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Original Research Article

Evaluation of Renal Veins in Healthy Adult North Indian Population

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Abstract:

Background: In normal population, each kidney is drained by a single renal vein. The renal veins show a wide range of anatomical variations in the general population which is influenced by race and ethnicity. These variations play an important role in selection of the donor kidney for renal transplantation and also influence the renal vasculature surgeries. Majority of the CT based studies on variations of renal veins are from western countries. These studies have evaluated the number, confluence pattern and other variations of renal veins. There are few studies from Asian countries and India and hence we do not have adequate data on the prevalence of anatomical variations of renal veins for our population.

Objectives: The aim of the present study was to observe the length and diameter of renal veins and estimate the prevalence of the anatomical variations in healthy North Indian population.

Material & Methods: In this observational study eighty-seven prospective healthy voluntary kidney donors (males and females; mean age of years), were evaluated for the renal vein anatomy by MDCT and CT angiography as part of preoperative assessment prior to donor nephrectomy. The number, length, diameter of the renal vein and presence of anatomical variations on either side was recorded.

Results: The right and left Kidney was drained by single renal vein in 70.1% and 98.6% cases respectively. The mean length of the right renal vein was 15.28 ±7.02 mm and the left renal vein measured 24.04 ±11.51 mm in length. The mean diameter of right renal vein was 10.39±2.63 mm and the left renal vein measured 10.9±3.99 mm in diameter. Twenty-six of 87 (29.9%) of right kidney had an extra or supernumerary renal vein. On the left side only one kidney (1.1%) had a single supernumerary renal vein. Late confluence of the renal veins was observed in 28.7% cases on the right side and in 12.6% cases on the left side. Circumaortic left renal vein was seen in 5.7% cases. No retroaortic left renal vein was observed in our study.

Discussion: The anatomical variations of renal veins are quite frequent in our population. The right renal vein shows a higher percentage of supernumerary renal veins and late confluence of the veins compared to the left renal vein. This information is of great importance to transplant surgeons as it facilitates the decision to harvest the donor left kidney for renal transplantation.

Keywords: Renal Veins, Renal Vein Length, Renal Vein Variations, Renal Vein Diameter.

Introduction

Each kidney is supplied by a single renal artery arising from the abdominal aorta at the level of L1-L2 intervertebral disc in approximately 70% of population. It is drained by a single renal vein [1].

The renal vein lies anterior to the renal artery at the level of renal hilum. The left renal vein is longer than the right renal vein; the right renal vein drains directly into the inferior vena cava (IVC), whereas the left renal vein receives the tributaries adrenal vein, gonadal vein and lumbar veins before it drains into the IVC [2]. Both renal artery and vein show a wide range of anatomical variations, the prevalence of which vary with race and ethnicity [3]. The most common renal vein malformations are presence of accessory or supernumerary renal veins, late confluence of vein, circumaortic and retro aortic left renal vein [1,4]. Renal transplantation is treatment of choice for patients suffering from end stage renal disease. The donor kidney is harvested from voluntary healthy adult kidney donors and the left kidney is preferred because of its longer renal vein [5]. Laparoscopic technique for harvesting donor kidney is the preferred surgical procedure. Prior knowledge of renal vasculature anatomy and its variations is essential for the transplant surgeons because during laparoscopic donor nephrectomy, presence of these variations can lead to significant surgical complications or even life-threatening events if unrecognised. Majority of the studies on renal

vasculature in normal population are from western countries. There are few studies from Asian countries and India. The aim of the present study was to observe the length and diameter of renal veins and estimate the prevalence of the morphological variations of the renal veins in healthy North Indian population.

