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Araştırma Makalesi / Research Article

Evaluation of Renal Vascular Variations in Routine Computed Tomography Examinations

Rutin bilgisayarlı tomografi incelemelerinde renal vasküler varyasyonların değerlendirilmesi

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Abstract

Aim: Anatomical variations of the kidney, including multiple renal arteries are crucial for renal and abdominal aortic surgery and renovascular hypertension. In this study, we aimed to investigate the frequency of multiple renal arteries in a Turkish population by evaluating the images of patients who underwent contrast-enhanced computed tomography (CT) for various reasons.
Material and Methods: Images of patients who underwent contrast abdominal computed tomography in our hospital due to various health problems were evaluated retrospectively. The presence, number, and exit levels of multiple renal arteries were examined.
Results: In the study, CT scans of 470 patients, aged between 18 and 69 years (43.7 ± 14.1) were analyzed retrospectively. Of the 940 kidneys evaluated, 113 had multiple renal arteries. Of the multiple renal arteries, 59 belonged to women and 54 to men, and the difference was found to be statistically insignificant. The incidence of multiple renal arteries was determined as 20.6% in evaluated cases and 12% in evaluated kidneys. The number and frequency of occurrence is 53 (47%) in the right kidney and 60 (53%) in the left kidney, respectively, and there is no significant difference between the two sides. Accessory renal arteries originated from the abdominal aorta between lumbar 1 vertebra (L1) and L4, except for 2 cases where they originated from the iliac artery.
Conclusion: The incidence of multiple renal arteries in the Turkish population was found at rates similar to the literature, using CT. CT is found to be a reliable method in detecting multiple renal arteries. Considering the presence of multiple renal arteries in CT examinations, we think that valuable information can be obtained in the investigation of renovascular hypertension.

Keywords: Multiple renal arteries; anatomical variations; computed tomography; renal vasculature

Öz

Amaç: Çoklu renal arter varlığı böbrek ve abdominal aorta cerrahisinde, renovasküler hipertansiyonda önemli bir rol oynar. Çeşitli nedenlerle kontrastlı bilgisayarlı tomografi (BT) yapılmış hastaların görüntülerini değerlendirerek Türk toplumunda çoklu renal arter sıklığını araştırmayı amaçladık.
Gereç ve yöntem: Çeşitli sağlık problemleri nedeni ile hastanemizde kontrastlı abdominal bilgisayarlı tomografi yapılmış hastaların görüntüleri geriye dönük olarak değerlendirildi. Çoklu renal arter varlığı, sayısı ve çıkış düzeyleri incelendi.
Bulgular: Çalışmada 470 hastanın BT taraması retrospektif olarak incelendi. Olguların yaş ortalaması 43.7±14.1 olup yaş aralığı 18-69 idi. Değerlendirilen 940 böbreğin 113'ünde çoklu renal arter mevcuttu. Çoklu renal arterlerin 59'u kadın, 54'ü ise erkek olup cinsiyetler arasında anlamlı farklılık yoktu. Değerlendirilen olgularda çoklu renal arter görülme sıklığı %20.6, değerlendirilen böbrekler için ise %12 olarak belirlendi. Görülme sayı ve sıklığı sırası ile sağ böbrekte 53 (%47) ve sol böbrekte 60 (%53) olup iki taraf arasında anlamlı farklılık yoktu. Aksesuar renal arterler iliak arterden köken aldığı 2 vaka dışında lomber 1-4 vertebralar (L1-L4) arası abdominal aortadan köken almakta idi.
Sonuç: BT ile Türk toplumunda çoklu renal arter sıklığı literatür ile benzer oranlarda tespit edilmiştir. Çoklu renal arter tespitinde BT güvenilir bir yöntemdir. BT incelemelerinde çoklu renal arter varlığının dikkate alınması ile renovasküler hipertansiyon araştırılmasında ve cerrahi girişimler öncesinde değerli bilgiler edinilebileceğini düşünmekteyiz.

