DOI: 10.7860/IJARS/2022/53739.2817

Original Article

Anatomy Section

Morphological Variations in Renal Artery in Cadavers in Solapur, Maharashtra: A Cross-sectional Study

SONAL PRADEEP NAHAR

ABSTRACT

Introduction: Each kidney has a single renal artery. The kidney receives about 20% of the cardiac output. Renal artery variations are a common entity that becomes an important consideration while performing renal surgeries.

Aim: To study the variability of the renal arteries concerning emergence, diameter, and length.

Materials and Methods: This cross-sectional study was conducted in the Department of Anatomy of VMGMC, Solapur, Maharashtra, India for three years, from August 2012 to September 2015. The pattern of the renal artery in humans were studied for emergence, length, and it's branching by dissection method in 75 human cadavers. A thorough dissection of these specimens were done by routine dissection instruments. Statistical analysis of specimens of both sides were carried out by Epi info 7.2.5.0. Unpaired t-test was applied and p-value was derived for the length and diameter of the artery.

Results: Right renal artery 37 (49.4%) had proximal origin in relation to the left renal artery in a greater number of specimens. Average distance between the superior mesenteric and the left renal artery was 11.03±4.8 mm. The average diameter of right renal artery was 6.65±1.6 mm. The average length of the Right Renal Artery (RRA) 39.5±11.8 mm was significantly greater than Left Renal Artery (LRA) 30.7±12.6 mm, p-value <0.01. In 10 (13.3%) specimens length of LRA without ramification was 45.1-60 mm.

Conclusion: Morphology and morphometric knowledge about renal artery help the surgeons to reduce mortality and lead to the successful outcomes of laparoscopic, retroperitoneal, renal transplantation surgeries and various interventional procedures.

Keywords: Dissection, Emergence, Morphometric, Renal system

INTRODUCTION

The right renal artery arises from the anterolateral surface of the aorta. After originating from the aorta, it runs posteriorly to the inferior vena cava before reaching the right kidney. The left renal artery arises from the aorta at slightly higher point and then moves horizontally to reach the left kidney [1]. The renal vein is anterior to its renal artery and then enters the renal, hilum which is anterior to the renal pelvis [2]. The renal artery provides blood to the adrenal gland and ureter on the same side.

More precise knowledge of renal vascularisation helps to find more conservative methods for renal surgery. Both kidneys are equally suitable for donation, but the left kidney is usually preferred due to its more favourable anatomy: it is more accessible and has longer vessels, rendering the subsequent transplantation technically less challenging [3]. Since the left renal artery is closer to aorta than the right, the chances of vascular complications will be higher in right renal surgeries. Poiseuille's law states that the vessel's diameter is a determining factor in the volume of blood flow in a vessel and flow is directly proportional to the fourth power of vessel diameter [4]. Renal artery stenosis can be treated by percutaneous arterial stenting which requires measurement of renal artery diameter and length [5].

Such aspects provide an anatomical landmark for surgeons when considering many surgical conditions like renal artery stenosis, renal artery aneurysms, fibromuscular dysplasia and renal artery dissection [6,7]. The present study was conducted to study the variability of the renal artery in morphological expression concerning emergence, diameter, and length.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Anatomy of VMGMC, Solapur, Maharashtra, India for three years from August 2012 to September 2015.

Sample Size Calculation: Calculation of sample size was done at 95% confidence interval considering previous article [8]:

$$N=\frac{4\times p\times q}{d^2}$$

where, p= 84.8% (prevalence of emergence of renal artery),

q=100-p; q=100-84.8

q=15.2%

d= allowable error, 10% of p=8.4.

Inclusion criteria: The cadavers were used for teaching purpose with no renal abnormalities like renal mass, renal surgery or abdominal scar were included in the study.

Exclusion criteria: The presence of abnormal abdominal mass or growth, evidence of renal trauma or surgical scar on the abdomen were excluded from the study.

The study included 55 male and 20 female cadavers. They were dissected at the dissection hall of the Department of Anatomy. Cadavers were already dissected for teaching purposes as per Cunningham's Manual of practical Anatomy [9]. Dissection was done through the anterior abdominal wall in the supine position. The fascia covering the kidney was removed, and the renal arteries was studied carefully. Careful observation of the aorta was performed to note down an emergence surface of the renal artery.

