RESEARCH ARTICLE / *Araştırma Makalesi*

Percentages and Gender Distribution of Anatomic Variations of Inferior Vena Cava, Renal Veins, and Posterior Lumbar Tributaries of the Left Renal Vein

İnferior Vena Kava, Renal Venler ve Sol Renal Venin Posterior Lomber Dallarının Anatomik Varyasyonlarının Yüzdeleri ve Cinsiyet Dağılımı

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Öz

Introduction	The aim of this study was to investigate percentages and gender distribution of the variations of the inferior vena cava (IVC), renal veins, and posterior lumbar tributaries of the left renal vein (LRV).
Materials and Methods	For this cross sectional observational study, the computed tomography (CT) images of 1949 patients were evaluated retrospectively.
Results	In the present study, percentages of double IVC, left IVC, and IVC interruption with azygos continuation were 0.5%, 0.2%, and 0.1%, respectively; circumaortic left renal vein (CLRV) was 6% and retroaortic left renal vein (RLRV) was 4.2%. Multiple renal vein variations were 24.1% on the right, but none on the left. Posterior lumbar tributaries of the renal veins were 0.15% on the right and 48% on the left. There was no difference between genders in terms of LRV and IVC variations. While the incidence of multiple right renal veins was statistically significantly higher in male patients compared to female patients (p = 0.045), the opposite was true for the posterior lumbar tributaries of the LRV (p = 0.035).
Conclusion	The venous system has a wide variety of variations, and the renal venous circulation is supported by number variations on the right in men and collaterals on the left in women.
Keywords	Renal veins; inferior vena cava; anatomic variation

Abstract

Amaç	*Bu çalışmanın amacı, inferior vena kava (İVK), renal venler ve sol renal venin posterior lomber dallarının varyasyonlarının yüzdelerini ve cinsiyet dağılımını araştırmaktı.*
Yöntem ve Gereçler	*Bu kesitsel gözlemsel çalışma için 1949 hastanın bilgisayarlı tomografi (BT) görüntüleri retrospektif olarak değerlendirildi.*
Bulgular	*Bu çalışmada çift İVK, sol İVK ve azigos veni ile devam eden İVK kesintisi yüzdeleri sırasıyla %0,50, %0,20 ve %0,10; sirkumaortik sol renal ven %6 ve retroaortik sol renal ven %4,20 idi. Multipl renal ven varyasyonları sağda %24,10 iken solda yoktu. Renal venlerin arka lomber dalları sağda %0,15 ve solda %48 idi. Sol renal ven ve İVK varyasyonları açısından cinsiyetler arasında fark yoktu. Multipl sağ renal ven insidansı erkek hastalarda kadın hastalara kıyasla istatistiksel olarak anlamlı derecede yüksek iken (p = 0,045), sol renal venin arka lomber dalları için bunun tersi doğruydu (p = 0,035).*
Sonuç	*Venöz sistem çok çeşitli varyasyonlara sahiptir ve renal venöz dolaşım erkeklerde sağda sayı varyasyonları ve kadınlarda solda kollaterallerle desteklenmektedir.*
Anahtar Kelimeler	*Renal venler; inferior vena kava; anatomik varyasyon*

INTRODUCTION

The systemic venous system exhibits embryologically complex developmental stages. During the 4th to 8th weeks of gestation, the infrahepatic IVC forms from the development, anastomosis, and regression phases of the posterior cardinal, subcardinal, and supracardinal veins, respectively. Pauses or deviations in these developmental stages cause IVC variations.[1,2] Therefore, venous system has diverse and much more variations than the arterial system.[1-3] Variations can be an advantage or a disadvantage.

