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Morphology and morphometry of the renal artery and its variations: A cadaveric study

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***Abstract*---**Aim: To study of the morphology and the morphometry of renal artery and its variations in the branching pattern of the renal artery in the cadavers. Introduction: The kidneys are pair of essential excretory organs which elaborate urine and eliminate nitrogenous waste products of protein metabolism from the blood and maintain electrolyte and water balance of the body. Each kidney is situated retroperitoneally in the posterior abdominal wall by the side of the vertebral column, extends from T12 to L3 vertebra. Right kidney is slightly lower than the left kidney due to the presence of liver. The structures passing through renal hilum antero posteriorly are renal vein, renal artery and renal pelvis. Variations in renal vessels are mainly due to various developmental positions of the kidneys. Renal artery variations are becoming more important due to the gradual increase in interventional radiological procedures, urological and vascular operations, and renal transplantation. Methods: The present study was carried out in 50 specimens obtained from formalin preserved human cadavers, and studied by dissection method. The Renal arteries were and their branching pattern were noted then, photographed, and numbered the abnormalities if any were noted. Results: A total of 50 specimens were utilized in the present study. It was observed that, Single renal artery was observed in 76% of the specimens, 80% on the right side and 64.3% on the left side. Double renal artery was observed in 20%, on the right side 16% and 24% on

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the left side and Triple renal artery was observed in 4%. In 24% the origin of the renal artery was in same level, 60% of right renal artery had a higher origin and 16% left renal artery had a higher origin. 22% of accessory renal arteries arose from Aorta and 6% originated from main renal artery. 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. The length of the right sided renal artery varied from 2cm to 6cm and left sided varied from 2cm to 5.5cm. The mean length and SD of the right accessory renal arteries were 3.53cm and 1.403cm and the left accessory renal arteries were 3.93cmand 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. Extra renal division of renal arteries was observed in 98% and the intra renal division was in 2% which was seen only on right side. Prevalence of accessory renal artery was 28%, 24% right sided and 32% left sided. Hilar type of ARA was seen in 14%. 24% on the right side and 8 % on the left side. Superior Polar Artery was seen in 4%. Inferior Polar Artery was seen in 8% of the specimens. Both SPA & IPA was seen in 2% of the specimens. It was seen only on the left side. Single accessory renal artery was seen in 20% of the specimens.16% on the right side and 24% on the left side and double accessory renal artery was seen in 4% of the specimens. Both right and left had 4%. 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% ofthe specimens. Conclusions: 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. The arterial pattern of kidneys show differences among different populations. Accordingly, with increasing use of invasive diagnostic and interventional procedures, data on type and frequencies of vascular variations from various populations is essential. Knowledge on anatomical variations is important in the surgical procedures.

***Keywords*---**RA – Renal artery, RRA – Right Renal artery, LRA – Left Renal artery, ACoRA – Accessory Renal artery.

Introduction

The kidneys are pair of essential excretory organs which elaborate urine and eliminate nitrogenous waste products of protein metabolism from the blood and maintain electrolyte and water balance of the body. They also have endocrine functions like production of renin, erythropoietin and 1, 25-hydroxycholecalciferol. Each kidney is situated retroperitoneally in the posterior abdominal wall by the side of the vertebral column, extends from T12 to L3 vertebra. Right kidney is slightly lower than the left kidney due to the presence of

liver.[1] The kidneys are bean shaped with hilum directed medially and reddish brown in colour and presents two poles-upper and lower, two surfaces-anterior and posterior and two borders- concave medial and convex lateral. The structures passing through renal hilum antero posteriorly are renal vein, renal artery and renal pelvis.[2]

The paired renal arteries take 20% of cadiac output to supply organs thatrepresent less than one hundredth of the total body weight. The renal arteries branch laterally from the aorta just below the origin of the superior mesenteric artery between L1-L2. The left renal artery is a little lower and passesbehind the left renal vein, the body of the pancreas and splenic vein. It may be crossed anteriorly by the inferior mesenteric vein. [2].

A single renal artery to each kidney is present in 70% of individuals. These arteries vary in their level of origin and calibre, obliquity and precise relations. In its extra renal course each renal artery gives off one or more inferior suprarenal arteries, a branch to the ureter and branches which supply the perinephric tissue, the renal capsule and the pelvis. Near the renal hilum, each artery divides into an anterior and a posterior division, and these divide into segmental arteries supplying the renal vascular segments.[2].

Variations in renal vessels are mainly due to various developmental positions of the kidneys.[13] Renal arteries exhibit a high degree of variations compared to the renal veins. Variations occurring in both arteries and vein are rare; also, variations among the renal veins are not as common as arteries.

Kidneys with their most cranial arterial branches from abdominal aorta, that become permanent renal artery.[4] 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 persistant 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.[2]

Renal artery variations are becoming more important due to the gradual increase in interventional radiological procedures, urological and vascular operations, and renal transplantation. Renal artery variations including their number, source and course are very common. Various congenital anomalies of kidneys are almost always associated with anomalous vasculature. The knowledge of these variations provide safety guidelines for surgical management during renal transplantation, vascular surgeries and endovascular procedures like therapeutic embolization, renal angioplasties and intravenous pyelogram.

The arterial pattern of kidneys show differences among different populations (Buddhiraja et al 2013[5], Ephraim et al 2015[6], Sujatha et al 2016[7] etc). Accordingly, with increasing use of invasive diagnostic and interventional procedures, data on types and frequencies of vascular variations from various populations is essential.

The present study was undertaken to know the origin, course and relationsof renal arteries and accessory renal arteries and the possible variations in it. Alsothe study focuses on to make out the ethnic differences in the variations by comparing it with the previous studies undertaken and to add additional data to the existing pattern in and around West Bengal.