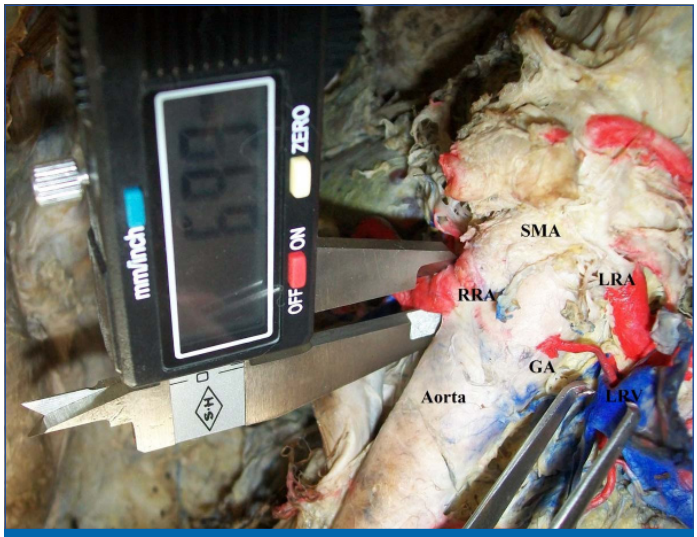
The emergence level of the right renal artery on the aorta, according to that of the left renal artery, was noted as proximal, distal or at the same level. Distance between the superior mesenteric artery and right renal artery, at their origin on the aorta was measured. Same procedure was done for left renal artery.

The length of the renal artery was measured using instrument vernier caliper between the following points:

a. Point on the aorta from where it originates

b. Point at which first extrahilar branch of renal artery arises [8].

The diameter of each renal artery was measured using an vernier caliper [Table/Fig-1].



[Table/Fig-1]: Anterior view of the abdomen illustrating measurement of diameter of RRA using vernier caliper.
RRA: Right renal artery; SMA: Superior mesenteric artery; LRA: Left renal artery; GA: Gonadal artery; LRV: Left renal vein

STATISTICAL ANALYSIS

The detailed data was entered into a Microsoft excel sheet and subsequently analysed statistically by Epi info 7.2.5.0. Values were reported as in percentage. Distances were calculated as mean and standard deviation. Unpaired t-test was applied and p-value was derived for the length and diameter of the artery.

RESULTS

Out of 75 cadavers, 55 (73.3%) were males and 20 (26.7%) were females. The anterolateral emergence of renal artery was the most common presentation 120 (80%); while only 2 (1.3%) renal arteries emerged from the posterolateral surface of the aorta [Table/Fig-2].

Emergence surface	RRA specimens (N=75); n (%)	LRA specimens (N=75); n (%)	Total specimens (N=150); n (%)
Lateral	15 (20)	13 (17.3)	28 (18.7)
Anterolateral	60 (80)	60 (80)	120 (80)
Posterolateral	0	2 (2.7)	2 (1.3)

[Table/Fig-2]: Emergence of renal artery from the surface of the aorta.
RRA: Right renal artery; LRA: Left renal artery

Also, in the present study, it was found, in 37 (49.3%) cadavers, the right renal artery emerged proximally than the left renal artery. Left renal artery emerged proximal to the origin of the right renal artery on the aorta in 12 (16%) cadavers. Both renal arteries emerged at same level in 26 cadavers (34.6%).

In 37.3% of specimens, the distance between Superior Mesenteric Artery (SMA) and RRA was 10.1-15 mm; while in 34.7% of specimens the distance between SMA and LRA was 10.1-15 mm [Table/Fig-3].

The average distance between the SMA and RRA was 10.76±4.66 mm. The average distance between the SMA and LRA was 11.03±4.84 mm.

Distance (mm)	Right renal artery	Left renal artery	Total
	Specimens n (%)	Specimens n (%)	Specimens n (%)
0-5	11 (14.6)	10 (13.3)	21 (14)
5.1-10	25 (33.3)	23 (30.6)	48 (32)
10.1-15	28 (37.3)	26 (34.7)	54 (36)
15.1-20	9 (12)	14 (18.7)	23 (15.3)
≥20.1	2 (2.7)	2 (2.7)	4 (2.7)

[Table/Fig-3]: Distance between the superior mesenteric artery (SMA) and renal arteries (RA).

In 41 (54.7%) of specimens, the length of RRA having ramification was 30.1-45 mm; while in 28 (37.3%) of specimens, the length of LRA having ramification was 30.1-45mm. This was the most common presentation [Table/Fig-4].

