

# Renal Arterial and Venous System Variations in 1,073 Kidney Donors in Turkey

## 1.073 Türk Böbrek Donöründe Renal Arterial ve Venöz Sistem Varyasyonları

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### ABSTRACT

**Introduction:** Renal vasculature variations are seen in both arterial and venous systems. In Turkey, 80% of kidney transplantations are performed by living donors. Therefore, this study aimed to identify the incidence and morphologic variations of renal vessels in a group of Turkish kidney donors.

**Methods:** The computed tomography angiography of 1,073 kidney donors were retrospectively evaluated for vascular variations, such as multiple renal arteries (MRA), polar or accessory renal arteries (ARA), early division of renal artery, multiple renal veins (MRV), retro-aortic renal vein (RARV), and inferior vena cava duplication.

**Results:** One vascular variation in the renal vascular system was found in 637 of 1,073 (59.4%) kidney donors. The MRA was observed in 380 (35.4%) donors. The ARA were reported in 180 (16.8%) and 227 (20.2%) donors, respectively. Renal arteries were divided earlier than expected in 230 (21.4%) donors. The MRV and RARV were seen in 205 (19.1%) and 77 (7.2%) patients, respectively. Only 2 cases of inferior vena cava duplication were determined.

**Conclusion:** Renal arterial and venous system variations are very common, and detailed preoperative evaluation provides an opportunity to choose the best surgical modality and minimize intra- and post-operative complications.

**Keywords:** Renal arterial variations, renal venous variations, multiple renal artery, multiple renal vein

### ÖZ

**Amaç:** Renal vaskülatür varyasyonları hem arteriyel hem de venöz sistemlerde görülür. Türkiye'de böbrek nakillerinin %80'i canlı vericiler tarafından yapılmaktadır. Bu yüzden, bu çalışma, bir grup Türk böbrek donöründe böbrek damarlarının insidansını ve morfolojik varyasyonlarını belirlemeyi amaçladı.

**Yöntemler:** Bin yetmiş üç böbrek vericisinin bilgisayarlı tomografi anjiyografisi; çoklu renal arterler (MRA), polar veya aksesuar renal arterler (ARA), renal arterin erken bölünmesi, çoklu renal venler (MRV), retro-aortik renal ven (RARV) ve inferior vena kava duplikasyonu gibi vasküler varyasyonlar açısından retrospektif olarak değerlendirildi.

**Bulgular:** Renal vasküler sistemde bir vasküler varyasyon 1.073 böbrek vericisinin 637'sinde (%59,4) bulundu. MRA, böbrek donörünün 380'inde (%35,4) saptanmıştır. ARA varlığı sırasıyla 180 (%16,8) ve 227 (%20,2) donörde tespit edilmiştir. 230 (%21,4) canlı böbrek donöründe renal arter beklenenden erken dallanmıştır. MRV ve RARV sırasıyla; 205 (%19,1) ve 77 (%7,2) hastada görülmüştür. Sadece 2 olguda vena cava inferior duplikasyonu saptandı.

**Sonuç:** Renal arteriyel ve venöz sistem varyasyonları çok yaygındır, ve detaylı preoperatif değerlendirme, en iyi cerrahi tekniği seçme, intra-operatif ve post-operatif komplikasyonları en aza indirme fırsatı sağlar.

**Anahtar Kelimeler:** Renal arteriyel varyasyonlar, renal venöz varyasyonlar, multipl renal arter, multipl renal ven



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## Introduction

Kidney transplantation is the most desired and cost-effective renal replacement therapy modality for patients with end-stage renal disease (ESRD). Living kidney donation has gained importance in ESRD treatment in response to increasing organ need and shortage.

Renal vascular variations are common in the general population and essential for preoperative surgical evaluation. A wide range of variations is observed in both renal arterial and venous systems, with unequal prevalence in different populations (1). Ethnic and racial differences cause a wide range of variation frequencies worldwide (1,2).

This study aimed to define and detect the rate of renal vascular variations in living kidney donors from our transplant center in Turkey.