The inferior vena cava (IVC), left renal vein (LRV), right renal vein (RRV) and posterior lumbar tributaries of LRV variations are important in surgical and interventional procedures, such as donor nephrectomy.4 It is evident that alternative pathways of venous drainage from the kidney can be life-saving or offer options to the surgeon. Variability can help ensure the survival of the organ with alternative venous circulation if veins are cut or damaged during surgery or traumas.[3] It has been reported that the LRV can be resected or ligated without reconstruction during surgery.[5] This is due to its extensive venous collateralisation.[6-8] Because the LRV is longer than the RRV, the left kidney is preferred to the right in transplantation, facilitating implantation in these recipients.[4,9] The LRV as opposed to the RRV has several tributaries. Before reaching the IVC, it receives the left adrenal, left inferior phrenic, left capsural, and left gonadal veins, and the posterior lumbar veins.[3] For renal transplantation and other urological procedures, it is necessary to know the anatomic variations of the renal veins and their tributaries.[4,10] The posterior lumbar tributaries of the LRV are especially important in donor nephrectomy operations and their variations have been investigated.[3,11] Since lumbar veins can be hidden in laparoscopic surgery and their sizes are variable, informing the surgeon by the radiologist before the procedure is of great importance in order to prevent complications.[3]

In this study, the posterior lumbar arms of the LRV and the variations in the renal veins and IVC were examined and it was evaluated whether they differed according to gender. Although renal vein and IVC variations have been evaluated in this respect, the posterior tributaries of the LRV have not been evaluated yet.

MATERIALS and METHODS

This study was approved by the Clinical Research Ethics Committee of the hospital where it was conducted, with the decision number 593 taken at the meeting number 43 held on 06.11.2019. As this study was retrospective, the patients' consent was waived.

The IVC, renal veins, and posterior lumbar tributaries of the renal veins were evaluated in the images of 2095 patients who were requested upper abdominal computed tomography (CT) with different indications from different clinics in our hospital those examined in the Radiology Department between 1-25 October 2019. Suboptimal examinations, nephrectomy, kidney agenesis, anomalies of kidney shape and position, and tumoral involvement of kidney and renal vessels were excluded. The ages, genders, and venous variations of the remaining 1949 patients were evaluated.

The study included 477 non-contrast examinations in which retroperitoneal adipose tissue was adequate to evaluate vascular structures and 1472 contrast-enhanced examinations. Images obtained using a multislice single detector row helical CT (Philips Ingenuity Core 128, 2017, Cleveland, Ohio, USA). Slice thickness was 3 mm with interval reconstruction 1.5 mm. Scans were obtained 55 seconds after bolus tracking in contrast enhanced examinations.

A SPSS 23.0 Statistics Program package was used for statistical analysis of the data. Categorical measurements were summarised as numbers and percentages, and continuous measurements as mean and standard deviation (median and minimum-maximum where appropriate). A chi-square test and Fisher's Exact Test were used to compare

categorical variables. The Shapiro-Wilk test was used to determine whether the parameters in the study showed a normal distribution. The Mann-Whitney U test was used for parameters that did not show normal distribution in continuous measurements between groups. A statistical significance level of 0.05 was used in all tests.

RESULTS

1100 (56.4%) of patients were male and 849 (43.6%) were female. The age range of patients was 0-108 (median=51, mean ± SD= 49.31 ± 20.37). In a patient who underwent left renal vein resection, left renal venous drainage was through the lumbar venous system (Figure 1).