Anahtar Kelimeler : Çoklu renal arter, anatomik varyasyon, bilgisayarlı tomografi, böbrek damarları

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INTRODUCTION

The renal arteries leave the lateral faces of the abdominal aorta at the level of L1-L2 vertebrae. The right renal artery (RLA) having an elongated track compared to the left renal artery (LLA), passes behind the inferior vena cava (IVC) (1,2). Renal arteries tend to appear with numerical variations, although they are usually found as one for each side. Along with their numbers, variations can also be seen in the levels of separation from the aorta. Moreover, course variations can be seen in renal veins, with less numerical variations (3-5). The knowledge of renal vascular variations and separation levels is crucial for the surgical management of various pathologies, interventional radiological procedures, and especially transplantation (6,7). In addition, to date, many studies suggested that the presence of multiple renal arteries may be associated with hypertension (8,9). There are studies, suggesting that renal artery variations are observed at higher rates in African blacks. Although the frequency of variation varies between 9% and 76% in various studies, the average rate, in general, is found to be 28% to 30% (3-5). Although there have been past studies about the renal vasculature variations including the Turkish community, the numbers are insufficient in terms of elucidating the literature. Studies conducted for the Turkish population have generally been conducted by detecting multiple renal arteries as an additional finding in those who undergo digital subtraction angiography (DSA) for another reason (3,5,10). There are studies examining renal vascular variations with computed tomography (CT) angiography (11). To our knowledge, to date, a comprehensive study for the detection of accessory renal arteries by routine abdominal CT, among the Turkish population was not reported.

There are differences in the definition of the accessory renal artery. In addition, in the presence of multiple renal arteries, if the diameters are similar, it may not be possible to define which artery is true and which artery is an accessory. Therefore, it can be said that it is correct to use multiple renal artery definitions as much as possible. In some studies, the number of arteries departing from the abdominal aorta was evaluated, whereas, in other studies, the number of renal arteries entering the kidney was evaluated. Therefore, there are studies with quite different rates of multiple renal arteries from each other (3-5,12). In our study, the presence of multiple renal arteries that separate from the aorta from different points and progress to the kidney were evaluated. In our study, we aimed to evaluate the frequency of multiple renal arteries by computed tomography. In addition, remarkable renal vein course variations were evaluated in the cases.

MATERIAL AND METHOD

Four hundred and seventy patients who underwent contrast-enhanced abdominal CT examinations in Fatih Sultan Mehmet Training and Research Hospital, between January 2019 and June 2019 were evaluated retrospectively. Examinations were performed with a 128-slice CT device (GE Healthcare Optima CT660, USA). In our hospital, routine abdominal CT examinations are performed with this device using the following parameters: fixed noise index of 30, 1.25 mm slice thickness, 120 kVp, and a gantry rotation time of 0.5 seconds. Repeated examinations, technically unsatisfactory arterial phases, artifact formations, total nephrectomy, kidney tumors, kidney anomalies, end-stage renal failure, vasculitis such as polyarteritis nodosa, and intra-abdominal pathologies that complicate evaluations were accepted as exclusion criteria from the study. All CT scans were examined by a radiologist with 14 years of CT experience as images in the axial and coronal planes. Remarkable renal vein variations were recorded together with multiple renal arteries (Figures 1 and 2). This retrospective study is not a clinical study on human subjects or laboratory experimental animals. The study was carried out with the protocol in accordance with the Declaration of Helsinki, and was submitted by the institutional review board with the approval number 17073117_050.06.

Statistical Analysis

Statistical Package for the Social Science 22 (version 22 for Windows; SPSS, Turkey) program was used for statistical analyzes. A chi-square test was used to compare the difference between males and females of double renal arteries and the difference between the right and left sides. Data were expressed as mean ± standard deviation. A p-value of <0.05 was considered statistically significant.

