at the urinary pole leads into the proximal convoluted tubule (25).

Renal corpuscles about three types were identified depend on their location in the renal cortex which they are cortical, mid-cortical and juxtamedullary renal corpuscles [26].The diameter of cortical renal corpuscles about (65±8 um) while mid-cortical about (68±6 um) and juxtamedullary about (72±8 um). This variation in size leads one to suspect that the glomerular filtration surface would be much greater in the large juxtamedullary population of glomeruli, this could lead to preferential filtration in these nephrons and because they have long loops many results indicated maximal concentrating capacity, so it’s thought that the glomerular filtration rate of the juxtamedullary nephron is approximately eight times that of nephron in the outer cortex (27).

The proximal convoluted tubules (P.C.T.) in rabbit is the longest lined by tall cuboidal epithelial tissue possess a round to elliptical nucleus light in color and central in location reset on visible basement membrane. The basal surface of cells larger than the apical portion and occupied by dense element of cytoplasm while the lumen narrow in diameter and appear occupied by brush border was homogenous and represented the future of this segment and contain 3-4 cells in cross-section. The proximal convoluted tubules diameter about (7.5 um) in cortical region otherwise the transition from the proximal straight tubule to the thin descending limb of Henle is abrupt. In comparison to other animals like camel, the P.C.T. of rabbit has no clear brush border and less acidophilic appearance, this may lead to decrease the tubular re-absorption and accordingly increase the tubular excretion from the kidney of rabbit and this variation due to desert environment of some animals (28).

The Helene loop in rabbit kidney conforms consists of the thin and thick limb of the heel loop are more evident in medulla. The thin segment of Henle loop was lined by simple squamous epithelium tissue with cells reset on visible basement membrane which appear in cross-section compose of two cells number, spindle-shaped with prominent oval nuclei and central in location which bulging to inside of tubule forming narrow lumen and diameter about half of a thick segment and characteristic by lack brush border while the thick segment of Helene loop lined by cuboidal epithelium (29), while (30) found in fish that the Henle loop absent, this variation due tok aquatic environment for these animals. On the other hand the rabbit kidney have relatively more ratio of short Henle loop and this is because the rabbit did not need high re-absorption of water as compared with desert animals like camel, lizard and spiny mouse whose excrete concentrated urine moreover, this is due to the ability of camel to stand extended periods without water and produce highly concentrated urine. This higher level of development in the camel compare with rabbit, rodent and other mammals species is likely to be advantageous in the hot weather which may be reach to (50°C), high dryness, arid desert, and rocky environment these animals naturally inhabit (31).

Distal convoluted tubules in rabbit kidney are short and not encountered as frequently in sections as proximal tubules, this will leads to decrease the water re-absorption (32), their luminal diameters are greater than proximal tubules and narrower than collecting tubules and the brush border is not seen. While the lining cells are low cuboidal epithelium cells with rounded or oval nucleus central in location reset on visible basement membrane, more nuclei in cross-section, the cells less acidophilic than proximal convoluted tubules, otherwise the wall of the distal tubule is in close contact with the wall of the afferent arteriole in vascular pole, at this point the tubular epithelium appears denser and darker in microscopic preparations than it does in the other areas because of the close proximity of its nuclei, is called the macula densa (29, 33).

The collecting tubules continue from terminal part of distal tubule and converge in the renal cortex to form bundles of tubules called medullary rays. The collecting segment was short segment that joins the distal tubule with collecting duct system. The superficial nephron empties directly into a cortical collecting duct via collecting tubules whilst the connecting segment of juxtamedullary and some of mid-cortical nephron join to form an arcade that ascends in the cortex before draining into initial collective tubules. The collecting tubules lined by cuboidal epithelial tissue with relatively large nucleus occupy the entire cell and reset on visible basement membrane, the cytoplasm of cuboidal cells was pale and has dark oval nucleus (34).

The collecting duct begins in the cortex and descends to reach the tip of the papilla and during it is course, there is an increase in diameter from cortical portion to terminal segment at the area cribrosa and divided into cortical collecting duct and medullary collecting duct, the cortical colleting duct lined by cuboidal epithelium tissue and the medullary collecting duct by tall columnar epithelium tissue with nucleus para-basal in location and well cellular outline, pale stain cytoplasm and there is no brush border. The medullary collecting duct represents the terminal portion of collecting duct called papillary duct (duct of Bellini) that passes down through the medulla and opens onto a papilla. The collecting duct when descends through the deep medulla, the collecting duct join in successive fusion forms arborescent architectural arrangement and there is significant increase in diameter and lined by tall columnar epithelium cells and gradually altered into transitional near renal papilla (35, 36).

