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ABSTRACT

Background: It is important to know the morphology of the glomerulus in order to explain kidney infiltration. The present study aims to research the morphology of afferent and efferent domains of sheep kidney glomeruli.

Materials and methods: In this study, 2000 glomeruli from 20 kidneys of Akkaraman sheep were examined using the polyester resin method.

Results: It was found that the glomeruli of sheep kidney usually have an afferent arteriole as well as an efferent arteriole. Besides, it was also found that five glomeruli have two efferent arterioles. It is known that the afferent domain constitutes the largest part of the glomerulus. In two of the glomeruli that we examined, the afferent domain forms the ½ of the glomeruli wherein the other two glomeruli afferent domain forms the ¾.

Conclusions: It is known that there are many anastomoses between the afferent and efferent domain capillaries. However, it is not well-explained how anastomosis is created between the afferent and efferent domains. In our study, it was identified that those anastomoses are not inside the lobes but between the surrounding capillaries.

Key words: morphology, sheep glomerulus, afferent arteriole, efferent arteriole
INTRODUCTION

Kidney is a significant organ which controls homeostasis, water volume and electrolytes in blood, blood pressure. The foremost function of the kidney is urine filtration. Histologically, the kidney is formed of peripherally situated cortex and a centrally located medulla. The cortex is very rich in nephrons that considered the main functional unit consisting of the renal corpuscle and renal tubules. On histological specimens, renal corpuscle looks like a small rounded structure that has a centrally located glomerulus surrounded peripherally with Bowman's capsule. The glomerulus is a collection of capillaries lined united by a delicate mesangial matrix, while, the Bowman's capsule consists of two epithelium layers: visceral (envelops glomerulus) and parietal [1].

It is essential to know the morphology of the glomerulus in order to explain kidney infiltration. In 1666 Malpighi first described the glomeruli and demonstrated their continuity with the renal vasculature. About 175 years later, Bowman elucidated in detail the capillary architecture of glomerulus and the continuity between its surrounding capsule and the proximal tubule [2, 3]. The renal corpuscle consist of a tuft of interconnected capillaries and an enclosing capsule named after Bowman. The term ‘’Glomerulus’’ is commonly used refer to glomerular capillary tuft and Bowman’s capsule, although the term ‘’renal corpucle’’ is more accurate in a strick ball of capillaries. Providing structural support for the capillary tuft is a central region termed the mesangium, which contains cells and their surrounding matrix material. The capillaries are thin layer of endotelial cells, contain a basement membran, and covered by epitelial cells that form the visceral layer of Bowman’s capsule. The parietal epithelium is continous with the visceral epithelium at the vascular pole where the afferent arteriole enters the glomerulus and the efferent arteriole exits [3, 4].

The human glomerulus average diameter is 200 µm, juxtaglomedullary glomeruli is approximately 20 to 50% greater than superficial glomeruli in mammals [3, 4].

Afferent arteriole capillaries entering the Bowman’s capsule form the afferent domain via heading towards the urinary pole. These capillaries bend into the urinary pole in a U shape to form an efferent domain. Capillaries of efferent domain merge and form efferent arteriole. Efferent arteriole leaves the glomerulus from the blood vascular pole [5, 6].

The glomerular tuft, originating from afferent arteriole that enters from the vascular pole, separates into lobules. Each lobule has an afferent and efferent domain. The afferent domain of lobules constitutes most of the glomerular tuft. The human and some animals, the
glomerular tuft is split into three to eight lobules [3, 6, 7].

The efferent domain is located in the middle of the afferent domain [6, 8]. Glomeruli have an afferent domain and efferent arteriole. Some animals glomeruli have two afferent or four efferent arterioles [5, 8, 9].

The diameter of the efferent arteriole is smaller than the diameter of the afferent arteriole [5, 8, 10, 11].

There are a few studies investigating sheep kidney glomerulus. These studies can not show the morphology of sheep glomerulus clearly [11, 12, 13]. It is known that there are anastomoses between the capillaries of the afferent and efferent domains. However, it is not explained how these anastomoses are formed [5, 7, 14, 15]. The present study aims to research the morphology of afferent and efferent domains of sheep kidney glomeruli.

MATERIALS AND METHODS

Twenty sheep kidneys from 10 Akkaraman sheep (12-20 months old and 35-45 kg) were used in this study. Ten ml physiological saline containing 2% heparin was injected into the renal arteries after cleaning the tissues surrounding the kidney. In order to show the glomeruli, 15 ml of the polyester resin solution was injected into renal arteries with a 120-mmHg pressure. Twenty-four hours passed for the solidification of the polyester solution. The kidneys were put into a 37% HCL solution for 24 hours. Kidney tissues that were dissolved were washed under tap water and air-dried. With the use of a stereomicroscope, glomeruli with afferent and efferent domains were dissected with a forceps from the blood vessels of the kidneys (2000 glomeruli were analyzed on average) [11, 16, 17]. Isolated glomeruli were placed in metal plates, and then they were covered with gold in a vacuum evaporator (Polaron 7650 Mini Sputter Coater). They were studied with a scanning electron microscope (LEO 440).

