# Intrarenal Segmentation of the Renal Arteries in the Red Fox (*Vulpes Vulpes Leinnoleus 1758*) from Anatolia.

**Zekeriya Özüdoğru[1], Derviş Özdemir[2*], Mehmet Can[3], Gürsoy Aksoy[4]**

[1]Department of Anatomy, Faculty of Veterinary Medicine, University of Aksaray, Aksaray, Turkey.
[2]Department of Anatomy, Faculty of Veterinary Medicine, University of Atatürk, Erzurum, Turkey.
[3]Department of Anatomy, Faculty of Veterinary Medicine, University of Balıkesir, Balıkesir, Turkey.
[4]Department of Anatomy, Faculty of Veterinary Medicine, University of Kafkas, Kars, Turkey.

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**Abstract:** This study was carried out to determine the biometric parameters and intrarenal segmentation of the renal arteries of kidney in the Red fox (*Vulpes Vulpes Leinnoleus 1758*). Corrosion cast method was applied to fourteen kidneys. It was found that the means for diameter of the aorta abdominalis, arteria renalis dextra and arteria renalis sinistra were 6.09 mm, 2.45 mm and 1.94 mm, respectively. Arteria renalis dextra was longer than the left artery. The renal arteries were divided into the dorsal and ventral branches. Both dorsal and ventral branches gave off the arteria interlobaris, arteria arcuata and arteria interlobularis, respectively. The right dorsal branch gave off 6 to 7 segmental arteries, the right ventral branch 5 to 7 segmental arteries, the left dorsal branch 6 to 8 segmental arteries and the left ventral branch 4 to 7 segmental arteries. Double renal arteries were determined in 3 of 10 (30%) kidneys but only on the left side. As a result, arterial vascularization of red fox kidneys was examined and similarities and differences with other animal species were determined.

***Keywords**: Aorta abdominalis, Arteria renalis, Division, Kidney, Red fox.*

## Anadolu'daki Kırmızı Tilki (*Vulpes Vulpes Leinnoleus 1758*) Böbrek Arterlerinin İntrarenal Segmentasyonu

**Özet:** Bu çalışma Kızıl tilkinin (*Vulpes Vulpes Leinnoleus 1758*) böbrek arterlerinin biyometrik parametrelerini ve intrarenal segmentasyonunu belirlemek amacıyla yapıldı. Ondört adet böbreğe ait arterlere korozyon kast yöntemi uygulandı. Aorta abdominalis ile arteria renalis dextra ve arteria renalis sinistra'nın çaplarının ortalamaları sırasıyla 6.09 mm, 2.45 mm ve 1.94 mm olarak ölçüldü. Arteria renalis dextra arteria renalis sinistra'dan daha uzundu. Renal arterler dorsal ve ventral dallara ayrılmaktaydı. Dorsal ve ventral dallar sırasıyla arteria interlobaris, arteria arcuata ve arteria interlobularis'I vermekteydi. Sağ dorsal dal, 6-7 segmental artere, sağ ventral dal 5-7 segmental artere, sol dorsal dal 6-8 segmental artere ve sol ventral dal ise 4-7 segmental artere bölünmekteydi. Duble böbrek arteri 10 (% 30) böbrekten 3'ünde, sadece solda tespit edildi. Sonuç olarak, kızıl tilki böbreklerinin arterial vaskularizasyonu incelenerek, diğer hayvan türleriyle olan benzerlik ve farklılıkları ortaya konulmuştur.