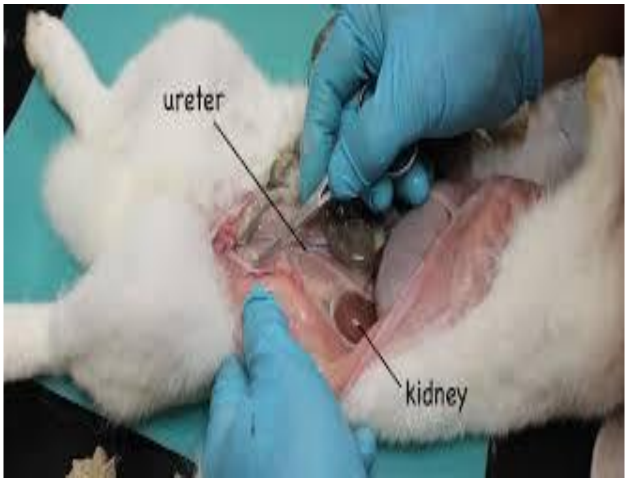

Figure 1. Gross section to the kidney in the rabbit.

Figure 2. Anatomical section of the kidney showed the cortex (C) and the medulla (M).

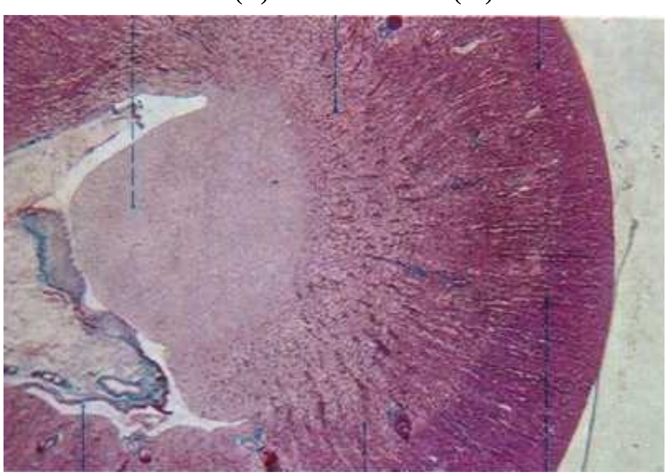

Figure 3. Histological section of the kidney showed the unilobular arrangement H&E X40.

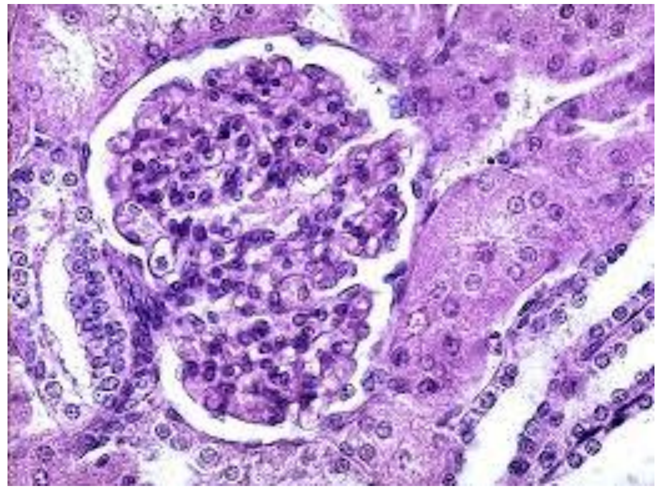

Figure 4. Histological section of the kidney showed the renal corpuscle H&E X400.