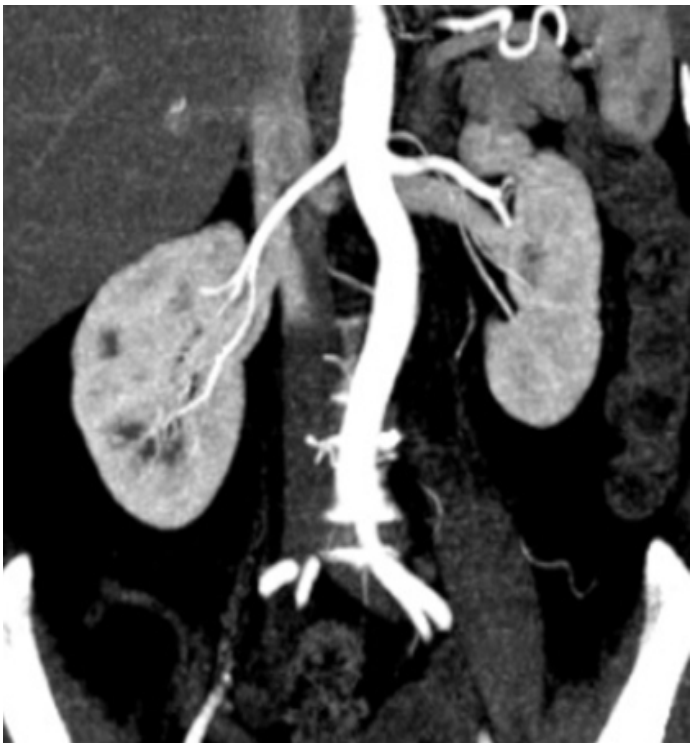

Figure 1. Double renal arteries are seen on the left. Thin diameter renal artery, which comes out from the top, crosses the other and extends to the lower half of the kidney

Figure 2. Two renal arteries that supply the left kidney

RESULT

Images of 470 patients who underwent contrast-enhanced abdominal computed tomography examination were retrospectively analyzed. 211 of the cases were male (44.9%) and 259 were female (55.1%). The mean age of male cases was 42.7 ± 14.7, while the mean age of female cases was 44.6 ± 13.6. The mean age of the patients was 43.7 ± 14.1 with the range 18-69. Of the 940 kidneys evaluated, 113 had multiple renal arteries. No patients were found to have more than two renal arteries on one side. 59 of the cases with multiple renal arteries were female and 54 were male, and the difference between each gender was noted to be statistically insignificant (p = 0.38). The incidence of multiple renal arteries in the evaluated kidneys was found to be 12%, and the incidence of multiple renal arteries was 20.6% in cases. The number and frequency of occurrence was 53 (47%) in the right kidney and 60 (53%) in the left kidney, respectively, and there was no significant difference between the two sides (p = 0.19). In 37 (7.9%) of the cases, there were multiple renal arteries in the right kidney, 44 (9.4%) in the left kidney, and 16 (3.4%) in the bilateral renal artery (Table 1). Of the 827 kidneys fed by one renal artery, 282 of the renal arteries originated from the level of the L1 vertebra (34.1%), 296 from the L1-L2 intervertebral disc level (35.8%), 243 from the L2 vertebra (29.4%), and 6 from the L3 vertebra (0.7%) (Table 2). Accessory renal arteries originated from the abdominal aorta between L1 and L4, except for 2 cases where they originated from the iliac artery. In addition, the retroaortic left renal vein variation was notified in 24 cases (5%), circumaortic left renal vein was found in 5 cases (1%) (Figure 3), and inferior vena cava transposition (Figure 4) (left-sided inferior vena cava) variation was seen in 1 case (Table 3).