## Methods

A total of 1,073 patients underwent living kidney donation from October 2010 to September 2020 in our center. Informed consent was obtained preoperatively from all donors and recipients. Computed tomography (CT) angiography (Siemens SOMATOM definition AS CT scanner, Siemens AS, Berlin and Munchen) was performed preoperatively on every living donor candidate to determine renal vascular anatomy and surgical modality. A volume of 70-90 mL of non-ionic contrast medium was injected at 3.5-4 mL/s through an antecubital vein with an automatic power injector. Images were obtained from the level of the diaphragm to the end of the pelvis. Axial, sagittal, coronal, and three-dimensional reconstruction images were assessed by a radiologist.

Reports of CT angiograms were retrospectively investigated to confirm renal vessel number and morphology. Renal arterial blood supply variations were grouped under three titles: Accessory renal artery (ARA), polar renal artery (PRA), and early division (ED) (Figure 1, 2). An additional renal artery, which arises from the abdominal aorta and enters the renal hilum other than the main renal artery, was named ARA (1,3,4). Renal arteries that directly enter into the kidney poles were called PRA (1,5). The presence of ARA or PRA was categorized as multiple renal arteries (MRA). ED of the renal artery was defined as branching within the proximal 1.5 cm of the main renal artery (6,7).

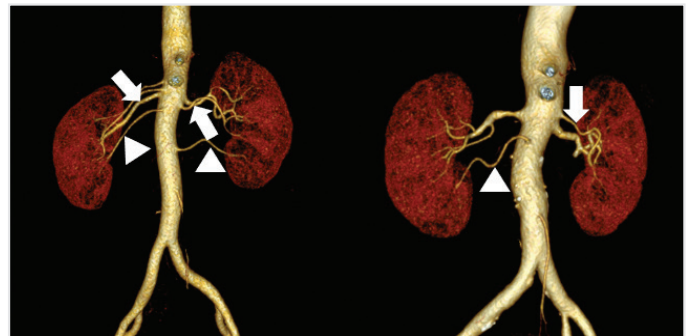
Variations in renal venous vasculature occurred in three different types: Multiple renal veins (MRV) (Figure 3), retro-aortic renal vein (RARV) (Figure 4), and inferior vena cava duplication (Figure 5). An additional renal vein that arises from the renal hilum and separately drains into the inferior vena cava from the main renal vein was named MRV (6). RARV means the abnormal passage of renal vein posterior to the aorta and drains into the inferior vena cava (8,9). A couple of infra-renal inferior vena cava was defined as inferior vena cava duplication (10). This study was approved by the Acibadem Mehmet Ali Aydınlar University Medical Research Ethical Committee (approval number: 2021-06/22, date: 24.03.2021).

## Statistical Analysis

Statistical analysis was done by Statistical Package for the Social Sciences software, version 24 (SPSS, Chicago, IL). Demographic data were expressed as mean ± standard deviation of ages and gender frequencies. A chi-square test was used to search the correlation between the gender and renal arterial and venous system variations. A p-value of <0.05 was considered statistically significant.

## Results

The study group included 481 (44.8%) males and 592 (55.2%) females with a mean age of 49±12.4 years. Frequencies and percentages of renal

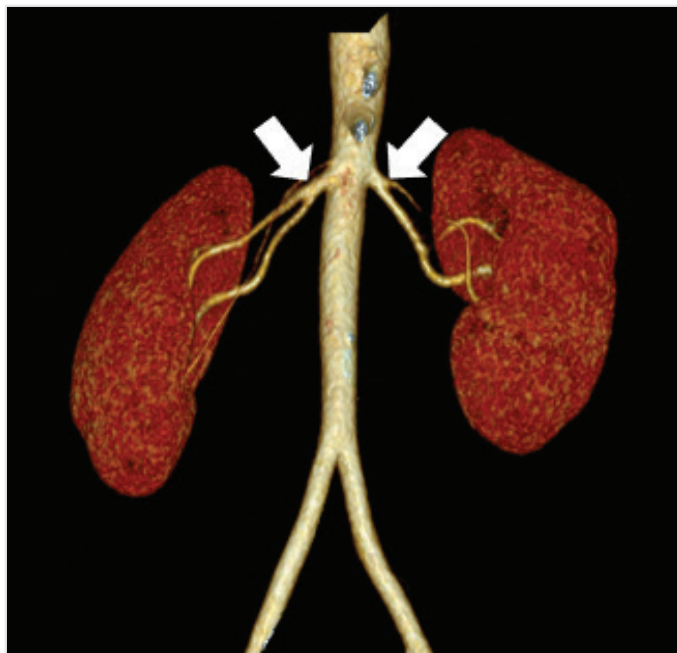


**Figure 1.** Three-dimensional computed tomography reconstruction of the abdominal arteries; accessory renal artery (arrow), polar renal artery (arrowhead)