Aims And Objectives

a) To study the number of renal arteries
b) To study the level of origin of renal arteries
c) To study the source of origin of renal arteries
d) To study the dimensions of renal arteries
e) To study the site of division of renal arteries
f) To study accessory renal arteries
g) To document any variations and compare it with previous studies.

Materials And Methods

The present study was conducted in Institute of Anatomy at Jagannath Gupta Institute of Medical Sciences and Hospital, Kolkata.

Source
The present study was carried out in 50 specimens obtained from formalin preserved human cadavers of Institute of Anatomy, Jagannath Gupta Institute of Medical Sciences and Hospital, Kolkata.

Inclusion Criteria
The cadavers belonging to different age groups and both the sexes available from the Institute of Anatomy, were included in the study. Embryologically defective kidneys were included in thestudy.

Exclusion Criteria
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.

Study Duration: June 2021 – August 2022.
Ethical Clearance: Obtained.

Instruments Used For Measurement

1. Measuring tape 2. Vernier Caliper
The cadavers were embalmed with the fluid of the following Formalin (10%) - And stored in dilute formalin filled tanks. The specimens were removed from the cadavers in the dissection room. In the above specimens collected from the dissection hall, the observations were made pertaining to the following parameters
1. Number of renal arteries
   a. Single, b. Double, c. Triple
2. Level of origin of renal arteries

a. Right higher, b. Left higher, c. Same level
3. Source of origin of renal arteries
a. Aorta, b. Any other
4. Dimentions of renal arteries
a. Length, b. Width,
5. Site of division of renal arteries
   a. Prerenal, b. Intrarenal
6. Accessory renal arteries
   a. Prevalence, b. Number, c. Side, d. Type, e. Symmetry, f. Course.

After observation, the parameters were documented. Normal and abnormal patterns were photographed. The data were classified and statistically analysed using student t test and Chi Square test . Diagramatic representations were made to compare with the studies done previously. Level of significance of 5 ($P<0.05$) percent was used for all analysis.

Methodology

Dissection Method

Dissection of renal artery was done by dissection method as per the Cunningham's Manual. The fat and fascia from the anterior surface of the left kidney and suprarenal gland were removed. The left suprarenal vein and the left testicular or ovarian vein were found and traced both to the left renal vein. Displaced the vein to expose the left renal artery and followed its branches to the left suprarenal gland and ureter and also lifted to the posterior surface for its vessels and ureter, the muscles, vessels and nerves which were posterior to them. Carried out the same dissection on the right side.[20]

Results

The renal arteries arise laterally from the aorta just below the origin of the superior mesenteric artery between L1-L2. Both cross the corresponding crus of the diaphragm at right angles to the aorta. The right renal artery is longer and often higher, passing posterior to the inferior venacava, right renal vein, head of the pancreas and descending part of the duodenum. The left renal artery is a little lower and passes behind the left renal vein, the body of the pancreas and splenic vein.
The following are the parameters observed in the
study:

I Number of renal artery
II Level of origin of renal artery
III Source of origin of renal artery
IV Length of the renal artery
V Width of the renal artery
VI Division of renal artery
VII Prevalence and side of accessory renal artery
VIII Type of Accessory renal artery
IX Number of Accessory renal artery
X Course of Accessory renal artery
XI Symmetry of Accessory renal artery.

I Number of Renal Artery

Among the 50 kidneys dissected, one left kidney and one right kidney were supplied by three renal arteries (Fig-3). Six left kidneys were supplied by two renal arteries (Fig-2) and four right kidneys were supplied by two renal arteries. Rest of thirty eight (twenty right and eighteen left) kidneys were supplied by single renal artery fig: 1(Table-1).

Table :1

Number	Right		Left		Total	
	No. of Specimens	%	No. of Specimens	%	No. of Specimens	%
Single	20	80	18	64.3	38	76
Double	4	16	6	24	10	20
Triple	1	4	1	4	2	4

II Level of origin of Renal artery

Right and left renal artery had the same level of origin from the Aorta in 12 specimens. (Fig-4). Higher level of right renal artery were present in 15 specimens. (Fig-5). Higher level of left renal artery were present in 4 specimens. There was an increased frequency of higher right renal arteries than the left renal arteries (Table-2).

Table: 2

Level	Right side		Left side		Total	
	No. of specimens	%	No. of Specimens	%	No. of specimens	%
Same level	6	24	6	24	12	24
High	15	60	4	16	19	38
Low	4	16	15	60	19	38

III Source of Origin of Renal artery

a) Main renal artery : In all 50 kidneys renal arteries arose from aorta both on right andleft side(Table-3).

Table :3

Source	Right side		Left side		Total	
	No. of specimens	%	No. of specimens	%	No. of specimens	%
Aorta	25	50	25	50	50	100
Others	0	0	0	0	0	0