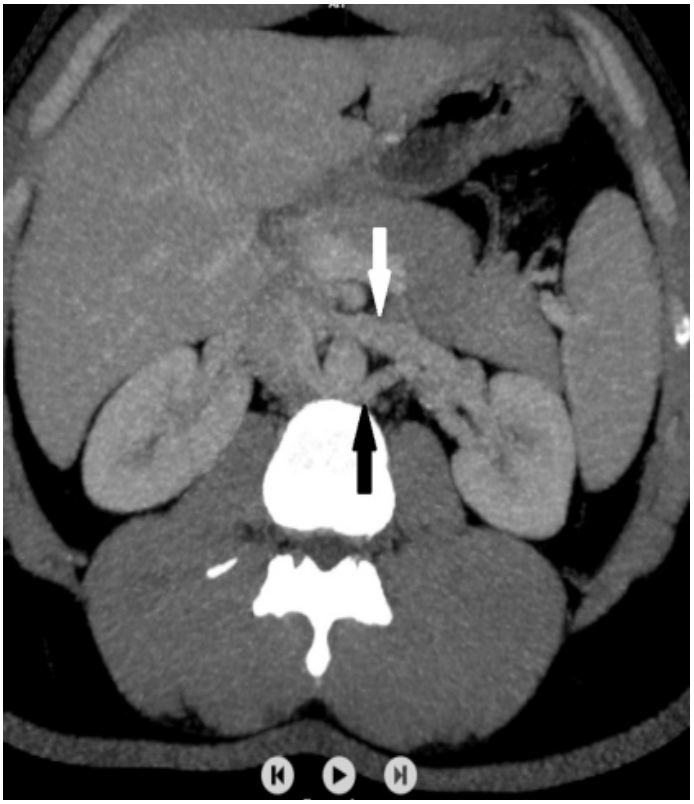

Figure 3. Axial CT image of the anterior branch (white arrow) and posterior branch (black arrow) of the circumaortic left renal vein

Figure 4. Transposition of inferior vena cava (Left-sided Inferior Vena Cava). The inferior vena cava, lying to the left of the aorta, crosses the aorta at the level of the renal veins and passes to the right

Table 1. Multiple renal arteries incidence rates

	Number (n)	Distribution (%)
Normal	373	79.4
Right-side multiple renal arteries	37	7.9
Left-side multiple renal arteries	44	9.4
Bilateral multiple renal arteries	16	3.4
Total	470	20.6

Table 2. Renal arteries origin levels

	Number (n)	Distribution (%)
L1 vertebra	313	33.3
L1-L2 intervertebral disc	326	34.7
L2 vertebra	273	29
L3 vertebra	17	1.8
L4 vertebra	9	1
Left iliac artery	2	0.2
Total	940	100

Table 3. Additional vascular variations

	Number (n)
Retroaortic left renal vein	24
Circumaortic left renal vein	5
Transposition of inferior vena cava (left-sided IVC)	1
Total	30

DISCUSSION

The differences in the number and exit points of the renal arteries from the aorta are explained by the embryological development of the mesonephric arteries (13). In the embryological period, these arteries form a vascular network on both sides of the aorta, between the 6th cervical and 3rd lumbar vertebrae, feeding the adrenal glands, kidneys, and gonads. With time, these arteries disappear by involution and a single mesonephric artery remains and takes over the circulation of the kidney. As a result of the persistence of the mesonephric arteries, more than one renal artery may arise that feeds the kidney (13). Renal arteries usually branch off from the aorta below the superior mesenteric artery. Renal arteries enter the kidney from the renal hilum. In the presence of more than one renal artery, additional renal arteries can enter the kidney from the hilum or parenchymal level. It is important to identify the presence of more than one renal artery, especially before surgical operations (14). There are studies about the number and variations of renal vascular structures that present with dissections, radiological examinations, and surgical findings. For the evaluation of vascular structures, DSA for arteries and venography for venous structures are accepted as the golden standard. However, with the development of technology and the fact that angiography is an invasive method, contrast-enhanced CT and magnetic resonance imaging provide results as successful as conventional angiography (15,16). In our study, we investigated the separation levels and numbers of renal arteries. We also evaluated conditions such as retroaortic course or circumaortic variation of the left renal vein. Although there are many studies on the number of renal arteries, few studies focused on exit levels and additional renal vein variations (5).

