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Original Article

Anatomy Section

A Cadaveric Study of Variations of Renal Artery from Nashik, Maharashtra, India

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ABSTRACT

Introduction: 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.

Aim: To study the variations of renal arteries in cadavers and to compare it based on laterality, sex and symmetry in Nashik region, Maharashtra, India.

Materials and Methods: The present cross-sectional study was conducted at SMBT Institute of Medical Sciences and Research Centre, Dhamangaon, Nashik, Maharashtra, India, from May 2019 to June 2020 during routine abdominal dissection for medical undergraduate students. Total 25 cadavers (21 males and four females) were dissected to expose kidneys along with its arteries. The morphological variations (early branching renal artery and accessory renal artery) of renal arteries were noted and the data gathered were compared with respect to laterality, sex and symmetry. Statistical analysis was done using Chi-square test.

Results: Out of 24 cadavers, six {5 (25%) males and 1 (25%) female} were found to have variations in renal arteries. The renal artery variations were present bilaterally in 2 (8.3%) cadavers. The variations in the renal artery were in the form of accessory renal artery in 6 (12.5%) kidneys and early branching renal artery in 2 (4.2%) kidneys. The variation based on sex were found in 5 (25%) males, while based on laterality were found in five (20.8%) right and three (12.5%) left kidneys.

Conclusion: In the present study, 25% were found to have variations in renal arteries This finding will provide anatomical knowledge of variations in the renal arteries amongst the donor for kidney transplantation surgeries in the Nashik region of Maharashtra.

Keywords: Accessory renal artery, Kidney transplantation, Polar artery

INTRODUCTION

Various cadaveric and imaging studies showed that renal arteries have a wide range of variations [1,2]. Renal vessel variations are of great use to urologist, surgeon and radiologist for their implication in renal transplant surgery, urological vascular surgery and interventional radiological procedures. The continuous changing nature of renal artery during its development process of ascent of kidney justifies the embryological basis of huge number of variations in renal artery. The renal artery variations are divided into two groups as early branching arteries and accessory renal artery. The accessory renal artery are those which arises as an extra artery from aorta [2] and early branching artery arises from the renal artery more proximal than the segmental artery [2,3]. Different authors defined it as originating from renal artery at maximum of 1-2 cm distance from aorta [4].

Accessory renal arteries are further divided as Hilar and Polar renal arteries according to their point of termination [3]. It is very well documented in the literature, the incidence of variations in the renal artery varies from 23-30% [5]. Though few studies from Kenya have documented the incidences as low as 11.4% to as high as 59% in some Indian studies, such huge differences in the incidences may be due to genetic makeup of varied nature in different population [1]. This has made us to individualise the study in Nashik region of Maharashtra, India, so that the variation pattern and types in this region can be documented and which could be of great help for continuous growing and developing surgical procedures such as renal transplant, partial nephrectomy of renal tumour, vascular reconstruction etc. Thus, the aim of the present study was to study the variations of renal artery in cadavers and to compare it based on laterality, sex and symmetry in Nashik region, Maharashtra, India.

MATERIALS AND METHODS

The present cross-sectional study was conducted at SMBT Institute of Medical Sciences and Research Centre, Dhamangaon, Nashik, Maharashtra, India, from May 2019 to June 2020 on cadavers during routine abdominal dissection for medical undergraduate students. Ethical clearance was obtained from Institutional Ethical Committee (SMBT/IEC/2017/Project-78).

Inclusion criteria: All the cadavers used for dissection of undergraduate teaching in the year 2019-2020 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.

Study Procedure

Twenty-five cadavers comprising of 21 males and four females were dissected according to standard dissection technique given in Cunningham's practical manual [6]. One male cadaver in the present study had a congenital anomaly in the form of Horse shoe shaped kidney, hence excluded. The corrected sample size was 24 including 20 male and four female cadavers.

The other abdominal viscera were removed and both the kidneys with their renal arteries were exposed. The morphological variations of renal arteries were identified as early branching renal artery and accessory renal artery. The accessory renal artery was further divided as hilar and polar renal artery according to their distribution into hilum and poles of kidney, respectively [2]. The specimens with renal artery variations were numbered and photographed. The data gathered were compared with respect to laterality, sex and symmetry.