***Anahtar Kelimeler:** Aorta abdominalis, arteria renalis, böbrek, kırmızı tilki, segmentasyon.*

## Introduction

The kidneys are fed by the arteria renalis dextra et sinistra originating from the aorta abdominalis (Aksoy and Ozudogru, 2003; Aslan, 1995; Atalar and Yilmaz, 2004; Christensen, 1952; Fuller and Huelke, 1973; Jain and Singh, 1987; Kurtul *et al*., 2002; Nickel *et al*., 1981; Ozdemir *et al*., 2009; Ozudogru and Ozdemir, 2005; Ozudogru *et al*., 2017; Reis and Tepe, 1956; Shively, 1978; Singh *et al*., 1982; Wiland and Indykiewicz, 1999). Renal arteries arrise sometimes double or multible renal artery (Brudnicki *et al*., 1986; Goscicka and Tomasik, 1979; Pollak *et al*., 1986; Reis and Tepe, 1956; Sajjarengpong and Adiektaworn, 2006; Wiland *et al*., 1996; Wiland and Indykiewicz, 1999). The renal arteries give rise to the ventral and dorsal branches before entering at the kidney's hilus. Ventral and dorsal branches are separated into interlobar, arcuate and interlobular arteries, respectively (Evans and Christensen, 1993; Hadziselimovic and Cus, 1975; Maros *et al*., 1984; Horacek and Earle, 1987; Marques-Sampaio *et al*., 2007; Mazensky and Flesarova, 2017; Pereira-Sampaio *et al*., 2004; Smith, 1999). Although many articles on fox kidney arteries have been published in the literature (Brudnicki *et al*., 1996; Hadziselimovic and Cus, 1975; Nowicki, 2005; Wiland *et al*., 1996), there are no reports on the details about this vessel's segmentation, biometric parameters and relationship with fox kidney. We have aimed to examine the biometric parameters and intrarenal segmentation of renal arteries in Red Fox.

## Materials and Methods

Red foxes brought to the clinic of Ataturk University Veterinary Faculty for treatment but not able to be treated were sent to Department of Anatomy. In the study, kidneys of seven adult foxes were used without gender differences. Corrosion cast method was applied to the arteries of the kidneys (Nerantsiz *et al*. 1978, Sindel *et al*. 1990, Tompset 1970). The arteries were washed with 0.9% salt solution via a cannula placed in the aorta abdominalis. The renal arteries were injected with takilon, 20% powder monomethyl-methacrylate and 80% liquid polymethyl-methacrylate. Polymerization was carried out at room temperature for 24 hours to these materials. They were exposed to corrosion at 30% KOH at 60 ° C for 24-48 hours. for 24 hours 48 hours and then washed with tap water. These materials had photographed. An electronic calibrator was used for measurements. Descriptive statistics have been made with the help of excel program.

## Results

The biometric parameters and intrarenal division of the arteria renalis in the Red Fox was investigated. The diameter and lengths of the arteriae renales and their branches had been given in the Table 1 and 2. It was determined that aorta abdominalis was 6.09 mm diameter, arteria renalis dextra was 2.45 mm diameter and arteria renalis sinistra was 1.94 mm, on average in Red fox. The distance of arteria renalis dextra et sinistra was 5.56 mm. Arteria renalis dextra was 2.09 cm far from the hilus and arteria renalis sinistra was 2.08 cm. Arteria renalis dextra slightly arose cranial to the arteria renalis sinistra and was longer (Figure 1, 2). Arteria renalis dextra et sinistra gave dorsal and ventral branches after 1.46 cm and 1.19 cm from the hilus respectively. Furthermore, in three samples, ventral and dorsal branches of arteria renalis sinistra arose from abdominal aorta directly (Figure 1, 2).

**Table 1.** Biometric parameters of the aorta abdominalis, arteria renalis dextra et sinistra.

| Character | **1** | **2** | **3** | **4** | *Mean* | | **5** | **6** | **7** | *Mean* |
|---|---|---|---|---|---|---|---|---|---|---|
| Diameter of aorta abdominalis (mm) | 5.44 | 5.84 | 5.72 | 5.34 | | | 7.23 | 6.92 | 6.12 | 6.09 |
| Diameter of arteria renalis dextra (mm) | 2.09 | 2.19 | 2.28 | 1.98 | | | 2.91 | 3.24 | 2.45 | 2.45 |
| Diameter of arteria renalis sinistra (mm) | 2.04 | 1.98 | 2.13 | 1.62 | 1.94 | Dorsal branch | 2.00 | 2.78 | 1.94 | 2.34 |
| | | | | | | Ventral branch | 1.34 | 2.35 | 1.67 | 1.78 |