In our study, it was found that the renal arteries most frequently originated from the lateral of L1-L2 intervertebral disc level. More rarely, we encountered a small number of renal artery cases originating from the L3 vertebra level. Accessory renal arteries were observed to originate from the aorta between the L1-L4 vertebra, except for two cases that originated from the iliac artery. Similar results have been shown in other studies on this subject. Our findings were consistent with the literature information. Some studies reported the presence of renal arteries originating from the T12 vertebra level (17,18). Renal artery variations gain more importance due to increased renal transplantations, interventional radiological procedures, urological and vascular interventions (19-22). In addition, it has been reported in various studies that there is a possibility of a relationship between the presence of multiple renal arteries and hypertension. The

accessory renal artery generally has lower calibration and according to a hypothesis, the kidney segment fed by this artery secretes more renin than other renal parenchyma segments, causing hypertension (8,9,23,24). Atasoyu et al. reported in their study that the presence of an additional renal artery may cause hypertension (23). Of the 940 kidneys evaluated in our study, 113 had multiple renal arteries. Of the patients with multiple renal arteries, 58 were women and 53 were men. The incidence of multiple renal arteries in the evaluated kidneys was 11%, and multiple renal arteries were detected in 20.6% of the cases. The number and frequency of occurrence are 53 (47%) in the right kidney and 60 (53%) in the left kidney, respectively, and there is no significant difference between the two sides. Accessory renal arteries originated from the abdominal aorta between L1 and L4, except for 2 cases where they originated from the iliac artery.

Satyapal et al examined the incidence and morphometry of the accessory renal artery; and reported that 102 of 440 kidneys (23.2%) had accessory renal arteries and 40 of them were on the right side, where 62 of them were on the left side (20). In the study performed by Sevinç et al., they stated that the frequency of additional renal arteries was 22% (25). Sampaio et al., as a result of an anatomical evaluation of 266 kidneys, determined the additional renal artery rate as 30.4% and Bordei as 14% (21,26). In our study, the rate of multiple renal arteries was determined to be 20.6%, and it is in parallel with some studies, it is seen to be lower than in some studies. However, in some studies, the renal artery that diverges only from the aorta but enters the kidney more than one by branching early was evaluated as multiple renal arteries. In our study, arteries that separate from the aorta and reach the kidney independently were accepted as additional renal arteries. During the reporting of contrast-enhanced computed tomography, evaluation of the presence of additional renal artery is often overlooked. Similarly, the retroaortic course of the left renal vein and circumaortic variation may be ignored or overlooked in reporting. Because of the effects of venous variations on the function of the left kidney and the possibility of the presence of an additional renal artery to be associated with hypertension, the importance of the findings in our study was aimed to be emphasized. In addition, transplantation of a kidney with a single renal artery is technically easier and the rates of postoperative complications and kidney loss are lower than kidney transplantation with more than one renal artery (18,26).

The fact that CT angiography images optimized for imaging only the renal arteries were not used in our study can be considered as an important limitation. It is difficult to show very thin vascular structures with routine abdominal computed tomography. This may be the reason why 3 or more renal artery variations were not observed on one side in our study. In addition, the insufficient number of subjects can be mentioned as one of the limitations of our study for the evaluation made through routine CT examinations.

CONCLUSION

Our study aimed to investigate the incidence of vascular variations of the kidney, which is crucial for interventional radiological procedures and surgical approaches, with increasing frequency of application. It is seen that these variations can be successfully demonstrated with the contrast-enhanced computed tomography procedure. For this reason, the importance of evaluating these variations becomes evident when preparing computed tomography reports.

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Conflict of Interest: *The authors declare that they have no competing interest.*

Ethical approval: *The study was carried out with the protocol in accordance with the Declaration of Helsinki, and was submitted by the institutional review board with the approval number 17073117_050.06.*

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