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Original Research Article

Anatomical Variations in Renal Arterial Pattern in Human Cadavers

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Abstract:

Background: Various cadaveric and imaging studies showed that renal arteries have a wide range of variations. Hence, the present study was undertaken to know the origin, course, and relations of renal arteries (RA) and accessory renal arteries (ARA) and the possible variations of renal arteries in cadavers.

Method: The study was conducted in 50 Kidney specimens obtained from formalin preserved human cadavers available from the Department of Anatomy of tertiary care hospital during a period from March 2021–December 2023.Dissection of RA was done by dissection method as per the Cunningham's Manual.

Results: Among the 50 kidneys dissected, single RA was observed in 78% of specimens, double RA in 16% and Triple RA in 6% of specimens. In 26% of specimens the origin of RA was in same level, 28% of right RA and 8% left RA had higher origin. The origin of main renal arteries was from aorta in all specimens. 22% of ARA arose from Aorta and 6% originated from main RA. The length of right sided RA varied from 2cm to 6cm and left sided RA varied from 2cm to 5.5cm.Extrarenal division of renal arteries was observed in 98% and intra renal division was in 2% of specimens which was seen only on right side. Prevalence of ARA was 28%, 24% right sided and 32% left sided. Hilar type of ARA was seen in 14% of the specimen, superior polar artery (SPA) in 4% and inferior polar artery (IPA) in 8% of the specimens. Both SPA & IPA was seen in 2% of the specimens. Single ARA was seen in 20% and double ASA in 4% of the specimens. ARA was passing in front of IVC in 2% and behind IVC in 22% of the specimens. Unilateral ARA was seen in 12% and bilateral ARA was seen in 6% of the specimens.

Conclusion: To conclude the usual textbook description of renal arterial pattern may not be found in all the patients under investigation. Variations observed were single, double, or triple renal arteries, extrarenal division of the renal arteries and ARA. This kind of different pattern of variations may play an important role in renal transplants and any surgeries involving the renal arteries.

Keywords: Renal arteries; Accessory renal arteries; Cadavers; Kidneys; Aorta; Specimens; Polar artery

Introduction

Blood supply to kidney is characterised by the presence of variations, both in renal artery and renal vein, which are significantly predominant in most of the studies. So, a detailed knowledge of the anatomy and variational pattern in the blood supply of kidney is more important in an era of renal transplantations and conservative renal surgeries [1]. The renal arteries are paired arteries which originates at right angle from the abdominal aorta just below the superior mesenteric artery at the level of intervertebral disc between L1 and L2 vertebra but very rarely the main renal artery originates from superior mesenteric artery, coeliac trunk, common iliac artery, external iliac artery, gonadial artery [2]. These are end arteries with no anastomoses. Abdominal aorta lies on the left side of the vertebral column; therefore, the right renal artery is longer than the left renal artery [3]. The venous drainage occurs through the paired renal veins which drain into the inferior vena cava. Both these vessels enter through the hilum of the kidney. The renal arteries take about 20% of the cardiac output [4].

However, accessory renal arteries are common (30%) of individuals, and usually arise from the aorta above or below the main renal artery and follow it to the renal hilum. They are regarded as persistent embryonic lateral splanchnic arteries. Accessory vessels to the inferior pole cross anterior to the ureter and may, by obstructing the ureter cause hydronephrosis. Rarely, accessory renal arteries arise from the celiac or superior mesenteric

arteries near the aortic bifurcation or from the common iliac arteries[5].

The arterial pattern of kidneys shows differences among different populations (Buddhiraja et al [6], Ephraim et al [7] and Sujatha et al [8] etc). Accordingly, with increasing use of invasive diagnostic and interventional procedures, data on types and frequencies of vascular variations from various populations is essential. However, renal vascular anatomy is well known in the literature about its variations. The data of cadaveric study performed by different authors in different populations is suggestive of variable nature of existence of renal artery variations. A thorough knowledge of accessory renal arteries is important for planning and performing endovascular, laparoscopic, urological, and radiological procedures and renal transplants [9]. Hence the present study was undertaken to know the origin, course and relations of renal arteries and accessory renal arteries and the possible variations of renal arteries in cadavers.

