ORIGINAL ARTICLE ASIAN JOURNAL OF MEDICAL SCIENCES

Variations in the branching pattern of renal artery

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Submission: 08-08-2022 Revision: 27-10-2022 Publication: 01-12-2022

ABSTRACT

Background: In terms of living kidney transplantation programs worldwide, India is only second to the United States of America. Every year, over 7500 renal transplants are done in India, with 90% of the transplants coming from living donors and the rest from deceased donors. **Aims and Objectives:** The aim of the study is to examine and describe differences in human renal arteries, compare past studies with the present study, and report the occurrence of major categories of variation. **Materials and Methods:** This observational study was carried out on 25 well-embalmed adult cadavers in the Department of Anatomy, Rajah Muthiah Medical College, Annamalai Nagar, Chidambaram from December 2016 to October 2018. In all the 25 specimens, the renal artery took its origin from the lateral side of the abdominal aorta. **Results:** We observed that there is a 92% correlation between L1 and L2, 8% between L3 and L1, and zero between L1 and L2. Accessory renal artery (ARA) was discovered in 18 specimens (36%), with 10 on the right side and eight on the left. Superior polar arteries – 4 (8%), inferior polar arteries – 1 (2%), and hilar arteries – 5% on the right side (10%). Superior polar arteries – 6%, inferior polar arteries – 0%, and hilar arteries – 5% on the left side (10%). **Conclusion:** Living donor grafts have become a primary source for preserving the donor pool as the need for kidney transplantation rises, and a successful allograft with numerous arteries has become a must. All major vascular channels have not entirely regressed if there are polar or numerous renal arteries to a regularly positioned kidney.

Key words: Kidney transplantation; Living donor; Renal artery

Access this article online

Website: http://nepjol.info/index.php/AJMS

DOI: 10.3126/ajms.v13i12.47325

E-ISSN: 2091-0576

P-ISSN: 2467-9100

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INTRODUCTION

In terms of living kidney transplantation programs worldwide, India is only second to the United States of America. Every year, over 7500 renal transplants are done in India, with 90% of the transplants coming from living donors and the rest from deceased donors.[1] Pre-operative examination of renal vascular architecture in live donors is critical for predicting and managing possible hazards as well as avoiding problems during renal surgery. The examination and treatment of renal trauma, kidney transplantation, renal vascular hypertension, and renal artery embolization all need an understanding of renal vascular variation.[2,3] It also allows for segmental artery ligation, which significantly minimizes renal parenchyma injury during segmental laparoscopic procedures.[4] Anatomical changes in renal vessels can be found in 25–40% of kidneys. Atherosclerosis and renovascular hypertension, which are well-established causes of urosurgical complications, are linked to variations in the renal vasculature, including the auxiliary renal artery and early division of the renal artery.[5,6] One of the most prevalent changes that requires therapeutic attention is the auxiliary renal artery.[7,8] The branching pattern of renal arteries has been described using many terminologies in the

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past.[9] Graves (1954)[10] defined the renal artery's segmental branching arrangement, which has been followed to this day. He explained that each kidney contains five segments, each of which is fed by a segmental artery that branches out from either the anterior or posterior division of the main renal artery. Graves' segmental categorization of renal arteries ignores the perihilar branching pattern. The perihilar branching pattern of the renal artery is crucial to understand and is being researched more and more with the advancement of radio diagnostic technology. The shape and branching pattern of the renal artery are studied to minimize difficulties after kidney transplantation and surgery. There were significant ethnic and racial differences in the renal artery branches and branching patterns.[11] However, a review of the literature reveals that there are few research on the perihilar branching pattern of the renal artery. Only a few studies in India have used CT angiograms to identify the changes of the renal artery and renal artery branching pattern in live kidney donors.[12,13] There are just a few research[6,9] on the peri-hilar branching pattern of the renal artery across the world, and none on the Indian population.

The differences in renal vessels are mostly attributable to the kidney's developmental locations.[14] When compared to renal veins, renal arteries have a lot of variety. It is unusual to see a difference in both arteries and veins at the same time. Variations in renal veins are also less prevalent than in arteries.[15] As the belly and pelvis expand, the kidneys develop in the pelvis; the kidneys come into the abdomen and attain their adult position by the 9th week. The embryological rationale for these differences is that nine pairs of lateral mesonephric arteries emerging from the dorsal aorta supply the developing mesonephros, metanephros, suprarenal glands, and gonads. These arteries are classified into three groups: The cranial group consists of the 1st–2nd arteries, whereas the intermediate group consists of the 3rd–5th arteries, and the caudal group consists of the 6th–9th arteries.

