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Prehilar branching pattern variation in renal artery – A cadaveric study

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ABSTRACT

Introduction: The surge in living kidney transplantation surgeries in recent decades has greatly evolved due to changes in environmental, oncological, and metabolic factors. Live kidney donors have become essential to successful transplantation surgeries. This required complete awareness of prehilar branching pattern variations in renal arteries.

Aims and objectives: The aim was to carry out a descriptive observational study on the prehilar branching pattern of renal vascularity in cadavers.

Materials and Methods: The present study comprises an adult male human cadaver, Scalpel, forceps, scissors. The blunt dissection was carried out to clear the fat and fascia from the anterior surface of the kidneys and expose the renal arteries. Then carefully examine the renal vascularity

Findings: The current study has shown that the right renal artery arises from the abdominal aorta at a higher level than the left renal artery. Then it passed towards the right side for 2 cm and showed ladder-type division as primary and secondary branches (Type III). Then the primary branch showed a fork type of division as a trifurcation (Type II). The left side renal artery was identified as a fork-type division with trifurcation (Type II).

Conclusion: The variation in the right renal artery showing ladder type and primary branch fork type with the trifurcation is not included in the classification of the prehilar branching pattern of the renal artery by the previous studies. Hence, we are proposing it as a Type M III a variety. Awareness of variations in prehilar branching patterns is essential for surgical management during renal transplantation procedures.

Keywords: renal artery, kidney, carcinoma, cadaver

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INTRODUCTION

The living kidney transplantation program has greatly evolved in recent decades across the world, and when it comes to India, it is the second largest program after the USA, with a number of 7,500 renal transplantation surgeries every year. Of these transplant surgeries, 90% are performed by live donors, and the remaining are from deceased donors [1]. The complete preoperative knowledge of the morphological variation of renal vascularity is essential to assess and manage the potential risks during the surgery, to prevent further complications due to the surgery, and to explore and treat renal trauma, renal transplantation, renal vascular hypertension, and renal artery embolization [2]. Morphological variations of renal vessels occur in 25% to 40% of kidneys, usually, these variations may be associated with atherosclerosis, renal carcinoma, and renal vascular hypertension, which are known to cause transplantation-related surgical complications [3].

The renal arteries are vital blood vessels that supply the kidneys with oxygenated blood. These are the branches of the abdominal aorta arise at the level of the intervertebral disc between L1 and L2. The right artery is longer than the left because the abdominal aorta lies close to the left side of the vertebral column. The renal arteries reach the hilum of the kidney between the renal vein front side and pelvis of the ureter behind and divide into anterior and posterior trunks. Usually, anterior trunk divides into four segmental arteries apical, anterior upper, anterior middle, and anterior inferior. The posterior trunk continued as a posterior segmental artery. Further segmental arteries are branched as lobar, inter lobar, arcuate arteries to supply the parenchyma of the kidney [4, 5]. Renal artery branching patterns have been referred to by a number of names, including segmental and prehilar branching patterns. The perhilar branching pattern was not taken into consideration when describing the segmental classification of renal arteries by Graves (1954) [5].

The pre-hilar branching pattern refers to how the renal arteries split into smaller branches before entering the renal hilum, the medial depression of the kidney where the renal pelvis, renal arteries, and renal veins are located. In most individuals, the right renal artery typically branches off directly from the abdominal aorta, while the left renal artery arises from the abdominal aorta slightly higher and longer than the right renal artery due to the presence of the coeliac trunk and superior mesenteric artery. Understanding the anatomical variations in the pre-hilar region is crucial for oncological surgeons, radiologists, and other

healthcare professionals when planning and performing renal transplantation procedures during the carcinoma of kidney and renal failure cases.

However, variations in the pre-hilar branching pattern of the renal arteries are not uncommon. These variations can include accessory renal arteries, anomalous origins, or abnormal branching patterns. For example, accessory renal arteries, which are additional arteries that supply blood to the kidneys, can arise from various locations with or without the combination of anomalous origins of the main renal artery, such as the aorta, common iliac artery, superior mesenteric, inferior mesenteric, spermatic, ovarian, right colic or even the opposite renal artery. These variations can have implications for renal function and may pose challenges during surgical procedures such as kidney transplants or nephrectomies [6 - 8].

When it comes to the abnormal branching pattern variations, based on an earlier study by Shoja et al. (2008) classified into 2 types: fork-type and ladder-type. Fork-type is defines as the artery showing single point of division which could be duplicated as type I (upper and lower branches) or triplicate as type II (upper, middle, lower branch). The ladder type is referred to as a type III where branching pattern appears sequential points: the first division is termed a primary and the next sequential division is termed a secondary tertiary branch, studying these patterns greatly helps avoiding potential complications during the renal transplantation surgeries. However, there is very limited focus on the research on the pre-hilar branching pattern of the renal arteries [9].

