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Original Article

EVALUATION OF ANATOMICAL VARIATIONS OF EXTRARENAL RENAL ARTERIAL VASCULATURE IN VOLUNTARY KIDNEY DONORS

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ABSTRACT

Objective: The present study was aimed at evaluating the variations in extrarenal renal arterial vasculature in voluntary kidney donors who had undergone Multi-Detector Computed Tomography (MDCT) renal angiography for preoperative workup.

Methods: A retrospective hospital based cross-sectional study was carried out in a tertiary care Army hospital in Delhi from Jan 2019 to June 2020. All voluntary kidney donors included in the study underwent Multi-Detector Computed Tomography Angiography (MDCTA) of renal arteries as a part of routine pre-operative imaging protocol and were referred by the treating physician/surgeon for MDCTA study. Retrospective analysis of the image datasets was undertaken by the principal investigator and individual patient consent was waived off by the institutional Ethics committee.

Results: The mean age of study participants was 45.9±10.2 y. Accessory renal artery was relatively more common on left side (p-value 0.001). There was statistically no significant difference between gender and the presence of accessory renal artery. There was statistically no significant difference on the comparison of side and gender with distance of segmentary bifurcation of MRA. The orthogonal diameters at the origin of the MRA and accessory renal artery on both sides were also comparable. Origin of accessory renal arteries were caudal to MRA was more frequently seen. Early segmentary bifurcation of MRA was commoner on the right side.

Conclusion: The study emphasizes the importance of meticulous preoperative assessment, highlighting the need for surgeons to be cognizant of the potential variations in extrarenal renal artery anatomy. Such awareness is crucial for planning successful kidney transplant surgeries.

Keywords: Anatomical variations, Extra renal arteries, Kidney donors

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INTRODUCTION

Chronic kidney disease (CKD) globally accounts for approximately 735,000 deaths per year [1]. The prevalence of end-stage renal disease requiring transplantation in India is estimated to be between 151 and 232 per million population [2]. If an average of these fig. is taken, it is estimated that almost 220,000 people require kidney transplantation in India per year. However, as per recent data approximately 7500 kidney transplantations are performed at 250 kidney transplant centres in India. Of these, about 90% come from living donors and 10% from cadaveric donors [3]. It has been well established that related or unrelated living donor renal allografts have a higher graft survival than cadaveric donor transplants [4].

Laparoscopic nephrectomy has become the preferred surgical procedure for procuring kidneys from living donors instead of open nephrectomy approach practiced earlier [5]. Overall, the mortality rate of laparoscopic nephrectomy is estimated to be close to 0.03% [6]. Maximum number of fatal events occur in the postoperative period and were attributed to haemorrhage, CO2 embolism and pulmonary embolism [6]. Intra-operative haemorrhage during laparoscopic nephrectomy has an estimated risk of 0.6 and 1.6% [7].

Donor kidneys with single renal artery and vein are usually preferred owing to lesser chances of inter as well as post-operative complications. Earlier, left side kidney was preferred due to longer course of left renal vein and easier surgical approach; however, with increasing expertise right kidney donations have become equally common [8]. Considerable anatomical variation in renal vasculature have been reported in the literature; therefore, accurate pre-operative evaluation of the renal vascular anatomy is crucial before donor nephrectomy and also to ensure good recipient graft function [9-11]. The present study was aimed at evaluating the variations in extrarenal renal arterial vasculature in voluntary kidney donors who had undergone MDCT renal angiography for preoperative workup.

MATERIALS AND METHODS

Study design

A retrospective hospital-based cross-sectional study.

Study site

It was carried out in a tertiary care Army hospital in Delhi from Jan 2019 to June 2020. Informed consent was obtained from participants before initiating the study. Institutional Ethical Committee approval was obtained before conducting the study, [AH/DELHI/IEC/15/2018].

Inclusion criteria

Multi-Detector Computed Tomography Angiography (MDCTA) data of voluntary kidney donors who had undergone CT renal angiography in the department of radiodiagnosis of our institute for pre-operative workup during the study period were considered for the study.

Exclusion criteria

Patients with deranged renal function, history of allergic reaction to iodinated contrast media, claustrophobia, diabetes mellitus, asthma, cardiac disease or thyroid disorders were excluded from the study.

Sample size

The study conducted by Satyapal *et al.* [12] observed incidence of additional arteries was 27.7%. Taking this value as a reference, at 10% absolute error and 5% level of significance, the minimum required sample size was calculated to be 77 patients.