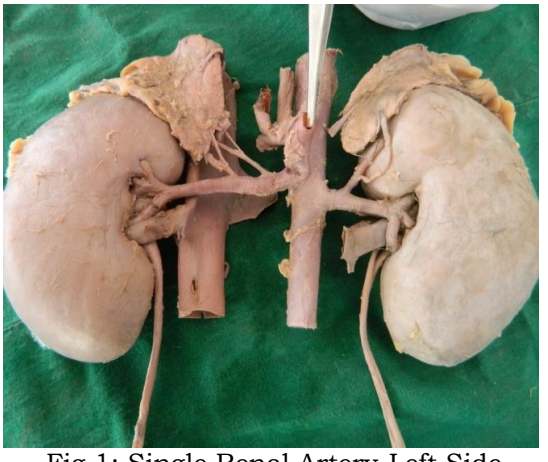

Fig 1: Single Renal Artery-Left Side

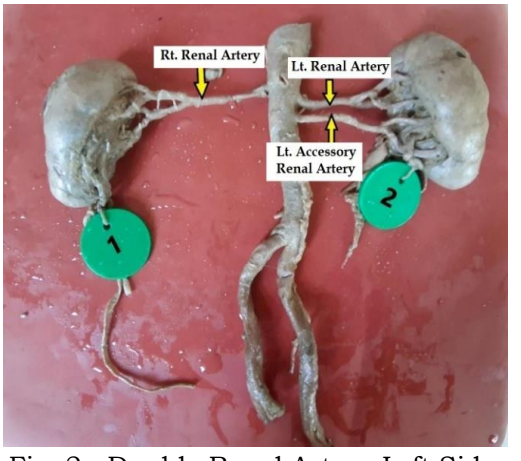

Fig .2: Double Renal Artery-Left Side

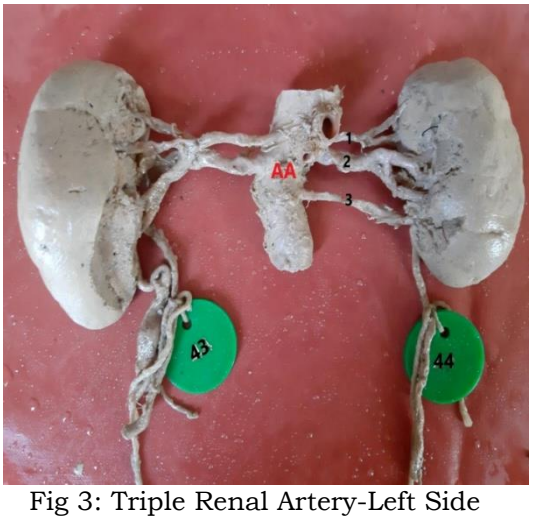

Fig 3: Triple Renal Artery-Left Side Artery

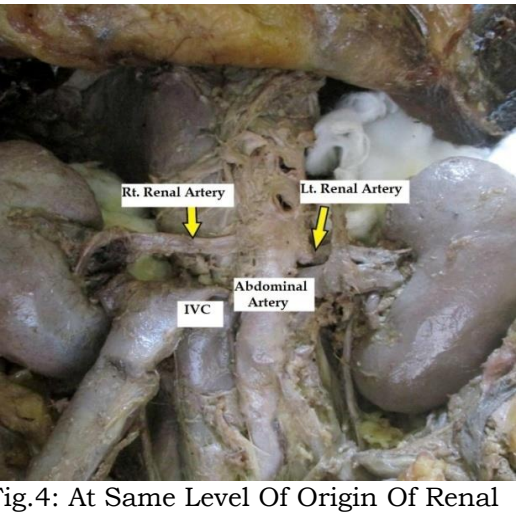

Fig.4: At Same Level Of Origin Of Renal

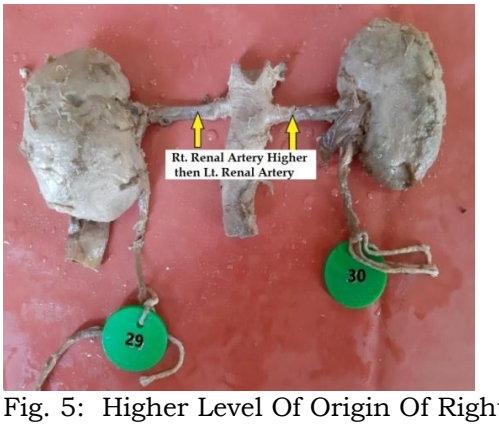

Fig. 5: Higher Level Of Origin Of Right Ra Arsing From Main Renal Artery

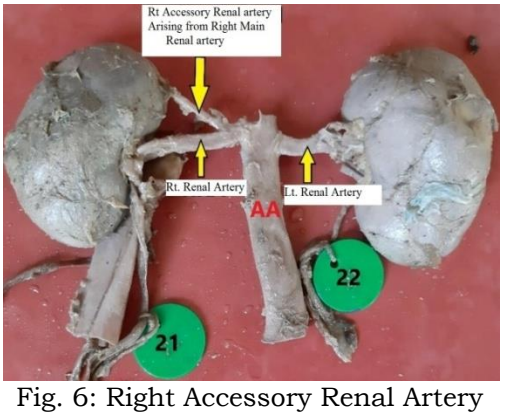

Fig. 6: Right Accessory Renal Artery

b) Accessory Renal Artery: Four right and seven left accessory renal arteries arose from Aorta (Table- 4) and two right renal arteries (Fig-6) and one left accessory renal artery take origin from Main renal artery.

Table :4

Source	Right side		Left side		Total	
	No. of specimens	%	No. of specimens	%	No. of specimens	%
Aorta	4	16	7	28	11	22
MRA	2	8	1	4	3	6