STATISTICAL ANALYSIS

Total number of variations were identified in the form of percentages by using the Epi info software. Chi-square test of significance was

applied for the comparison of the variations with the laterality, sex and symmetry considering statistical significance at p-value <0.05.

RESULTS

The study included 24 cadavers comprising of 20 males and 4 females. Six (25%) cadavers were found to have variations in renal arteries while 18 (75%) cadavers show presence of single renal artery going to each kidney.

The variations in the renal arteries were present bilaterally in 2 (8.3%) cadavers and unilaterally in 4 (16.7%) cadavers. The data based on laterality showed five (20.8%) right and three (12.5%) left kidneys while the variations based on sex confirmed five (25%) male cadavers and one (25%) female cadaver. The variations in the renal artery were in the form of accessory renal artery in 6 (12.5%) kidneys and early branching renal artery in 2 (4.2%) kidneys. The female cadavers showed unilateral variations in the form of accessory renal artery on the right side while male cadavers showed two bilateral and three unilateral variations in the form of accessory renal artery in five kidneys and two kidneys with early branching renal artery. Cadavers had been numbered showing variations in renal artery and photographs were taken [Table/Fig-1-3].

Variations	Right kidneys n (%)	Left kidneys n (%)	Total n (%)
Yes	5 (20.8)	3 (12.5)	8 (16.6)
No	19 (79.2)	21 (87.5)	40 (83.4)
Total	24	24	48

[Table/Fig-1]: Comparison of the data of the variations of renal artery on the basis of laterality.
p-value=0.44 (Chi-square test)

Variations	Males n (%)	Females n (%)	Total n (%)
Yes	5 (25)	1 (25)	6 (29.2)
No	15 (75)	3 (75)	18 (70.8)
Total	20	4	24

[Table/Fig-2]: Comparison of the data of the variations of renal artery on the basis of sex.
p-value=1 (Chi-square test)

Variations	Bilateral n (%)	Unilateral n (%)	Total n (%)
Yes	2 (8.3)	4 (16.7)	6 (29.2)
No	22 (91.7)	20 (83.3)	18 (70.8)
Total	24	24	24

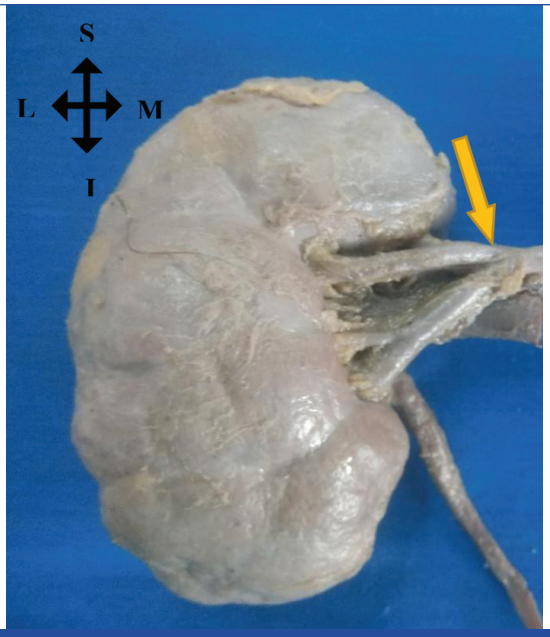
[Table/Fig-3]: Comparison of the data of the variations of renal artery on the basis of symmetry.
p-value=0.39 (Chi-square test)

Cadaver 1: In this male cadaver bilateral variations in the renal arteries were seen. On the right side the early branching renal artery was arising from main renal artery and it was piercing the kidney at the hilum. On the left side one accessory renal artery was seen arising from abdominal aorta and it was piercing the kidney at its upper pole, hence can be called as upper polar artery [Table/Fig-4,5].