Length (mm)	Right renal artery		Left renal artery	
	With ramification n (%)	Without ramification n (%)	With ramification n (%)	Without ramification n (%)
4.1-15	4 (5.3)	0	13 (17.33)	0
15.1-30	12 (16)	0	22 (29.33)	0
30.1-45	41 (54.7)	1 (1.35)	28 (37.33)	2 (2.67)
45.1-60	12 (16)	1 (1.35)	0	10 (13.33)
≥60.1	0	4 (5.3)	0	0
Total	69	6	63	12

[Table/Fig-4]: Length of the right renal artery and the left renal artery with and without ramification.

Statistically significant difference was found between the length of the right and left renal arteries. No significant difference was found between the diameters of the right and left renal arteries. The average diameter of the right renal artery was 6.65±1.6 mm, and that of the left renal artery was 6.56±1.44 mm [Table/Fig-5].

Renal artery dimensions	Maximum	Minimum	Mean±SD	p-value
Length of RRA (mm)	62.5	11.5	39.5±11.8	<0.01
Length of LRA (mm)	59.2	8.2	30.7±12.6	
Diameter of RRA (mm)	9.6	2.7	6.65±1.6	0.72
Diameter of LRA (mm)	9.3	2.5	6.56±1.4	

[Table/Fig-5]: Average length and diameter of the renal artery on both sides.
For length: t=4.4147, DF=148, standard error of difference=1.993 significant;
For diameter: t=0.3570, DF=148, standard error of difference=0.252 not significant

DISCUSSION

The knowledge of the emergence level of the renal artery on the aorta is vital for urological surgical procedures like renal transplants. Renal, suprarenal and gonadal organs are supplied by the dorsal aorta by lateral mesonephric arteries. During embryological development, these lateral mesonephric arteries are divided into upper, middle and lower groups [10]. The middle group, namely the 6-9th segment, gives rise to renal arteries. Variable growth gradient in the walls of aorta can also cause this variation.

Cicekcibasi AE et al., [11] in (2005) observed that the Right Renal Artery (RRA) emerged from the anterolateral surface in 26.9% of specimens; while in 73% RRA emerged from the lateral side of the aorta. They also found that in 90.3% of cadavers, the Left Renal Artery (LRA) originated from the lateral surface of the aorta compared to 17.3% in the present study. Saldarriaga B et al., [8] in 2008 found that both renal arteries emerged more from anterolateral surface of the aorta than lateral surface.

In the present study, it was seen that 80% RRAs emerged from the anterolateral surface and 20% RRAs emerged from the lateral surfaces; while no specimen showed posterolateral emergence of RRA. This knowledge will provide a relative avascular plane for safer urological surgeries on kidneys. The results of the current study was similar to that of Saldarriaga B et al [8]. But it was different from the result of Cicekcibasi AE et al., [11]. This can be because; authors conducted a study on the human foetuses of spontaneous abortion with no congenital anomaly in Turkey. The advanced age of individuals providing most cadavers hampered determining ostium by direct dissection (as the aorta was sinous) [8].

Rameshbabu CS et al., [12] reported 24 cases of supradiaphragmatic thoracic origin of renal arteries with 20 on the right and four on the left side. The current study did not find such variation.

In the current the study, the comparison was made on emergence level of the right to that of the left renal artery, it was found that

Beregi JP et al., in 1999 had described a higher frequency for the same level of emergence of renal arteries (50%) [13]. A greater frequency (65%) of proximal origin of the right renal artery had been reported by Garcier JM et al., in 2001 [14]. The RRA had a proximal origin in relation to LRA in greater number of specimens (49.4%) in the present study, similar to studies done by Cicekcibasi AE et al., in 2005 [11], and Saldarriaga B et al., in 2008 [8]. The cranial origin of the right renal artery relative to the left and the lower position of the human right kidney relative to the left may indicate that the right kidney undergoes secondary caudal movement after finishing its primary ascent [15].

To know the emergence level, can be considered the distance from the origin of the renal arteries to SMA on the aorta [10]. Saldarriaga B et al., [8] found that the distance between SMA and RRA was 10.36 mm, while that of SMA and LRA was 11.23 mm. In the present study, the findings were almost similar to Saldarriaga B et al., [8]. The renal arteries originated between 2 and 4 o'clock on the left and between 9 and 10 o'clock on the right side [16]. It means RRA originated proximally to LRA. This knowledge helps in the development of new stents for endovascular repair.

