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Original Research Article

A COMPUTED TOMOGRAPHY (CT) EVALUATION OF RENAL ARTERY EVALUATION IN HEALTHY ADULT NORTH INDIAN POPULATION

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ABSTRACT

Aims and Objective: In 70% of normal population, each kidney is applied by a single renal artery. Renal arteries are known to present with wide range of anatomic variations. These variations are frequently related to the number of renal arteries, level of origin, length, diameter and branching pattern. Renal transplantation is the only curative option for end stage renal disease. Laparoscopic donor nephrectomy has become the preferred technique in renal transplant programs. The transplant surgeon requires at least 2 cm of renal artery length before hilar branching and diameter of 3 mm to ensure adequate vascular anastomosis. Therefore, a prior knowledge of number of renal arteries, the length and diameter of renal artery and branching pattern has become essential for renal transplant surgeons.

Material and Methods: One hundred prospective healthy voluntary kidney donors (16 males and 84 females; mean age of 43.5±10.42 years), were evaluated for the renal artery anatomy by MDCT and CT angiography as part of preoperative assessment prior to donor nephrectomy. The number, level of origin, the diameter and length of renal artery on either side was recorded.

Results: Single renal artery was present in 75.5% kidneys. The right MRA originated from aorta at the level of L1 vertebra in 78% cases and left MRA originated from aorta at lower level(L2 vertebra) in 47% of cases.The mean length of left and right renal artery was 26.2±10.6 mm and 29.6±12.8 mm respectively; mean diameter was 5.8±1.2 mm and 5.2±1.0 mm respectively. The difference between length and diameter of both sides was statistically significant. The mean diameter of left MRA was 5.8±1.2 mm and right MRA 5.2±1.0 mm and difference was statistically significant (p=0.001). Both in males and females the mean diameter of left MRA was more than that of right MRA.

Conclusion: In the present study it was observed that single renal artery was present in 75.5% kidneys. The right MRA originated from aorta at a higher level compared to left MRA. The left renal artery was shorter and wider than right renal artery. In 22.5% cases the length of renal artery was less than 2.0 cm.

KEY WORD: Renal Arteries, Renal artery length, Renal artery diameter.

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INTRODUCTION

Each kidney is supplied by a single renal artery in approximately 70% of population. The renal arteries are branches of the abdominal aorta and arise just below the origin of the superior mesenteric artery at the level of L1 vertebra and intervertebral disc between L1 and L2 vertebra [1-3]. The right renal artery is longer and often arises a little higher than the left renal artery. Renal arteries measure between 4-6 cm in length and 5-6 mm in diameter [4].

A wide range of anatomical variations of renal arteries have been described. These relate to number, level of origin, site of origin and the branching pattern. The most common vertebral level of origin of the right and left main renal arteries (MRA) is at the level of L1 vertebra. In 10 to 12% cases, left MRA may originate at any level between T12 to L2 vertebral level whereas the right MRA may originate at the level between T12 to L3 vertebra in 10% cases [2,3]. Rarely renal artery may arise from abdominal aorta below the level of origin of superior mesenteric artery. The branching pattern of renal artery can also display variation in the form of early division i.e. branching of the main renal artery into segmental branches more proximally than the renal hilum [5-6].

Laparoscopic procedures have become a preferred technique for donor kidney harvesting in renal transplant program, endovascular repair of abdominal aorta aneurysm and treatment of renal artery stenosis. The surgeon requires a prior knowledge of level of origin of renal arteries, the number of renal arteries, the length and diameter of renal artery and branching pattern before harvesting to avoid surgical complications or any life-threatening events. Secondly in renal transplantation, the donor kidney should have at least 2 cm of renal artery length before hilar branching and arterial diameter of 3 mm is needed to ensure adequate vascular anastomosis. Therefore, complete anatomical information of renal artery anatomy is essential for renal transplant surgeons.

Majority of the studies on renal vasculature in normal population are from western countries. There are few studies from Asian countries and India and hence we do not have the standard reference value for the length of the renal artery and its diameter in our population.

The aim of the present study was to observe the length and diameter of renal artery and define a standard reference value in healthy North Indian population.

During lapa-roscopic donor nephrectomy, presence of these variations is clinically signifi-cant as they can lead to significant surgical complications or even life-threatening events if unrecognised. Therefore the knowledge of kidney size and its arterial supply is of paramount importance.

