

## ORIGINAL ARTICLE

## ANATOMIC PATTERNS OF RIGHT RENAL VEIN

Robina Shaheen, Muhammad Nasir Jamil\*, Umar Farooq\*\*

Department of Anatomy, \*Department of Urology, Ayub Medical College, Abbottabad, \*\*King Abdullah Teaching Hospital, Mansehra-Pakistan

**Background:** Preoperative surgical planning assumes a central role in avoiding catastrophic outcomes of a surgery in the field of renal transplantation, and other urological procedures. This study was aimed to study the different anatomic patterns of human renal venous system. **Methods:** It is a descriptive cross-sectional study including 50 adult male cadavers with well-preserved kidneys, renal vasculature and the inferior vena cava. Cadavers with deformed or congenitally anomalous kidney, evidence of surgery, solitary kidney, tumours of kidneys or injured renal vessels / inferior vena cava were excluded from the study. The kidneys, renal veins and the inferior vena cava were exposed. After securing inferior vena cava fifty ml mixture of Indian ink and gelatine was injected into renal veins via inferior vena cava and was allowed to solidify. Following this, the renal venous anatomy was studied. **Results:** Twenty-eight cadavers had their right renal vein formed by 2 tributaries (56%), 13 (26%) had 3 tributaries, 5 (10%) had 4 tributaries, 1 cadaver had a posterior tributary (2%), while 3 cadavers had other numbers of tributaries (6%). Out of total 50 cadavers 40 (80%) had normal distribution of right renal vein. Additional renal veins were found in 14 (7%) cadavers, double renal veins in 1 (2%) and proximally double renal veins in 2 cadavers (4%). **Conclusions:** There is considerable variation in renal venous anatomy. Knowledge of common venous patterns is necessary for minimizing intra-operative damage to renal anatomy and to prevent intra- and post-operative complications.

**Keywords:** Renal vein; Anatomy; Kidney

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## INTRODUCTION

The importance of normal as well as abnormal renal venous patterns cannot be overlooked as the advances in the field of renal transplantation, radical renal surgery as well as urology demand detail knowledge of renal venous architecture and since laparoscopic approach is being employed more commonly, preoperative surgical planning assumes a central role in avoiding catastrophic unnecessary outcomes of a surgery. A renewed interest in conservative approach to the renal diseases and advances in the field of radiology have re-kindled an interest in normal as well as abnormal architecture of renal veins.<sup>1</sup> The variant renal veins are often recognized incidentally, without a clinically significant effect on renal function.<sup>2</sup>

Renal veins usually start at the hilum of the kidneys following union of a variable number of smaller vessels, the primary tributaries, and end at inferior vena cava at a right angle in front of the body of L2 vertebra.<sup>3</sup> The normal order of structures at renal hilum from anterior to posterior is vein, artery and renal pelvis.<sup>4,5</sup> Although a single renal vein on either side is the normal pattern, variations such as additional renal veins or double renal veins are not uncommon.<sup>6</sup> Multiple renal veins are more common on right side than left.<sup>7</sup> The difference in the lengths of right and left renal veins and their draining territories leaves little resemblance between them.<sup>5</sup>

The complex development of renal veins beginning in 5<sup>th</sup> week of development results in a highly variable architecture. The major embryonic structures that participate in renal vein formation are the posterior cardinal, the sub-cardinal and the supra-cardinal venous systems and their accompanying anastomoses.<sup>8,9</sup> The posterior cardinal veins appear at about 5<sup>th</sup> week of development as a pair of two longitudinal veins that ascend upwards. They serve as the veins of mesonephros. These veins disappear along with the mesonephros.<sup>10,11</sup> This system is later supplanted and replaced by the paired supra-cardinal and sub-cardinal veins which develop medial to these veins. Not only they are connected to it at both cranial and caudal ends but also anastomose with each other.<sup>9</sup> These veins and anastomoses partly persist to form renal veins and IVC.

Sufficient knowledge of anatomy of renal vasculature and possible variations is necessary for investigations and proper management of renal diseases especially when racial differences in renal venous anatomy have been noted.<sup>12,13</sup> Even though renal veins have been a subject of interest there exists a lack of consensus on the incidence of variant renal veins. The knowledge of renal venous anatomy can be helpful for research purposes as well as for therapeutic decisions even though these variations are clinically silent.<sup>2</sup> Most of the research on renal venous architecture is from western hemisphere with very little contribution from elsewhere. Awareness of

common patterns in a population can be helpful in successfully dealing with undetected anomalies. In view of the lack of studies on renal venous anatomy in Pakistani population, this study will be a pioneering piece of work from Pakistan.

