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Research Article

Anatomical Variations of Renal Vessels- A Cadaveric Study with Clinical Relevance

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ABSTRACT:
Introduction: Blood supply to the kidneys is characterized by more frequent presence of variations in arteries and veins supplying them. Normally each kidney is supplied by single renal artery and drained by single renal vein. Variation in the number, origin, pathway and branching pattern of renal arteries is common. Frequently seen anatomical variation is additional renal artery. **Aim:** To identify the presence of variations of renal vessels in the human cadavers. **Material and methods:** An observational cadaveric study was conducted on 80 kidneys from 40 formalin-fixed human cadavers from 2019 to 2025 in the Department of Anatomy, Chalmeda Anandarao institute of medical sciences, Karimnagar, Telangana, India. The number of cadavers showing variations of renal vessels was determined. **Results:** The study included 80 kidneys from 40 formalin-fixed human cadavers. Eight (20%) cadavers were found to have variations in renal vessels while 32 (80%) cadavers show presence of single renal vessel going to each kidney. The double renal artery variations were present bilaterally in 01 (2.5%) cadaver and aberrant renal artery in 02 (5%) cadavers but both are in left side. The superior polar artery was present in 01 (2.5%) cadaver right side and inferior polar artery was present in 01 (2.5%) cadaver left side. Early divisions of renal artery were present in 2 (5%) cadavers. Accessory renal vein were present in right side 1 (2.5%) cadaver. **Conclusion:** Variations of renal vessels supplying to the kidneys it is necessary to have prior knowledge of them as now a day's more number of patients is undergoing renal transplants, angiography procedures. The knowledge of these variations is also useful for treatment of renal trauma and tumors.

INTRODUCTION

Blood supply to the kidneys is characterized by more frequent presence of variations in arteries and veins supplying them. The renal arteries begin as a lateral branch of the abdominal aorta below the superior mesenteric artery (L1-L2). Normally each kidney is supplied by single renal artery and drained by single renal vein. Variation in the number, origin, pathway and branching pattern of renal arteries is common. Frequently seen anatomical variation is additional renal artery. Additional renal artery can be accessory or aberrant renal artery. An accessory renal artery is accessory to the main renal artery, usually arising from the abdominal aorta and entering the kidney through hilum and aberrant renal artery is the one which enters the kidney through either pole whether it is derived from main renal artery, aorta or a branch of abdominal aorta. Branching of main renal artery into anterior and posterior divisions proximal to the hilum is called early division. The right renal artery is longer and runs behind the inferior vena cava, the right renal vein, the head of the pancreas, and the second part of the duodenum. The left renal artery passes behind the body of the pancreas, the left renal vein and the splenic vein. Each artery gives off the inferior suprarenal and urethral branches, and is then distributed to the kidney. The renal veins join the inferior vena cava just below the transpyloric plane. The right renal vein is shorter than the left and lies behind the second part of duodenum. The left vein crosses in front of the aorta, and lies behind the pancreas and splenic vein. It receives the left suprarenal and gonadal veins. It is very well documented in the literature; the incidence of variations in the renal artery varies from 23-30%. The incidences are

different in different group of studies may be due to genetic makeup of varied nature in different population. Thus, the aim of the present study was to study the variations of renal vessels in cadavers, Telangana, India. In view of these variations of renal vessels supplying to the kidneys it is necessary to have prior knowledge of them as now a day's more number of patients is undergoing renal transplants or angiography procedures. The knowledge of these variations is also useful for treatment of renal trauma and tumors.

MATERIAL AND METHODS

An observational cadaveric study was conducted on 80 kidneys from 40 formalin-fixed human cadavers from 2019 to 2025 in the Department of Anatomy, Chalmeda Anandarao institute of medical sciences, Karimnagar, Telangana, India. The number of cadavers showing variations of renal vessels was determined. Abdomen opened as per Cunningham's manual anterior abdominal wall was reflected and the abdominal viscera were removed. Both the kidneys were identified. Renal arteries and renal veins were traced from their origin to distribution. The length of the abnormal renal artery was measured with inch tape from the origin to its division into branches, if the main renal artery was dividing into segmental branches within 1 cm from its origin, it is called as early division and additional vessels from abdominal aorta which supply to kidney, is called as ARA. If more than two vessels supply the kidney from abdominal aorta, it is called a double renal artery. The number and course of both the right and left renal vessels were noted. Photographs were taken and analysed.