Material& Methods

This observational study was conducted in the Department of Anatomy, in collaboration with the Department of Radio-diagnosis, Sanjay Gandhi Post Graduate Institute of Medical Sciences (SGPGIMS), Lucknow. Normal adult kidney donors were the subject of the study. Eighty-seven normal healthy adults (males and females) in age group 21-61 years who were volunteer kidney donors were the subject of the study. All the voluntary kidney donors are routinely evaluated pre-operatively by MDCT and CT angiography for renal anatomy and its vascular supply and drainage. The arterial phase of CT angiography is useful for studying the renal arteries and variations. The main renal veins are also well visualized during this phase. The systemic tributaries and variations of renal veins are usually not well visualized in the venous phase hence a more delayed nephrogenic phase is preferred (Ref).

All images obtained were independently analysed in random order using a workstation (Extended Brilliance workspace, Philips Medical Systems). Axial, multi-planar reformatted image (MPR), volume rendered images (VRI) and maximum intensity projections (MIP) were reviewed. Maximum intensity projection (MIPs) was obtained using various thicknesses (5-10 mm). MIP is a method wherein the raw data are reconstructed using the maximum intensity signal along each ray through the data set. MIP enhances visual distinction between the blood vessel and background tissue and provides angiography like images, thereby giving a good overview of the vascular anatomy. Volume rendered images was also obtained using various orientations. These processed images were processed and analysed on the computer work station.

Cases with presence of renal or extra-renal pathological conditions were excluded from further analysis. The images obtained were further analysed for normal renal venous drainage and its variations.

The following parameters were observed for evaluation of renal veins:

1. Number of renal veins: Kidneys were identified in both axial, coronal, sagittal and volume rendered images and observed for the number of renal veins exiting the kidney on each side was recorded. When a kidney had two or more veins, the vein with the greatest diameter was considered to be the main renal vein and others as accessory venous**.**

2. Diameter of renal vein: It was measured at the site of drainage into aorta.

3. Length of trunk of renal vein: It was measured in volume rendered as well as MIP images with help of electronic callipers.

4. Variations in renal veins: the following variations were noted

a) **Late confluence:** Late renal venous confluence was considered when the renal vein branches coalesce within 1.5 cm from the left lateral wall of the abdominal aorta on left side and within 1.5 cm of the anastomosis with IVC on the right side.
b) **Circumaortic Left Renal Vein (CLRV):** the left renal vein is represented by two venous trunks, the dorsal and ventral venous limbs before draining into the IVC.
c) **Retroaortic Left Renal Vein (RLRV):** the left renal vein passes posterior to the abdominal aorta before draining into the IVC.

Statistical Analysis: The statistical analysis was done using SPSS (Statistical Package for Social Sciences) Version 22.0 statistical Analysis Software. The mean and standard deviations were calculated. The difference in values were considered significant if the "p" values was <0.05.

The study was conducted as per the institute research body guidelines and ethical committee approval.

Results

Table1: Length and diameter of renal veins

Parameter	Right renal Vein (N=87)	Left Renal Vein (N=87)
Length Mean ± SD (mm) Range (mm)	 15.28 ± 7.02 3.8-33.9	 24.04 ± 11.51 1.0-55.4
Diameter Mean ± SD (mm) Range (mm)	 10.39 ± 2.63 2.8-17.3	 10.92 ± 3.99 3.5-39.5