## MATERIAL AND METHODS

The study was conducted to study the normal as well as abnormal and variant anatomic patterns of human renal venous system. The study design was descriptive cross-sectional. It was conducted at the Forensic and Anatomy departments of King Edward Medical College Lahore, and Anatomy departments of Services Institute of Medical Sciences, Fatima Jinnah Medical College, Allama Iqbal Medical College and Postgraduate Medical Institute, Lahore for which ethical approval was obtained. Fifty adult male cadavers with well-preserved kidneys, renal vasculature and the inferior vena cava were included in study. Cadavers with deformed kidneys, or congenital anomalies such as horse-shoe kidney, evidence of surgery i.e., partial nephrectomy, congenital or acquired absence of one kidney, tumours of kidneys or injured renal vessels / inferior vena cava were excluded from the study. The kidneys, renal veins and the inferior vena cava of the cadavers were exposed after dissection through the anterior abdominal wall. For the purpose of identification of renal vasculature, an incision was made into inferior vena cava after it was either clamped or ligated with braided silk well below and above the point where renal veins joined the inferior vena cava and a fifty ml mixture of Indian ink and gelatine was injected into renal veins via inferior vena cava and was allowed to solidify.<sup>14</sup> Following this, the renal venous anatomy was studied.

## RESULTS

Majority of cadavers (n=28; 56%) were found to have a right renal vein formed by two tributaries (Table-1, figure-1). Three primary tributaries usually arising from the anterior aspect of hilum leading to formation of a renal vein were found in 26% (n=13) cadavers (Table 1). In one case, the renal vein formed by two tributaries at hilum was joined by a third tributary from the lower part of hilum 0.5–1 cm distal to its formation. Yet another case had a tributary emerging from the medial side of lower renal pole. One case had right renal vein formed by two ventral and one dorsal tributary (Table-1). The point of origin of ventral and dorsal tributaries was usually the ventral and dorsal surface of renal hilum respectively. The dorsal tributaries were noted to pass above or posterior to renal pelvis and course between the branches of renal artery on their way to joining the renal vein on the posterior surface of renal vein little distal to its formation.

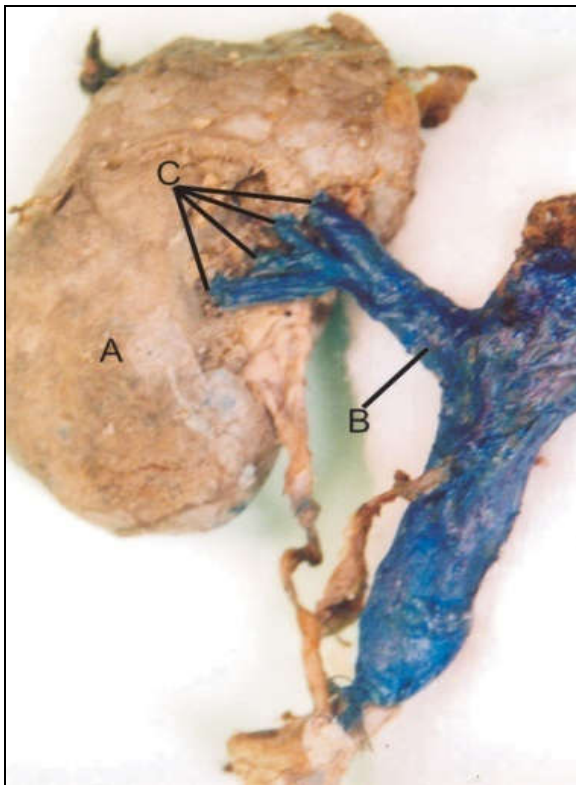
Five cases (10%) had right renal vein arising from four primary tributaries (Table-1, Figure-2). Most of these tributaries arose from ventral aspect of hilum. Three primary tributaries arising from ventral surface of the hilum and the fourth one from the medial surface of upper renal pole was found in one case. The fourth tributary joined one of the ventral tributaries instead of renal vein. The highest number of tributaries forming a right renal vein in this study was noted to be five. Two cases had renal vein formed inside kidney before emerging as a single renal vein.

Smaller veins that arose from kidney and ended in inferior vena cava separately from the main renal vein that was already present were considered additional renal veins.<sup>4</sup> On the other hand, two morphologically separate renal veins of equal calibre connecting the renal venous architecture to inferior vena cava, were considered as double renal veins. Three (6%) cases had an additional renal vein on right side in the presence of a renal vein formed by two primary tributaries. These additional renal veins originated separately from the dorsal surface of hilum before ending separately on the posterior aspect of inferior vena cava at a level same as that of main renal veins. It was not possible to observe or study the tributaries of additional renal veins as they were formed in the renal parenchyma before emerging from the kidney. Four (8%) cases had an additional renal vein in the presence of a renal vein with three primary tributaries (Table-2, Figure-3).