The creation of renal arteries is the responsibility of the intermediate group. Multiple renal arteries develop in the intermediate group when more than one renal artery survives. As a result, two lateral mesonephric arteries from the middle group persist in our study, resulting in duplicated renal arteries. The blood supply to the kidneys is provided by vessels near to them as their location changes. The renal arteries originate as branches of the common iliac artery and later from the aorta's distal end.

Renal angiography, balloon angioplasty, and stent implantation are now standard diagnostic and therapeutic endovascular procedures for treating renal artery disease. The direction of the renal arteries from the aorta must be precisely known before the renal stent may be successfully implanted. A greater prevalence of vascular complications, such as arterial thrombosis and renal artery stenosis, has been linked to multiple renal arteries. Variations in the renal artery have been studied extensively, and there is a large body of research on the issue. However, the issue merits additional investigation, not just from a morphological but also from a surgical standpoint. However, the most of the research used ultrasonography and angiography, and angiographic studies have shown that auxiliary renal arteries are found less frequently. As a result, numerous academics, mostly surgeons, have looked at the differences in renal arteries.

Aims and objectives

This study used the cadaver dissection method to examine and describe differences in renal arteries in people, as well as to compare prior studies with the current study to report the incidence of major categories of variation.

MATERIALS AND METHODS

This observational study was carried out on 25 well-embalmed adult cadavers in the department of Anatomy, Rajah Muthiah Medical College, Annamalai Nagar, Chidambaram, over the period of December 2016–October 2018. Cunningham's manual of practical anatomy[16] was used to do the dissection in the abdomen. The peritoneum and all abdominal viscera were removed during the abdominal dissection, which was conducted through a midline incision. The mesentery and the rest of the peritoneum were pulled from the posterior abdominal wall to access the retroperitoneal tissues after the spleen, liver, stomach, small intestine, large intestine, and pancreas were dissected and removed. The abdominal aorta's fascia was removed.

Renal and auxiliary renal arteries, which go from the abdominal aorta to the kidneys, were found and precisely defined. The kidney fasciae, as well as the suprarenal, were dissected and removed. The kidneys and their arteries were investigated. The renal arteries' route, branching pattern, and morphological changes were observed, and any extra renal arteries were carefully identified, and their course determined.

Only angiograms from individuals (age>18 years) without renal illness, pathological conditions that might impair the renal vasculature, and significant contrast medium enhancement in the arterial phase were collected and examined. The study was carried out in accordance with the declaration, and the Institutional Human Ethical Committee granted approval.

RESULTS

In all 25 specimens, the renal artery took its origin from the lateral side of the abdominal aorta. We observed 92%

between L1and L2 and only 8% at L3 and none at L1 (Table 1).

Table shows the comparison of the present study with the previous studies on the number of renal arteries entering the kidney (Table 2).

Accessory renal artery (ARA) was found in 18 specimens (36%), 10 specimens on the right side, eight specimens on the left side (Table 3).

Table shows the comparison of studies on the prevalence of accessory renal arteries (Table 4).

Table shows the comparison of the studies on types of accessory renal arteries (Table 5).

Four (8%) superior polar arteries, 1 (2%) inferior polar arteries, and 5 (10%) hilar arteries were found on the right side. On the left side, 3 (6%) superior polar arteries, no inferior polar artery, and 5 (10%) hilar arteries were found (Table 6).

We observed duplicate in 16%, triplicate in 16%, fork pattern in 2%, and ladder pattern in 2% of kidneys and no multiple pre-segmental branching of renal arteries (Table 7).

Table shows the comparison of the present study with those on the prevalence of pre-segmental arteries (Table 8).