**Table 2.** The number and lengths of the arteriae renales and their branches.

| **N** | **1 6d** | **2 6s** | **3 7d** | **4 7s** | **5 1d** | **6 1s** | **7 5d** | **8 5s** | **9 4d** | **10 4s** | **11 2d** | **12 2s** | **13 3d** | **14 3s** | **M** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **D** | | | | | | | | | | 2.23 | | 1.90 | | 2.68 | 2.08 |
| **V** | | | | | | | | | | 2.19 | | 1.75 | | 2.43 | 2.12 |
| **L** | 1.67 | 1.40 | 1.83 | 1.35 | 2.37 | 2.10 | 1.89 | 1.36 | 3.18 | | 2.52 | | 3.32 | | 2.09 |
| **W** | 1.18 | 1.03 | 1.25 | 1.01 | 1.09 | 1.19 | 1.14 | 1.19 | 1.78 | double | 1.44 | double | 1.84 | double | 1.29 |
| **Dn** | 5 | 4 | 6 | 5 | 6 | 6 | 7 | 6 | 6 | 6 | 6 | 8 | 6 | 7 | 6 |
| **Vn** | 5 | 4 | 5 | 5 | 6 | 5 | 7 | 6 | 5 | 4 | 7 | 7 | 5 | 7 | 5.57 |
| **X** | 4.43 | 5.37 | 4.62 | 3.00 | 7.35 | 7.12 | 7.03 | 5.56 | | | | | | | |

N: Number of kidney, D: Length of the dorsal branch before giving the first interlobar artery (cm), V: Length of the ventral branch before giving the first interlobar artery (cm), L: Length of arteria renalis from its origination to the hilus of the kidney (cm), W: Length of arteria renalis dextra et sinistra before bifurcating the dorsal and ventral branch, Dn: Number of arteria interlobaris originating from the dorsal branch, Vn: Number of arteria interlobaris originating from the ventral branch, X: Distance between the origins of the arteria renalis dextra et sinistra, M: Mean value, d: Right, s: Left.

It was observed that right dorsal branch gave off 6 to 7 arteriae interlobares dextra, the right ventral branch ramified as 5 to 7 arteriae interlobares dextra, the left dorsal branch gave off 6 to 8 left arteriae interlobares sinistra and the left ventral branch ramified as 4 to 7 left arteriae interlobares sinistra (Figure 3-6). In one sample, 2 arteriae interlobares were found to be fed from the ventral branch of the arteria renalis sinistra for the dorsal surface of the kidney.

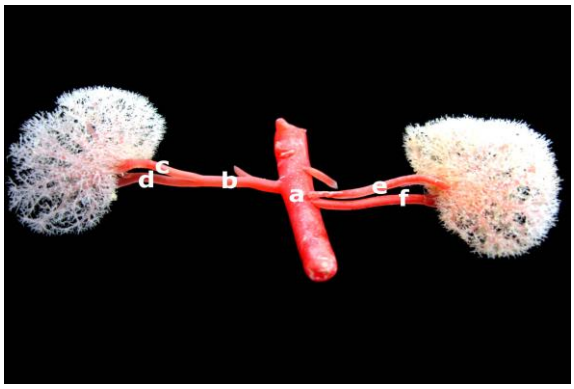


**Figure 1.** Ventral view of the intrarenal branches of the renal arteries. a. Aorta abdominalis, b. arteria renalis dextra, c. Right ventral branch, d. Right dorsal branch, e. Left ventral branch, f. Left dorsal branch.