Study process

After the initial routine medical evaluation, the patient was positioned on the CT table in supine position, a power injector

was used to administer contrast medium (350 mg/ml of Iohexol {Omnipaque TM}) through a 20-gauge high pressure IV cannula at a rate of 4 ml/second using pressure injector (Optivantage TM DH). The total volume of administered contrast was 1.5 ml/kg of body weight with a bolus-triggered technique in which the cursor was placed on the infra-diaphragmatic suprarenal abdominal aorta and the threshold was set at 150 HU with a threshold delay of 5.8 seconds. Arterial phase images were obtained in a cranio-caudal direction from diaphragm to the pubic symphysis. The data obtained from MDCTA was evaluated on a dedicated 3D workstation.

When a kidney has two or more arteries with a separate ostium, the vessel with the greatest diameter is considered to be the main renal artery and the others as accessory arteries [13]. Early segmentary bifurcation of the right renal artery was defined as bifurcation within 1 cm of the right margin of IVC or behind the IVC (retrocaval) and early segmentary bifurcation of the left renal artery within 15 mm from origin [14]. All voluntary kidney donors included in the study underwent MDCTA of renal arteries as a part of routine pre-operative imaging protocol and were referred by the treating physician/surgeon for MDCTA study. Retrospective analysis of the image datasets was undertaken by the principal investigator and individual patient consent was waived off by the institutional Ethics committee. Besides, no patient was subjected to additional CT scan for the purpose of the study. Ethical approval was obtained from institutional ethical committee.

Statistical analysis

The data was entered in MS excel spreadsheet and analysed using Statistical Package for Social Sciences (SPSS) version 21.0. Categorical variables are presented in number and percentage (%) and continuous variables were presented as mean±standard deviation (SD). Categorical data have been analysed used chi-square test. A p-value of<0.05 was considered statistically significant.

RESULTS

A total of 95 prospective voluntary kidney donors who were referred to the department of radiodiagnosis for MDCTA as a part of pre-operative workup were included in the study. The study group consisted of 38 males (40 %) and 57 females (60 %). The mean age of study participants was 45.9±10.2 y, majority of the participants were in the age group of 41-50 y (34 cases, 35.8%), followed by 51-60 y (25 cases, 26.3%) and 31-40 y (21 cases, 22.1%). Eight participants (8.4%) were in the age group of 25-30 y and seven (7.4%) in the age group of above 60 y.

No accessory renal artery was seen in 56 participants (58.9%) and accessory renal artery was present in 39 participants (41.1%). Accessory renal artery on the right was seen in 23 subjects (24.2%) and the same for left side was seen in 30 participants (31.6%). Fourteen subjects (14.7%) had accessory renal arteries on both the sides i.e., nearly two-thirds of cases who had accessory right renal artery (14/23 participants, 60.9%) also had accessory renal artery on left side and similarly, almost half of the participants who had accessory left renal artery (14/30 participants, 46.7%) also had accessory renal artery on the other side. The above difference was found to be statistically significant, with a p-value of 0.001 (table 1).

Out of 23 accessory renal arteries on right side, origins of accessory renal arteries were caudal to main renal artery (MRA) in 18 subjects, cranial to MRA in four subjects and anterior to MRA in one subject. Out of 30 accessory renal arteries on left side, origins of accessory renal arteries were caudal to MRA in 22 subjects, cranial to MRA in five subjects and anterior to MRA in two subjects and posterior to MRA in one subject.

The presence of accessory renal artery was slightly more common on right side among female study subjects compared to male participants but similar occurrence was seen on left side. Overall, there was statistically no significant difference between gender and the presence of accessory renal artery (table 2).

Table 1: Comparison of accessory renal arteries among study subjects

Side and accessory renal artery		Left kidney		Total
		No accessory artery	Accessory artery seen	
Right kidney	No accessory artery	56 (58.9%)	16 (16.8%)	72 (75.8%)
	Accessory artery present	09 (9.5%)	14 (14.7%)	23 (24.2%)
Total		65 (68.4%)	30 (31.6%)	95 (100%)
p-value		0.001		

Table 2: Gender-wise comparison of accessory renal arteries among study subjects

Parameter	Gender		Total	p-value
	Female	Male		
Accessory renal artery on right side				
No accessory artery	41 (71.9%)	31 (81.6%)	72 (75.8%)	0.282
Accessory artery present	16 (28.1%)	07 (18.4%)	23 (24.2%)	
Accessory renal artery on left side				
No accessory artery	39 (68.4%)	26 (68.4%)	65 (68.4%)	1.000
Accessory artery present	18 (31.6%)	12 (31.6%)	30 (31.6%)	
Accessory renal artery on any side				
No accessory artery	33 (57.9%)	23 (60.5%)	56 (58.9%)	0.798
Accessory artery present	24 (42.1%)	15 (39.5%)	39 (41.1%)	
Total	57 (100%)	38 (100%)	95 (100%)	