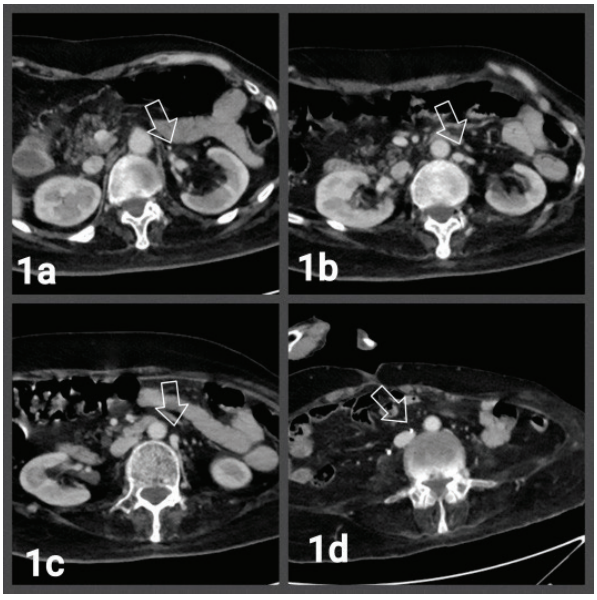

Figure 1: Contrast-enhanced axial CT scans show that intrarenal veins drain into the lumbar venous system after left renal vein resection in a patient undergoing hysterectomy for endometrial cancer. Intrarenal veins are seen to be collected in the renal hilus (arrow), but there is no left renal vein that passes in front or behind the aorta and drains into the inferior vena cava (Figure 1a). It is observed that the venous drainage of the left kidney is in the vein (arrow) located just to the left of the aorta (Figure 1b). In the section passing through the lower level, it is seen that the vein (arrow) is the lumbar vein (Figure 1c). In the operated patient with endometrial cancer, a surgical clip (arrow) is observed for the ligation of the lower-located left renal vein at the point where it drains into the inferior vena cava (Figure 1d).

Frequency and percentage of variations are presented in Table 1.

Table 1. Frequency and percentage of variations

Variations	n	(%)
One RRV	1480	75.9
Two RRVs	402	20.6
Three RRVs	62	3.2
Four RRVs	5	0.3
One RRV	1480	75.9
Multiple RRVs	469	24.1
RLRV	80	4.1
CLRV	116	6.0
D IVC	8	0.4
L IVC	3	0.2
IVC Interruption with azygos/hemiazygos continuation	2	0.1
One posterior lumbar tributary of LRV	842	90.1
Two posterior lumbar tributaries of LRV	85	9.1
Three posterior lumbar tributaries of LRV	7	0.7
One posterior lumbar tributary of LRV	842	90.1
Multiple posterior lumbar tributaries of LRV	92	9.9
Posterior lumbar tributary of LRV available	934	47.9
Posterior lumbar tributary of LRV absent	1015	52.1

Abbreviations: RRV, right renal vein; RLRV, retroaortic left renal vein; CLRV, circumaortic left renal vein; D IVC, double inferior vena cava; L IVC, left inferior vena cava; IVC, inferior vena cava; LRV, left renal vein.

Posterior lumbar tributaries of the RRV were detected in 3 patients, all at the L2 level (0.15%). In 934 patients (47.9%), 1033 posterior lumbar tributaries of the LRV were detected. The number and frequency of posterior lumbar tributaries for levels L1, L2, L3, and L4 were 314 (30.4%), 648 (62.7%), 68 (6.6%), and 3 (0.3%), respectively.

Table 2. shows comparisons of anatomical RRV, LRV, IVC and posterior lumbar tributaries of LRV variations by gender. There was no difference between genders in terms of LRV and IVC variations. Multiple RRV variations were

found to be significantly higher in male patients included in the study compared to female patients (p = 0.045) (Figure 2). In the female population, the number of posterior lumbar tributaries of the LRV was significantly higher than in the male population (p = 0.002) (Figure 3). While there was no difference between genders in terms of a single posterior lumbar tributary of the LRV; percentages of two, three, and multiple posterior lumbar tributaries were statistically significantly higher in females than males (p = 0.035).

Table 2. Comparison of anatomical RRV, LRV, IVC and posterior lumbar tributaries of LRV variations by gender

Anatomical variation	**Male**		**Female**		**p**
	n	**(%)**	**n**	**(%)**	
One RRV	819	(74.5)	661	(77.9)	**0.244**
Two RRVs	238	(21.6)	164	(19.3)	
Three RRVs	39	(3.5)	23	(2.7)	
Four RRVs	4	(0.4)	1	(0.1)	
One RRV	819	(74.5)	661	(77.9)	**0.045***
Multiple RRVs	281	(25.5)	188	(22.1)	
IVC and LRV variation	108	(9.8)	101	(11.9)	**0.141**
RLRV	38	(3.5)	42	(4.9)	
CLRV	63	(5.7)	53	(6.2)	
Double IVC	4	(0.4)	4	(0,5)	
Left IVC	2	(0.2)	1	(0.1)	
IVC Interruption with azygos/hemiazygos continuation	1	(0.1)	1	(0.1)	
One posterior lumbar tributary of LRV	454	(92.1)	388	(88.0)	**0.033***
Two posterior lumbar tributaries of LRV	38	(7.7)	47	(10.7)	
Three posterior lumbar tributaries of LRV	1	(0.2)	6	(1.4)	
One posterior lumbar tributary of LRV	454	(92.1)	388	(88.0)	**0.035***
Multiple posterior lumbar tributaries of LRV	39	(7.9)	53	(12.0)	

