

## ANATOMICAL AND EMBRYOLOGICAL STUDY OF RENAL HILUM

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### ABSTRACT

**Introduction:** As per standard text, the anteroposterior topographical arrangement of renal hilar structures are: vein-artery-renal pelvis. However, hilar variations are very common. **Aim:** The present study intends to increase awareness of possible variations in the hilar anatomy as they are of immense importance in invasive renal interventions.

**Materials and methods:** A careful dissection of 51 embalmed cadaveric kidneys was carried out for the proper visualization of renal hilar structures and their relations were clearly defined.

**Observations and Results:** Enormous renal hilar variation was observed. We classified these renal variations in 8 different patterns. Normal hilar arrangement was seen in 25.5% kidneys and in 74.5% cases this arrangement is disturbed. 43.1% kidneys demonstrated presence of retropelvic structures. Anterior and posterior tributaries of renal vein were displayed in 9.8% of cases

**Conclusion:** Knowledge of the pattern of renal hilar structures is of great importance in the interventional radiological & laparoscopic renal surgeries thereby reducing the risk of vascular complications.

**KEY WORDS:** Hilum, Kidneys, Arrangement, Variation, Anatomy.

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### INTRODUCTION

Kidneys are a pair of excretory organs which lie retroperitoneal one on each side of vertebral column in paravertebral gutter [1]. Each kidney is bean shaped and has a deep vertical slit situated on its medial aspect called hilum which is bounded by the thick lips of the renal substance. Hilum of the right kidney lies below and that of the left kidney just above the transpyloric plane about 5cms away from the mid line. It communicates with the renal sinus within the kidney [2]. Hilum of the kidney is lined by the renal capsule and transmits the renal vessels, nerves, lymphatics and renal pelvis, the remaining space is occupied with fat [3]. At birth

the hilum faces anteriorly [4]. Sometimes it can lie laterally, leading to an unusual configuration on excretory urography [5]. As the kidneys ascend from the pelvis anteriorly faced hilum rotates 90° medially [4].

The arrangement of structures entering or leaving the hilum from before backwards are renal vein, renal artery and renal pelvis. Usually one branch of renal artery and a corresponding tributary of renal vein may pass behind the renal pelvis. In about two thirds of the population, i.e.70% each kidney is supplied by a single renal artery and in 30% of kidneys there may be more than one renal artery [3]. Multiple renal arteries may be seen in normal kidneys but are

more common in congenitally malformed or mal positioned kidneys [6]. Accessory renal arteries, may enter the kidney either through the hilum or at one of its poles. Each Renal artery divides into branches at or near the hilum and the pattern of branching may vary [3]. Five or six tributaries of renal vein unite at the hilum to from the single renal vein on each side which drains into inferior vena cava. Left renal vein is longer than the right as inferior vena cava lies more towards the right side. The left renal vein may be double, one vein passing anterior and the other posterior to the aorta to join the inferior vena cava. The renal pelvis, the funnel shaped commencement of the ureter, is normally the posterior most of the three main structures at the hilum [1].

The extension of renal pelvis is variable. In some individuals, the entire renal pelvis may lie inside the sinus of the kidney [3]. Sometimes due to early splitting of ureteric bud there may be partial or complete duplication of ureter and pelvis. Capacity of the pelvis is about 5-7 ml [7]. Various studies on human kidneys have been carried out in past on different races to explore the arrangement of structures at the hilum. However very few research work has been performed in our country regarding arrangement of structures at hilum of kidney. The present study was intended to evaluate the variation in the arrangement of structures at hilum of kidney collected from cadavers of North Indian origin. Considerable changes in the arrangement of main structures at the hilum was observed in 51 kidneys taken for the study. A precise normal and variant anatomy of hilar structures is essential while performing various surgical, invasive and renal transplant procedures and also during interpretation of various radiological techniques related to the kidney [8]. The findings of this study will contribute in further strengthening the above knowledge.