Out of 23 accessory renal arteries on right side, origins of accessory renal arteries were caudal to MRA in 18 subjects (78.3%), cranial to MRA in 04 subjects and anterior to MRA in 01 subject. Out of 30 accessory renal arteries on left side, origins of accessory renal arteries were caudal to MRA in 22 subjects (73.3%), cranial to MRA in 05 subjects and anterior to MRA in 02 subjects and posterior to MRA in 01 subject. On the right side, accessory renal arteries were polar in 19 subjects (17 lower and 02 upper) and hilar in 4 subjects. On the left side, accessory renal arteries were polar in 27 subjects (23 lower and 04 upper) and hilar in three subjects. Around one-third of subjects who had accessory artery on right were within 5-10 mm (34.8%) and less than 5 mm (30.4%) from the main artery, whereas on left side, one-third of the subjects had accessory artery at a distance of more than 20 mm from the main artery. However, the above differences were statistically not significant (p value>0.05) (table 3).

Early segmentary bifurcation of MRA was determined on the basis of distances of bifurcation from origin. On right side, retrocaval bifurcation and bifurcation at a distance of<10 mm from right margin of IVC was considered early. While on left side, distance of bifurcation<15 mm was considered early. Early segmentary

bifurcation was seen in 40 subjects (42.1%) on right side, which included 27 retrocaval and 13 subjects with less than 10 mm from the right margin of IVC. While early segmentary bifurcation on left side was seen in 15 subjects (15.8%). There was statistically no significant difference on comparison of side and gender with distance of segmentary bifurcation of MRA (table 4).

Table 3: Details of accessory renal arteries among study subjects

Parameters	Accessory artery		p-value
	Right	Left	
Origin			
Caudal to MRA	18 (78.3%)	22 (73.3%)	0.817
Cranial to MRA	04 (17.4%)	05 (16.7%)	
Anterior to MRA	01 (4.3%)	02 (6.7%)	
Posterior to MRA	0	01 (3.3%)	
Classification			
Hilar	04 (17.4%)	03 (10.0%)	0.671
Polar (lower)	17 (73.9%)	23 (76.7%)	
Polar (upper)	02 (8.7%)	04 (13.3%)	
Distance from MRA (in mm)			
<5	07 (30.4%)	07 (23.3%)	0.236
5-10	08 (34.8%)	05 (16.7%)	
11-15	02 (8.7%)	07 (23.3%)	
16-20	02 (8.7%)	01 (13.3%)	
>20	04 (17.4%)	10 (33.3%)	
Total	23 (100%)	30 (100%)	

Table 4: Distance of segmentary bifurcation of main renal artery

Gender		Side		
		Right		Left
		From origin (mm)	From IVC (mm)	From origin (mm)
Female	Mean	35.0	13.7	26.6
	SD	9.1	5.4	9.3
Male	Mean	32.5	11.0	26.8
	SD	11.7	5.5	10.1
Total	Mean	34.0	12.6	26.7
	SD	10.2	5.5	9.5
p-value		0.241	0.412	0.933

The orthogonal diameters at origin of the MRA and accessory renal artery on both sides were also comparable (fig. 1).

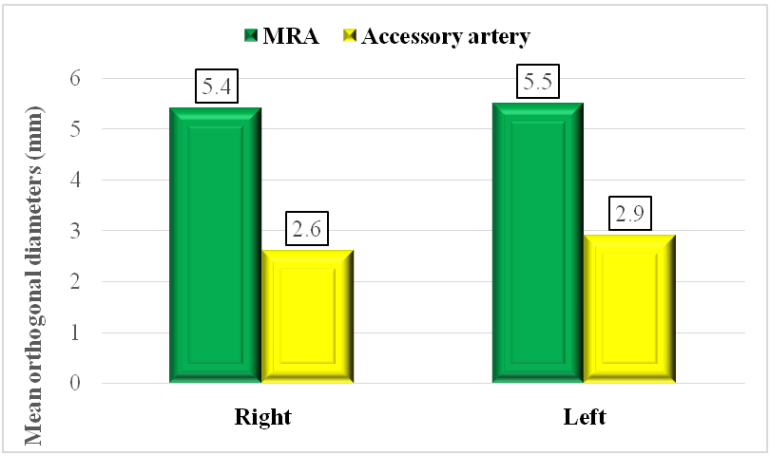

Fig. 1: Orthogonal diameters at origin of MRA and accessory renal artery among study subjects