Statistical significance was considered at $p < 0.05$.
Abbreviations: RRV, right renal vein; LRV, left renal vein; IVC, inferior vena cava; RLRV, retroaortic left renal vein; CLRV, circumaortic left renal vein.

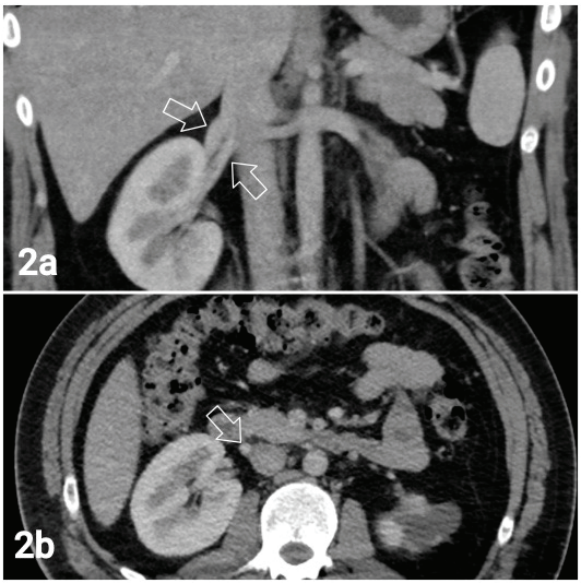

Figure 2: CT images of the patient with 3 right renal veins. Coronal contrast-enhanced CT scan shows the right renal veins (arrows) draining into the inferior vena cava (Figure 2a). In the axial contrast-enhanced CT scan, the third right renal vein (arrow) draining more caudally into the inferior vena cava is seen (Figure 2b).

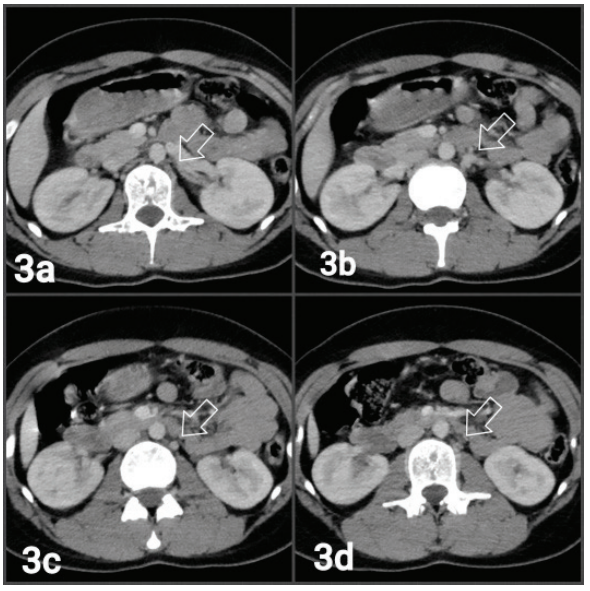

Figure 3: Axial contrast-enhanced CT images show that the lumbar veins at the L1 and L2 levels are draining into the left renal vein. The left renal vein and the left lumbar vein (arrow) at the L1 level are visible (Figure 3a). It is seen that the left lumbar vein originating from the L1 level drains into the left renal vein (arrow) (Figure 3b). It is observed that the vein (arrow) continues inferior to the left of the aorta (Figure 3c). More caudally, it is observed that it drains the left lumbar vein at L2 level.

DISCUSSION

It was observed that the renal venous system was supported by multiplicity on the right and lumbal venous collaterals on the left. The frequency of these variations was also found to differ in terms of sexes. Statistically significant, right multiple renal veins were more common in men and left renal vein with multiple posterior lumbar arms more frequently in women.