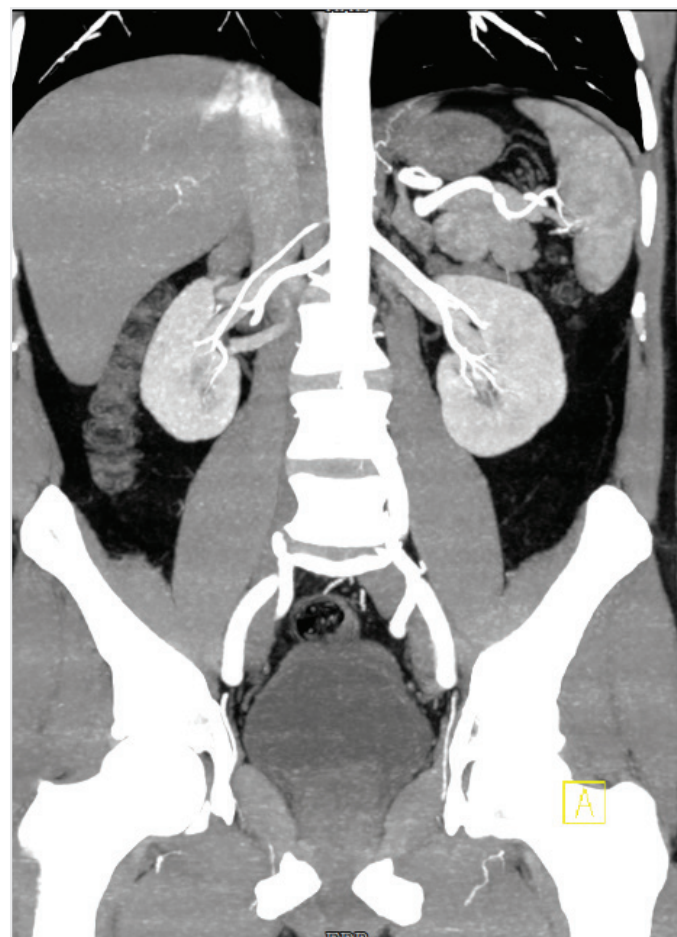
**Table 1.** Frequencies and percentages of renal vascular variations

Type of vascular variations	Male (%)	Female (%)	Total (%)
<b>Renal arterial variations</b>			
Multiple renal artery	181 (16.9%)	199 (18.5%)	380 (35.4%)
Accessory renal artery	119 (11.1%)*	108 (10.1%)*	227 (20.2%)
Polar renal artery	78 (7.3%)	102 (9.5%)	180 (16.8%)
Early division	97 (9%)	133 (12.4%)	230 (21.4%)
<b>Renal venous variations</b>			
Multiple renal vein	93 (8.7%)	112(10.4%)	205 (19.1%)
Retro-aortic renal vein	33 (3.1%)	44 (4.1%)	77 (7.2%)
Vena cava inferior duplication	1 (0.1%)	1 (0.1%)	2 (0.2%)
Any vascular variation	293 (27.3%)	344 (32.1%)	637 (59.4%)

Statistically significant association was found between the male gender and ARA in this study, \*p<0.05



**Figure 2.** Three-dimensional computed tomography reconstruction of the renal arteries; early division point of the renal artery (arrow)



**Figure 3.** Coronal section of abdominal computed tomography angiography; multiple renal veins (arrow), polar renal artery (arrowhead)

vascular variations are demonstrated in Table 1. MRA was found as the most common variation in the renal arterial system and MRV in the renal venous system.

A correlation was found between MRA and MRV in our study ( $p=0.001$ ). MRA and MRV were seen concurrently in 93 (8.7%) kidney donors. ARA had simultaneous PRA in 26 (2.4%) donors ( $p=0.016$ ). MRV appeared with ARA in 63 (5.9%) donor candidates ( $p=0.001$ ).