DISCUSSION

A thorough understanding of anatomical variations in the extrarenal renal artery is crucial during the preoperative assessment phase, as it helps surgeons plan and execute successful kidney transplant surgeries minimizes operative risks, and ensure better long-term health and quality of life for both donors and recipients. In the present study accessory renal artery was present in 41.1% of study subjects (39/95 participants) of which accessory renal artery on the right was seen in 23 subjects (24.2%) and on left side in 30 participants (31.6%). Fourteen subjects (14.7%) had accessory renal arteries on both the sides and the finding was statistically significant. Aremu *et al.*, observed accessory renal artery in nearly one-third of study subjects (32%), and left-sided accessory arteries were slightly more common than the right [15]. The results were comparable to the study conducted by Satyapal *et al.*, which showed a prevalence of accessory renal arteries to be 27.7% [12]. Bilateral accessory renal arteries were seen in 14 subjects (14.7 %) in our study, which was marginally higher

than findings of Kumaresan Munnusamy *et al.*, (12 %) and comparable to findings of Swarna *et al.* (15 %) [16, 17].

In the present study, the most common origin of accessory renal arteries was caudal to MRA seen in more than three-fourths of the study subjects who had accessory renal artery, followed by cranial origin and caudal origin on both sides. Only one patient had posterior origin on left side and none on right side. The distance of origin of accessory renal arteries showed great variation, with most common being 5-10 mm on right side (34.8%) and>20 mm on left side (33.3 %). Majority of accessory renal arteries were seen entering at poles of kidneys and were classified as polar with lower polar variant being most common (82.6 % on right side and 90.0 % on left side among subjects with accessory artery). The hilar accessory renal arteries were seen in only 4 subjects on the right and 3 subjects on left side. Contrary to our findings Swarna *et al.* observed that 58.5% of right accessory renal arteries were hilar and 41.5% were polar arteries, and out of the left-side accessory arteries, 61.8% were hilar and 38.2% were polar arteries [17].

Early segmentary bifurcation of MRA was commoner on right side (42.1%) than left (15.8%). Among the 40 subjects with early segmentary bifurcation, retrocaval bifurcation was observed in 27 subjects. Swarna *et al.* in their study observed right early segmentary bifurcation in 85.6% of study subjects, with 42% being retro-caval, and early segmentary bifurcation of the left renal artery was seen in 12.3% of patients [17]. This further consolidated the great variability seen in anatomy of accessory renal arteries.

The mean orthogonal diameter of MRAs at origin were 5.4 mm and 5.5 mm on right and left sides, respectively. The mean orthogonal diameter of accessory renal artery/arteries on right side was 2.6 mm, while on the left, the mean orthogonal diameter of accessory renal artery/arteries was 2.9 mm. These results were comparable with the findings of Swarna *et al.* [17].

The present study has limitations like not including the evaluation the venous/ureteric anatomical variations and functional status of kidneys which are possible and routinely done during pre-operative MDCTA.

Very small (<1 mm) accessory renal arteries maybe missed during MDCTA; however study by Shaffer *et al.* suggested that small missed renal arteries during pre-operative imaging can be ligated safely without significant risk of ischemic injuries to the renal parenchyma and thus are of lesser clinical significance [18].

CONCLUSION

The study demonstrates consistency in the prevalence of accessory renal arteries, with the reported rates falling within similar ranges, bilateral accessory renal arteries were slightly more common in the current study. The study also delves into the origins of these accessory renal arteries, with the majority originating caudally to the main renal artery, followed by cranial and caudal origins. The location of artery entry was predominantly at the poles of the kidneys, with the lower polar variant being the most common. In contrast to certain previous research, the present study's observations lean towards polar rather than hilar arteries. The anatomical variability extended to the pattern of early segmentary bifurcation of the main renal artery. Collectively, the study underscores the importance of meticulous preoperative assessment, highlighting the need for surgeons to be cognizant of the potential variations in extrarenal renal artery anatomy.

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AUTHORS CONTRIBUTIONS

Dr. Rajat Shukla and Dr. T Murari designed the entire work. Dr. Harpreet Singh and Dr. Chandra Sekhar Ponnada contribute in making necessary correction and revision of the manuscript. The final draft was checked by all the authors.