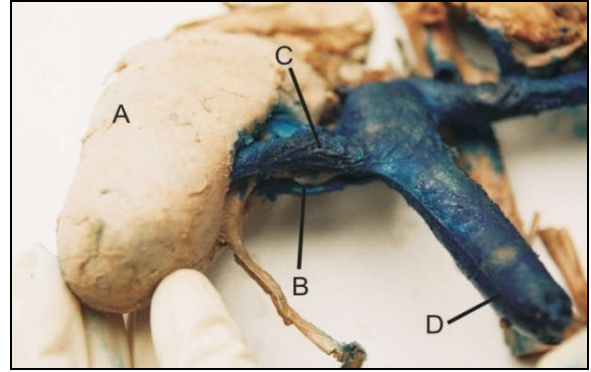
One case had double renal vein on right side, one of which emerged from the ventral surface of the hilum and went up to join the inferior vena cava at the orthotopic position. The other renal vein emerged dorsal to the first renal vein from the mid part of hilum with a branch of renal artery separating them. It went downwards to join the inferior vena cava 0.4 cm below the termination of first renal vein (Table-2, Figure-4). A renal vein formed by four tributaries with an associated variant pattern was seen in 2 cases (4%) on right side. In all these cases, there was proximal duplication of renal vein. In proximal duplication, renal vein is double in proximal half and single in distal half (Table-2, Figure-5). In case of proximally double right renal vein two renal veins, each formed by the union of two primary tributaries, emerged from anterior aspect of hilum. One vein emerged from the upper part of hilum, while the second vein emerged from the lower part of hilum. The two veins converged and joined to form single renal vein. In the present study all normal, additional and variable renal veins terminated in IVC and no case was seen to terminate in veins other than IVC.



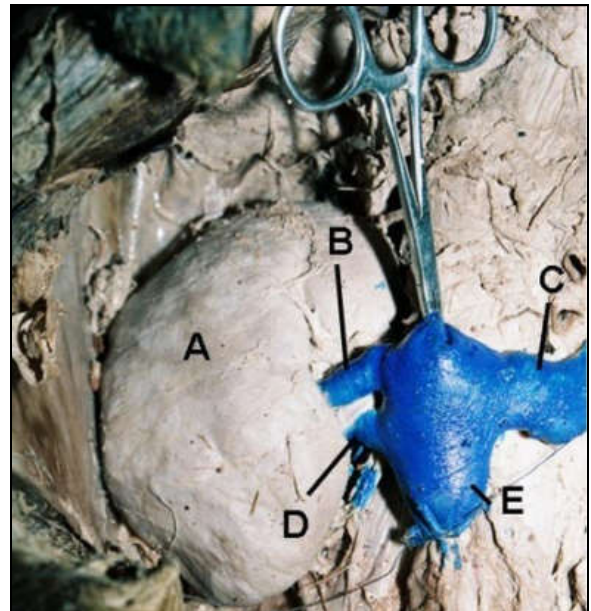
**Figure-1: Anterior view of right kidney showing right renal vein formed by two primary tributaries from anterior aspect of hilum**



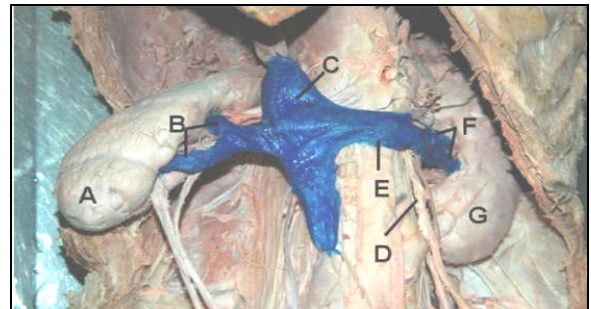
**Figure-2: Anterior view of right kidney (A) shows right renal vein (B) formed by four primary tributaries (C).**



**Figure-3: Anterior aspect of right kidney (A) shows an additional renal vein (B) emerging from posterior aspect of hilum, while main renal vein (C) is formed by two tributaries. D, IVC.**



**Figure-4: Anterior aspect of right kidney (A) shows double right renal vein (B, D). B, upper right renal vein; D, lower right renal vein; C, left renal vein; E, IVC.**



**Figure-5: Anterior aspect of kidneys (A, G) showing proximally double (B) right renal vein (H) and left renal vein (E) is also proximally double (F). Both renal veins (B, F) later join to form single renal vein of its side. C, IVC; D, aorta.**

**Table-1: Distribution of various groups of renal veins on right side.**

No. of Primary Tributaries	Right n = 50	
	No of cases	Percentage
Two	28	56.0
Three	13	26.0
Four	5	10.0
Posterior tributary	1	2.0
Any other no.	3	6.0