Dimensions of Renal artery

Table: 5

Kidney Number	Side	Length in CM	Width in CM	Kidney Number	Side	Length in CM	Width in CM
1	R	4.8	0.3	26	L	3.8	0.3
2	L	3.7	0.3	27	R	4.3	0.3
	L1	5	0.2	28	L	4.2	0.3
3	R	4.2	0.5		L1	3.5	0.4
4	L	4.8	0.5	29	R	5.3	0.6
5	R	3.2	0.7	30	L	4	0.6
	R1	2.5	0.3	31	R	3.2	0.4
	R2	4.3	0.4	32	L	3	0.5
6	L	3.5	0.6	33	R	2.2	0.5
7	R	4.2	0.5	34	L	4.1	0.6
8	L	4	0.5	35	R	4.2	0.7
9	R	4.2	0.4	36	L	3	0.6
	R1	4.8	0.3	37	R	4.3	0.4
10	L	3.2	0.4	38	L	2.3	0.5
	L1	3.3	0.3		L1	4.5	0.2
11	R	4.2	0.3	39	R	2.1	0.3
12	L	3.5	0.3	40	L	4.1	0.4
	L1	3	0.3	41	R	4.2	0.4
13	R	6	0.7	42	L	3.3	0.4
14	L	3.3	0.8	44	L	3.2	0.4
15	R	3.5	0.5		L1	3	0.2
16	L	3.8	0.6		L2	5.5	0.2
17	R	3	0.4	43	R	5.2	0.4
18	L	3	0.3		R1	3.5	0.3
19	R	4.3	0.4	45	R	4.1	0.4
20	L	3.2	0.6	46	L	3.3	0.3
21	R	4.2	0.7	47	R	4.1	0.6
	R1	4.8	0.2		R1	1.3	0.5
22	L	4.2	0.6	48	L	4.1	0.7
23	R	4.2	0.5		L1	5.6	0.4
24	L	3	0.4	49	R	4.8	0.6
25	R	6	0.3	50	L	2.8	0.5

IV Length of Renal Artery

a) Main renal artery: Length of the renal arteries varied from 2cm to 6 cm in 25 right sided kidneys as tabulated below:

Length of right sided renal artery:

1. 2cm to 3 cm (2>= 3) = 4
2. 3 cm to 4 cm (3>=4) = 15
3. 4 cm to 5 cm (4>=5) = 5
4. 5 cm to 6 cm (5>=6) = 1

Length of left sided renal artery:

1. 2 cm to 3 cm (2>=3) = 2
2. 3 cm to 4 cm (3>=4) = 5
3. 4 cm to 5 cm (4>=5) = 15
4. 5 cm to 6 cm (5>=6) = 3

Length of the left sided renal arteries varied from 2cm to 5.5 cm asshown below:

Table: 6

Side	Sample size	Mean Length	SD	P-Value	Inference
Right	25	4.104	0.923	0.009	Significant
Left	25	3.56	0.648		

Mean length and Standard deviation are compared on both sides .P value is 0.009 which is > 0.005. Significant side difference is noted in lengthof renal arteries on comparing both sides.

b) Length of ARA

Table: 7

Side	Sample Size	Mean Length	SD	P-Value	Inference
Right	6	3.53	1.403	0.249	Not Significant
Left	8	3.93	0.755		

Mean length and Standard deviation for the length of accessory renal artery are compared on both sides. Observed P value is 0.249 (P>0.05) .No significant side difference is noted on comparing the length of accessory renal arteries on both side.