Materials and Methods

The present study was carried out in 50 Renal specimens obtained from formalin preserved human cadavers of different age groups and both the sexes available from the Department of Anatomy, of tertiary care hospital during a period from March 2021–December 2023 and embryologically defective kidneys were also included in the study. The specimens which were damaged during dissection or the specimens which have suffered from any Surgeries, or any mass lesions were excluded from the study. The ethical clearance was obtained for the study.

The cadavers were embalmed with the fluid of the- Formalin (10%)- 2 Litres; Glycerine- 1 Litre; Absolute Alcohol- 1 Litre; Common salt- 1 kg and Water- 2-4 Litres and stored in dilute formalin filled tanks. Dissection of renal artery was done by dissection method as per the Cunningham's Manual [10]. Two incisions were made over the anterior abdominal wall. First incision was a vertical incision extends from Xiphoid process to Pubic Symphysis. Second Incision was a transverse incision extends from Xiphoid process laterally towards midaxillary line. The specimens were removed from the cadavers in the dissection hall.

In the above specimens collected from the dissection hall, the observations were made pertaining to the parameters such as number of renal arteries (Single, Double, Triple); level of origin of renal arteries (Right higher, left higher, same level); source of origin of renal arteries (aorta, any other); dimensions of renal arteries (length, width); site of division of renal arteries (prerenal, intrarenal); accessory renal arteries (prevalence, number, side, type, symmetry, course). After observation, the parameters were documented. Normal and abnormal patterns were photographed. The kidneys were tied with discs and given serial numbers. Then the kidneys were preserved in diluted formalin filled tub.

Statistical Analysis

The data were classified and statistically analysed using student t test and Chi Square test. Diagrammatic representations were made to compare with the studies done previously. Level of significance of 5 ($P<0.05$) percent was used for all analysis.

Observations and Results

Among the 50 dissected Renal specimen, single renal artery was observed in 78% of the specimens, double renal artery was observed in 16% of the specimens, and Triple renal artery was observed in 6% of specimens. In 26% of the specimens the origin of the renal artery was in same level, 28% of right renal artery had a higher origin and 8% left renal artery had a higher origin. The origin of main renal arteries was from aorta in all specimens. 22% of accessory renal arteries arose from Aorta and 6% originated from main renal artery, (Table 1).

Table 1: Number, level of origin and source of origin of renal arteries

Variables		Right		Left		Total	
		No. of Specimens	%	No. of Specimens	%	No. of Specimens	%
Number of renal arteries	Single	21	42.0	18	36.0	39	78.0
	Double	02	4.0	06	12.0	08	16.0
	Triple	02	4.0	01	2.0	03	6.0
Level of origin of RA	Same level	07	14.0	06	12.0	13	26.0
	High	14	28.0	04	8.0	18	36.0
	Low	04	16.0	15	60.0	19	38.0
Source of Origin of Main RA	Aorta	25	50.0	25	50.0	50	100
	Others	00	0.0	00	0.0	00	0.0
Source of Origin of ARA	Aorta	04	16.0	07	28.0	11	22.0
	MRA	02	8.0	01	4.0	03	6.0

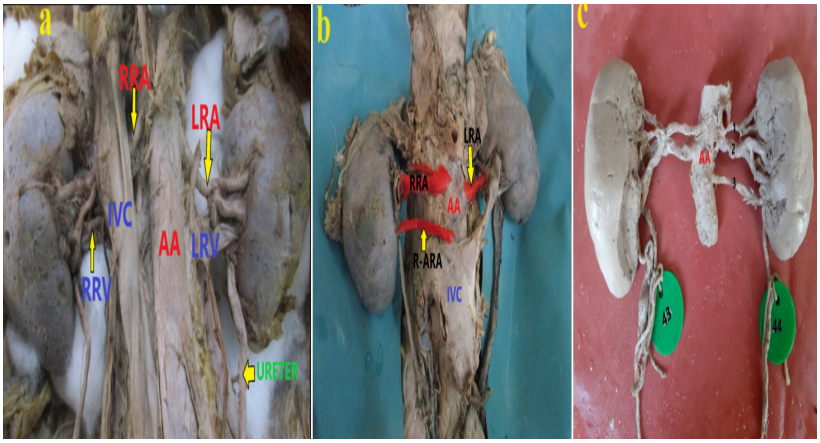

Figure 1: a) Normal Renal Artery; b) Showing double renal artery-right side; c) Showing triple renal artery – left side.