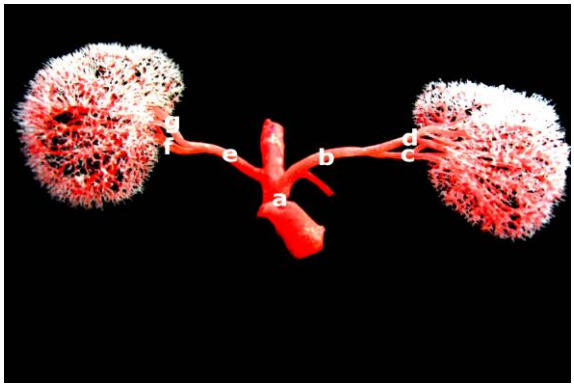


**Figure 2.** Dorsal view of the intrarenal branches of the arteriae renales. a. Aorta abdominalis, b. Arteria renalis dextra, c. Right ventral branch, d. Right dorsal branch, e. Arteria renalis sinistra, f. Left ventral branch, g. Left dorsal branch.

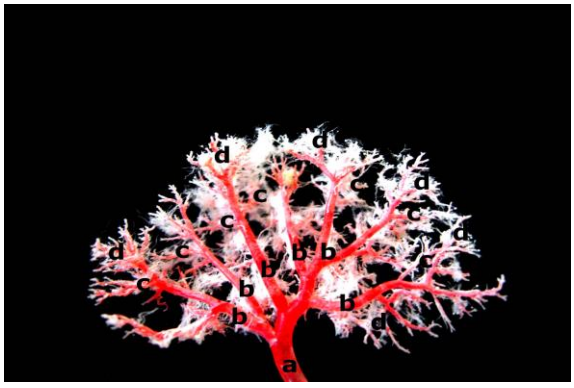

**Figure 3.** Ventral view of the arteria renalis dextra. a. Right ventral branch, b. Right ventral interlobar arteries, c. Right ventral arcuate arteries, d. Right ventral interlobular arteries.

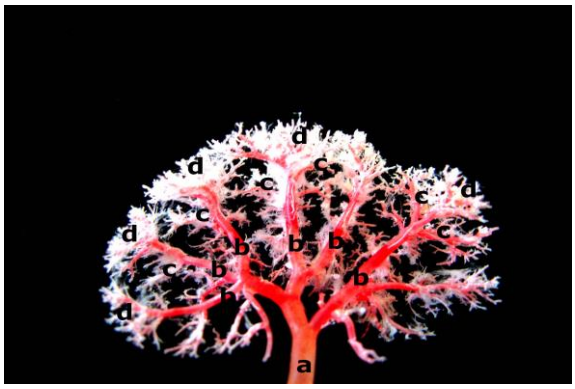


**Figure 4.** Dorsal view of the arteria renalis dextra. a. Right dorsal branch, b. Right dorsal interlobar arteries, c. Right dorsal arcuate arteries, d. Right dorsal interlobular arteries.

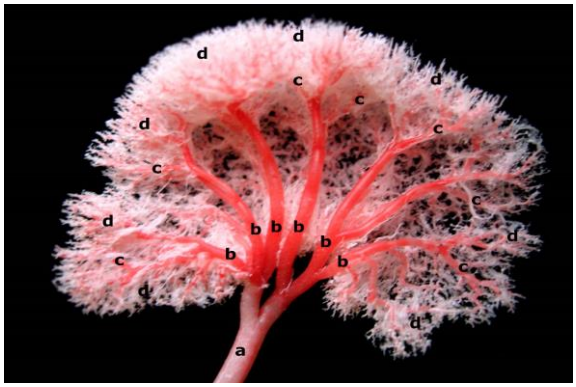


**Figure 5.** Dorsal view of the arteria renalis sinistra. a. Left dorsal branch, b. Left dorsal interlobar arteries, c. Left dorsal arcuate arteries, d. Left dorsal interlobular arteries.

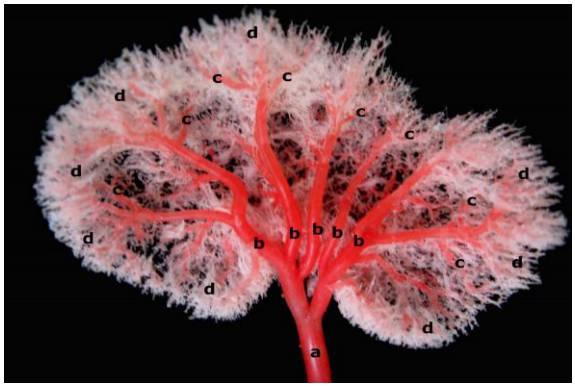

**Figure 6.** Ventral view of the arteria renalis sinistra. a. Left ventral branch, b. Left ventral interlobar arteries, c. Left ventral arcuate arteries, d. Left ventral interlobular arteries.