Table 1: Level of origin of renal arteries in percentage

S. No	Vertebral level	On right in %	On left in %
1	L1	0	0
2	L1 and L2	50	42
3	L2	0	8

Table 2: Comparison of studies on the number of renal arteries entering the kidney

Studies	Single renal artery	Double renal arteries	Triple renal arteries
Khamanarong *et al* . (2004)[17]	82%	17%	1%
Çiçekcibaşi *et al* . (2005)[18]	75%	21.6%	3.3%
Ankolekar and Sengupta (2013)[19]	73.33%	23.33%	3.33%
Present Study	64%	36%	-

Table 3: Prevalence of ARA

Side	Right	Left
ARA	10	8

ARA: Accessory renal artery

DISCUSSION

The branching pattern of the renal artery can vary. Surgeons and radiologists can utilize knowledge of existing variances in the renal artery to safely execute any surgical or diagnostic treatment.

According to Graves[25] 1956, every artery emerging from the aorta other than the primary renal artery should be designated "accessory," whereas renal arteries coming from other sources should be considered "aberrant."

Table 4: Comparison of studies on the prevalence of accessory renal arteries

Studies	Percentage
Bude *et al* . (2003)[20]	17%
Gupta *et al* . (2004)[21]	24%
Özkan *et al* . (2006)[22]	24%
Das (2008)[23]	30–35%
Ankolekar and Sengupta (2013)[19]	25%
Present study	36%

Table 5: Comparison of studies on type of accessory renal arteries

Studies	Superior polar	Inferior polar	Hilar
Bordei *et al*.(2004)[24]	11.11%	29.62%	5%
Çiçekcibaşi *et al*.(2005)[18]	3.33%	10.5%	11.1%
Ankolekar and Sengupta.(2013)[19]	6.67%	10%	11.67%
Present study	14%	2%	20%

Table 6: Prevalence of type of ARA on the right and left sides

ARA	Superior polar	Inferior polar	Hilar
Right	4	1	5
Left	3	0	5

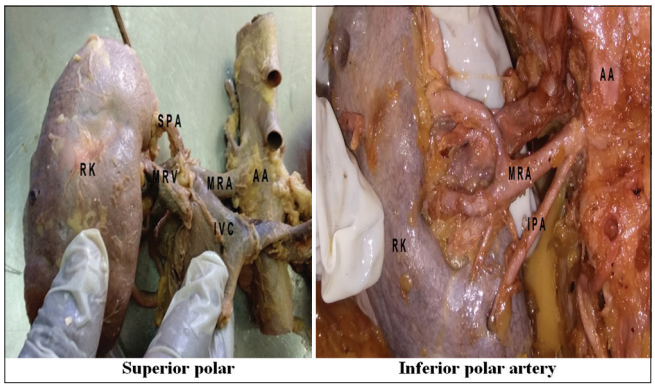
ARA: Accessory renal artery

Table 7: Regarding pre-segmental branching pattern of renal artery

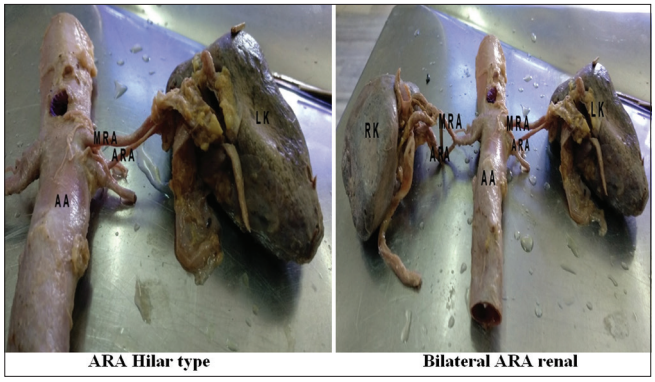
Types	Right	Left	Percentage
Duplicate	7	1	16%
Triplicate	1	7	16%
Fork pattern	1	0	2%
Ladder pattern	1	0	2%
Multiple	0	0	0%

Table 8: Comparison of studies of the prevalence of pre-segmental arteries

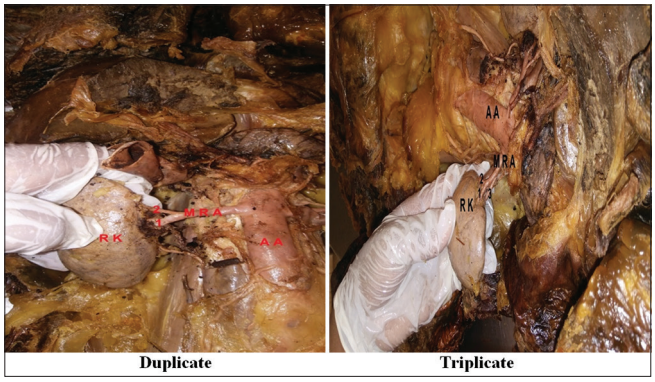
Studies	Percentage
Ankolekar and Sengupta (2013)[19]	11.67
Present Study	36