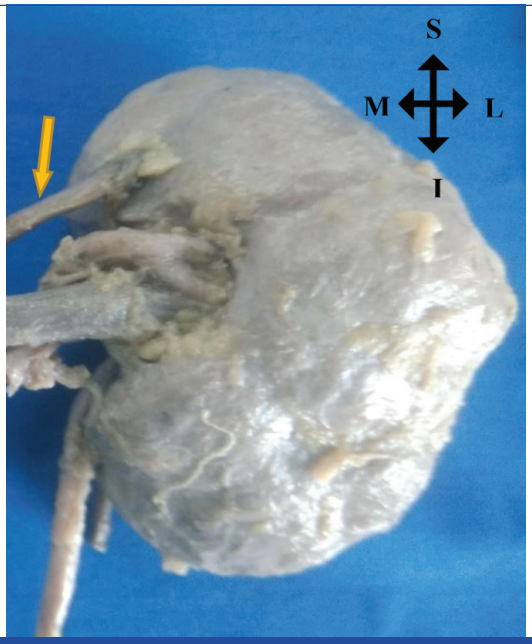
Cadaver 2: Bilateral accessory renal arteries were noted in this male cadaver. On the right side, the accessory renal artery was running parallel distal to the origin of main renal artery. The course was towards the hilum of the kidney while on the left side, the accessory renal artery was giving a branch to the upper pole of kidney with the stump heading towards hilum [Table/Fig-6,7].

Cadaver 3: Unilateral renal artery variations were noted in this male cadaver on the right kidney. Early branching of renal artery was seen arising from the main renal artery. The further course of this branch was towards the upper pole of the kidney, hence can be called as upper polar artery [Table/Fig-8].

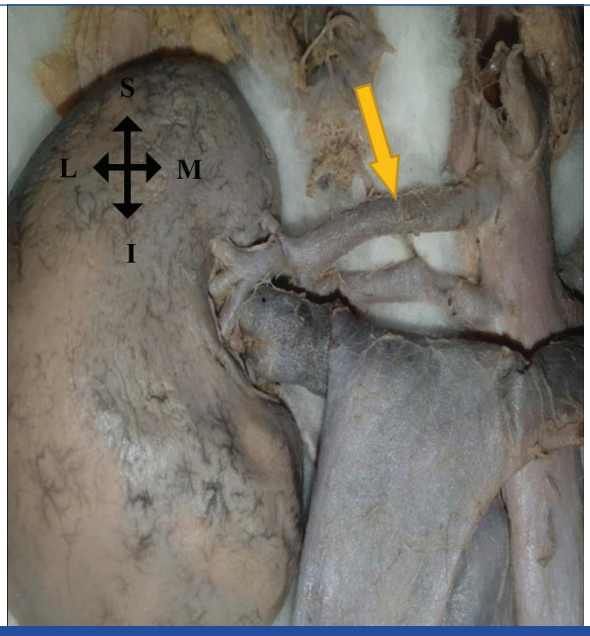
Cadaver 4: Unilateral renal artery variations were noted in this male cadaver on the left kidney. One accessory renal artery was seen



[Table/Fig-4]: Early branching of renal artery in right kidney (Yellow arrow).
S: Superior; I: Inferior; M: Medial; L: Lateral

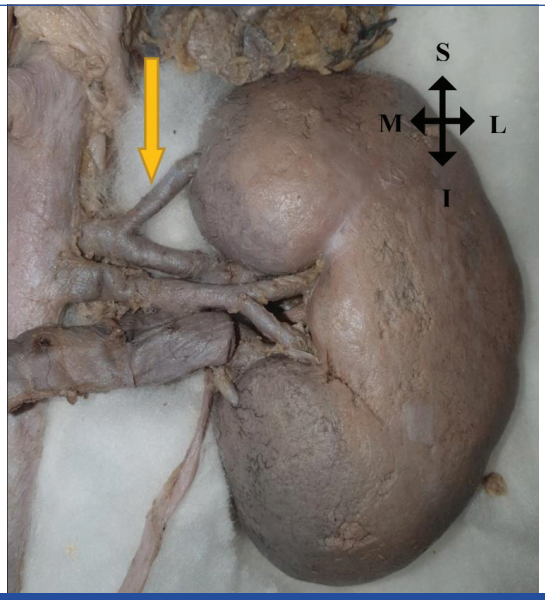


[Table/Fig-5]: Upper polar artery in left kidney (Yellow arrow).