**Table-2: Different patterns of right renal vein.**

Pattern	Right side (n=50)	
	No of cases	Percentage
Additional RV	7	14
Double RV	1	2
Proximally Double RV	2	4
Normal	40	80

## DISCUSSION

We focused on the anatomy of renal venous system with respect to the patterns of renal vein formation and during this study we noted the number and anatomical relationships of the primary tributaries contributing to formation of right renal vein. A renal vein formed by two primary tributaries was the most common finding present in 28 (56%) cases. The reported frequency of two primary tributaries contributing to a renal vein formation in literature varies from 18% to 38.6%.<sup>15-17</sup>

The commonest variant pattern found was additional right renal vein (n=7; 14%). The reported frequency of right sided additional renal veins in literature varies between 10.8% to 33%.<sup>6,7,18-22</sup> A second additional renal vein, encountered in 3.3% of cases by Satyapal<sup>6</sup>, was found in 2% of cases in our study.

Multiple right renal veins have also been reported in literature. There was only one case of double renal vein (2% of cases) on right side our study. The two renal veins were of approximately equal calibre and they ended in inferior vena cava independent of each other. Fernandes *et al*<sup>23</sup> reported a case of triple right renal veins arising from ventral aspect of hilum and terminating independent of each other into the inferior vena cava. Double right side renal veins have been reported elsewhere too.<sup>9,24</sup> These authors did report cases of multiple right renal vein but did not give the incidence. Whereas Baptista-Silva<sup>25</sup> and Lappas *et al*<sup>26</sup> reported incidence of double right renal vein to be 29% and 29.58% respectively. These researchers did not differentiate them from ARV so that the actual incidence of double renal vein cannot be calculated.

In thirteen cases (26%), right renal vein was formed by three primary tributaries. Sampaio *et al* found three tributaries giving rise to a renal vein in 53.8% of cases. While only a fraction of cases (10%) were found to have four primary tributaries giving

rise to a renal vein. Four primary tributaries giving rise to right renal vein were found to be present in 10% of cases. It was found in 15.4% of cases in one study.<sup>15</sup> Besides the two cases where one of the tributaries did not emerge from renal hilum, all tributaries giving rise to the renal vein were found to emerge from the ventral aspect of renal hilum.

While posterior primary tributary was found in only 2% of cases on right side in this study, the over-all incidence varies between 21.1–35.5%.<sup>15,16,19</sup> While reporting the incidence of posterior tributary and proximal duplication of renal veins most authors give combined incidence of both right and left side so that actual incidence on right side only cannot be calculated. Two (4%) cases with renal vein formed by four primary tributaries had a proximally double renal vein on right side. Proximal<sup>9,27-29</sup> as well as distal<sup>30,31</sup> duplications of left renal vein have also been reported. Although this variant pattern has been reported by some authors, it has not been described by most of the previous studies. While this variation has been described with terms such as “partially bifurcate” or “partially bifid renal vein”, we suggest that the terms “proximally double” or “distally double” renal vein should be used for this particular pattern. One (2%) case had renal vein formed by more than four tributaries, i.e., five. In two (4%) cases renal vein was formed in the substance of kidney and emerged as single vein from the hilum so that no tributaries were observed at hilum. Maximum number of tributaries giving rise to a right renal vein reported in literature has been five.<sup>6,15</sup>

Renal veins have gained increasing importance in context with the procurement of donor kidneys and renal transplantation surgeries.<sup>32</sup> It is clear from the present as well as the recent studies that the variations in the venous pattern are encountered more often than reported earlier in the literature. The difference in the incidence of various variant patterns in different studies is presumably due to racial differences. With prior knowledge of possible variation of renal veins, inadvertent injury and unwelcome bleeding can be avoided to a greater extent during various endourological and other interventional procedures.<sup>33,34</sup> The presence or absence of various venous variations can influence both the management and outcome of surgical procedures which surround renal veins.

## CONCLUSION

There is considerable variation in renal venous anatomy whose incidence varies within a wide range. Familiarity with common renal venous patterns in a population is essential for pre-operative detection and planning. It will also ensure minimizing damage to

renal anatomy in case of undetected anomaly so as to prevent intra- and post-operative complications.

### AUTHORS' CONTRIBUTION

RS: Concept and Design of Study, data collection, literature research. MNJ: Data Analysis, Revisiting Critically. UF: Manuscript writing, Revisiting Critically. RS, MNJ, UF: Final Approval.

### CONFLICT OF INTEREST:

There is no conflict of interest by any author.

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### Address for Correspondence:

Dr. Robina Shaheen, Department of Anatomy, Ayub Medical College, Abbottabad-Pakistan

Email: rad407@gmail.com