Inclusion criteria: All the cadavers used for dissection of undergraduate teaching in the year of 2019 to 2025 obtained from the Department of Anatomy, irrespective of age and sex were included in the study.

Exclusion criteria

Kidneys with the major congenital anomalies, damaged kidneys due to improper handling by the students during dissection were excluded from the study.

RESULTS

The study included 80 kidneys from 40 formalin-fixed human cadavers. Eight (20%) cadavers were found to have variations in renal vessels while 32 (80%) cadavers show presence of single renal vessel going to each kidney. The variations seen in the eight cadavers were as follows:

The double renal artery variations were present bilaterally in 01 (2.5%) cadaver and aberrant renal artery in 02 (5%) cadavers but both are in left side. The superior polar artery was present in 01 (2.5%) cadaver right side and inferior polar artery was present in 01 (2.5%) cadaver left side. Early divisions of renal artery were present in 2 (5%) cadavers. Accessory renal vein were present in right side 1 (2.5%) cadaver.

Out of 40 cadavers, variations in the renal vessels were seen in eight cadavers are shown in table-1.

Type of variation	Number of cases	Right kidney	Left kidney
Bilateral double renal artery	01	---	----
Aberrant renal artery	02	00	02
Superior polar artery	01	01	00
Inferior polar artery	01	00	01
Early division of Renal artery	02	01	01
Accessory renal vein	01	01	00

Table 1. Showing Variations of Renal Vessels

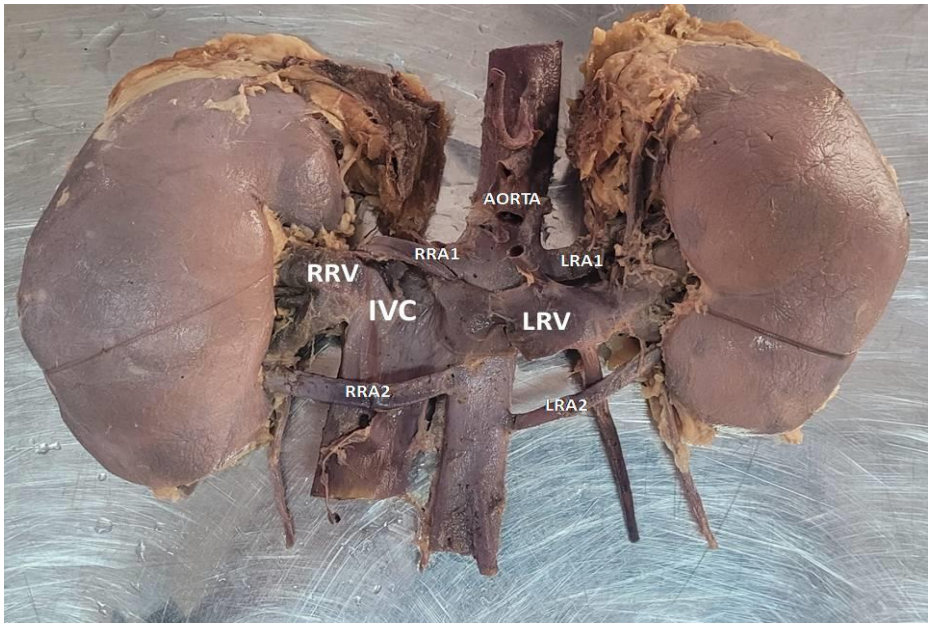

Fig 1. Bilateral Double Renal Artery, IVC-Inferior Vena Cava, RRV- Right Renal Vein, LRV-Left Renal Vein, RRA[1,2]- Right Renal Artery, LRA[1,2]- Left Renal Artery