The embryological development of mesonephric arteries plays a great role in the variation of renal arteries. During the early period of the embryological stage, while the primordial kidneys are located in the pelvis the mesonephric arteries from the common iliac arteries supply the kidneys along with the suprarenal glands, gonads bilaterally. As the embryo grows, the kidneys ascend upwards to the abdominal cavity and relocate into the adult position by the end of the ninth week of gestation. While the kidneys are ascended, they receive new branches from the distal part of the aorta meanwhile the previous branches gradually disappear and arterial branches from the aorta establish themselves as permanent renal arteries. There is a chance of existence of one or multiple accessory renal arteries because of non-obliteration of early stages mesonephric arteries. The existence of these arteries plays a major clinical importance role during renal transplant surgeries, overlooking them causes great complications during and post -operative conditions [3, 10].

Overall, variations in pre-hilar branching patterns in the right and left renal arteries are a common occurrence and can have significant implications for kidney function and surgical procedures. By studying and understanding these variations, healthcare professionals can better care for patients with renal issues and improve outcomes for those undergoing kidney-related surgeries.

MATERIALS AND METHODS

Materials

- Scalpel:

  With blade

- Forceps:

  Small pointed, tooth forceps, non-toothed forceps

- Scissors

Methods

The present study was conducted in the department of anatomy, Sree Balaji Medical College, Chennai. During routine cadveric dissection on 50 years male embalmed body. The dissection was carried according to guidelines of "Cunningham's manual of practical anatomy" volume two, fifteenth edition. Fat and fascia cleared with blunt dissection from anterior surface of the kidneys and suprarenal glands after removal viscera of the gastro intestinal tract. Found the left suprarenal vein followed it upto the left renal vein then inferior vena cava and also traced the right renal vein which was extended from the inferior vena cava to the right kidney, displaced the renal veins bilaterally with blunt dissection to expose the renal arteries. Then carefully examined the prehilar branches pattern of both kidneys and noted its variations after highlighted with fevicryl crimson red color [11, 12].

RESULTS

Findings

The author observed the following findings:

- Both renal arteries are raised from the abdominal aorta.
- The right renal artery originates at higher level and longer than the length of the left renal artery.
- The right renal artery passed to the right side behind the inferior vena cava and showed ladder type of division (Type III) as a primary and secondary branch.
- The primary branch of right renal artery again showed fork-type division at the single point as a trifurcation (Type II).
- The secondary branch of the right renal artery showed normal termination without any division.
- The left renal artery origin lies lower level and shorter in length than the right renal artery.
- The left renal artery identified as a fork- type division at the single point as a trifurcation (Type II) Figure 1.

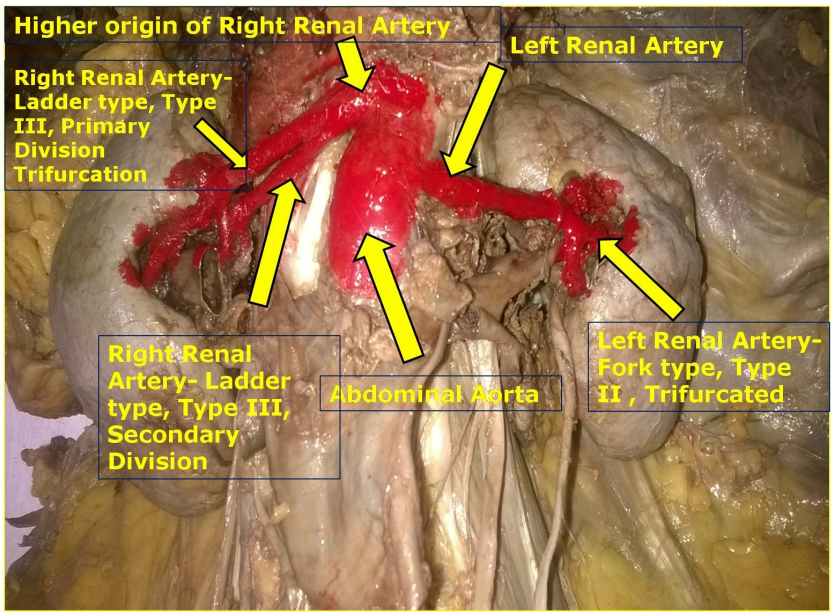

Fig. 1. The pre-hilar branching pattern of the renal artery in human cadaver shows that the right renal artery has a higher-level origin and a ladder type of division with primary branching trifurcation (fork type), while the left renal artery shows fork type of division with trifurcation

DISCUSSION

According to Kumaresan et al. and Shoja M et al. Pre-hilar branches classified into cardinal branching pattern which had occur equal or more than 5% and remaining types less than 5% included in the minor branching patterns Table 1. Subtypes I, II, III were included under each type as a descending order and again further division within the sub types included as a, b, c descending order [3-9].