MATERIALS AND METHODS

This prospective study was conducted in the Department of Anatomy, King George's Medical University in collaboration with the Department of Radio-diagnosis, Sanjay Gandhi Post Graduate Institute of Medical Sciences (SGPGIMS), Lucknow. Normal adult kidney donors were the subject of the study. One hundred consecutive normal healthy adults (16 males and 84 females) in age group 21-61 years who were volunteer kidney donors were the subject of the study. All the voluntary kidney donors are routinely evaluated pre-operatively by MDCT and CT angiography for renal anatomy and vascular anatomy. The images obtained were analysed for normal renal position, size, arterial supply and its variations.

MDCT Protocol: The voluntary donors were given 1.0 to 1.5 litres of plain water to drink 45-60 minutes before the examination. Unenhanced CT acquisition extended from upper pole of the kidney to pubic symphysis. This phase is used to detect nephrolithiasis and serves as a baseline for enhancement of lesions. The enhanced CT acquisition extended from the diaphragm to the pubic symphysis with breath held in inspiration. Non-ionic contrast medium (Omnipaque/ iohexol-350, GE Healthcare, 350 mg of Iodine/ml) measuring 30 ml was administered intravenously at the rate of 1 ml/s through a 18G cannula placed in the antecubital fossa, another 20 ml of contrast was given at 3 ml/s. After 25 seconds pause, another 50 ml of contrast medium was given at the rate of 5ml/s. Subsequently, 30 ml saline chase was given at the rate of 3.5 ml/s using automatic injector

(STELLANT-MEDRAD version 102.OSH). Region of interest was drawn on aorta at the level of the diaphragm. Monitoring scan was started 5 seconds after 2nd phase of contrast injection at the rate of 5 ml/s. Image acquisition was started manually, when high density contrast reached in abdominal aorta at the level of diaphragm.

All images obtained were independently analysed in random order using a workstation (Extended Brilliance workspace, Philips Medical Systems). Axial, multi-planar reformatted image (MPR), volume rendered images (VRI) and maximum intensity projections (MIP) were reviewed. Maximum intensity projection (MIPs) was obtained using various thicknesses (5-10 mm). MIP is a method wherein the raw data are reconstructed using the maximum intensity signal along each ray through the data set. MIP enhances visual distinction between the blood vessel and background tissue and provides angiography like images, thereby giving a good overview of the vascular anatomy. Volume rendered images was also obtained using various orientations. These processed images were processed and analysed on the computer work station.

Cases with presence of renal or extra-renal pathological conditions were excluded from further analysis.

The following parameters were observed for evaluation of renal arteries:

Number of renal arteries: Kidneys were identified in both axial, coronal, sagittal and volume rendered images and observed for arteries entering and supplying them. The number of renal arteries entering the kidney on each side was recorded. When a kidney had two or more arteries with a separate level of origin from the abdominal aorta, the artery with the greatest diameter was considered to be the main renal artery and others as accessory arteries [7].

Level of origin of renal arteries: The vertebral level of origin of renal arteries was recorded in both sagittal MIP images as well as volume rendered images.

Diameter of renal artery: It was measured at the site of origin from aorta.

Length of trunk of renal artery: It was measured in volume rendered as well as MIP images with help of electronic callipers. The length was measured from the point of origin to the emergence of first branch.

The statistical analysis was done using SPSS (Statistical Package for Social Sciences) Version 15.0 statistical Analysis Software. The mean and standard deviations were calculated. The difference in values were considered significant if the “p” values was <0.05.

RESULTS

One hundred consecutive normal healthy voluntary kidney donors (84 females and 16 males) were evaluated. The mean age was 43.5±10.42 (range 21-66) years. .

In the present study, it was observed that 151 of the total 200 kidneys (75.5%) were supplied by a single renal artery. In males, 75.0% of the kidneys had a single renal artery and in females 75.6% of the kidneys were supplied by a single renal artery. Seventy-six percent of the left kidney and 75% of the right kidney was supplied by a single renal artery.

Level of origin of Main renal Artery: In 78% of cases the right MRA originated at the level of L1 vertebra and in 47% of the left MRA originated at the level of L2 vertebra. Only 8% of both right and left MRA originated at the level of L1-L2 intervertebral disc.

In 81.3% of males and 77.4% of females the right MRA originated at the level of L1 vertebra. The left MRA originated at a lower level (L2 vertebra) in 81.3% of males and 40.5% of females **(Table 1)**

Length of Main Renal Artery (MRA): In our study, the mean length of left and right MRA was 26.2±10.6 mm and 29.6±12.8 mm respectively. This difference in length was statistically significant (p=0.040). The mean length of right MRA in males was 40.1±14.0 mm and in females it was 27.5±11.5 mm (p=0.010). On left side, the mean length of MRA in males was 32.3±8.7 mm and in females it was 24.8±10.3 mm. The difference in renal length between the two genders was statistically significant (<0.001 respectively) (Table 2).