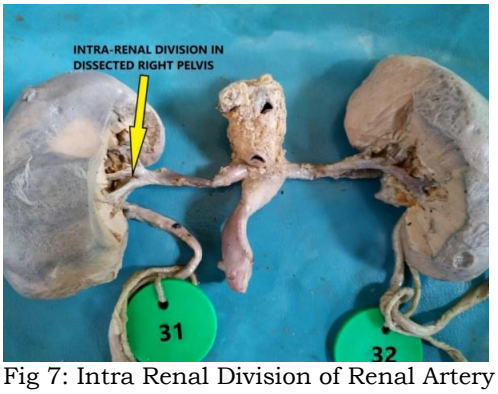

Fig 7: Intra Renal Division of Renal Artery

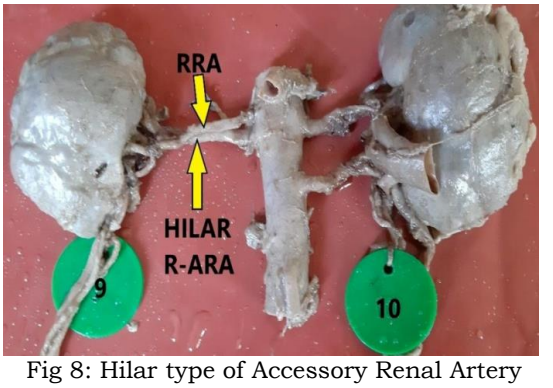

Fig 8: Hilar type of Accessory Renal Artery

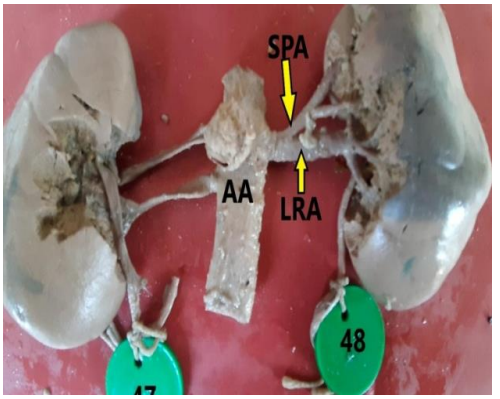

Fig 9: Lt. Superior polar type of ARA

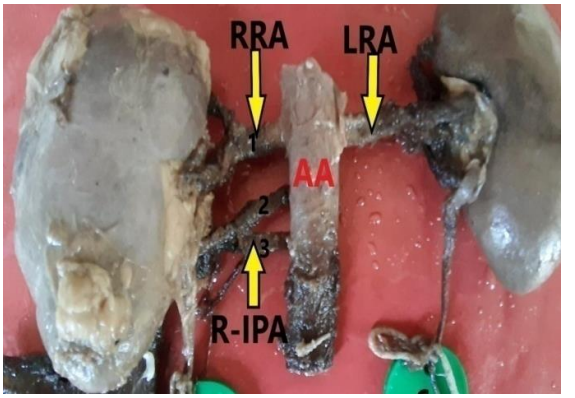

Fig 10: Rt. Inferior Polar Type of ARA

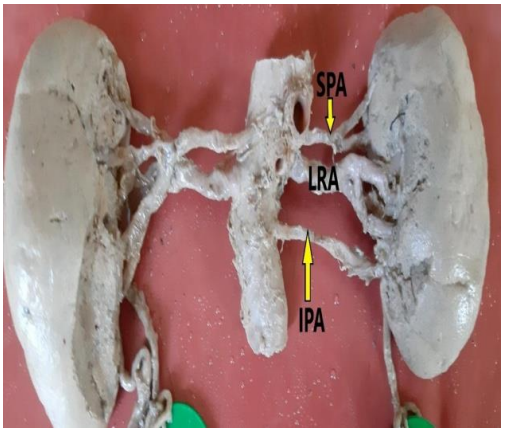

Fig 11: Both Superior & Inferior Polar ARA

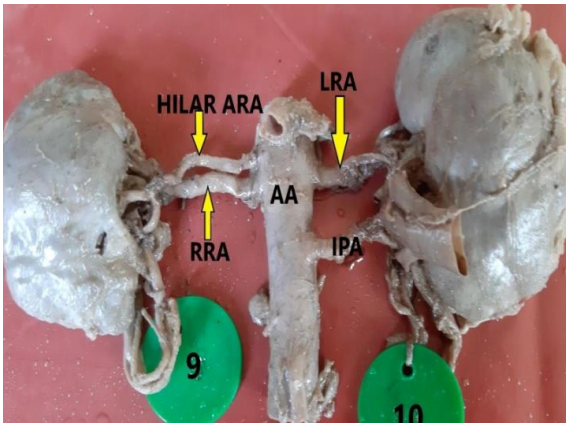

Fig 12: Bilateral Accessory Renal Artery

V Width of Renal artery

a) Width of main renal artery

Width of the main renal artery on both sides varied from 0.3 cmto 0.7cm.

Table: 8

Side	Sample Size	Mean Width	SD	P-Value	Inference
Right	25	0.444	0.132	0.235	Not significant
Left	25	0.472	0.14		

Mean length and Standard deviation for the Width of main renal artery are compared on both sides. Observed P value is 0.249 (P>0.05). No significant side difference is noted on comparing the length ofaccessory renal arteries on both sides.

b) Width of ARA

Width of the accessory renal artery varied from 0.2 cm to 0.5cm on bothsides.

Table: 9

Side	Sample Size	Mean Width	SD	P-Value	Inference
Right	6	0.33	0.109		
Left	8	0.26	0.074	0.21	Not significant

Mean width and Standard deviation for the accessory renal artery are compared on both sides. Observed P value is 0.21 (P>0.05). No significant side difference is noted on comparing the width of accessory renal arteries on both sides.

VI Site of division

Extra renal division of renal artery was observed in 49 specimens, 24 on right side and 25 on left side(Table:10). Intra renal division was present in one specimen on right side (Fig.7).

Table: 10

Site of Division	Right side		Left side		Total	
	No. of specimens	%	No. of specimens	%	No. of specimens	%
External	24	96	25	100	49	98
Intrarenal	1	4	0	0	1	2

VII Prevalence and side of ARA

Accessory renal artery was found in 14 specimens, six specimens onright side and eight specimens on left side (Table-11).

Table: 11

Side	Right	Left	Total
Frequency	6	8	14
Percentage	24%	32%	28%

VIII Type of ARA

There are three types of accessory renal arteries found in the study .Theyare name as Hilar, Superior polar and inferior polar artery (Table-12). Hilar arteries are seven in number, three on right side and four on left side (Fig-8).Superior polar arteries(SPA) are two in number one on each sides (Fig-9). Inferior polar arteries (IPA) are four in number two on each side (Fig-10). Both SPA and IPA are together seen in one left sided kidney.

Table: 12

Type	Right side		Left side		Total	
	No. of specimens	%	No. of specimens	%	No. of specimens	%
Hilar	3	24	4	8	7	14
SPA	1	4	1	4	2	4
IPA	2	8	2	8	4	8
Both SPA &IPA	0	0	1	4	1	2

IX Number of Accessory Renal artery

In ten specimens (Table -13),single accessory renal artery was seen, four on right side and six on left side (Fig-2). Double accessory renal artery was seen two specimens one on each side.

Table: 13

Number	Right		Left		Total	
	No. of Specimens	%	No. of Specimens	%	No. of Specimens	%
Single	4	16	6	24	10	20
Double	1	4	1	4	2	4

X Course of ARA

Normally, the renal arteries from Aorta pass posterior to the Inferior venacava to reach the hilum of the kidney .One accessory renal artery on right side was found to be passing in front of IVC to reach the hilum of the kidney.

Table: 14

Course	No. of specimens	%
Behind IVC	13	26
Front of IVC	1	2

X1 Symmetry

In six specimens (Table-15), unilateral accessory renal artery waspresent and Bilateral ARA was seen in three specimens (Fig-12).

Table: 15

Symmetry	No. of specimens	%
Unilateral	6	12
Bilateral	3	6

Discussion

A total of 50 kidneys were studied in by gross dissection method. The observations have been recorded, summarized and discussed from the point of view of their surgical application with special reference to the renal transplant that is becoming popular and life saving in cases of chronic renal failure. The data obtained in the present study was correlated with data of the previous studies. As proved by the statistical analysis there is a significant difference noted between length of right and left main renal arteries and no significant difference between the length of accessory renal artery and width of the main and accessory renal arteries. Following are the parameters for discussion.