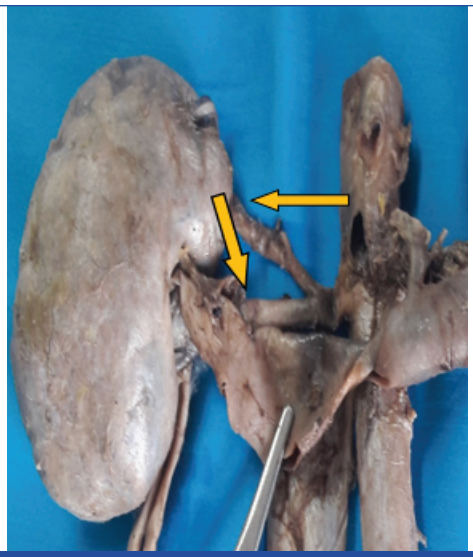


[Table/Fig-6]: Accessory renal artery in the right kidney (Yellow arrow).

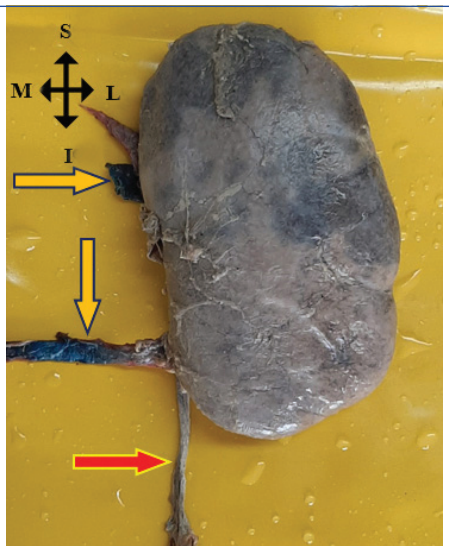
arising from abdominal aorta and pierced the kidney at its lower pole, hence can be called as lower polar artery [Table/Fig-9].



[Table/Fig-7]: Upper polar artery in the left kidney (Yellow arrow).

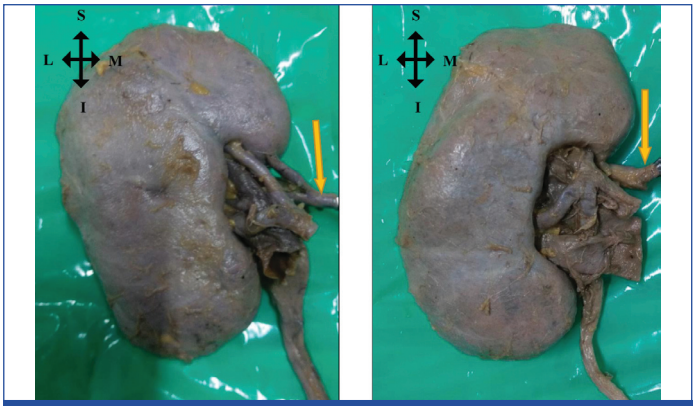


[Table/Fig-8]: Early branching renal artery (Horizontal yellow arrow); Main right renal artery (Oblique yellow arrow).



[Table/Fig-9]: Lower polar renal artery (Vertical yellow arrow); Main renal artery (Horizontal yellow arrow); Ureter (Red arrow).

Cadaver 5 and 6: Unilateral accessory renal artery variation in the form of upper polar artery were noted in the right kidney of one male [Table/Fig-10] and one female cadaver [Table/Fig-11].



[Table/Fig-10,11]: Upper polar arteries (Yellow arrow). (Images from left to right)
S: Superior; I: Inferior; M: Medial; L: Lateral

DISCUSSION

This study was based on cadaveric dissection and revealed the incidence of variations of 25% of total sample in the renal arteries of cadaver from Nashik region of Maharashtra, India. Evidence-based approach had been used in determining nature of variation as suggested by Yammine K [7]. These findings were further supplemented by statistical comparison between variables like sex, laterality and symmetry. The findings of the present study reflected data presented on standard anatomical based literature which states the incidence of renal artery variations as 23-30% [5]. The individual study done by Natsis K et al., (23.3%), Satyapal K et al., (28.1%), Merklin R and Michels N, (28%) also had a similarity with the present study [8-10].

Despite the similarities between the present study and above-mentioned literature, distinct differences have been observed on the basis of ethnicity. In extensive review of article by Natsis K et al., a range of incidence from 4% in Malaysian population to 61.5% in a Brazilian population was reported [8]. The study done in Indian population by Munnusamy K et al., showed the incidence of 51% amongst the kidney donor using Computed Tomography (CT) angiography [2]. The cadaveric study done by Budhiraja V et al., suggested 57.1% of variation in renal artery [11]. Understanding the huge difference in the data pertaining to the variation of renal artery in the same as well as different ethnic groups have aroused interest in the present study to determine the incidence and pattern of variation amongst the population of Nashik region of Maharashtra, India.