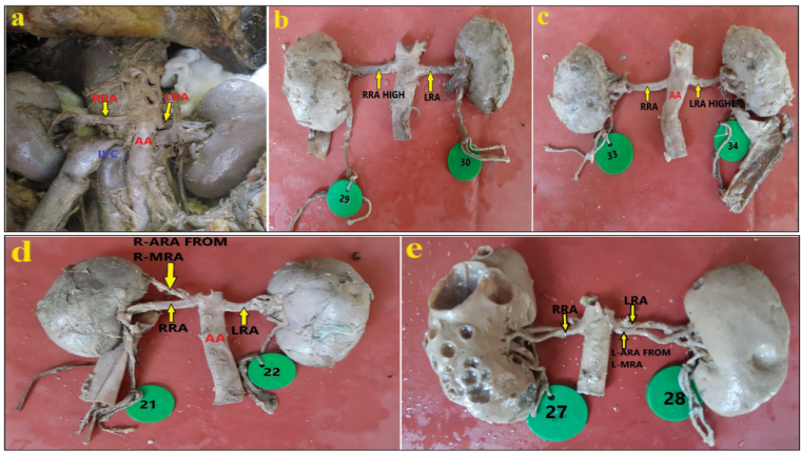

Figure 2: a) Showing same level of origin of renal artery; b) Showing higher level of origin of right renal artery; c) Showing higher level of origin of leftrenal artery; d) Showing right ARAarising from main RA; e) Showing left ARA arising from main RA.

Accessory renal artery (ARA) was found in 14 specimens, six specimens on right side and eight specimens on left side. Table 2 show the mean length and width of main and accessory renal artery.

Table 2: Dimensions of Renal artery

Side		Mean ± SD	P value
Length Main RA	Right (N=25)	4.104±0.92	0.009
	Left (N=25)	3.56±0.64	
Length of ARA	Right (N=6)	3.53±1.40	0.249
	Left (N=8)	3.93±0.75	
Width of main RA	Right (N=25)	0.44±0.13	0.235
	Left (N=25)	0.47±0.14	
Width of ARA	Right (N=6)	0.33±0.10	0.21
	Left (N=8)	0.26±0.07	

Extra renal division of renal artery was observed in 49 specimens,24 on right side and 25 on left side. Intra renal division was present in one specimen on right side (Figure 3).

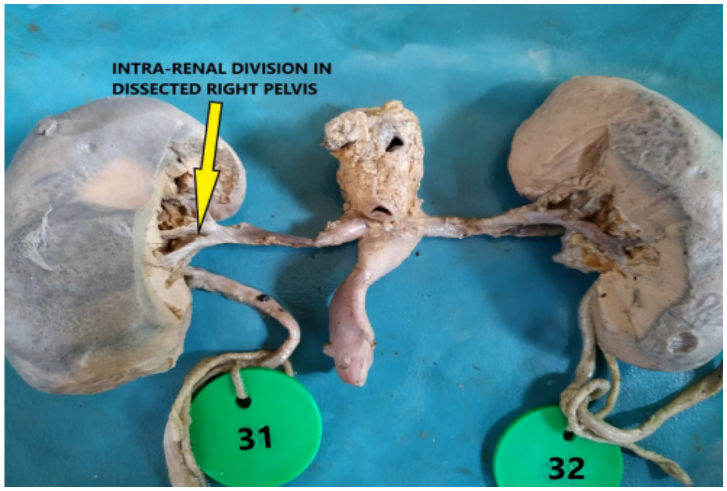

Figure 3: Showing intrarenal division of renal artery.

There are three types of accessory renal arteries found in the study. They are name as Hilar, Superior polar and Inferior polar artery (figure 4 & 5). In ten specimens, single ARA was seen, four on right side and six on left side. Double ARA was seen two specimens one on each side. Normally, the renal arteries from Aorta pass posterior to the Inferior venacava to reach the hilum of the kidney. One ARA on right side was found to be passing in front of IVC to reach the hilum of the kidney, (Figure 6a). In six specimens, unilateral ARA was present and Bilateral ARA was seen in three specimens, (Figure 6b).