In the present study, the average diameter of the renal artery 6.65 mm was slightly more than 5.9 mm, as reported in angiographic studies done by Aytac SK et al., [17] in 2003. Saldarriaga B et al., [8] found 4.8 mm was an average diameter, while Weld K et al., [18] in 2005 observed an average diameter of 7.9 mm. This may be because data from diagnostic imaging studies varies, depending on the technique used. They may have focused on pathological cases eg. hypertension associated stenosis.

In the present study, the comparsion was made on the average length of the RRA (39.5 mm) which was significantly greater than LRA (30.7mm) which was similar to Saldarriaga B et al., [8] (34.6 mm for RRA and 28.6 mm for LRA). Mohiuddin M et al., [19] also found significance difference (p-value=0.001) was seen between mean right renal artery (diameter 6.66±0.39 mm; length 44.69±2.48 mm) and left renal artery (diameter 6.79±0.36; length 35.10±2.86 mm) using multidetector computer tomography. This difference between results can be attributed to different races. Most specimens had renal artery the lengths ranging from 30.1-45 mm. It will be help in renal transplantation to decrease accidental injuries to renal arteries during surgeries.

In 132 specimens (88%), author found the greater frequency of the renal artery having ramification than the renal artery without ramifications in 18 specimens (12%). Short length arteries, determined by early ramification of the main renal artery were those with length less than 15 mm. The short length renal artery frequency (early ramification) observed in the present study (11.3%) was less than that reported [20,21]. Kawamoto S et al., [22] reported a greater frequency of short length renal arteries (19%). The low frequency (2.6%) reported by Sampaio FJ and Passos MA, [23] was noted.

Knowledge of renal anatomy will also help develop new techniques for removing of calculi or affected parts of kidneys and in partial renal transplantation surgeries with end to end anastomosis of the resected part of the kidney. Comprehensive knowledge of renal arterial patterns remains critical in determining the technical feasibility of surgical interventions like living renal donation, vascular reconstruction, renovascular hypertension, or radical nephrectomy.

Limitation(s)

The study could be extrapolated with Computed Tomography (CT) and angiographic findings. A sample consisting of an unequal number of males and females, so the comparison of differences in morphological variations between sexes could not be made.

CONCLUSION(S)

In present study, the anterolateral emergence as the most common presentation. The difference was statistically significant between average length of the right renal artery and left renal artery. Considering all this, the knowledge of the anatomy of the renal vessels, branches and variations in them is essential for dealing with kidney retrieval and transplantation, various endourologic procedures and numerous interventional techniques.

Acknowledgement

Author is thankful to the Department of Anatomy of various medical colleges in Maharashtra for their support in this study.