Fig 2. Aberrant Renal Artery-ARA, RRA- Right Renal Artery, LRA- Left Renal Artery

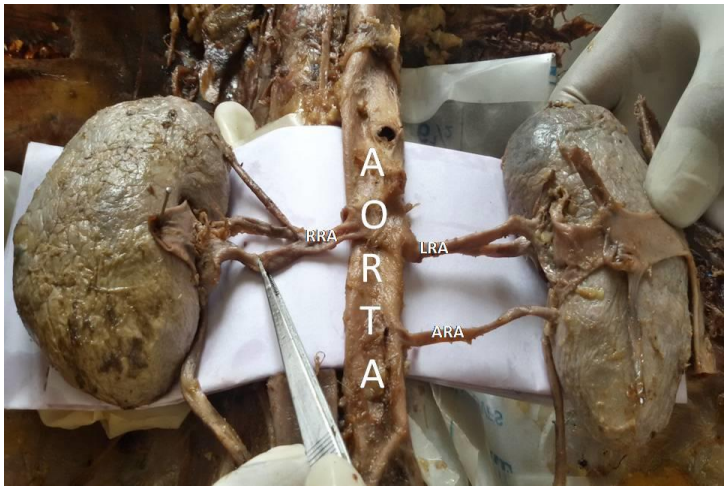

Fig 3. Aberrant Renal Artery-ARA, RRA- Right Renal Artery, LRA- Left Renal Artery

Fig 4. SPA-Superior Polar Artery arising from Right Renal Artery

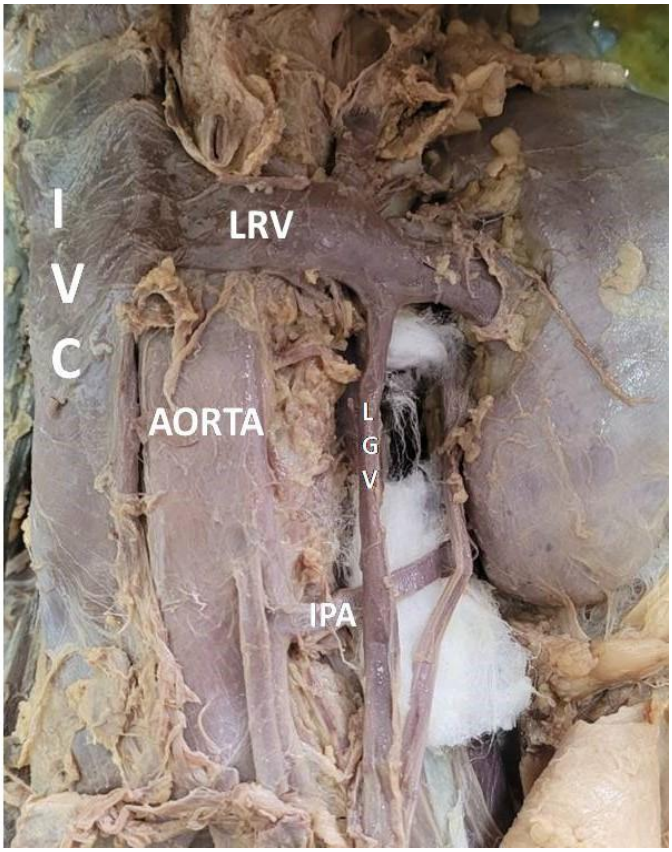

Fig 5. IPA-Inferior Polar Artery Arising From Abdominal Aorta, LRV- Left Renal Vein, LGV- Left Gonadal Vein.