I Number of Renal arteries

Konstantinos (2014)[8] observed single renal artery in 83% of specimens and Ephraim vickram rao (2015)[6] in 88% of specimens. Vrinda and Sengupta (2013)[10] observed single renal arteries in 73.3% of specimens which was found to be with the current study of 76%. Konstantinos (2014)[8] and Ephraim (2015)[9] observed double renal arteries in 13% and 12% respectively. Vrinda & Sengupta (2013)[10] observed double renal arteries in 23.3% of specimens which correlates with present study of 20%. Triple renal artery was observed in 4% of specimens in present study as compared with 3.3% in Vrinda & Sengupta (2013)[75] and Konstantinos (2014)[8].

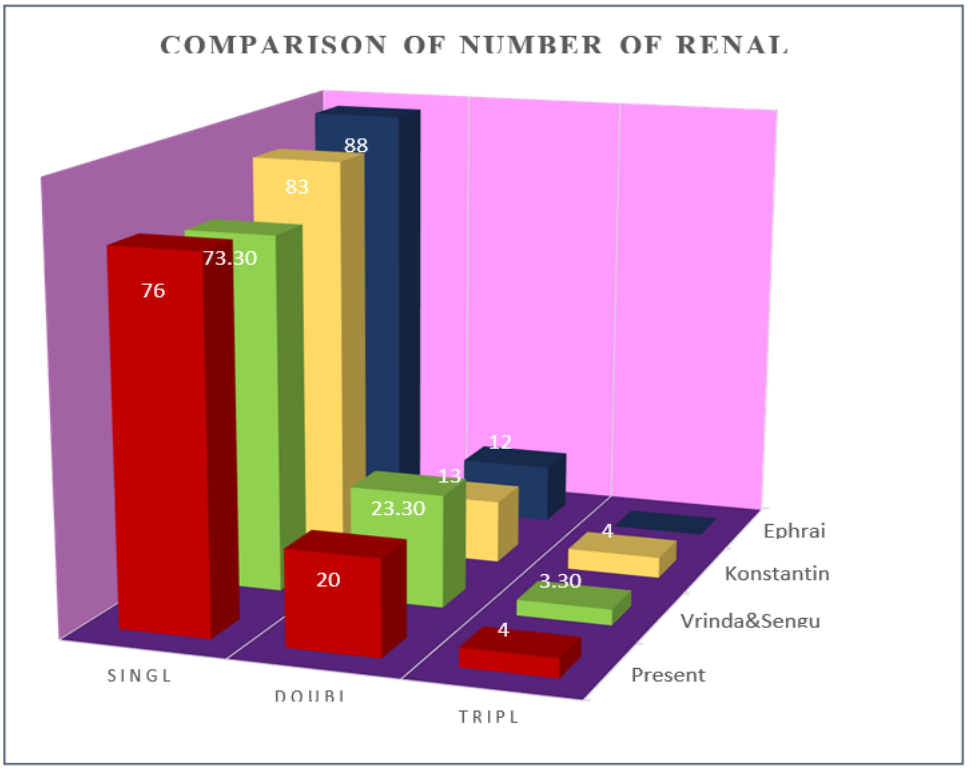

Chart: 15

II Level of origin of Renal Arteries

Right renal artery had a higher origin in 60% of specimens in present study compared with Vrinda & Sengupta (2013)[10] in 63.3% of specimens, Ephraim (2015)[9] in 75% and Sujatha (2016)[7] in 44% of specimens. Present study correlates with Vrinda and Sengupta (2013)[10].

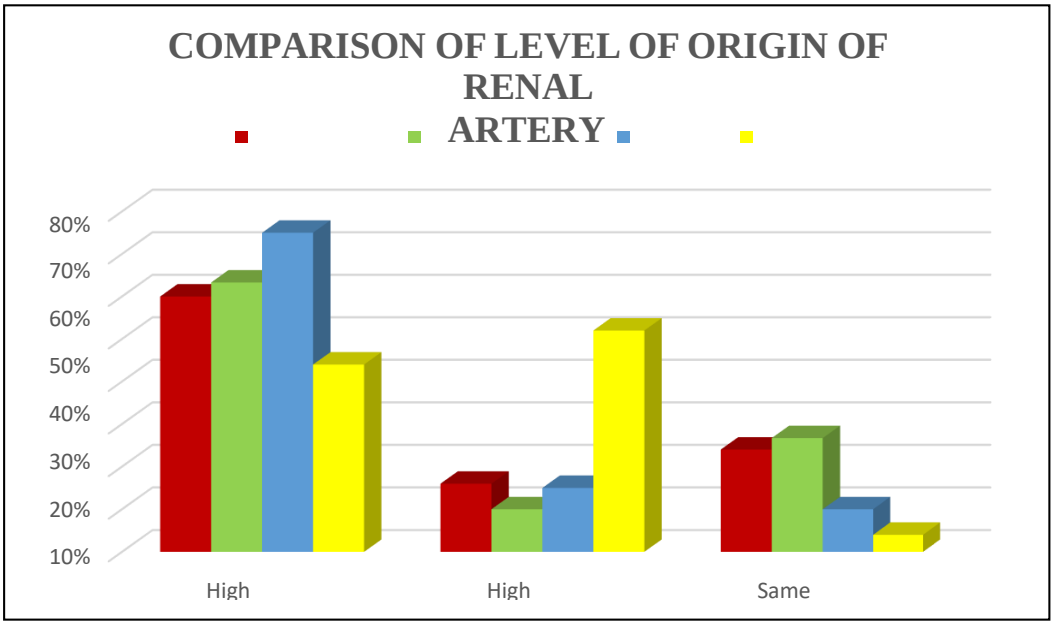

Chart: 16
Source of origin of renal arteries-ARA

In the study of Vrinda and Sengupta (2013)[10] 20% of accessory renal arteries took origin from Aorta and 8.3% of ARA originated from Main Renal Artery. In Ephraim's (2015)[9] study also 20% of ARA took origin from Aorta and 7.8% from MRA. In Apurba's (2016)[11] study 15.6% of ARA arose from Aorta and 7.5% ARA arose from MRA. In Present study, 22% of ARA had its origin from Aorta and 6% of ARA originated from MRA which correlates with Vrinda and Sengupta(2013)[10] (Table 18).