REFERENCES

[1] Standring S. Gray's Anatomy. The Anatomical Basis of Clinical Practice. 39th Edition, Elsevier, Churchill Livingstone. 2004, ISBN 00443071683, pp1274-76.
[2] Datta A. Essentials of human anatomy(thorax and abdomen). 8th edition. Current book international. 2009, pp302.
[3] Burn F, Schirpenbach C, Bidlingmaier M, Reincke M, Vetter D, Weishaupt D et al. Left-sided living kidney donation leads to transiently reduced adrenocortical responsiveness. Am J Transplant. 2017;17(7):1879-84. https://doi.org/10.1111/ajt.14184
[4] Guyton AC. Overview of the circulation and medical physics of pressure, flow, and resistance. In: Guyton AC (ed). Textbook of Medical Physiology. 8th ed. Philadelphia, PA: WB Saunders Co; 1991:150-158.
[5] Weber BR, Dieter RS. Renal artery stenosis: epidemiology and treatment. Int J Nephrol Renovasc Dis. 2014;7:169-181. doi:10.2147/IJNRD.S4015.
[6] Leslie SW, Sajjad H. Anatomy, abdomen and pelvis, renal Artery. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021. Available from: https://www.ncbi.nlm.nih.gov/books/NBK459158
[7] Lescay H, Jiang J, Tuma F. Anatomy, abdomen and pelvis, ureter. StatPearls [Internet]. StatPearls Publishing; Treasure Island (FL): 2021.
[8] Saldarriaga B, Pinto S, Ballesteros L. Morphological expression of the renal artery. A direct anatomical study in a Colombian half-caste population. Int J Morphol. 2008;26(1):31-8.
[9] Romanes G. Cunningham's manual of practical anatomy- Thorax and abdomen. 15th Edn, volume 2. Oxford medical publication, New York Tokyo. 2000; pp 91-9, 114-55, 165-9.
[10] Felix W. Mesonephric arteries (aa mesonephricae). In: Keibel F, Mall F (eds), Manual of Human Embryology, 2nd edition, Lippincott, Philadelphi. 1910-12, pp 820-5.
[11] Cicekcibasi AE, Salbacak A, Seker M, Ziylan T, Büyükmumcu M, Uysal II. The origin of gonadal arteries in human fetuses: anatomical variations. Ann Anat. 2005; 187:421-7.
[12] Rameshbabu C, Kumar A, Gupta O, Sharma Y. Supradiaphragmatic origin of right renal artery from thoracic aorta: case report and literature review. Int J Anat Res 2020, 8(4.2):7829-34. ISSN 2321-4287 DOI: https://dx.doi.org/10.16965/ijar.2020.238
[13] Beregi JP, Mauroy B, Willoteaux S, Mounier-Vehier C, Rémy-Jardin M, Francke J. Anatomic variation in the origin of the main renal arteries: spiral CTA evaluation. Eur Radiol. 1999; 9(7): 1330-4.
[14] Garcier JM, De Fraissinette B, Filaire M, Gayard P, Therre, T, Ravel A. Origin and initial course of the renal arteries: a radiological study. Surg Radiol. Anat. 2001;23(1):51-5.
[15] Yokota E, Kawashima T, Ohkubo F, Sasaki H. Comparative anatomical study of the kidney position in amniotes using the origin of the renal artery as a landmark. Okajimas Folia Anat Jpn. 2005; 81(6):135-47.
[16] Wijesinghe LD, Scott DJ, Kessel D. Analysis of renal artery geometry may assist in the design of new stents for endovascular aortic aneurysm repair. Br J Surg. 1997;84(6):797-9.
[17] Aytac SK, Yigit H, Sancak T, Ozzcan H. Correlation between the diameter of the main renal artery and the presence of an accessory renal artery: sonographic and angiographic evaluation. J Ultrasound Med. 2003;22(5):433-39.
[18] Weld KJ, Bhayani SB, Belani J, Ames CD, Hruby G, Landman J. Extrarenal vascular anatomy of kidney: assessment of variations and their relevance partial nephrectomy. Urology. 2005;66(5):985-89.
[19] Mohiuddin M, Mansoor A, Ali M, Hassan N. Analysis of renal artery morphometery in adults: A study conducted by using multidetector computed tomography angiography. Pak J Med Sci. 2017;33(4):943-47. 10.12669/pjms.334.13063
[20] Holden A, Smith A, Dukes P, Pilmore H, Yasutomi M. Assessment of 100 live potential renal donors for laparoscopic Nephrectomy with Multi-Detector row helical CT. Radiology. 2005;237(3):973-80.
[21] Kapoor A, Kapoor A, Mahajan G, Singh A, Sarin P. Multispiral CT angiography of renal arteries of live potencial renal donors: A review of 118 cases. J Transplantation. 2004;77(10):1535-39.

[22] Kawamoto S, Montgomery RA, Lawler LP, Horton KM, Fishman EK. Multidetector CT Angiography for preoperative evaluation of living laparoscopic kidney donors. AJR Am J Roentgenol. 2003;180(6):1633-8.

[23] Sampaio FJ, Passos MA. Renal arteries: anatomic study for surgical and radiological practice. Surg Radiol Anat.1992;14(2):113-17.

PARTICULARS OF CONTRIBUTORS:
1. Associate Professor, Department of Anatomy, MGV's KBH DCH, Nashik, Maharashtra, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Sonal Pradeep Nahar,
A 103, Flora Heights, Amrutdham, Nasik, Maharshatra, India.
E-mail: sonaljain7@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Jan 10, 2022
- Manual Googling: Mar 06, 2022
- iThenticate Software: May 12, 2022 (22%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? NA
- Was informed consent obtained from the subjects involved in the study? No
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Jan 04, 2022**
Date of Peer Review: **Jan 28, 2022**
Date of Acceptance: **Mar 07, 2022**
Date of Publishing: **Jul 01, 2022**