**MATERIALS AND METHODS**

51 kidneys obtained from the cadavers dissected during routine dissection for undergraduate students were taken for study. Out of which 28 kidneys were of right side and 23 of the left side. Hilar and adjacent pre hilar dissection was carried out to observe the arrangement of structures entering or leaving the hilum of the

kidney. Vein, artery and pelvis were identified and documented. The various patterns of arrangement of the hilar structures were carefully noted and about 08 major patterns were observed which were classified as below:

Classification of various patterns observed at the hilum:

- PATTERN I V A P
- PATTERN II A V P
- PATTERN III V AD P PD
- PATTERN IV AD V P PD
- PATTERN V AD V PD P
- PATTERN VI V AD PD P
- PATTERN VII AT AD PT P PD
- PATTERN VIII A P V

**OBSERVATIONS AND RESULTS**

The results of the study are depicted as per table below:

**Table 1:** Shows the anatomical arrangement of hilar structures (anterior to posterior) and their percentages of occurrence.

Arrangement of structures at hilum	No. of kidneys (n=51)	Incidence (%)	Right (n=28)	Left (n=23)
V-A-P	13	25.5	8	5
A-V-P	5	9.8	3	2
V-AD-P-PD	8	15.69	4	4
AD-V-P-PD	9	17.65	2	7
AD-V-PD -P	7	13.72	4	3
V-AD-PD-P	3	5.88	3	Nil
AT-AD -PT - P-PD	5	9.8	4	1
A-P-V	1	1.96	Nil	1

V: Renal vein, A: Renal artery, P: Renal pelvis, AD: Anterior division of Renal artery, PD: Posterior division of Renal artery, AT: Anterior tributary of Renal vein, PT: Posterior tributary of Renal vein.

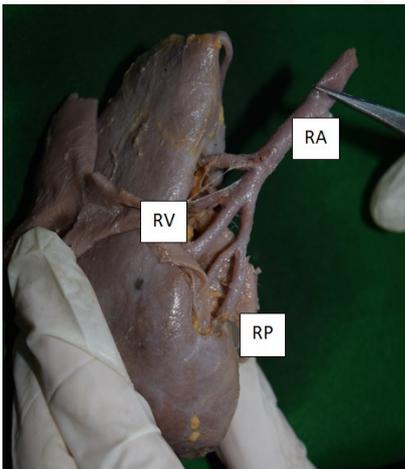
In the present study we found great variation in the arrangement of renal vein, renal artery and the renal pelvis, antero posteriorly at the hilum. In majority of the cases renal artery divided into anterior and posterior divisions. In few cases anterior trunk of renal artery was the most anteriorly placed structure at the renal hilum. Retro pelvic structures were observed at the hilum in some specimens. The sample size taken in the study was of 51 kidneys. There were 28 kidneys of right side and 23 of left side. The classical arrangement (V-A-P), as is given in the standard text books, was observed in 13 out of 51 cases, which accounted for the highest

(25.5%) incidence in our study. It was seen in 15.7% on right side and 9.8% on left side. In 38 (74.5 %) kidneys in the present study this arrangement was disturbed. Out of which 20 (39.21%) belonged to right side and 18 (35.29%) to left side. The highest incidence of disturbed relationship was the AD-V-P-PD type of arrangement which was seen in 9 (17.64%) kidneys. We also noted a total of 45.09% cases wherein the renal pelvis was entrapped between the renal vessels.

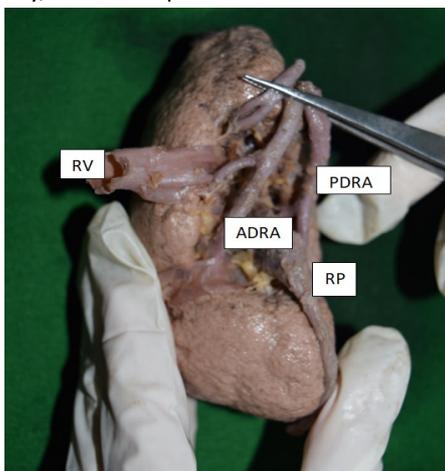
**Table 2:** Shows the no. of venous tributaries at the hilum and their percentage of incidence.