In a meta-analysis study of renal vein variations, multiple renal veins were detected at 16.7%, and it was reportedly much more common on the right (16.6%) than the left (2.1%).[12] There are also studies where multiple renal vein variations were detected none on the left.[9,13] Similarly, more than one LRV was not detected in this study.

Multiple renal vein variations on the right have been reported ranging from 20.4%- 38.79%.[3,9,13,14] In a study where multiple RRVs were reported as the most common renal vein variation, the percentages were reported at 21.6%, 19.2%, 2.2%, and 0.2% for multiple RRVs, two right renal veins, three right renal veins and four right renal veins, respectively.[15] In another study, they were reported at 29% for two right renal veins and 9.7% for three or more renal veins.[9] In present study, the percentages of multiple RRVs, two RRVs and three or more RRVs were found to be

24.1%, 20.6% and 3.5%, respectively, and consistent with the literature.

In different studies, percentages of posterior lumbar tributaries of the LRV have been reported with a range of 43%-90.9%.11 In this study posterior lumbar tributaries of the LRV were detected in 934 (47.9%) of patients. The number of patients for single, two, and three posterior lumbar tributaries were, respectively, 842, 85, and 3. Regarding the levels, the number of patients for L1, L2, L3, and L4 were, respectively, 314, 648, 68, and 3.

In the study by Li et al., the percentages of one, two, and three posterior lumbar tributaries were 47.5%, 32.8%, and 3.3%, respectively.[11] In this study, these rates were, respectively, 43%, 4.5%, and 0.4%.

There are no gender assessment studies in terms of posterior lumbar tributaries in the literature. Although our study is the first on this subject, additional studies are needed to create a general consensus. The variations differ widely, and there may be discrepancies between studies in terms of sexes.

In this study, 8 patients had duplication of the IVC (0.4%), 3 patients had left IVC (0.2%), and 2 patients had IVC interruption with azygos continuation (0.1%) variations.

In the duplication of the IVC variation, the IVC is observed on both sides of the aorta below the renal level, then at the level of the renal veins, the left IVC passes anterior or posterior to the aorta and ends by joining with the right IVC. In the literature, it has been reported with a range of 0.2-3%.16 The results found in this study were within this range.

In the left IVC variation, the IVC is observed to the left of the aorta below the renal level. This variation has been reported with a range of 0.2-0.5% in the literature.[1,2] In this study, it was found at the lower end of the range (0.2%).

In the IVC interruption with azygos continuation variation, there is no hepatic segment of the IVC, and after receiving the renal veins, the IVC passes the diaphragm crus posteriorly and continues to the azygos system. In the literature this variation has been reported with a frequency of 0.6%.2 The results found in this study were lower than this value.

During embryological development of the LRV, the subcardinal veins anastomose anterior to the aorta and the supracardinal veins posterior to the aorta. Normally, the posterior anastomosis regresses and the LRV passing in front of the aorta is observed. If it does not regress, the CLRV variation occurs. It has been reported with a range of 1.07%-17%. The RLRV variation develops if the anterior anastomosis regresses and the posterior anastomosis persists. The range has been reported as 0.8%-4.2%.[2,3,9,13,14] In a meta-analysis study of renal vein variations, CLRV and RLRV variations were reported at 3.5% and 3%, respectively.12 In this study, percentages of CLRV and RLRV variations were consistent with the literature.

Dilli et al. reported that IVC and LRV variations are independent of gender.[17] Renal vein variations have reportedly been more common in women.[13,18] But they have also been reported as independent of gender.[15] In a study where no statistically significant correlation was found between gender and variations of the LRV and CLRV, RLRV was found to be statistically significantly higher in men than in women ($p = 0.039$).[19] In the present study, no difference was found between genders in terms of IVC and LRV variations.

Evaluation of venous structures with abdominal CT rather than CT angiography is a limitation. Evaluation of images by a single radiologist is also a limitation.

Renal veins exhibit high variability. The RRV is supported by number variations, especially in men, and the LRV has considerable collateral circulation, especially in women.

The knowledge of these anatomical variations, as obtained by imaging before the operation will undoubtedly benefit surgeons.

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