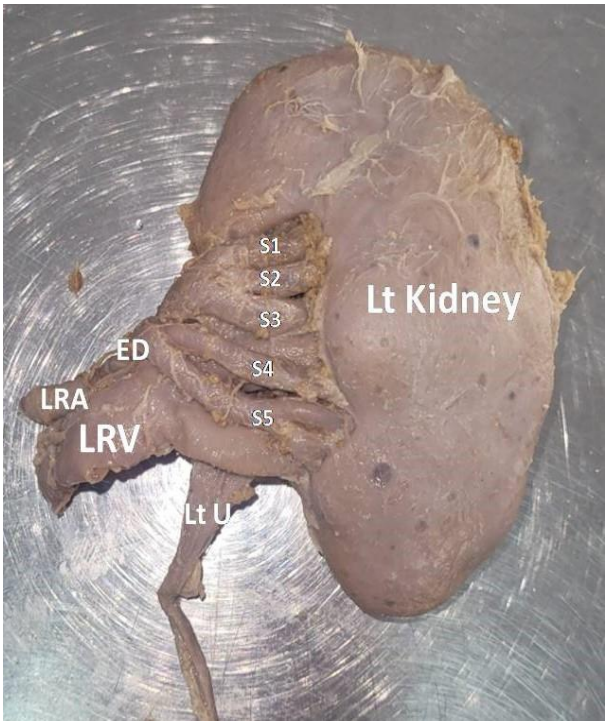

Fig 6. Early Division of Left Renal Artery, S1 to S5- Segmental Branches of Left Renal Artery, Lt U- Left Ureter.

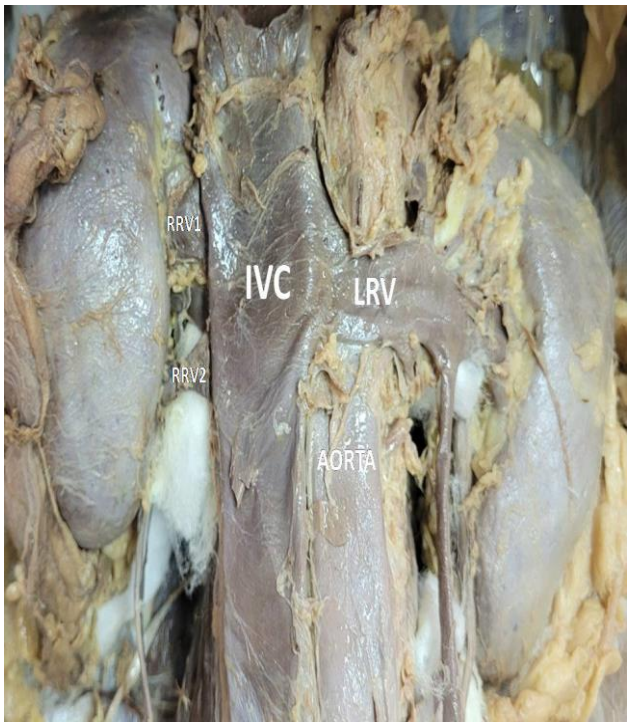

Fig 7. Accessory Renal Vein In Right Side, IVC- Inferior Vena Cava, RRV[1,2]- Right Renal Vein, LRV- Left Renal Vein

DISCUSSION

Knowledge of variations in the origin, course, relations and branching pattern of renal vessels is very essential in performing surgical procedures including transplantation of kidneys during infancy, childhood and in adults. The various types of accessory renal arteries, their positions, method of entry to the kidney and its segmentation were studied extensively by Sykes (1963). Most of the abnormalities of renal artery are due to changing position of kidney as a part of its normal development and ascent. The kidney begins their development in pelvic cavity.

During further development they ascend to lumber region which is their final position. When they are in pelvic cavity they are supplied by internal iliac artery or common iliac artery. While the kidney ascends to lumber region their arterial supply also shifts from common iliac to abdominal aorta. Embryological explanation of these variations has been presented and discussed by Felix (1912).

The present study focused on gross variations in anatomical aspects of renal arteries and their clinical correlations. According to Ramesh Rao et al. study, renal artery variations occur in 30% of population. According to Lippert et al. study, accessory renal arteries are reported in 26% of individuals. Accessory renal artery is noted in 12 kidneys (24%) out of 25 cadavers according to study done by R Chitra. According to study done by Archana Srivastava et al (11) accessory renal arteries were observed in 25% of kidney specimens and are same in both sexes. These are seen in 26% kidneys on right side and 24% on left side. According to Karmalkar AS et al 2019 found duplicate renal artery were noted in 7 specimens out of which 5 (71.42%) on the right side & 2 (28.57%) on the left side. In the present study bilateral double renal arteries are observed in 1 case (2.5%) and aberrant renal arteries are observed in 2 cases (5%) but both are in left side.