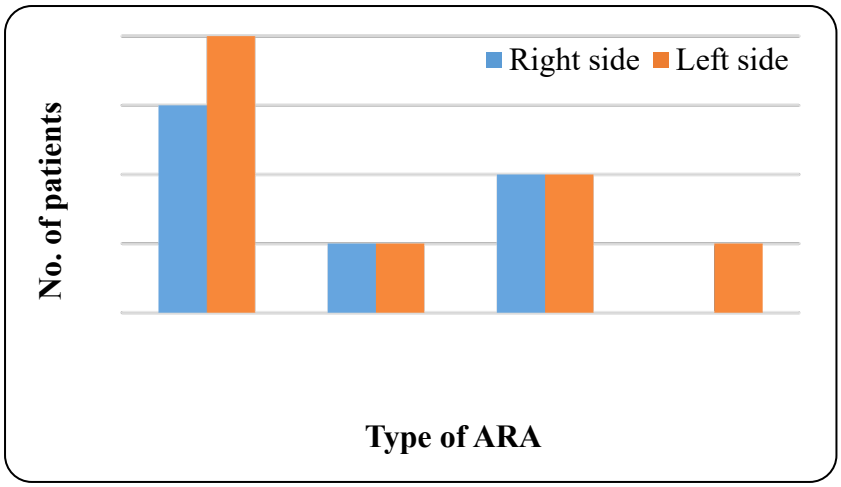

Figure 4: Type of ARA

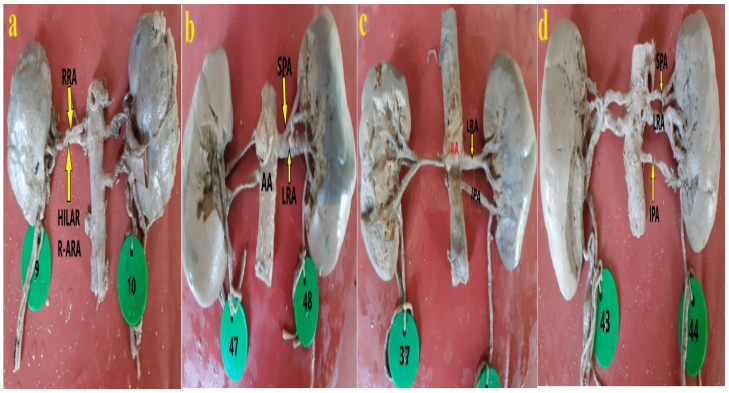

Figure 5: a) Hilar type of ARA; b) Left superior polar type of ARA; c) Leftinferior polar ARA; d) Both superior and inferior polar ARA.

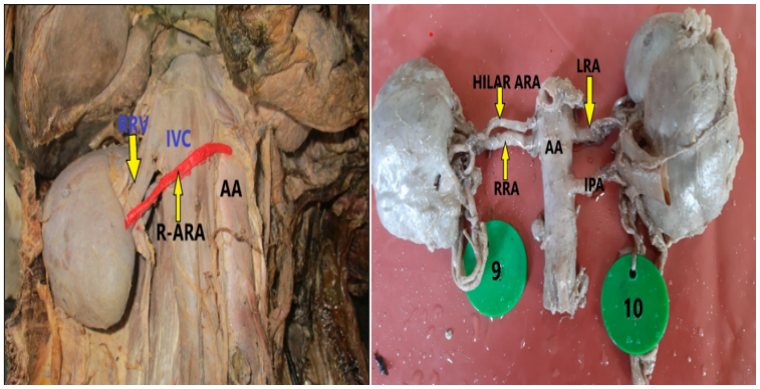

Figure 6: a) Showing abnormal course of ARA -in front of IVC; b) Bilateral ARA

Discussion

Variational anatomy forming part of any system in human anatomy gains more importance day after day with the advent of transplant surgeries. Either to the variational anatomy, having found a small area of importance had gained momentum since the first transplant surgery in heart, kidney, and liver. The advent of renal transplantation has opened new vistas for the study of variational anatomy of renal arteries. Most of these variations observed in the present study have fallen into the groups, which have been already described by previous studies. Knowledge of these variations are important in both surgical and diagnostic purposes. To the surgeon concerned with the problem of renal transplantation, the morphology of renal vessels acquires a special significance. An abnormality may greatly influence the technical feasibility of the operation. When relative donors were not available as an alternative method of harvesting organs from the brain-dead patients, victims of road traffic accidents and cadaver transplant were suggested. This procedure warrants a few precautions such as patients who die of cancer, severe hypertension, infection, road traffic accidents with severe hypotension are unsuitable for transplantation.