No. of venous tributaries	No. of kidneys (n=51)	Incidence (%)	Right (n=28)	Left (n=23)
One	17	33.33%	10	7
Two	24	47.05%	13	11
Three	6	11.76%	4	2
Four	3	5.88%	1	2
Five	1	1.96%	0	1

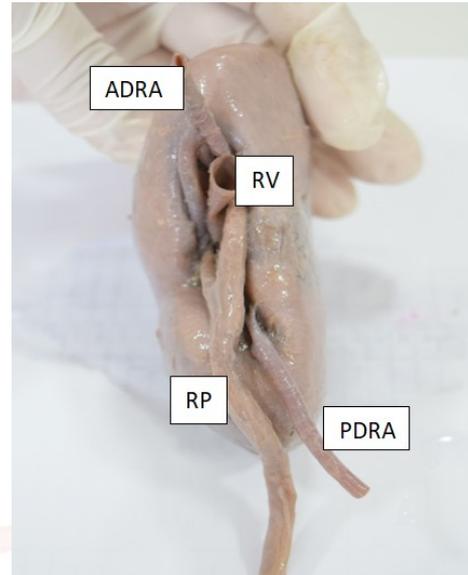
**Fig. 1:** Showing the typical arrangement of structures at the hilum of kidney. (RV=Renal vein, RA=Renal Artery, RP=Renal Pelvis).



**Fig. 2:** Showing pattern III where ant and post divisions of renal artery are enclosing the renal pelvis. RV=Renal vein, ADRA= ant div of renal artery, PDRA= Post div of Renal artery, RP=Renal pelvis.



**Fig. 3:** Showing pattern IV where the renal vein and renal pelvis are enclosed by ant and post divisions of renal artery. (RV=Renal vein, ADRA= ant div of renal artery, PDRA= Post div of Renal artery, RP=Renal pelvis)



In the present study single renal vein was found in 17(33.33%) of specimens out of which 10 were on right and seven were on left side. The highest incidence was of two tributaries which was observed in 24(47.05%) kidneys. Next in order of frequency was three venous tributaries found in 6(11.76%) specimens followed by four tributaries in 3(5.88%) specimens. One left sided kidney was found to be drained by as much as five tributaries.

**DISCUSSION**

Various kidney disorders pose fatal complications such as a risk of cardio morbidity, hospitalization or even death. Nephrectomy is being used as a choice of a therapeutic procedure towards certain kidney disorders in which the functional units of the nephrons are spared. A Laparoscopic Partial Nephrectomy (LPN) minimizes the risk of a radical nephrectomy. However, the LPN procedure is a very complicated and a technically challenging task for the urologists, as it requires the skill of ligation or clamping of the vessels which are present in the narrow spaced hilum [8]. Clamping of the individual structures is beneficial than the en-bloc clamping procedures [9].

Hence, it is necessary for the urologists to have an ample knowledge on the arrangements of the renal hilar structures before making a surgical approach. Conventional textbooks of anatomy define the relation of renal vein, renal artery

and pelvis antero-posteriorly and above downwards at the hilum of each kidney. These arrangements and the number of structures in the hilum are highly variable. On reaching the hilum, the renal arteries usually divide into anterior and posterior divisions. The posterior division of the renal artery and the posterior tributary of the renal vein may generally enter the kidney tissue, posterior to the pelvis, in some cases [3]. Variations of renal vessels are frequently observed but variations in renal arterial pattern are more common as compared to venous pattern. Variations in the configuration of renal calices, pelvis and ureter have been reported by Bergman et al [10] in 2000 & Poirier and Nicolas[11] in 1912.

The incidence in classical position of the renal vein anterior to the renal artery has been reported to be 65%, while the position of artery, anterior to the vein has been reported to be 35% of cases, respectively in a study done by Kolster in 1901 [12]. Present study demonstrates that structures at the renal hilum show variable arrangements. Pattern I is the one that conforms to the description of normal anatomy of standard text books while other are variant patterns. Variant patterns are more commonly observed on left side. This might be because embryologically left renal vein is a composite structure derived from multiple anastomotic channels whereas the right renal vein is derived from a single anastomotic channel. Deviant development of these channels may change interrelationship of renal hilar structures with respect to renal vein [7].