Bordei P et al., 2004 in their renal vasculature, studied 54 cases, out of which 24 cases had entered through the hilum, 16 were inferior polar arteries and in 5 cases, it was superior polar arteries. Sharmila Aristotle et al., 2013 found 3 inferior polar arteries. Out of 3 specimens, 2 arose from the abdominal aorta and in 1 case; they arose from the renal artery. In the present study only one superior polar artery arising from right renal artery and one inferior polar artery arising from abdominal aorta in left side. According to Parimala Sirikonda et al., 2023 found early division of renal arteries in 4 cases. In the present study two early division of left renal artery is observed.

Renal arterial variations are more frequently observed than renal veins, Sharmila Aristotle et al., 2013 reported Accessory renal vein 18% of the cases [6]. Anupama et al. reported various congenital variations of renal veins, in which the study described about supernumerary renal vein, in which presence of an additional vein arising from the hilum of kidney and draining into inferior vena cava. Out of 30 cadavers which were studied, they described a right side supernumerary renal vein in 10 cases and in only one case; they described a bilateral renal vein variation.Variations in renal veins are caused by anomalies which are related to the development of inferior vena cava. The literature has described renal vein variations which were more common on the right side (28%) than on the left side (1%). In our study, we reported only one accessory renal vein on the right side.

Due to existence of such huge number of variations based on location and ethnicity, this study will guide researchers to conduct similar studies [Table-2] [23,25,26,27,34,28,14,24] is showing comparison of the present study results with similar previous studies.

Author (Year)	Study and sample size	Place of the study	EBR	BL	UL	Right side	Left side
Budhiraja V et al. 2013	Cadaver (42)	India (Bhopal)	26/84 (31%)	--	--	24/42 (57.1%)	22/42 (52.4%)
Ankolekar V And Sengupta R, 2013	Cadaver (30)	India (Manipal)	--	6.67%	11.67%	8 (26.7%)	7 (23.3%)
Rao K and Battula R 2015	Cadaver (32)	India (Hyderabad)	--	4 (6.2%)	10 (15.6%)	10 (31.25%)	8 (25%)
Lama P and Pradhan A 2019	Cadaver (15)	Nepal	4/30 (13.33%)	--	--	5/15 (33.3%)	5/15 (33.3%)

Karmalkar AS et al., 2019	Cadaver (50)	India (Kolhapur)	13/100 (13%)	--	--	19/50 (38%)	13/50 (26%)
Chandrika P and Jakka L. 2021	Cadaver (36)	India (Vijayawada)	9/72 (12.5%)	4/36 (11.1%)	16/36 (44.4%)	9/36 (25%)	11/36 (30.5%)
Vaishali Anturlikar et al., 2022	Cadaver (24)	India (Nashik)	2/48 (4.2%)	2/24 (8.3%)	4/24 (16.7%)	5/24 (20.8%)	3/24 (12.5%)
Parimala Sirikonda et al., 2023	Cadaver (50)	India (Hyderabad)	4/100 (4%)	--	--	3/50 (6%)	5/50 (10%)
In the present study	Cadavers(40)	India (Karimnagar)	02/80 (2.5%)	01/40 (2.5%)	07/40 (17.5%)	03/40 (7.5%)	04/40 (10%)

Table 2. Showing Comparision Of Similar Study Done By Different Authors.

EBR: Early branching of renal artery, BL: Bilateral variation, UL:Unilateral variation

CONCLUSION

Variations of renal vessels supplying to the kidneys it is necessary to have prior knowledge of them as now a day's more number of patients is undergoing renal transplants, angiography procedures. The knowledge of these variations is also useful for treatment of renal trauma and tumors.

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