The Professional Medical Journal
www.theprofesional.com

DOI: 10.29309/TPMJ/2019.26.02.3113

ORIGINAL PROF-0-3113

VENOUS DRAINAGE OF KIDNEY;

NEW CLASSIFICATION OF THE VENOUS DRAINAGE PATTERN OF KIDNEYS.

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Article received on:
29/05/2018
Accepted for publication:
15/11/2018
Received after proof reading:
31/01/2019

ABSTRACT… Background: In the era of changing trends in favour of laparoscopic and minimally invasive surgery, a better understanding of renal veins is of paramount importance. Although various classifications of renal veins have been proposed, none is without shortcomings. We investigated the drainage pattern of renal veins in cadavers and aim to address the shortcomings in previous classifications by proposing a new classification of renal veins. **Study Design:** Observational cross-sectional study. **Setting:** Embalmed cadavers or autopsy cases in anatomy and forensic departments of various medical colleges of Lahore (Fatima Jinnah, King Edwards, Allama Iqbal). **Period:** One year from Feb 2008 to Jan 2009. **Methods:** The kidneys and inferior vena cava were well exposed in cases with well-preserved renal vessels and kidneys. A mixture of gelatin and Indian ink were injected into inferior vena cava which in turn filled renal veins. Renal vein patterns were studied. We report frequencies in the proposed renal vein groups and subgroups. **Results:** A total of 50 pairs of kidneys were studied (50 right, 50 left). The renal veins were classified into five groups (A-E) depending on number and arrangement of primary tributaries that formed renal vein. All groups were further divided into three sub groups (1, 2 and 3) depending on whether or not an additional renal vein or any other variant pattern existed, except group E. Subgroup1 represented normal renal vein across all groups. Groups A, B, C consisted of renal veins formed by union of 2, 3, 4 primary tributaries respectively, all from anterior aspect. Group D consisted of renal veins where a posterior primary tributary existed. While group E included renal veins formed by any other number or pattern of primary tributaries. Group A was the most frequent type overall (40%), more common on the right side (56% vs 24%). Group B was the most frequent group on the left side (38%). The least frequent group was group E with equal frequency on both sides (6%), closely preceded by group D, which was more frequent on the left side (12% vs 2%). The only statistically significant difference in relation to major groups between right and left kidneys was in group A (56% vs 24% respectively; P=0.001). **Conclusion:** We proposed a comprehensive classification of renal veins taking into account their variant and anomalous patterns and tributaries not previously considered by other classifications. Future studies in diverse populations with bigger sample are warranted to investigate some of the patterns not observed in this study.

Key words: Renal Vein; Classification; Kidne, Inferior vracara tributaries.

Article Citation: Shaheen R, Jamil MN, Aminullah. Venous Drainage Kidneys; New classification of the venous drainage pattern of kidneys. Professional Med J 2019; 26(2):312-317. **DOI:** 10.29309/TPMJ/2019.26.02.3113

INTRODUCTION

The variable pattern of renal vasculature has made it a topic of repeated anatomical investigations but venous drainage is relatively less studied as compared to arterial pattern.[1] The variations in the branching patterns of the renal vessels is a critical issue and a challenging task for radiologists who interpret renal angiograms and for the urologists who perform laproscopies.[2] Over the past few decades, numerous classifications have been proposed for the drainage patterns of the kidneys, yet there is little consensus on a classification. The changing trends in favour of minimally invasive renal surgery and new modalities of radiology have rekindled the curiosity to study the various normal and abnormal patterns of renal veins in a greater detail.[3]

A renal vein is formed by the convergence and union of a varying number of primary tributaries emerging from the kidney and which terminates separately into the inferior vena cava (IVC).[4] It is the most anterior structure in renal hilum. The fact that renal vein is not always single, rather it may present as double, additional or as another variant pattern, has made the task of classifying renal vein more challenging. Further, the right and left renal veins often vary in their length, pattern and territory drained by them, and hence bear little resemblance with each other.[5] The renal veins on both sides join inferior vena cava (IVC) at right angle at the level of L2 vertebra. The left renal vein (LRV) enters IVC a little superior to right renal vein (RRV).

Despite difficulties in classification of renal veins, a logical classification is necessary to ascertain whether an unusual pattern of formation, anomaly or some kind of variation is present. An adequate knowledge of renal venous anatomy, its variation and anomalies is essential for surgery, angiography, venography, selection for segmental vein renin assay sampling, doppler studies and CT scan evaluation. Renal vein classifications to date have been based on the number and arrangement of primary tributaries, the number of renal veins, and presence or absence of additional renal veins, but do not adequately take into account the presence of circumaortic and retroaortic veins and proximal or distal duplication of renal veins. The widely accepted classification by Satyapal et al[6] itself had short comings as they included any pattern of renal veins formed by more than two tributaries in a single group, and also did not accommodate variant patterns other than additional renal veins (ARV) in any group. In the present study, we investigate the drainage pattern of renal veins in cadavers and aim to address the shortcomings noted above by proposing a new classification of renal veins.