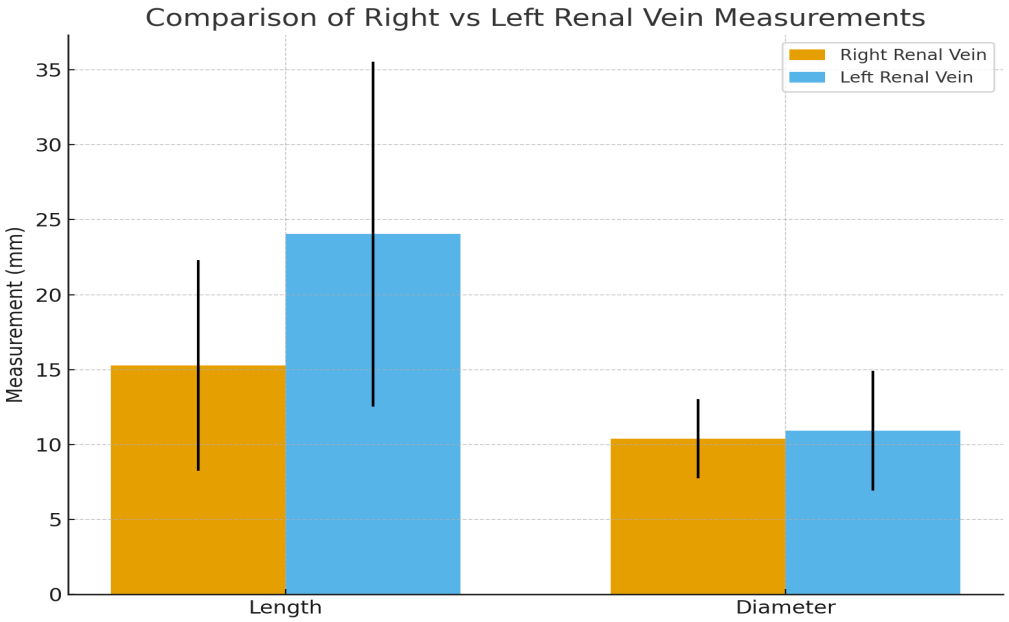

Figure 1: Comparison of right Vs left Renal Vein Measurements

Table 2: Prevalence of renal vein variations in present study

Types of anatomical variations	Right Side (N=87)	Left Side (N=87)
Single Renal Vein N (%)	61(70.1%)	86 (98.6%)
Supernumerary Veins One Two	 23 (26.4%) 03 (3.4%)	 1 (1.1%) nil
Late Confluence	25 (28.7%)	11 (12.6%)
Circumaortic Vein	nil	5 (5.7%)
Retroaortic Vein	nil	nil
Large gonadal vein (>5mm)	nil	6 (6.9%)
Large lumbar Vein (> 5mm)	nil	3 (3.4%)