CONFLICT OF INTERESTS

The authors declare no conflict of interest

REFERENCES

1. Gebremickael A, Afework M, Wondmagegn H, Bekele M. Renal vascular variations among kidney donors presented at the national kidney transplantation center, Addis Ababa, Ethiopia. Transl Res Anat. 2021;25:100145. doi: 10.1016/j.tria.2021.100145.
2. Ikidag MA, Uysal E. Evaluation of vascular structures of living donor kidneys by multislice computed tomography angiography before transplant surgery: is arterial phase sufficient for determination of both arteries and veins? J Belg Soc Radiol. 2019;103(1):23. doi: 10.5334/jbsr.1719, PMID 30972380.
3. Veroux M, Monte IP, Rodolico MS, Corona D, Bella R, Basile A. Screening for Fabry disease in kidney transplant recipients: experience of a multidisciplinary team. Biomedicines. 2020;8(10):396. doi: 10.3390/biomedicines8100396, PMID 33036343.
4. Mohamed T, Sequeira Lopez MLS. Development of the renal vasculature. Semin Cell Dev Biol. 2019;91:132-46. doi: 10.1016/j.semcdb.2018.06.001, PMID 29879472.
5. Global Observatory on Donation and Transplantation. Available from: http://www.transplant-observatory.org/Pages/Home.Aspx.
6. Karayagız AH, Cenal U, Erturk T, Ozdemir E, Polatkan SAV, Yılmaz G. Renal arterial and venous system variations in 1,073 kidney donors in turkey. Istanbul Med J. 2021;22(4):257-60. doi: 10.4274/imj.galenos.2021.31957.
7. Sattar A, Naeem S, Ali A, Akhtar M, Rizvi A, Naqvi A. Evaluation of number of renal arteries in live related renal donors by ct angiography and conventional angiography. Int J Endorsing Health Sci Res. 2014;2(1):11-5. doi: 10.29052/IJEHSR.v2.i1.2014.11-15.
8. Liu N, Wazir R, Wang J, Wang KJ. Maximizing the donor pool: left versus right laparoscopic live donor nephrectomy-systematic review and meta-analysis. Int Urol Nephrol. 2014;46(8):1511-9. doi: 10.1007/s11255-014-0671-8, PMID 24595603.
9. Shashikala P, Anjali W, Anshuman N, Jayashree D. A case report: double renal arteries. Int J Anat Var. 2012;5:22-4.
10. Shroff S. Current trends in kidney transplantation in India. Indian J Urol. 2016;32(3):173-4. doi: 10.4103/0970-1591.185092, PMID 27555672.
11. Budhiraja V, Rastogi R, Jain V, Bankwar V. Anatomical variations of renal artery and its clinical correlations: a cadaveric study from central India. J Morphol Sci. 2017;30(4).
12. Gulas E, Wysiadecki G, Cecot T, Majos A, Stefanczyk L, Topol M. Accessory (multiple) renal arteries–differences in frequency according to population, visualizing techniques and stage of morphological development. Vascular. 2016;24(5):531-7. doi: 10.1177/1708538116631223, PMID 26945775.
13. Saba M, Ebrahimi HA, Ahmaddipour H, Taziki MK. Evaluation of incidental findings on lumbosacral MRI in patients with low back pain. J Kerman Univ Med Sci. 2015;22(4):433-9.
14. Sebastia C, Peri L, Salvador R, Bunesch L, Revuelta I, Alcaraz A. Multidetector CT of living renal donors: lessons learned from surgeons. RadioGraphics. 2010;30(7):1875-90. doi: 10.1148/rg.307105032, PMID 21057125.
15. Aremu A, Igbokwe M, Olatise O, Lawal A, Maduadi K. Anatomical variations of the renal artery: a computerized tomographic angiogram study in living kidney donors at a nigerian kidney transplant center. Afr Health Sci. 2021 Sep;21(3):1155-62. doi: 10.4314/ahs.v21i3.24, PMID 35222578.
16. Munnusamy K, Kasirajan SP, Gurusamy K, Raghunath G, Bolshetty SL, Chakrabarti S. Variations in the branching pattern of renal artery in kidney donors using CT angiography. J Clin Diagn Res. 2016;10(3):AC01-3. doi: 10.7860/JCDR/2016/16690.7342, PMID 27134847.
17. Swarna AY, Agarwal Y, Jain S, Chawla A. Renal vasculature: spectrum of anatomical variations and the significance from a surgeon's standpoint. Astrocyte. 2018;4(4):233-9. doi: 10.4103/astrocyte.astrocyte_36_18.
18. Shaffer D, Sahyoun AI, Madras PN, Monaco AP. Two hundred-one consecutive living-donor nephrectomies. Arch Surg. 1998;133(4):426-31. doi: 10.1001/archsurg.133.4.426, PMID 9565124.