Tab. 1. Pre-hilar branching pattern of the renal artery

Type	Branching pattern
Cardinal perihilar branching pattern	
Type I a	Duplicated fork
Type I b	Duplicated fork with duplicated upper branch
Type I c	Duplicated Fork with upper (u) and lower (l) branches
Type I d	Duplicated fork with upper and lower branch with the duplicated lower branch
Type I e	Duplicated fork with duplicated lower and upper ladder branch
Type I f	Duplicated fork with the upper and lower branch ladder pattern
Type II	Triplicated fork pattern
Type III	Single ladder type
Minor perihilar branching pattern	
Type mI a	Duplicated fork with triplication of upper branch
Type mI b	Duplicated fork with duplicated upper and lower ladder branch
Type mI c	Duplicated fork with upper ladder pattern
Type mI d	Duplicated fork with lower ladder pattern
Type mI e	Duplicated fork with triplicated upper and duplicated lower branch
Type mI f	Duplicated fork with upper ladder and lower triplicated pattern
Type mII a	Triplicated fork with duplicated middle branch
Type mII b	Triplicated fork with duplication of upper and middle branch
Type mII c	Triplicated fork with duplication of lower branch
Type mII d	Triplicated fork with ladder pattern in upper and lower branch

The present study identified the right renal artery correlating with the type of ladder (Type III) with the triplication of primary branch (Type II). The left renal artery triplication fork type (Type II). However, as the best knowledge of the author the single artery showing the ladder type division associated with the trifurcation in primary division is not reported and not included in the pre-hilar branching pattern classification by previous studies. Hence the author proposing this variation to add to above classification as Type m III a - ladder type with triplication since it is belonged to sub type III and showing primary division trifurcation.

The present study branching pattern correlating with the Shoja et al. (2008) observed fork pattern in 92.6% kidneys, duplication in 80.2%, triplication in 12.4% and presence of ladder pattern in 7.4% kidneys [9]. Kumaresan M et al. (2022) observed pre-hilar branching pattern and identified 8 cardinal and 10 minor pre-hilar branching patterns. Type I (duplicated fork) pre-hilar branching pattern was found (70.2%) among 198 kidneys, followed by type II (triplicate fork) (19.2%) and type III (ladder) (10.6%). Duplicated fork pattern was both the right renal artery (75.7%) and left renal artery (64.6%), respectively [3]. Zumin vahed et al. (2020) observed based on pre-hilar branching patterns, the fork pattern was in 95% (242) while the ladder pattern was observed in 5% (13) of kidney grafts. In a later branching sub-categorization, among the fork pattern, 65.2% (158) were duplicated and 34.7% (84) had triplicate hilar branching patterns [13]. However, these studies were not reported and not included Type m III a - ladder type with trifurcation.

When comes to the early division of renal artery the current study correlating with the Budhiraja et al (2010) observed pre-hilar branching pattern in 11% of cases which were duplicated and triplicate [14]. Rao M et al. (2006) observed right renal artery duplication early 2cm away from its origin and left renal artery duplication immediately after its origin [15]. and also, Garcia et al. (2014) the rate of early branching of the main RA is 12.5% (6.25% on each side) [10]. This prevalence is 8.12% by Ozkan et al. (2006), and 21% by Holden et al. (2005) respectively [16, 17].

The higher origin of right renal artery than the left renal artery of current study can compare with the study of Ankolekar and Sepngupta (2013), and Arasu, Aishwarya et al. (2022) which were published as in 63.33% specimens showing the higher origin of right renal artery that the left renal artery [18 -19].

CONCLUSIONS

The 20th century saw a sharp rise in kidney transplant surgeries as a result of numerous environmental, ontological, and metabolic factors. Because of this, live donors are now an important source for maintain the pool of donors needed for surgeries. An allograft with numerous arteries is a must for conduction of surgeries successfully. A malfunction in the artery's regression could result in abnormal hemodynamic.

Our results indicate that there are variations present in kidneys bilaterally with various subtypes, and identified the unreported subtype as a Type m III a – ladder type with trifurcation. In conclusion, variations in the pre-hilar branching pattern of the right and left renal arteries are a common anatomical phenomenon that healthcare professionals should be familiar. Accurate diagnosis, treatment planning, and surgical interventions depend on an understanding of these variations. The preoperative awareness of possible variations in renal artery is essential for successful conduction of renal transplant surgeries to treat carcinoma and failure cases.

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