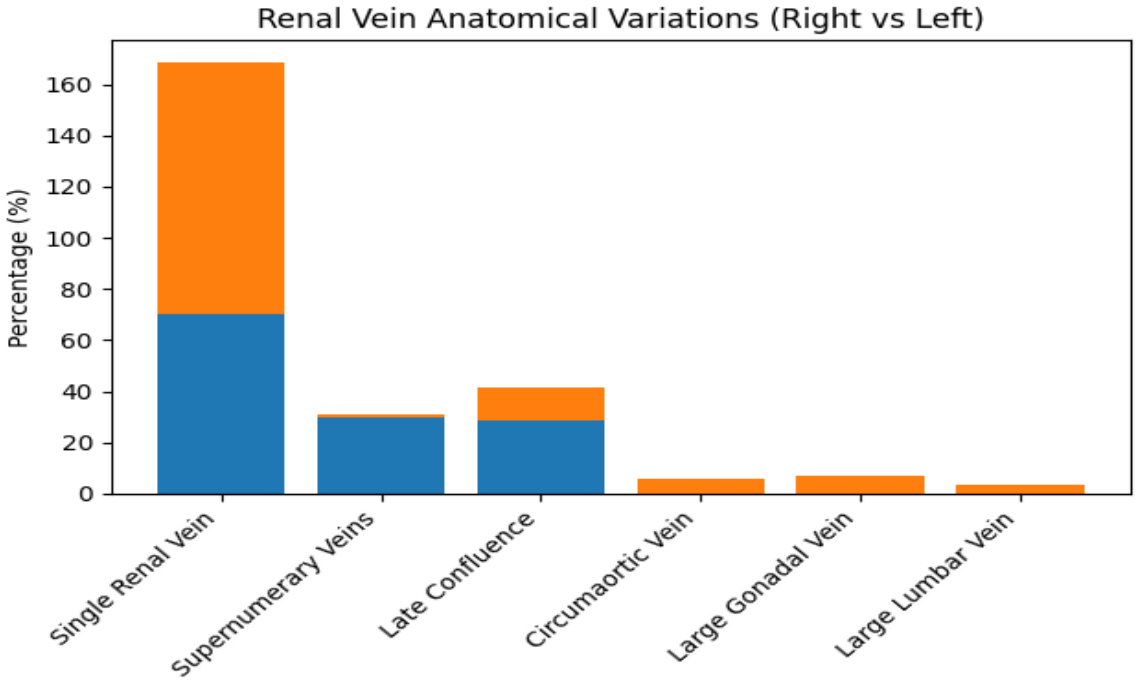

Figure 2: Renal vein anatomical variations (right vs left)

The mean length of the right renal vein was 15.28±7.02 (range 3.8-33.9) mm. The left renal vein measured 24.04 ± 11.51 (range 1.0-55.4) mm in length. The mean diameter of right renal vein was 10.39 ± 2.63 (range 2.8-17.3) mm and the left renal vein measured 10.9 ± 3.99 (range 3.5-39.5) mm in diameters (Table 1) (Figure 1).

In this observational study eighty-seven consecutive normal healthy voluntary kidney donors (females and males) were evaluated. The mean age was 43.24 ± 10.58 (range 21-66) years. The right kidney was drained by single renal vein in 61 of 87 (70.1%) cases and the 86 of 87 (98.6%) of left kidney was drained by single renal vein. Twenty-six of 87 (29.9%) of right kidney had an extra or supernumerary renal vein. Twenty-three (26.4%) had one extra renal vein and remaining three (3.4%) had an additional two renal veins. On the left side only one kidney (1.1%) had a single supernumerary renal vein (figure 2). Late confluence of the renal veins was observed in 25 of 87 (28.7%) on the right side and in 11 (12.6%) cases on the left side (figure 3). Circumaortic left renal vein was seen in 5.7% (5 of 87) cases (figure 4). No retroaortic left renal vein was observed in our study. The other variations observed in our study were large left gonadal vein (>5 mm diameter) in 6.9% (6 of 87) cases and prominent left lumbar vein (5mm diameter) in 3 of 87 (3.5%) cases. In one case the left gonadal vein and left lumbar vein showed a common trunk before draining into the left renal vein. (Table 2) (Figure 2).

Discussion

Each kidney is drained by a single renal vein. The right renal vein is usually located anterior or inferior from the right renal artery and is approximately 3.2 cm in length. The left renal vein is longer compared to right renal vein measuring about 8.4 cm. It is located anteriorly or inferiorly to the renal artery [6]. The knowledge of normal as well as variations in the vascular anatomy of the kidney has become essential because laparoscopic nephrectomy has become the preferred technique for harvesting donor kidney. It is associated with limited operative visibility and surgical exposure, thereby making details of renal vessel anatomy difficult to appreciate [7,8]. Hence, comprehensive preoperative knowledge of kidney and its vasculature is crucial for selecting proper donor, successful renal transplant surgery and avoiding surgery related complications [8-9].

Anatomical variations of the renal veins are common in general population with different frequencies among several ethnic and racial groups [7]. The mains of renal vein variations are: i) presence of multiple or supernumerary renal veins; ii) late confluence of renal vein; iii) CLRV and iv) RLRV [3,4]. Presence of multiple renal veins (supernumerary, accessory, additional) is the most common morphological variation of renal veins and is present in 15 to 30% of patients [2]. Supernumerary renal veins are more frequently observed on the right side compared to the left side. Hostiuc et al., in a meta-analysis of studies evaluating the renal venous system observed that the overall prevalence of multiple renal veins was 16.7% and it was approximately eight times more frequent on right side compared to the left (11). Studies from India have reported a prevalence of supernumerary renal veins to vary between 8.3% to 17.5% [12,13]. It has been postulated that the complex embryological development of left renal prevents the retention of extra left sided renal veins (14). In our study the overall prevalence of supernumerary renal veins was on the right side it was 29.9% compared to 1.1% left side and its in agreement with findings of Hostiuc et. al [11].