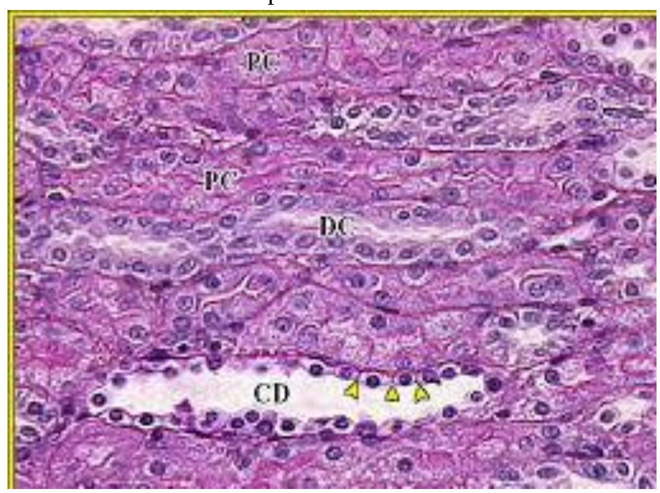

Figure 5. Histological section of the kidney showed the renal tubules which they are proximal convoluted tubule (PC), distal convoluted tubules (DC) and collecting duct (CD) H&E X400.

CONCLUSIONS

It was concluded from the highlight on this report that the rabbit have two single-partition kidneys with cortex and medulla that supplied with renal arteries from aorta, while histologically the kidney is unipapillary and composed of a superficial capsule, a dark and vascular outer cortex, and a less vascular inner medulla. Cross-sections reveal renal corpuscles, convoluted tubules, and cortical loops of Henle. The distribution of renal corpuscles varies, being sparse in the superficial cortex, more numerous in the mid-cortex, and fewer in the juxtamedullary region. The medulla contains straight tubules, collecting ducts, and a dense capillary network. Three types of renal corpuscles exist based on location: cortical, mid-cortical, and juxtamedullary. Juxtamedullary corpuscles are the largest and are associated with higher filtration rates and longer loops of Henle, contributing to more efficient urine concentration.