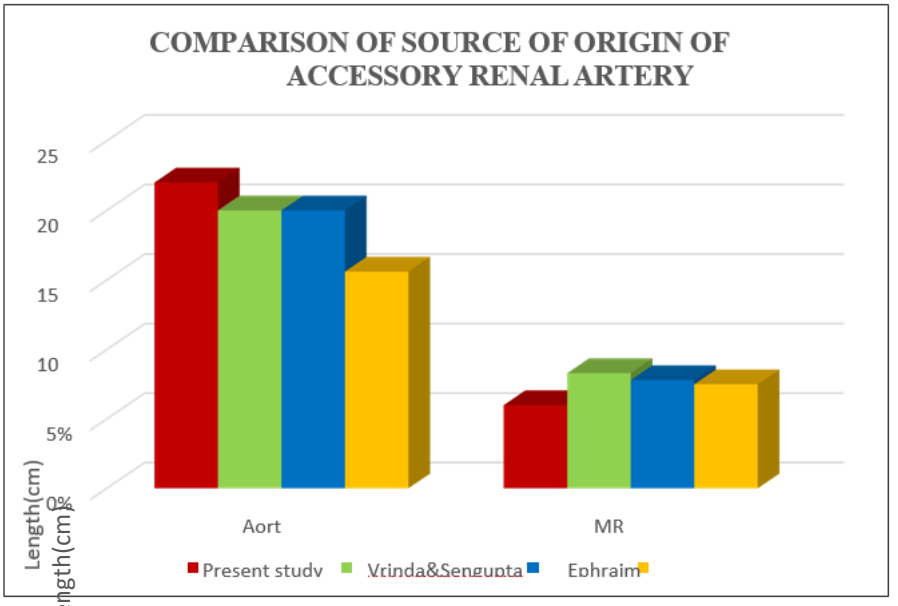

Chart: 17

III Length of Renal Artery

a) Length of Main Renal Artery: 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. In Sujatha's (2016)[7] study the mean length of right and left renal artery were 4.16cm and 3.16cm respectively. In R.Shalini's (2016)[12] study the mean length of the right and left renal artery were 3.75cm and 2.84cm respectively. Mean length of right main renal artery was 4.10 cm and the left renal artery was 3.56cm in the present study with SD of 0.92 and 0.65 respectively. The longer the main trunk of renal artery the more suitable it will be for renal transplantation, because the vessels can easily be isolated, ligated and re- anastamosed.

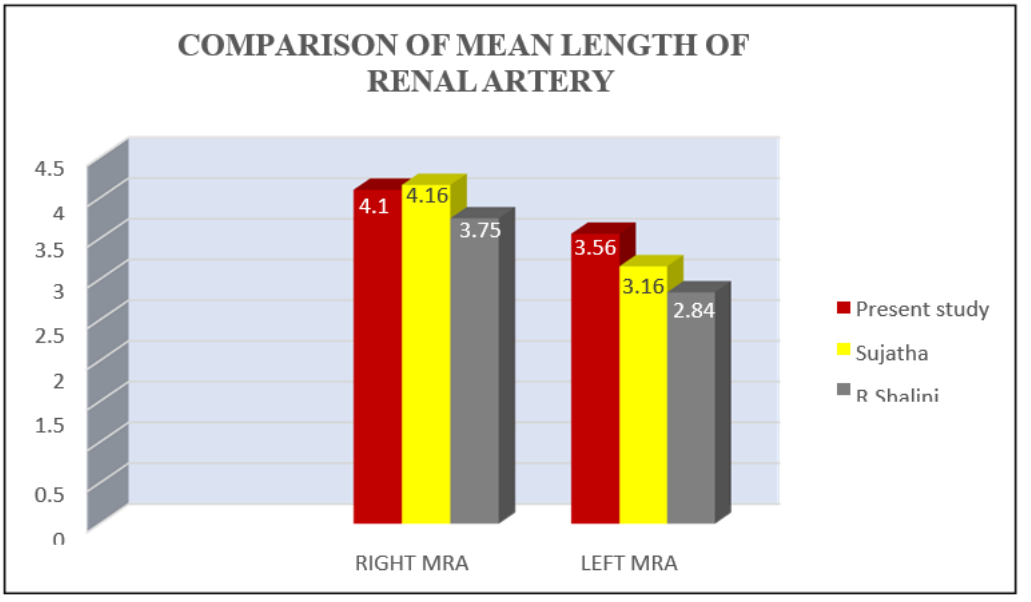

Chart :18

b) Length of ARA: The mean length of accessory renal artery on right side was 3.53cm and left was 3.93cm in the present study. In Dhar P & Lal K's[13] study the mean length of accessory renal arteries were 3.64cm and 3.66 cm on right and left side with SD of 1.4 and 0.75 respectively. It correlates with the present study.