MATERIAL AND METHODS

Inclusion Criteria

The one year study was conducted on embalmed cadavers or autopsy cases with well-preserved renal vessels in anatomy and forensic departments of various medical colleges of Lahore (Fatima Jinnah, King Edwards, Allama Iqbal) from Feb 2008 to Jan 2009. Apparently diseased or anomalous kidneys and those with signs of trauma or surgery were excluded from study.

Dissection

Inferior vena cava was exposed. Renal veins along with kidneys were well exposed. Inferior vena cava was ligated, well above and below the termination of renal veins with braided silk or clamped with the help of a clamp. An injection medium consisting of mixture of gelatin with Indian ink was prepared and injected by manual pressure into inferior vena cava which in turn filled renal veins.[7] The medium was allowed to set and solidify. Renal veins and their variants were outlined and studied.

An additional renal vein was defined as a vein of smaller caliber/diameter than main renal originating independently from kidney and terminating separately in IVC. A vein of approximately same caliber as main renal vein originating from hilum and terminating separately in IVC was defined as double renal vein.

Statistical Analysis

We report the proportion of kidneys that demonstrated different classification patterns. A Chi^2 tests was used to compare the proportions and $p<0.05$ was considered statistically significant. All analyses were performed using SPSS v21.

RESULTS

The 100 kidneys were divided into five major groups (A, B, C, D and E) based on the number of primary tributaries that united to form the renal veins and their arrangement in renal pelvis. Each group, except E, was further divided into three sub groups (1, 2 and 3) depending upon whether they were associated with an additional renal vein or any other associated variant pattern (Table-I). Subgroup1 represented normal renal vein across all groups.

Group A

This group had two primary tributaries. It was observed in 40% of cases. Subgroup A1 had renal veins formed by two tributaries without any associated variation, and occurred in 34 (34%) of 100 kidneys (Table-II). Subgroup A2 had renal vein formed by two tributaries and any additional vein and was found in 3 (3%) of kidneys. Subgroup A3 had renal vein formed by two tributaries with any other associated variant or anomalous pattern and was present in 3 (3%) of cases. The associated patterns observed were double renal vein and left circumaortic renal collar.

Group B

This group had renal vein formation by union of three primary tributaries from anterior aspect of hilum of respective kidney. Group B was observed in 32 (32%) kidneys. Subgroup B1 had three tributaries without associated variant pattern and was observed in 27 (27%) kidneys. Subgroup B2 had existence of three tributaries and any additional vein. This pattern was found in 4% of kidneys. Subgroup B3 had renal vein formed by three tributaries with any other associated anomalous or variant pattern. This subgroup was found in 1% of kidneys. It was a case of retroaortic left renal vein which was formed by convergence of three primary tributaries.

Groups	Subgroups	Description
A	A1	Two primary tributaries
	A2	Two tributaries and an additional renal vein
	A3	Two tributaries and any variant pattern
B	B1	Three primary tributaries
	B2	Three tributaries and an additional renal vein
	B3	Three tributaries and any variant pattern
C	C1	Four primary tributaries
	C2	Four tributaries with an additional renal vein
	C3	Four tributaries with any variant pattern
D	D1	Along with any number of anterior tributaries presence of a posterior tributary
	D2	D1and an additional renal vein
	D3	D1and any variant pattern
E		Any other pattern of tributaries

Table-I. Classification of renal veins

Group, Subgroup	Right Kidneys (n=50) n(%)	Left Kidneys (n=50) n(%)	Total (n=100) n(%)	P value*
A	28 (56)	12 (24)	40 (40)	0.001
A1	24 (48)	10 (20)	34 (34)	
A2	3 (6)	0	3 (3)	
A3	1 (2)	2 (4)	3 (3)	
B	13 (26)	19 (38)	32 (32)	0.198
B1	9 (18)	18 (36)	27 (27)	
B2	4 (8)	0	0	
B3	0	1 (2)	1 (1)	
C	5 (10)	10 (20)	15 (15)	0.161
C1	3 (6)	5 (10)	8 (8)	
C2	0	0	0	
C3	2 (4)	5 (10)	7 (7)	
D	1 (2)	6 (12)	7 (7)	0.050
D1	1 (2)	6 (12)	7 (7)	
D2	0	0	0	
D3	0	0	0	
E	3 (6)	3 (6)	6 (6)	1.0

Table-II. Number of kidneys in each classification group, by side.
***Chi^2 test for right vs left for major groups. Chi^2 test not performed for subgroups due to small numbers.**

Group C
Renal veins formed by union of four primary tributaries were included in this group. Group C was found in 15% of kidneys. Subgroup C1 included cases where four tributaries united to form renal vein and there was no associated variant pattern. It was found in 8% of kidneys. Subgroup C2 would include renal vein formed by four primary tributaries and an additional renal vein. None of kidneys fell in C2 on either side in our sample. Subgroup C3 included renal veins formed by four tributaries with any other associated variant or anomalous pattern. This subgroup was seen in 7% of kidneys.