Renal artery variations happen to appear in the kidney during the developmental process. Initially kidney lies in the pelvis later it ascends to its definite position. During its ascent the kidney gains multiple blood supply from the branches of aorta along its course depending on its location. The lower vessel generally regresses as the kidney ascent. But the persistence of any such vessel along its course of development may lead to the variations in the form of accessory renal artery [12,13]. Accessory renal artery was first described by Eustachi in 1564 and since then its nomenclature has been unclear. This extra renal artery has been differently named as aberrant, accessory, anomalous, supernumerary and many other terms [14]. Bergman R et al., proposed that these arteries are not the extra but essential ones, their absence may cause ischaemia to the parenchyma hence, the term accessory could be misnomer [15].

Variations in the renal artery were also noted as its origin from the point of division from the main renal artery. These arteries mimic segmental branches but were differentiated by its origin from the renal artery at a distance of 1-2 cm from the aorta and named as early branching renal artery. Early branching renal artery arose as a divisional branch from the main renal artery. The point of division was described at a distance of 1-2 cm from aorta [16]. The early branching renal artery could be due to delay in communication between factors present in mesenchyme of blood vessels and the factors of mesenchyme of metanephros like glial derived neutrophic

factor and hepatocytic growth factor. The early branching renal artery candidate is generally not a suitable for renal transplant surgery due to its small pedicle size of renal artery available for surgery [2]. In the present study the accessory renal arteries were present in six (12.5%) kidneys and early branching artery were seen in two (4.1%) kidneys. The accessory renal artery was considered as contradiction for the renal transplant surgery in the past. With the advent of new modalities like Magnetic Resonance Angiography (MRA), such patients are now easily accepted as donors. Considering the prolonged ischaemic time for anastomosis of all the vessels, there is high risk for a graft rejection in the recipients [17,18].

According to the study done by Saritha S et al., in 2013 a single renal artery was present in both kidneys in 88% of cadavers. Presence of accessory renal arteries was seen only in 3 cadavers (12%). Out of three cadavers additional renal arteries were seen unilaterally in one cadaver, on the left side. Accessory renal arteries were seen bilaterally in two cadavers i.e., in four kidneys [19]. In 2013, Budhiraja V et al., found that on the right-side, 48.6% of aortic origin and 13.5% of renal origin supernumerary arteries were present in 23 out of 37 cases and on left side, 45.9% of aortic origin and 10.8% of renal origin supernumerary arteries were present in 21 cases. Kidney has been probed by supernumerary renal arteries through hilum, superior pole and inferior pole [11]. Rao KE and Battula R, in their study found that the accessory renal arteries were found in 18 specimens (28%) [20]. Mugunthan N et al., in their study found that the multiple renal arteries were found in three out of 52 (6%) specimens. In two specimens, the left kidney was supplied by three renal arteries and the right kidney was supplied by a single artery. In one specimen, both side kidneys were supplied by two renal arteries each. All the arteries were arising from the abdominal aorta [21].

Bilateral variations are less common than unilateral variation as reported in the previous literature with the incidence occurring between 10.2% and 16% [9,10]. The data on symmetry showed that the present study had two (8.3%) cadavers with a bilateral presence of renal artery variation and four (16.7%) cadavers with a unilateral presence of variation in renal artery. No statistical significance was seen in the variations of the renal artery on the basis of symmetry (p-value=0.39).

The present study did not find any significant difference in male (25%) and female (25%) cadavers regarding the variations of the renal artery (p-value=1). Natsis K et al., stated that there is no significant difference in the renal artery variations on the basis of sex [8]. However, many authors explained the high prevalence of variation in male as compared to female cadavers [9,22,23]. Awareness of this increased incidence in men are noteworthy clinically because male is more prone to undergo kidney transplantation as they are affected by end stage renal disease more commonly than female [24]. Present study was done on 20 male and four female cadavers used during the undergraduate academic session, these difference in the sample size of males and females in the study population might have affected the result.