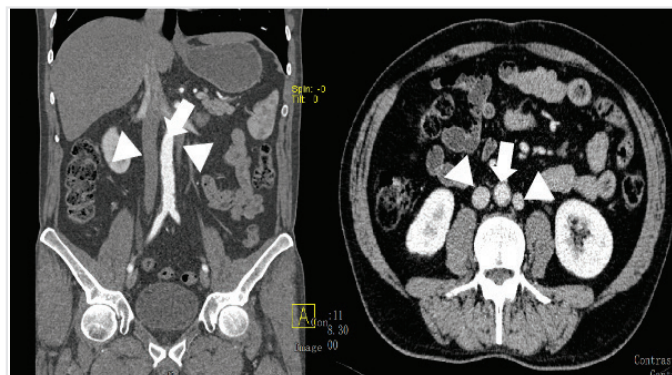
ARA was more commonly seen in male patients ( $p=0.01$ ). No statistical significance was found between the existence of any other renal arterial or venous system variations and gender ( $p>0.05$ ).

### Discussion

Variations of renal vasculature are seen in a wide range, with a critical role in many invasive procedures, especially in renal transplantation (11,12). Different rates of renal vascular variations were found in



**Figure 4.** Transverse scan of abdominal computed tomography angiography; retro-aortic renal vein (arrow), aorta (arrowhead)



**Figure 5.** Coronal and transverse imaging of abdominal computed tomography angiography; vena cava inferior duplication (arrowhead), aorta (arrow)

ethnically different populations (2,13). Complex renal embryogenesis, the sensitivity of visualizing technique, and the type of population are the causative factor for different MRA frequencies (14).

The MRA incidence fluctuates from 4% to 61.5% in literature (14). In the Turkish population, MRA frequency was established in 24-42% (1,7,9,12). This study revealed the MRA percentage (35.4%) was compatible with the Turkish population-based studies. Remarkable different percentages of ED were found by Çınar and Türkvatan (9), Ozkan et al. (1), and Gümüş et al. (7) in the Turkish population; 6%, 5%, 8%, and 26,7%, respectively. The prevalence of ED was found in 21.4% in our study.

The MRV incidence was established in 10.4-29% in literature (5,15,16). The MRV incidence is manifested in 21.6% and 18.8% in the Turkish population as reported by Çınar and Türkvatan (9) and Koc et al. (10), respectively. RARV occurs in a lower number compared to renal vein multiplication in the Turkish population between 3.1-4.7% in different studies (2,9,13,17). A comparatively higher prevalence (7.2%) was detected in the present study. The incidence of inferior vena cava duplication was determined in 0.1% and 0.2% in Turkey-based studies and the compatible result (0.2%) was obtained from our study (2,10,18).

In 2016, Çınar and Türkvatan (9) declared no association between the renal arterial and venous system variations. However, in our study, an association was found between MRA and MRV, ARA and MRV, PRA and ARA ( $p=0.001$ ;  $p=0.001$ ;  $p=0.016$ , respectively).

Gümüş et al. (7) found a higher prevalence of MRA and ED in males [ $(p=0.043)$  and  $(p=0.006)$ , respectively]. In 2012, Dilli et al. (2) revealed that RARV was two times more common in females than in males ( $p=0.036$ ). However, this study found a statistically significant association between the male gender and ARA ( $p=0.01$ ).

### Study Limitations

The limitations of this study are the lack of the circumaortic renal vein and the comparison of radiological and intraoperative findings of vascular variations.

### Conclusion

Therefore, 59.4% of living kidney donors have at least one anatomic variation in renal vasculature. MRA and MRV are the most common variations in the renal vascular system. Since 80% of kidney transplantation is performed from living donors in our country, renal vasculature variations must be evaluated before the operation to prevent possible intraoperative complications.

**Ethics Committee Approval:** This study was approved by the Acıbadem Mehmet Ali Aydınlar University Medical Research Ethical Committee (approval number: 2021-06/22, date: 24.03.2021).