The length of right MRA was between 20.0-49.9 mm in 76.0% of subjects. In 19% of subjects, right MRA length was less than 20.0 mm and in

5.0% cases, the length was above 50.0 mm. In 22.6% of females the right MRA length was below 20.0 main none of the males the length was below 20.0 mm. The difference in renal length was statistically significant between the two genders (p=0.001).

The length of left MRA was between 20.0-49.9 mm in 72% of cases and in 26.0% of subjects the length was below 20.0 mm in. In 29.8% of females and 6.3% males the renal artery length was less than 20.0 mm. Statistically no significant difference between the two genders was observed on the left side (p=0.104 **(Graph 1).**

Diameter of the Main Renal Artery (MRA): The diameter of right MRA in 70.0% of subjects was between 4 to 5.9 mm. In 72.6% females the diameter was between 4.0-5.9 mm and in 81.3% of males the diameter was between 5.0-6.9 mm. The difference was statistically significant (p=0.017).The diameter of left MRA was between 5.0 -6.9 mm in 62.0% of subjects. In 68.8% males and 60.7% females the left MRA diameter was between 5.0-6.9 mm. The difference was not statistically significant between the two genders on the left side (Graph 2).

The mean diameter of left MRA was 5.8±1.2 mm and right MRA 5.2±1.0 mm and difference was statistically significant (p=0.001). Both in males and females the mean diameter of left MRA was more than that of right MRA. The mean diameter of left and right MRA in males was 6.9±1.2 mm and 6.0±9 mm respectively and in females it was 5.6±1.1 mm and 5.1±.0 mm respectively. The difference was statistically significant **(Table 3).**

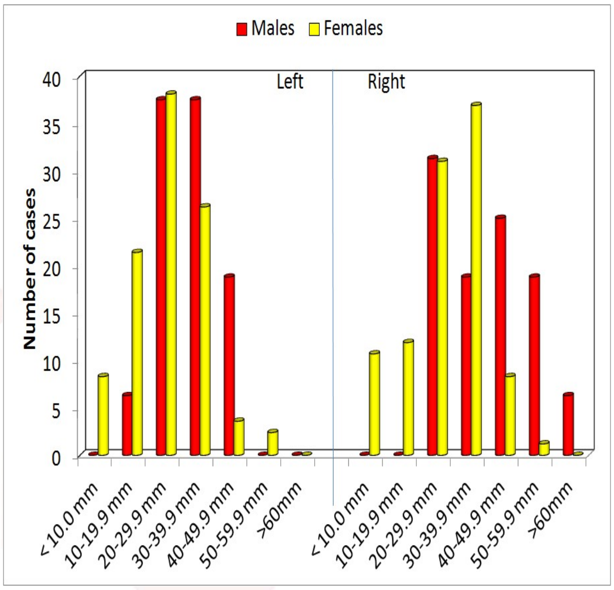
Table 1: Vertebral level of origin of main renal artery.

Vertebral Level of Origin	L1 Vertebrae N (%)	L1-L2 Disc N (%)	L2 Vertebrae N (%)
Right MRA			
Total (n=100)	78	8	14
Male (n=16)	13	1	2
Female (n=84)	65	7	12
Left MRA			
Total (n=100)	44	9	47
Male (n=16)	3	0	13
Female (n=84)	41	9	34
Male vs. Female	χ^2=12.0 (df=5); p=0.035	χ^2=14.7 (df=5); p=0.012	χ^2=11.2 (df=5);

Table 2: Mean length of main renal arteries.

Mean Length mean±SD mm	Main Renal Artery		
	Left n=100	Right n=100	'p' value
Male	32.3±8.7	40.1±14.0	0.059
Female	24.8±10.3	27.5±11.5	0.105
'p' value	0.01	<0.001	
Total	26.2±10.6	29.6±12.8	0.04

Graph 1: Length distribution of main renal artery according to sex and side.



Graph 2: Distribution of main renal artery diameter according to sex and side.

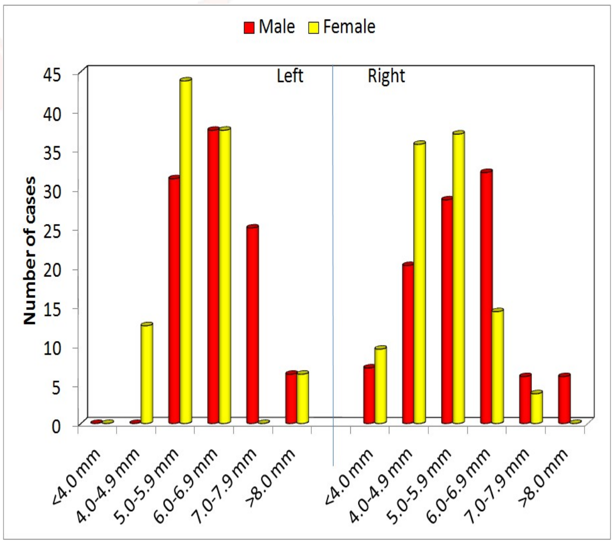


Table 3: Mean diameter of mean renal arteries.