REFERENCES

1) Assan, N. (2017). The significance of crossbreeding in influencing growth traits, reproduction and carcass characteristics in rabbits. Scientific Journal of Review 6(11), 555-562
2) 2. Jacobsen, I. A. (1978). Renal transplantation in the rabbit: A model for preservation studies. Laboratory Animals, 12(2), 63-70
3) 3. Sabourdry M.A (1988). Breeding and care of Laboratory animals. Vol. 1 WHO document (WHO / LAB /88.1) (Original French).
4) 4. Dutta,S., Sengupta, P. (2016). Rabbits and men: A brief review of the use of rabbits as laboratory animals in basic and applied research. International Journal of Preventive Medicine, 7(1), 56.
5) 5. Hristov, H.; Kostov, D.; Vladova, D., (2006). Topographical anatomy of some abdominal organs in rabits. Trakia J. Sci., 4,3: 7-10.
6) 6. Eken E., Çorumluolu Ö., Paksoy Y., Befloluk K., Kalayc b., (2009). A study on evaluation of 3D virtual rabbit kidney models by multidetector computed tomography images. doi:10.2399/ana.09.009.
7) 7. Alfidi RJ, Macintyre WJ, Meaney TF, et al., (1975). Experimental studies to determine application of CAT scanning to the human body. Am J Roentgenol; 124: 199-207.
8) 8. Capello, V. (2016). Diagnostic imaging of dental disease in pet rabbits and rodents. Veterinary clinics of north America: Exotic Animal Practice, 19(3), 757-782.
9) 9. Junqueira, L. C., and Carneiro J. (2005). Basic Histology: Text and Atlas (11th ed.). McGraw-Hill.
10) 10. Ritchison, G. (2008). Avian osmoregulation. Urinary system, salt glands and osmoregulation. J. Exp. Biol., 554:17-31.
11) 11. Salehi, E., and Morovati, M.S. (2012). Kidney Morphogenesis during Prenatal Development in Camelus dromedaries Embryoes. J. Anim. Vet. Adv., 1(6), 822-825.
12) 12. Awal1 M. A., Alam1 J., Kurohmaru M., Yabuki A., and M. Matsumoto, (2014). Sex-dependent kidney morphology of guinea pig – light microscopy and immunohistochemical study. Kagoshima University, 21-24-1, Korimako, Kagoshima -890-0065, Japan.
13) 13. Dyce, K.; Sack, W. and Wensing, C. (2010). The urogenital apparatus. In: Textbook of Veterinary Anatomy. 4nd edition, W. B. Saunders Company.
14) 14. Dimitrov R., Kostov D., Stamatova K., Yordanova V., (2012). anatomotopographical and morphological analysis of normal kidneys of rabbit (oryctolagus cuniculus . Trakia Journal of Sciences, Vol. 10, No 2, pp 79-84.
15) 15. Tomov I., and Naumov N., (1992). The Echographic Diagnosis in Internal Medicine. Medicine and Physical Education State Publishing House, Sofia, pp. 114-120.
16) 16. Bone, J.F. (1979). Animal anatomy and physiology .Reston publishing company Virginia. P: 280.
17) 17. Hamada, A. G. (2011). Clinical Anatomy and Histology of Compensatory of Renal Hypertrophy after Unilateral and Subtotal Nephrectomy in Rabbits (Oryctoagus cuniculus). University of Bagdad. Phd thesis.
18) 18. Jafar G.A and Farhar O.R., (2012). Histomorphological study of tubular system and collecting tubules in domestic rabbit's fetuses (Oryctolagus cuniculus), Kufa Journal For Veterinary Medical Sciences Vol. (3) No. (1).
19) 19. Supuka, P., Mazensky, D., Danko, J., Supukova, A., and Petrovova, E. (2014). Anatomical description of the renal arteries and veins in the European rabbit. Biologia, 69(7), 1059-1064.
20) 20. Maher, M. A., Palacio, L., Henao, J. C., and Elsharkawy, S. H. (2024). Gross morphological and ultrasonographic dimensions of normal feline kidney with referenceto resistive index. Veterinary Sciences, 11(10), 14209.
21) 21. Kuehnel, W. (2003). Color Atlas of Cytology, Histology and Microscopic Anatomy .4th ed. Thieme Stuttgart. New York. P: 352-372.
22) 22. Hussin, A.M., (2003). Seasonal Histological changes in kidney of one humped camel Camelus dromedarius in middle of Iraq. A thesis Vet. Medicine College, University of Baghdad. PP:29-32.
23) 23. Young, B., O'Dowd, G., and Woodforf, P. (2014). Whearer's Functional Histology: A text and Colour Atlas (6th ed.). Elsevier Health Sciences.
24) 24. Eurell, J. A., & Frappier, B. L. (2013). Dellmann's Textbook of Vetrinary Histology (6th ed.). Wiley-Blackwell.
25) 25. Dellmann, H. D. (1993). Textbook of Veterinary histology. 3rd ed. Lea and Febiger, Philadelphia P: 210-220.
26) 26. Bankir, L. and Farman, N. (1973). heterogeneite des glomlerules chez le lapin, Archs Ana. Microsc. Norph. Exp., 62:281-291.
27) 27. Hanssen, D. E. (1961): The frequency of temporarily inactive glomeruli in mice under physiologic condition. Acta Path. Micr. Scan., 53: 253–259.
28) 28. Inoue, C.N.; Kondo, Y.; Ohnuma, S.; Morimoto, T.; Nishio, T.; Iinuma, K. (2000). Use of cultured tubular cells isolated from human urine for investigation of renal transporter. Clin. Nephrol., 53, 90–98.
29) 29. Bacha, W.J. and Bacha, L.M. (2000). Color Atlas of Veterinary Histology. 2nd ed. Donna Balado. Lippincott Williams and Wilkins, p: 163-174.

30) 30. Charmi, A.; Parto, P.; Bahmani, M. and Kazemi, R. (2010). Morphological and Histological Study of Kidney in Juvenile Great Sturgeon (Huso huso) and Persian Sturgeon [Acipenser persicus]. American-Eurasian J. Agric. & Environ. Sci., 7 (5): 505- 511.

31) 31. Abdalla, M. and Abdalla, O. (1979). Morphometric observations on the kidney of the Camel, Camelus dromedaries.J.Anat. 129:45-50.

32) 32. Heino, V.; Teresa S.; Eleanor, A.; Gary, V.; Desir, D. (2001). The distal convoluted tubule of rabbit kidney does not express a functional sodium channel. Am. J. Renal Physiology. 280:F530-F539.

33) 33. Dellmann, H. D. and Brown, E. M. (1987). Text book of Veterinary histology "Urinary System". 3rd ed., Lea and Febiger, Philadelphia.

34) 34. Ross, M. H., & Pawlina, W. (2020). Histology: A text and Atlas (8th ed.). Wolters Kluwer.

35) 35. Vehaskari VM (1994) Ontogeny of cortical collecting duct sodium transport. Am J Physiol 267:F49-54

36) 36. Schuster VL (1993) Function and regulation of collecting duct intercalated cells. Annu Rev Physiol 55:267 –288.