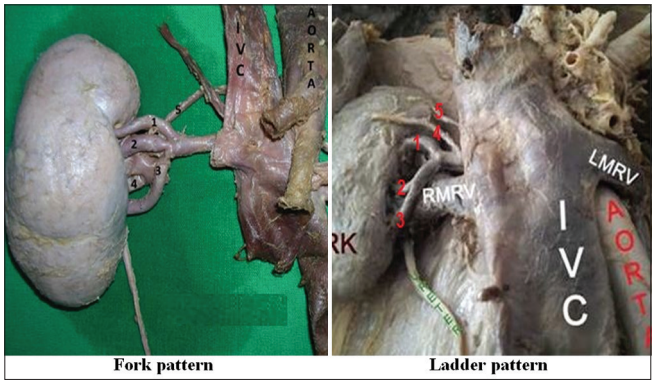
Superior polar | Inferior polar artery



ARA Hilar type | Bilateral ARA renal



Duplicate | Triplicate



Fork pattern | Ladder pattern

Additional arteries reach the kidney through the hilum alongside the primary renal artery or polar arteries reach the kidney surface.[14]

Another variety is when the renal artery branches into a segmental artery before entering the hilum, a pattern known as an early division or perihilar pattern. The perihilar pattern of renal arteries can be ladder, double, or triple, and reflects segmental distribution of the kidney by the renal artery.[26]

The lateral branches of the abdominal aorta are the renal arteries.[27] The renal artery in all 25 cases in our investigation originated from the lateral side of the abdominal aorta. Rao[28] found that the right and left renal arteries have a similar stem and emerge from the aorta. In a study by Ramulu and Prasanna.,[29] the renal artery was found to originate from the lateral side of the abdominal aorta in 46 of 50 specimens (92%) while it was found to originate from the anterolateral side of the abdominal aorta in 3 specimens (6%) and the posterolateral side of the abdominal aorta in 1 specimen (2%). The renal artery arises from the lateral surface of the aorta in most cases, according to Garcier et al.[30] The present study results are consistent with prior investigations.

The present study also discovered that the renal artery originates most commonly between the L1 and L2 vertebrae (92%). It is 50% on the right side and 42% on the left.

The most prevalent vertebral level of origin for the renal arteries, according to Salih and Hasan.,[31] was between the lower border of the L1 vertebra and the higher border of the L2 vertebra, on both the right (46%) and left sides (47.3%). L2 was the next level of origin on the right side (29.3%), while it was 27.3% on the left side. The renal artery originated above L1 on both sides in just 3.3% of patients, while it arose below L2 in only 2.6%. The origin of renal arteries from the aorta is more common in the intervertebral disc between L1 and L2, with 38.85% on the right side and 35.70% on the left, according to Palmieri et al.[32] According to Ankolekar and Sengupta.,[19] the right renal artery has a higher origin than the left. In our investigation, the right renal artery origin was at a higher level in 63.33% of specimens, the origin of both the right and left was at the same level in 26.67% of specimens, and the origin of the left was at a higher level in 10% of specimens.

The existence of accessory renal arteries was found in 36% of the participants in this research, with 20% and 16% on the right and left sides, respectively. These findings are consistent with those of Janschek et al.,[33] who found that the incidence of numerous arteries on the right and left sides was 20.2% and 19%, respectively. According to Saldarriaga et al.,[34] one extra artery was found in 43.5% of the right side and 56.3% of the left side. Bordei et al.,[24] looked examined 272 kidneys for research on renal vascularization and found 54 (20%) double renal arteries and 3 (1.1%) triple renal arteries. In a study by Kayalvizhi

et al.,[35] the presence of a double renal artery and a left accessory testicular artery was found.

According to the present study, all 36% of accessory renal arteries originate slightly below the major renal artery, which is consistent with Animaw and Ewnete.[36] Additional renal arteries are frequently discovered beneath the renal arteries. According to Aristotle et al.,[37] the level of origin of accessory renal arteries was found to be close to the superior mesenteric artery in one specimen, below the renal artery in another specimen, above the renal artery in another specimen, and in the last specimen, it was in between the superior mesenteric and renal arteries.