The data on the laterality in the present study showed that there was no significant difference in the renal artery variations on the basis of right and left kidney (p-value=0.44). Excluding few discrepancies, present study related with majority of the research stating that there is no statistical significance on the basis of laterality [9,22,23]. The absence of the dominance in right or left kidney variations suggest that alternative criteria can be utilised while surgical decision-making for performing nephrectomies of the donor kidney [10].

This study has opened an avenue for further research in this aspect using the radiological imaging modalities in the individuals undergoing renal transplant surgeries. Due to existence of such huge number of variations based on location and ethnicity, this study will guide researchers to conduct similar studies [Table/Fig-12] [1,8,9,11,13,14,25-27] is showing comparison of the present study results with similar previous studies.

Author (Year)	Study and sample size	Place of the study	ARA	EBR	BL	UL	Male	Female	Right	Left
Satyapal K et al., (2001) [9]	Renal angiogram and cadaver (440 kidneys)	South Africa	122/440 (27.7%)	-	-	-	-	-	50/220 (23.3%)	72/220 (32%)
Budhiraja V et al., (2013) [11]	Cadaver (42)	India (Bhopal)	46/84 (54.7%)	26/84 (31%)	-	-	-	-	24/42 (57.1%)	22/42 (52.4%)
Ankolekar V and Sengupta R, (2013) [25]	Cadaver (30)	India (Manipal)	15/60 (25%)	-	6.67%	11.67%	-	-	8 (26.7%)	7 (23.3%)
Natsis K et al., (2014) [8]	Cadaver (206 kidneys)	Greece	16/206 (7.8%)	7/206 (3.4%)	3/23 (13%)	20/23 (87%)	12/106 (11.3%)	11/100 (11%)	12/23 (52.2%)	11/23 (47.8%)
Rao K and Battula R (2015) [20]	Cadaver (32)	India (Hyderabad)	18/64 (28%)	-	4 (6.2%)	10 (15.6%)	-	-	10 (31.25%)	8 (25%))
Tardo D et al., (2017) [13]	Computed tomography angiogram and cadaver (297)	Australia	72/594 (12.12%)	-	10/297 (3.4%)	49/297 (16.7%)	37/136 (27.2%)	25/164 (15.2%)	41/297 (13.8%)	37/297 (12.5%)
Patil N and Dhapate SS (2019) [14]	Cadaver (30)	India (Ambejogai)	12/60 (20%)	10/60 (16.6%)	4/30 (13.3%)	4/30 (13.3%)	-	-	-	-
Lama P and Pradhan A, (2019) [26]	Cadaver (15)	Nepal	6/30 (20%)	4/30 (13.33%)	-	-	-	-	5/30 (16.6%)	5/30 (16.6%)
Chandrika P and Jakka L, (2021) [27]	Cadaver (36)	India (Vijayawada)	20/72 (27.7%)	9/72 (12.5%)	4/72 (5.6%)	16/72 (22.2%)	-	-	9/72 (12.5%)	11/72 (15.3%)
Gebremickael et al., (2021) [1]	Computed tomography angiogram (120)	Ethiopia	28 (23.3%)	13 (10.8%)	-	-	29 (47.5%)	17 (28.8%)	25 (20.8%)	34 (28.3%)
Present study (2022)	Cadaver (24)	India (Nashik)	6/48 (12.5%)	2/48 (4.2%)	2/24 (8.3%)	4/24 (16.7%)	5/20 (25%)	1/4 (25%)	5/24 (20.8%)	3/24 (12.5%)

[Table/Fig-12]: Comparison of similar study done by different authors [1,8,9,11,13,14,25-27].
ARA: Accessory renal artery; EBR: Early branching of renal artery; BL: Bilateral variation; UL: Unilateral variation

Limitation(s)

The present study lacked the information on cadaver's ethnicity and morphometric data as the focus of present study was on the presence and the profile of variations. The sample size was small and further studies can be same location with larger sample size for more accurate results.

CONCLUSION(S)

In the present study, the incidence of variation in the renal artery was noted 25%. Though the statistical comparison of the data

of variations on the basis of sex, laterality and symmetry did not show any significance, the information gathered with respect to the cadavers procured from Nashik region of Maharashtra, India will be of great help to the kidney transplant surgeons in this region. This knowledge is also necessary for repair of abdominal aorta aneurysm, renovascular reconstructions and other urological procedures.

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