RESULTS

In this study, the afferent and efferent domains of sheep glomeruli were investigated using the polyester resin method. The morphology of sheep kidney glomeruli is shown well with this method.

All of the sheep glomeruli studied have an afferent and efferent arteriole (Figs.1-
Glomeruli of sheep kidneys usually have five lobules (Figs. 1,10).

Branches of afferent arterioles form a ring-like cavity in the blood vascular pole of the glomerulus. Efferent arterioles that are formed by merged capillaries of the efferent domain come through this cavity (Figs. 1,2,5,9).

The capillaries of the efferent arteriole join at the vascular pole to form an efferent arteriole. Sometimes in the case of a failure of this joining, the glomerulus might have two efferent arterioles. In this study, five glomeruli having two efferent arterioles (5/2000) are observed (Figs. 5,6) Although the afferent domain constitutes most of the glomerular tuft, it is identified that the afferent domain forms ¾ of the glomerulus in two cases and ½ of the glomerulus in two other cases (Figs. 3, 4).

The outer surface of each lobule of sheep glomerulus is convex, whereas the inner surface is concave. The efferent domain resides in the flat inner surface of the lobule (Figs. 2,5). Anastomoses that are between the afferent domain arterioles show protrusions that are similar to the gyri of the brain. Some of these structures resemble the letters U, O, S, J, and H. There are holes inside the cavities between those protrusions (Figs. 7, 8).

Anastomoses that are located between the capillaries of the afferent and efferent domains exist around the lobule. There are no capillary anastomoses inside the lobule (Figs. 1, 9).

The average diameter of all glomerular capillary tufts is 139.5 µm, the average value for afferent arterioles is 12.08 µm, and the same value for efferent arteriole is 11.18 µm. The diameter of the afferent arterioles is greater than the diameter of the efferent arterioles.

DISCUSSION

Knowledge of glomerulus morphology is of great importance in explaining kidney infiltration. Therefore, the afferent and efferent domains of the glomerular tuft have been studied with different methods for years [5-11, 14, 18, 19]. The renal glomeruli of the sheep don’t explained yet, by corrosion casting method. The glomerulus is located in the cortex of the kidney. The cortex is studied in three parts: outer, middle, and inner cortex. In this study, the middle and outer cortex of 2000 sheep kidney glomeruli are examined [20]. It is known that at the origin of afferent arterioles from interlobular arteries [12], the sheep glomerulus origin afferent arteriole from interlobular arteries in our study. In our study, afferent arteriole
separated into five branch entered the Bowman’s capsule. Every branch of afferent arterioles constitute a lobule of glomerulus. Glomeruli of sheep kidneys usually have five lobules (Figs. 1,10). Every lobules has an afferent domain and efferent domain. Every efferent domain capillary is merge with each other constitute efferent arteriole. Capillary of every lobule anastomosed with each other, this capillary don’t anastomosed the other capillary of lobule.

Recent studies indicate that mouse, rabbit, dog, sheep, and human glomeruli have 2-8 lobules [3, 6, 7]. In our study, it is observed that sheep glomeruli have five lobules (Figs. 1, 10). Human glomerulus in health and disease shows that the human glomerulus comprises seven lobule-like structures with numerous anastomoses but there are no direct anastomoses between the afferent and efferent arterioles [13]. In our study, Akkaraman sheep glomerulus comprises five lobules. Every lobules has afferent and efferent domain. This domain’s of lobule don’t anastomoses other lobules. There are direct anastomoses between this domain’s arterioles.

Recent studies and our study show that the afferent domain composes most of each lobule or outer surface of the glomerular tuft. The efferent domain resides in the middle of the afferent domain [6]. Although the same cases are observed in our study, it is also indicated that the afferent domain forms ¾ of the glomerular tuft, whereas in the other two cases the afferent domain constitutes ½ of the glomerular tuft (Figs. 3, 4).

Various studies show that each glomerulus has one afferent arteriole. It is identified in our study that all sheep glomeruli have one afferent arteriole. However, same investigations shows that there are two or four afferent arterioles in a glomerulus. One of these feeds two lobules, whereas the other one feeds three lobules [5, 8, 9].

It is known that the efferent domains merge and form an efferent arteriole in the glomerulus. Sometimes when the merging fails, two or four efferent arterioles exist [5, 8, 17, 19]. Five glomeruli are identified in our study having two efferent arterioles (Figs. 5, 6).