Mean Diameter mean±SD mm	Main Renal Artery n=100		
	Left	Right	'P' value
Male	6.9 ± 1.2	6.0± 0.9	<0.001
Female	5.6 ± 1.1	5.1 ± 1.0	<0.001
'p' value	0.002	< 0.001	
Total	5.8±1.2	5.2±1.0	<0.001

DISCUSSION

Anatomical variations of the renal arteries are common in general population with different frequencies among several ethnic and racial groups [8]. The knowledge of normal as well as variations in the vascular anatomy of the kidney has become essential because laparoscopic nephrectomy has become the preferred technique for harvesting donor kidney. It is associated with limited operative visibility and surgical exposure, thereby making details of renal vessel anatomy difficult to appreciate [9,10]. Hence, comprehensive preoperative knowledge of kidney and its vasculature is crucial for selecting proper donor, successful renal transplant surgery and avoiding surgery related complications [10-12].

The prevalence of single renal artery has been reported to range from 69% to 75% [13, 14]. In the present study, single renal artery was present in 75.5%. Prevalence of accessory renal artery (ARA) has been reported to range from 24.5% to 32% [15-18]. The main renal artery originates from the abdominal aorta, just below the superior mesenteric artery at the level of L1 and L2 intervertebral disc. The renal artery originates at this level in 75% of the general population whereas in rest 25% it originates somewhere between lower margins of T12 and L2 vertebrae [19]**.** The right renal artery originates at a higher level than left renal artery. In our study, it was observed that in only 8% cases both the left and right MRA originated at the level of L1-L2 intervertebral disc. Ozkan et al [5] observed that 23% and 22% of renal arteries originated between L1-L2 intervertebral disc.

The right renal artery had a higher level of origin compared to left renal artery. In 78% of cases the right MRA originated at the level of L1 vertebra and in 47% of the left MRA originated at the level of L2 vertebra. The findings are similar to those observed by other authors [5, 20].

These observations should be kept in consideration while performing angiography and other non-invasive techniques for evaluation and management of renal artery stenosis as well as during surgery related to renal arteries [21].

As unanimously quoted in literature, in the present study also it was observed that the right MRA (29.6±12.79 mm) was significantly longer than left MRA (26.1±10.64 mm) [22-25]. The mean length of left MRA, observed in present study, is in agreement with that reported by Dhar and Lal [22] and Saldarriaga et al [23] in a cadaveric study, but is less than the length reported by Tarzamni et al [24] and Palmieri et al [25] in a CT study. As far as mean length of right MRA is concerned the length observed in present study was less than reported by Kapoor et al [26] and Janscheck et al. [27].

The length of renal artery is an important factor in renal transplant surgery. A minimum length of 2.0 cm is necessary for renal anastomosis with receptor iliac artery. Therefore, the short length of renal artery can cause technical problems in anastomosis of the renal artery to iliac artery during transplant surgery.

Diameter of Renal artery: The diameter of renal artery determined by any imaging modality has not been mentioned in any standard textbooks of radiology or transplant surgery.

In the present study, it was found that the mean diameter of right renal artery was 5.2±1.0 mm and the left renal artery diameter was 5.8±1.2 mm. These findings are similar as stated by Ramdan et al [28] who on a CT angiography study on 167 patients found that the average diameter of renal artery was 5.51±0.96 mm.

The average diameter in present study is higher than that reported by Saldarriaga et al [23] and Turba et al [24]. But it is lower than those observed by Soni and Wadhwa [30]; Tarzamni et al [24] and Palmieri et al [25]. In the present study, the mean diameter of left renal artery was larger as compared to the right renal artery and this difference was statistically significant. Though, Tarzamni et al [24] and Palmieri et al [25] also observed that diameter of left renal artery was larger than right renal artery but the difference was not statistically significant.

The diameter of renal artery is of great importance in renal transplant surgery. For safe recipient arterial graft anastomosis, arterial diameters must be at least 3 mm. In arteries less than 3 mm, anastomosis is difficult and therefore there is a high incidence of thrombosis within these arteries [12].

Conflicts of Interests: None

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