**Informed Consent:** Informed consent was obtained preoperatively from all donors and recipients.

**Peer-review:** Externally and internally peer-reviewed.

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**Conflict of Interest:** No conflict of interest was declared by the authors.

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### References

- Ozkan U, Oğuzkurt L, Tercan F, Kizilkiliç O, Koç Z, Koca N. Renal artery origins and variations: Angiographic evaluation of 855 consecutive patients. *Diagn Interv Radiol* 2006; 12: 183-6.
- Dilli A, Ayaz UY, Kaplanoğlu H, Saltas H, Hekimoglu B. Evaluation of the left renal vein variations and inferior vena cava variations by means of helical computed tomography. *Clin Imaging* 2013; 37: 530-5.
- Hazırolan T, Öz M, Türkbey B, Karaosmanoğlu AD, Oğuz BS, Canyığıt M. CT angiography of the renal arteries and veins: Normal anatomy and variants. *Diagnostic Interv Radiol* 2011; 17: 67-73.
- Sungura R, Onyambu C, Mathenge I. The CT Angiographic Prevalence of Renal Accessory Arteries in Kenya. *Int J Curr Microbiol Appl Sci* 2018; 7: 2745-54.
- Holden A, Smith A, Dukes P, Pilmore H, Yasutomi M. Assessment of 100 live potential renal donors for laparoscopic nephrectomy with multi-detector row helical CT. *Radiology* 2005; 237: 973-80.
- Chai JW, Lee W, Yin YH, Jae H, Chung JW, Kim HH, et al. CT angiography for living kidney donors: Accuracy, cause of misinterpretation and prevalence of variation. *Korean J Radiol* 2008; 9: 333-9.
- Gümüş H, Bükte Y, Özdemir E, Çetinçakmak MG, Tekbaş B, Ekici F, et al. Variations of renal artery in 820 patients using 64-detector CT-angiography. *Ren Fail* 2012; 34: 286-90.
- Satyapal KS. The renal veins: A review. *Eur J Anat* 2003; 7(Suppl1): 43-52.
- Çınar C, Türkvatan A. Prevalence of renal vascular variations: Evaluation with MDCT angiography. *Diagn Interv Imaging* 2016; 97: 891-7.
- Koc Z, Ulsan S, Oğuzkurt L, Tokmak N. Venous variants and anomalies on routine abdominal multi-detector row CT. *Eur J Radiol* 2007; 61: 267-78.
- Palmieri BJ, Petroianu A, Silva LC, Andrade LM, Alberti LR. Study of arterial pattern of 200 renal pedicle through angiotomography. *Rev Col Bras Cir* 2011; 38: 116-21.
- Zağyapan R, Pelin C, Kürkçüoğlu A. A retrospective study on multiple renal arteries in Turkish population. *Anat (International J Exp Clin Anatomy)* 2009; 3: 35-39.
- Batur A, Karaköse S, Alpaslan Y, Bora A. Left Renal Vein Anomalies in Routine Abdominal CT Scans. *Van Tıp Derg* 2015; 22: 185-7.
- Gulas E, Wysiadecki G, Cecot T, Majos A, Stefańczyk L, Topol M, et al. Accessory (multiple) renal arteries - Differences in frequency according to population, visualizing techniques and stage of morphological development. *Vascular* 2016; 24: 531-7.
- Namasivayam S, Kalra MK, Waldrop SM, Mittal PK, Small WC. Multidetector row CT angiography of living related renal donors: Is there a need for venous phase imaging? *Eur J Radiol* 2006; 59: 442-52.
- Sebastià C, Peri L, Salvador R, Buñesch L, Revuelta I, Alcaraz A, et al. Multidetector CT of living renal donors: Lessons learned from surgeons. *Radiographics* 2010; 30: 1875-90.
- Karaman B, Koplay M, Ozturk E, Basekim CC, Oğul H, Mutlu H, et al. Retroaortic left renal vein: Multidetector computed tomography angiography findings and its clinical importance. *Acta Radiol* 2007; 48: 355-60.
- Yılmaz Ovalı G, Örgüç Ş, Serter S, Gökten C, Pekindil G. Vena cava inferior anomalies on computed tomography. *Turkish J Thorac Cardiovasc Surg* 2006; 14: 169-71.