**Table 3:** Shows the comparison of pattern of arrangement of renal structures in the hilum with previous studies.

Arrangement of structures at the hilum	Present study [51]	Trivedi S et al [13]	Naveen K et al [14]
V-A-P	25.50%	19%	45.80%
A-V-P	9.80%	-	28.10%
V-AD-P-PD	15.70%	20%	8.30%
AD-V-P-PD	17.65%	8%	4.20%
AD-V-PD -P	13.70%	23%	2.10%
V-AD-PD-P	5.90%	8%	-
AT-AD-PT - P-PD	9.80%	-	-
A-P-V	1.96%	-	1%

We classified the arrangement of renal hilar structures into 8 patterns while Trivedi et al [13] in 2011 and Naveen Kumar et al [14] in 2013

observed 5 and 12 patterns respectively. In the present study normal arrangement of structures at the hilum as described in conventional textbooks of anatomy was observed in 25.5% cases and variant pattern was observed in 74.5%. This is similar to the study done by Trivedi et al [13] where they found normal arrangement in 19% of cases and variant pattern in majority (81%) of the population. Ant division of renal artery entering anterior to renal vein was observed in 31.35% specimens. Trivedi et al [13] in their study observed anterior div of renal artery in front of renal vein at the hilum in 31% of cases which is similar to our studies. They found that the renal pelvis was the posterior most structure in 50% of cases. In the present study also in 54.9 % of specimens renal pelvis was posterior most structure. The findings of the present study were quite different than those of Naveen K et al [14] where the classical pattern of VAP was observed in 45.8% specimens. The possible reasons for variability in incidence might be due to anatomic variations of renal vessels which are common in general population with different frequencies among several ethnic and racial groups. It may also be due to difference in sample size taken into account. Present study was carried out on 51 kidneys while Trivedi et al studied 100 kidneys & Naveen K et al observed 96 kidneys.

The renal veins show less variations than do the renal arteries. In one study multiple renal veins were found to be rare on the left side and common on the right side. Nayak et al [15] in his studies reported renal vein variations to be more common on the right side than left. Sampio and Passos [16] found the incidence of additional renal veins to be 3.3% on right side and 2.6% on left side. In the present study also variant pattern of renal veins were more often found on right side. The highest incidence was of 47.05% cases documented in our study, with a minimum of 2 tributaries of the renal veins. It coincided with the findings of the study conducted by Satyapal et al [17] on South African population. Considering the distribution of the extra-parenchymal renal vein, Joao A et al [18] observed that 2.6% of the kidneys had more than one renal vein and that 7% had bifurcated renal veins. The present study has demonstrated that in

majority of cases branches and tributaries of renal vessels occupy the prehilum and hilar regions rather than the main trunks of the renal vessels. Similar observation was also made by Samprio et al [19] during their various studies where they found that in majority of cases a branch of renal artery or a tributary of renal vein lies in close proximity of pelvis implying prehilum branching pattern of renal artery. Hassan et al [20] in 2012 studied the variation in arrangement of structures at renal hilum in Bangladesh population and observed that renal pelvis was the posterior most structure in 100% kidneys which is in disagreement with our observations.

## CONCLUSION

It is seen in the present study that arrangement of structures at renal hilum and their numbers are highly variable as compared to the classical pattern which is given in standard textbooks of Anatomy. The normal pattern of arrangement of structures at the hilum is observed only in 25% of specimens and in about three fourth of specimens variant pattern is observed. In about one third of cases anterior division of renal artery is the most anterior structure at the hilum and in about 45% of cases retropelvic structures are observed at the hilum. Surgeons performing renal surgeries should have ample knowledge of these variations which should be kept in mind during various urological, surgical procedures and renal transplantations where clamping of hilar vessels is the prerequisite.

**Conflicts of Interests: None**

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