The prevalence of bilateral ARA was found to be 2% in this study, meaning it was found in one out of every 25 specimens. According to Ankolekar and Sengupta,[19] bilateral supernumerary renal arteries are uncommon and are diagnosed in only 6.67% of cases, while bilateral double renal arteries are found in 4–10% of cases.

The superior polar forms of the ARA were discovered in seven cases in this investigation (14%). Budhiraja et al.,[38] discovered that the proportion of distribution of extra hilar superior polar renal artery on the right side is 21.4% and the left side is 19%, while Bordei et al.,[24] found that the artery directly reaches the superior pole as a superior polar artery in five instances. Budhiraja et al.,[38] found that the superior polar artery was involved in 10.7% of patients.

The inferior polar type of ARA was found in 1 (2%) of the right-side specimens in this investigation. Out of 54 instances analyzed, Bordei et al.,[24] found an inferior polar artery in 16 specimens that reached the inferior pole of the kidney as an inferior polar artery.

An inferior polar artery was discovered in 16 instances by Janschek et al.[33] According to Budhiraja et al.,[38] the right side has 11.9% additional hilar inferior polar artery while the left side has 2.4%.

A hilar form of auxiliary renal artery was found in ten cases in this investigation. The left side-5 coincides with the research listed above on the right side-5. Bordei et al.,[24] discovered hilar type in 24 of 54 kidneys tested in a similar study. A supplementary renal artery reached the kidney through the hilum in roughly 28 instances, according to Janschek et al.[33] On the right and left sides, the incidence of numerous arteries has been observed to be 20.2% and 19%, respectively. Salih and Hasan[31] found that the hilar type is 31.3% on the right side and 29.3% on the left side.

The perihilar branching pattern of the renal artery was investigated in this research. In 16% of the kidneys, we found duplicates, triplicates, fork patterns, and ladder patterns, but no perihilar multiple branching of renal arteries. Two pre-segmental arteries were found in the ARA, according to Aristotle et al.[37] The renal artery branching pattern was discovered by Shoja et al.[6] She saw a fork pattern in 92.6% of the kidneys, a duplicate pattern in 80.2%, a triple pattern in 12.4%, a ladder pattern in 7.4%, and perihilar multiple branching of renal arteries in 11.66%.

All pre-segmental arteries in this research are branches of the abdominal aorta. The artery ran anterior to the renal vein in 11 instances, according to Budhiraja et al.[38] The ARA does not have a bilateral hilar pattern in this research, and it does not have any branches that serve the nearby organs. The hilar pattern showed no such modifications in the research.

Limitations of the study

The small sample size could be considered a limitation to this study.

CONCLUSION

Living donor grafts have become the primary source for preserving the donor pool as the need for kidney transplantation grows, and a successful allograft with numerous arteries has become a must. A failure of full regression of all principal arterial channels is represented by a polar or multiple renal arteries to a regularly positioned kidney. The infundibulum, major calyx, or ureteropelvic junction may be constricted by these numerous arteries. In renal physiology, these arteries may cause abnormal hemodynamics.

It will be impossible to evaluate renal angiograms unless we are aware of these structural variances. Furthermore, renal arteries are functioning end arteries, and their obstruction might cause kidney degeneration in that segment. Kidney transplant operations are complicated by these many arteries, which might result in postoperative hemorrhage. Because they are end arteries, the urologist must save each of the many arteries to save the renal segment. A renal angiography is thus required before surgical surgery.

Furthermore, any surgeon must be aware of renal arterial variations since unintentional rupture of such arteries during renal surgery might result in serious bleeding or infarction of the renal parenchyma.

ACKNOWLEDGMENT

We would like to acknowledge all the individuals who have extended their help and assistance throughout all aspects of our study.

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Authors Contribution:
TA- Review of literature, Manuscript preparation, and Interpretation of results; **VM-** Concept and design of the study and Preparation of first draft of manuscript; **SS-** Concept, Coordination, Statistical analysis, and interpretation; and **VA-** Preparation of manuscript, Review and editing, and revision of manuscript.

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Source of Funding: Nil, **Conflicting Interest:** None declared.