Our investigations sheep glomeruli average diameter is 139.5 µm. The glomerulus average diameter is 200 µm. Juxtaglomerulillary glomeruli is approximately 20 to 50% greater than superficial glomeruli in mammals, other have found no significant size difference between these glomerular population in the normal human adult kidney [3, 4].

The calibres of the afferent and efferent arterioles of the glomeruli appear in the casts to be about the same. In the human juxtaglomerulillary glomeruli the afferent and efferent arterioles are of equal calibre, while in the cortical glomeruli the efferent arterioles are much
narrower than the afferent (Trueta, Barclay, Daniel, Franklin & Prichard, 1947). In the fowl, arterioles of both cortical and juxtaglommedullary glomeruli appear to be equal in diameter (22).

As in recent animal research, the diameter of the efferent arteriole is smaller than the diameter of the afferent arteriole [5, 8, 10, 11]. In the sheep the diameter of the afferent arteriole was greater than that of the efferent arteriole [12]. In our study afferent arteriole diameter is 12.08 µm, efferent arteriole diameter is 11.18 µm. The smaller diameter of efferent arteriole has great importance in filtration [11].

The total length of the capillaries in a single glomerulus is 0.95 cm. The total surface area of all glomerular capillaries is 6,000 cm² [13]. We have not measured the total length or total surface area of the capillaries in a single glomerulus.

Protrusions like the gyri of the brain were observed on the outer surface of afferent domain capillaries in our research (Figs. 7). It is understood that those protrusions are the anastomoses located between the capillaries. These structures that are formed by afferent domain resemble letters U, O, S, J, and H (Figs. 7, 8). This suggests that these protrusions have an essential role in filtration.

CONCLUSIONS

The morphology of sheep kidney glomeruli is shown well defined with corrosion method. Afferent arteriole separated into five branch entered the Bowman’s capsule in sheep glomeruli. Every branch of afferent arterioles constitute a lobule of glomerulus. Glomeruli of sheep kidneys usually have five lobules. Every lobules has an afferent domain and efferent domain. Every efferent domain capillary is merge with each other constitute efferent arteriole. Capillary of every lobule anastomosed with each other, this capillary don’t anastomosed the other capillary of lobule. Anastomoses that are located between the capillaries of the afferent and efferent domains exist around the lobule. There are no capillary anastomoses inside the lobule. There are holes inside the cavities of lobule.

The efferent domain resides in the flat inner surface of the lobule. The capillaries of the efferent arteriole join at the vascular pole to form an efferent arteriole. All of the sheep glomeruli have an afferent and efferent arteriole. Sometimes sheep glomerulus might have two efferent arterioles.

The diameter of the afferent arterioles is greater than the diameter of the efferent
arterioles. Anastomoses that are between the afferent domain arterioles show protrusions that are similar to the gyri of the brain. Some of these structures resemble the letters U, O, S, J, and H.

It is believed that the present study has a vital role in revealing the morphology of human or mammals glomeruli.

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**Figure 1.** Afferent domain of the sheep. Lob of the glomerulus (1–5), Capillary anastomoses between afferent and efferent domain (White arrow), No capillary anastomoses on the internal surface of the glomerular lob (dotted arrow), and Exit pore of the efferent arteriole (6).
Magnification x423

**Figure 2.** Glomerulus of the sheep. Afferent arteriole (1), Efferent arteriole (2). External view shows gyri of the cerebrum. Magnification x515.
**Figure 3.** Afferent domain covers 3/4 of the glomerular tuft. Afferent arteriole (domain) (1), Efferent arteriole (domain) (2). Magnification x 436

**Figure 4.** Afferent and efferent domain covers 1/2 of the glomerular tuft. Afferent arteriole (1), Efferent arteriole (2). Magnification x 41
Figure 5. Two roots of the efferent arteriole are merged out of the glomerulus. Afferent arteriole (1), Efferent arteriole (2). Magnification x370

Figure 6. Five sheep glomeruli have two efferent arterioles. Afferent arteriole (1), Efferent arteriole (2). Magnification x50
Figure 7. Capillary enlargement of the external surface of afferent domain. (S,C,H,O,U and J shape).

Figure 8. Capillar anastomoses in one lobule of the afferent domain (White arrow).
**Figure 9.** Schematic view of a lob of glomerular microvasculature. 1-Afferent arteriole, 2-Afferent domain, 3-Internal surface of the glomerular lobule (hollow in shape) (There is no capillary anastomoses between afferent and efferent arteriole in here), 4-Capillary enlargement of the afferent domain in gyrus shape, 5-Capillary anastomoses between afferent and efferent domain, 6-Efferent domain, 7-Efferent arteriole, 8-One lob of glomerulus

**Figure 10.** Schematic view of the glomerular lobe. 1,2,3,4,5-Afferent domain and afferent arteriole divided in five lob, 6-Afferent arteriole, 7-Efferent domain, 8-Efferent arteriole