Group D
This group included renal veins where a posterior tributary was present in addition to the anterior tributaries, regardless of number of tributaries. It was found in 7% of kidneys. Subgroup D1 consisted of those kidneys where there was no associated variant or anomalous pattern. All 7% of kidneys fell in subgroup D1. Subgroup D2 would include renal vein where along with anterior tributaries a posterior tributary existed and there was an associated additional renal vein. In subgroup D3 would include cases in which the associated variant pattern was other than additional renal vein. None of the veins fell in subgroup D2 or D3 on either side.

Group E
This group included veins having any other number or pattern of primary tributaries and occurred in 6% of kidneys. Maximum number of primary tributaries observed was seven. No other associated variant pattern was observed in this group. The anomalous and variant patterns observed in our study in subgroup3 were double renal vein, retroaortic renal vein, circumaortic renal collar and proximally double renal vein.

The only statistically significant difference in relation to major groups between right and left kidneys was in group A (56% vs 24% respectively; P=0.001; Table-II). The difference between the two sides for group D was marginally non-significant (2% on right vs 12% on left; P=0.050). On the right side, group A1 was most commonly observed (48%), while group B1 was most common on the left (38%). Only 19% of kidneys demonstrated similar pattern on both side in one individual, of these 13 belonged to group A1.

DISCUSSION
Our study provided a comprehensive classification of renal veins, and addressed the shortcomings in previous classifications by also taking into account various variant and anomalous patterns other than additional veins. Most of other studies[8,9] on the other hand classified the anomalous patterns only, regardless of normal drainage pattern. In our study, the overall most common renal venous drainage pattern was of two primary tributaries which occurred in more than half of kidneys on the right and one third on the left side. On the left side three primary tributaries were most frequent, found in two third of kidneys. Amongst the subgroups on the right side, subgroup A1 was most common observed in half of kidneys whereas sub group B1 was most common on the left observed in two third of kidneys. Subgroup A2 occurred 14 times more frequently on right side, while on the left side there was 10 times increase in occurrence of group D as compared to right side. None of groups on both sides had the same variant pattern in one individual. The anomalous patterns like distal duplication of renal and triple renal veins reported in some other studies[9,10] were not observed in our study. To our knowledge this is the first ever classification proposed in South Asia.

In our study, Group A was the most frequent group overall (40%). Previous studies have also reported renal vein formed by two tributaries was most frequent type, observed in 18-41% of cases.[2,6,12] In a study by Sampaio and colleagues,[13] it was second commonly observed group (28.8%) after group B (53.8%) which includes renal veins formed by three tributaries. In our study the least frequent group was D that included renal veins with a posterior tributary, found in 7% of kidneys overall. Previous studies have reported relatively higher frequency of this group in (25-27%), and was the second most frequently observed after group B in the latter study.[12,14] In group E the maximum number of tributaries was seven, all from anterior aspect of hilum, which is consistent with the findings by Kumar and colleagues.[2] Other studies have reported up to five tributaries.[13,15]

Overall frequency of posterior primary tributary in our study was 7%, which is much low compared to previous studies. It was more common on left than right side (12% vs 2%). The presence of posterior primary tributary has been reported as a potential risk factor for intra and postoperative heamorrhage in endourological procedures.[13] Various study have reported the frequency of posterior primary tributary between 21% and 31%.[11-16] This marked difference in frequency may be an indication of racial differences.

The presence of ARV in subgroup2 was noted in 14% of cases, all on the right side. This frequency is slightly lower than reported by previous studies,[19,20] though the frequency was consistently lower on the left side (1-7% vs 11-23%). Other studies reported an even higher frequency of ARV, however they did not differentiate ARV from double renal vein.[19,20] Future bigger studies with diverse sample are warranted to investigate some of the patterns not observed in this study and to explore racial and gender based differences in various subgroups.

There are a few limitations associated with this study. First, this was predominantly male sample, so findings may not be applicable to females. Though obtaining female cadavers are challenging to obtain in our setting, nevertheless future studies should attempt to incorporate both male and female cadavers. Secondly, some of our proposed subgroups had had zero frequencies. This is also an area for future research to quantify frequencies in these subgroups. Thirdly, our sample size may not be large enough to ascertain statistically significant between right and left sides for all subgroups. The above factors should be carefully considered when applying results to other settings. Familiarity with different patterns and arrangements of renal vein and its tributaries may guide surgery, and may help avoid inadvertent injury and unwelcome bleeding to a great extent during various endourological, laproscopic and transplant surgeries and other interventional procedures.[21,22]

CONCLUSION

We proposed the first comprehensive classification of renal veins taking into account variant and anomalous patterns of tributaries not previously considered by other classifications. Awareness of various drainage patterns of renal veins, their orientation in renal hilum and in para aortic region is of immense importance to surgeons in general, and urologists in particular. It may also assist angiographers in segmental renin sampling, and radiologists in assessment of preoperative imaging.

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If you fail to **plan**,
you are **planning** to fail.

"Benjamin Franklin"

AUTHORSHIP AND CONTRIBUTION DECLARATION

Sr. #	Author-s Full Name	Contribution to the paper	Author=s Signature
1	Robina Shaheen	Concept and design of study, data collection, literature research.	
2	Muhammad Nasir Jamil	Manuscript writing.	
3	Aminullah	Data analysis, Revisiting Critically	