Late venous confluence is another common venous anomaly and its prevalence is highly variable. Approximately 3.0 to 30% of the right renal vein shows this anomaly and on the left side it is around 2.5% [10,13,15]. In our study 28.7% of right renal vein and 12.6% of the left renal vein showed this anomaly. Circumaortic left renal vein (CLRV) is the most common anomaly of the left renal vein. The CLRV is represented by two venous trunks, ventral and dorsal which encircle the abdominal aorta before entering into IVC.

It is estimated that the prevalence of CLRV to be around 3-17% [2,11]. In our study the prevalence the prevalence of CLRV was 5.7%. Chai et al have also a low prevalence of 1.4% in their study [11]. Gillot et al. have described three types of CLRV variants; i) CLRV with partial distal bifidity, in this variation the retroaortic branch receives the root of the hemizygous vein; ii) CLRV with partial proximal bifidity, in this variant the origin is separate and and the two divisions join in front of aorta and it's the most common type of CLRV variant; iii) Complete CLRV, in this type there are two separate venous trunks exiting the renal hilum and remain separate till their drainage into the IVC.

Two subtypes of this variant have been described a) inferior polar type: in this subtype the main trunk is superior and preaortic and the retroaortic trunk is inferior and polar; b) Superior polar: in this subtype the main trunk is horizontal preaortic and the retroaortic trunk is superior polar [16].

In retroaortic left renal vein (RLRV) anomaly the left renal vein runs posterior to aorta and drains into the lumbar portion of the IVC. Rarely it may drain into the iliac vein and is present in 1.85 to 3% of the population [2,6,12]. The RLRV occurs when dorsal part of the supra-subcardinal anastomosis and the inter-supracardinal anastomosis persists

and the ventral part of the supra-subcardinal anastomosis and intersubcardinal anastomosis regresses. No cases of RLRV were observed in our study. The other less common variant seen in our study included prominent left gonadal vein (>5 mm) was seen in 6.9% and prominent left lumbar vein (> 5mm diameter).

The other less common variant includes prominent left gonadal vein (> 5 mm diameter), in 59-88% of the population the lumbar vein, ascending lumbar vein and hemiazygos vein drains into the left renal vein [2,17].

Raman et al. have classified the renal vein anomalies into major and minor anomalies based on their impact on the selection of voluntary donor kidney for renal transplantation and surgical management of aorta and IVC disorders. The major anomalies include the presence of additional renal veins, late venous confluence of either side, CLRV or RLRV, a left sided IVC or a duplicated IVC. Minor anomalies include large gonadal and lumbar veins (>5 mm diameter) and other anomalies associated with these veins [18].

In renal transplantation the donor left kidney is preferred as the left renal vein is longer and hence the kidney can easily be mobilized. Presence of multiple renal veins is a kidney is contraindication as it is associated with higher incidence of graft renal venous thrombosis. However, if the venous drainage by the smaller accessory renal vein is less than 20% it can be sacrificed (19, 20). From our study it is apparent that accessory or supernumerary renal veins are more frequently associated with right kidney than the left kidney (29.9% vs 1.1%) and therefore it reaffirms that the left kidney of donor should be preferred for renal transplantation. The circumaortic and retroaortic renal veins are more or less anatomical variants of the left renal vein. Their presence negates the advantage of the left renal vein longer and hence preferred for renal transplantation. Also, the presence of these variants is associated with greater risk of injury during retroperitoneal surgery [21]

In conclusion our findings are similar to other published work from Asian countries. Supernumerary renal veins are more closely associated with the right kidney. Whereas, circumaortic a retroaortic renal veins are exclusively associated with left kidney.

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