## Discussion

Nowicki (2005) reported that diameter of the aorta abdominalis; arteria renalis dextra et sinistra were 6.41 mm, 3.05 mm and, 2.71 in wild fox and 5.46 mm, 2.87 mm and 2.82 mm in silver fox on average respectively. We found that diameter of the aorta abdominalis; arteria renalis dextra et sinistra were 6.09 mm, 2.45 mm and 1.94 mm on average, respectively. In addition, in three

materials, the ventral and dorsal branches of the arteria renalis sinistra arose directly from aorta abdominalis. Diameters of dorsal and ventral branches were found 2.34 mm and 1.78 mm on average, respectively.

In the literature, frequency of double arteriae renales have been shown to be (Christensen, 1952), 24.79% (29 from 117 kidneys in dogs); (Reis and Tepe, 1956), 12.80% (64 from 500 dogs); (Shively, 1978) 13.40% (67 from 500 dogs ); (Brudnicki *et al*., 1986), (in racon dogs), (Pollak *et al*., 1986), 23% (184 from 800 kidneys); (Ulutas *et al*., 1987), 16.3% (14 from 92 kidneys); (Brudnicki *et al*., 1996), (in blue fox), (Wiland and Indykiewicz, 1999), 20% (7 from 35 dogs ); (Aksoy and Ozudogru, 2003), (1 from 12 kidneys in Van cats); (Bordei *et al*., 2004), 20% (54 from 272 kidneys); (Sajjarengpong and Adiektaworn, 2006), 9.72% (14 from 144 dogs); (Marques- Sampaio *et al*., 2007), 11.6% (11 from 95 kidneys in dogs). In the present research, frequency of double renal arteries was 30% (3 from 10 kidneys). In the present study double arteria renales were observed only on the left side. Christensen (1952), Reis and Tepe (1956), Shively (1978), Wiland and Indykiewicz (1999), have reported the observation of double arteriae renales on both sides in dogs, in humans,, but they had stated that the incidence of double arteriae renales was higher on the left side than on the right side. Similar to the findings of our study, on the otherhand, Wiland and Indykiewicz (1999) and Sajjarengpong and Adiektaworn (2006), observed double arteriae renales in minks and in dogs, respectively, only on the left side. Reis and Tepe (1956), Wiland and Knasiecka (1970), Shively (1978), Brudnicki *et al*. (1986), Sampaio and Passos (1992) have reported the observation oftriple and multiple arteriae renales, although we did not observe multiple arteriae renales in this study. Arteria renalis dextra was found longer than arteria renalis sinistra in our study. Christensen (1952), (in dog); Fuller and Huelka (1973), (in rat, cat and dog); Singh *et al*. (1982), (in dog, rabbit, pig and goat); Paryani (2012) in one humped camel; Aksoy *et al*. (2004), (in Tuj sheep); Sajjarengpong and Adirektaworn (2006), (in dog) have also similar findings in their studies. Although, Aksoy and Ozudogru (2003), (in Van cat); Ozudogru and Ozdemir (2005), (in wolf); Ozdemir *et al*. (2009), (in Kangal dog) reported that arteria renalis sinistra was longer than arteria renalis dextra. By examining 288 kidneys in dogs Sajjarengpong and Adirektaworn (2006) reported that arteriae renales dextra were separated from the aorta abdominalis before the arteria renalis sinistra in 69.23% of the samples, while in 30.76% arteria renalis dextra et sinistra emerged from the aorta abdominalis at the same level. In this study, arteria renalis dextra was separated from the aorta abdominalis before the arteria renalis sinistra.