In the present study, single renal arterial pattern was found in 78% of cases which is comparable with the study conducted by Ankolekar Vet al [11]. Even in the same individual the arterial pattern was not similar on both sides. Therefore, before planning a partial nephrectomy or renal transplantation a renal angiogram is the most essential investigation for the surgeon. Multiple renal arteries in present study were found to be 22%. Kidneys with multiple renal arteries are not ideal for renal transplant as rejection will be more in multiple renal arteries. So, it is required that the eligible donors are to be carefully investigated prior to donation of kidney.

In 26% of the specimens the origin of the renal artery was in same level, 28% of right renal artery had a higher origin and 8% left renal artery had a higher origin. The origin of main renal arteries was from aorta in all specimens. 22% of accessory renal arteries arose from Aorta and 6% originated from main renal artery. These findings are correlated with the study done by Ephraim et al [7], Sujatha et al [8] and Ankolekar V et al [11].

The mean length and SD of the right renal arteries were 4.10cm and 0.923cm and the left renal arteries were 3.56cm and 0.648cm respectively. Length of the renal artery varies from 2cm to 6cm on right side and 2cm to 5.5cm on left side. The right renal artery was longer than left and usually course behind the inferior vena cava. Left renal artery with length 20mm and above was found to be 64.3% in the present study whereas the right renal artery registered a higher percentage of 80%. The surgeons prefer long renal vascular pedicle for the transplant surgery to be ideal. However, the mean length and SD of the right ARA were 3.53cm and 1.403cm and the left accessory renal arteries were 3.93cm and 0.755cm respectively. The mean width and SD of the right renal arteries were 0.444cm and 0.132 and the left renal arteries were 0.472cm and 0.14 respectively. The mean width and SD of the right accessory renal arteries were 0.33cm and 0.10cm and the left accessory renal arteries were 0.26cm and 0.07 respectively. As proved by the statistical analysis there was a significant difference noted between length of right and left main renal arteries and no significant difference between the length of ARA and width of the main and accessory renal arteries. Similar findings are reported in previous studies [8, 12, 13].

Extrarenal division of the renal artery was the commonest pattern (98%),and the intra-renal division was in 2% of specimens which was seen only on right side which is comparable with the study conducted by Julius A et al [14]. Prevalence of ARA was 28%, left sided ARA was more common as seen in 32% of specimens than right side (24%) which correlates with Sathyapal KS et al [15] and Mehra G et al [16]. They also proved that left sided ARA is common than right side. In present study single ARA was seen in 20% of specimens and double ARA was seen in 4% of

specimens which correlates with the study done by Sathyapal KS et al [15].

Three types of renal arteries observed in the present study were hilar, SPA and IPA. Hilar type of ARA was seen in 14% of the specimen. 24% on the right side and 8 % on the left side. Superior Polar Artery was seen in 4% (2/50) of the specimens,4% (1/25) right sided and 4% (1/25) left sided. Inferior Polar Artery was seen in 8% (4/50) of the specimens,8% (2/25) in right side and 8% (2/25) in left side. Both SPA & IPA was seen in 2% (1/50) of the specimens. It was seen only on the left side. Single accessory renal artery was seen in 20% (10/50) of the specimens.16% (4/25) on the right side and 24% (6/25) on the left side and double accessory renal artery was seen in 4% (2/50) of the specimens. Both right and left had 4% (2/25). These findings are in accordance with the study conducted by Ankolekar V et al [11], Ramulu MV et al [17] and Olga kornafel's et al [18].

Accessory Renal Artery was passing in front of IVC in 2% and behind IVC in 22% of the specimens. Unilateral ARA was seen in 12 % and bilateral ARA was seen in 6% of the specimens. Similar findings are reported in earlier studies [7, 11, 19].

Conclusion

To conclude the usual textbook description of renal arterial pattern may not be found in all the patients under investigation. Variations observed were double or triple renal arteries, extrarenal division of the renal arteries and ARA. This kind of different pattern of variations may play an important role in renal transplants and any surgeries involving the renal arteries. However, the present study which had clearly indicated that the left renal vascular pedicle showed more accessory vessels compared to the right and this observation implies that careful angiographic study of left kidney becomes necessary before planning a renal transplant. The arterial pattern of kidneys shows differences among different populations. Accordingly, with increasing use of invasive diagnostic and interventional procedures, data on type and frequencies of vascular variations from various population is essential.

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