Fuller and Huelke (1973) reported that 4 segmental arteries arise from both the dorsal and ventral branches of kidney in the cat; Christie (1980) stated that kidney arteries form dorsal and ventral branches before entering the hilus, and that the dog gives 4 to 6 interlobar or arteriae arcuatae; Evans and Christensen (1993) determined that gave off 7 segmental arteries in the dog; Aksoy and Ozudoğru (2003) found that the right dorsal branch gave off 3 to 5, right ventral branch 4 to 6, and, left dorsal branch 3 to 6, left ventral branch gave off 3 to 4 arteriae interlobares in the Van cat; Ozudogru and Ozdemir (2005) observed that the right dorsal branch gave off 5 to 7, right ventral branch 4 to 5, and, left dorsal branch 6 to 9, left ventral branch gave off 7 to 8 arteriae interlobares in the wolf and Ozdemir et al. (2009) reported that the right dorsal branch was 5-6, the right ventral branch 4-6 and the left dorsal branch 5-7, and the left ventral branch was 6-8 arteriae interlobares in the Kangal dog. In the study, it was showed that the right dorsal branch gave off 5 to 7 arteriae interlobares, the right ventral branch gave off 5 to 7 arteriae interlobares, left dorsal branch 4 to 8 arteriae interlobares and left ventral branch 4 to 7 arteriae interlobares. Aslan (1995) reported that the arteria renalis gave off the ventral and dorsal branches 1.36 cm away from aorta abdominalis while the distance from the point where the dorsal and ventral branches separated to hilus of the kidney was 2 cm in the dog. Kurtul *et al*. (2002) showed in their study, the distances of arteria renalis dextra and sinistra from their dorsal and ventral branches were 2.3-2.5 cm 1.7-1.8 cm, respectively in the dog. Aksoy and Ozudogru (2003) reported that the dorsal branch was 0.55 cm in the first arteria interlobaris, 0.39 cm in the ventral branch, and 1.75 cm in the renal hilus in the Van cat. Aksoy *et al*. (2004) showed in their studythat the arteria renalis dextra was separated to the dorsal and ventral branches 1- 1.14 cm far from the hilus, the left one gave rise to the dorsal and ventral branches 1.3-1.7 cm in the Tuj sheep. Aksoy *et al*. (2004) demostrated that length of the dorsal branch before giving the first arteria interlobaris was 0.72 cm, length of the ventral branch 0.75 cm, and length of the arteria renalis from its origination to the hilus of the kidney was 2.34 cm in the Tuj sheep. Ozudogru and Ozdemir (2005) reported that the

dorsal and ventral branches of the arteria renalis dextra are 2.5-3.5 cm, the dorsal and ventral branches of the arteria renalis sinistra are 3.5-4 cm; 1.9-2 cm in the right dorsal branches, 1.5-1.6 cm in the right ventral branches, 1.8-2.1 cm in the left dorsal branches, and 1.6-1.7 cm in the left ventral branches away from the hilus in wolf. Sajjarengpong and Adirektaworn (2006) determined that the lengths of arteria renalis dextra and sinistra from the aorta abdominalis to kidney in male and female dogs were 4.01 and 3.66 cm as well as 3.98 and cm 3.56 cm respectively. Ozdemir et al. (2009) reported that the arteria renalis dextra had dorsal and ventral branches after a distance of 2-2.5 cm from the hilus and 2.2-2.7 cm from the arteria renalis sinistra in the Kangal dog.

In this study, arteria renalis dextra was 1.46 cm from the hilus and the arteria renalis sinistra was 1.19 cm away from the dorsal and ventral branches. Arteria renalis dextra was 2.65 cm and the arteria renalis sinistra was 2.09 cm away from the hilus. The mean distance between the origins of the arteria renalis dextra et sinistra was 5.56 mm. As a result, arterial vascularization of red fox kidneys was examined and similarities and differences with other animal species were determined.

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***Corrosponding Author:** Derviş Özdemir
Department of Anatomy, Faculty of Veterinary Medicine, Atatürk University, Erzurum/TURKEY
E-mail: dozdemir2544@hotmail.com