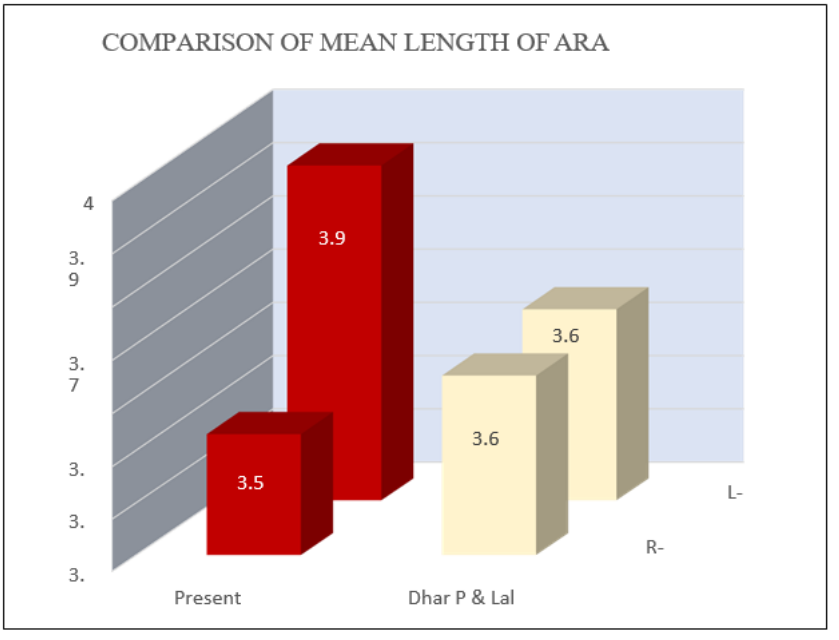

Chart :19

IV Width of Renal Artery

a) Width of Main Renal Artery: In Archana's (2018)[14] study the mean width of the main renal artery was 0.58cm on right side and 0.52cm on left side .In R.Shalini's (2016)[12] study the mean width of the right and left renal arteries were 0.65cm and 0.62cm respectively. In present study the mean length and width of right and left renal arteries were 0.44cm and 0.47 cm with SD of 0.13 and 0.14 respectively.

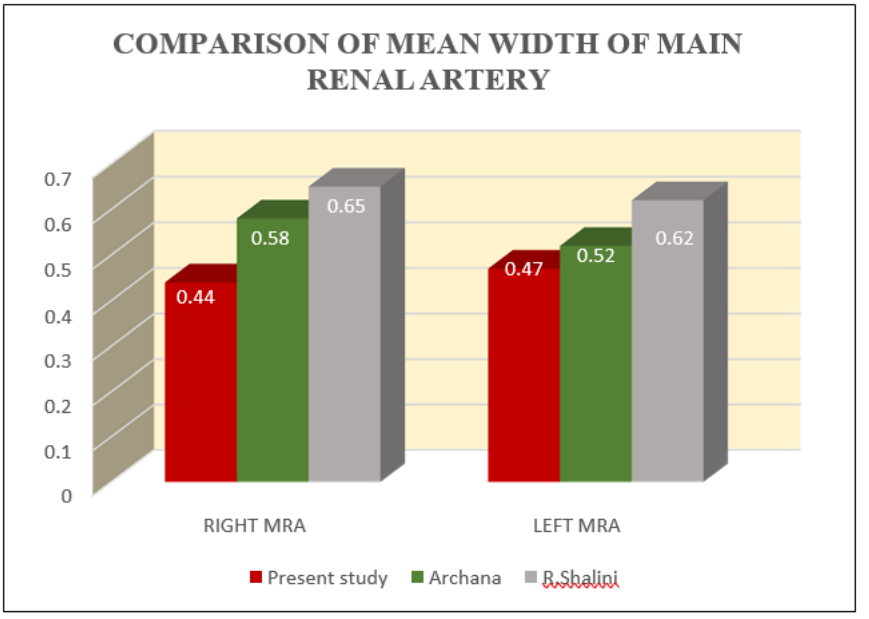

Chart :20

b) Width of ARA: The mean width of accessory renal artery on right side was 0.33cmand left side was 0.26cm with SD of 0.10 and 0.07 respectively in present study. In Sathyapal's (2001)[15] study the mean width of ARA on right and left side were 0.4cm and 0.3cm respectively which correlates with the present study.

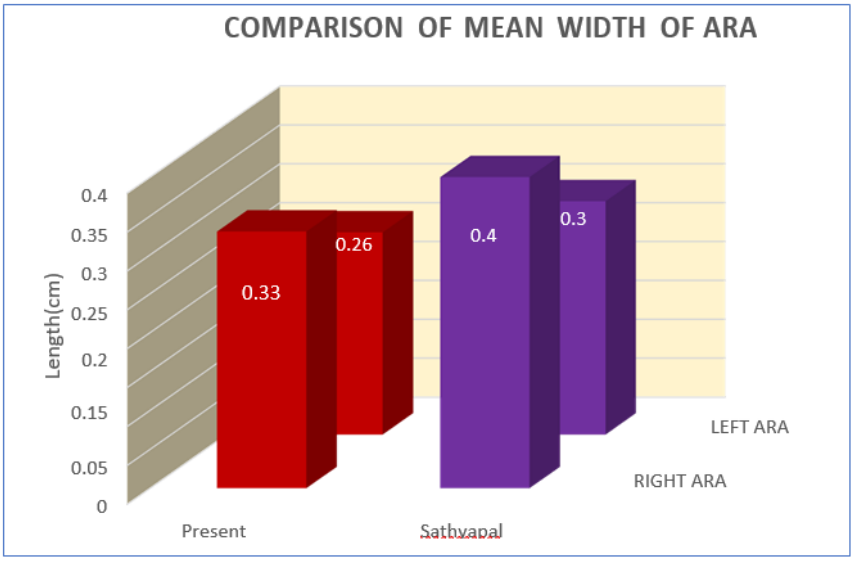

Chart: 21

V Site of Division of Renal Artery

External division of the renal artery was the commonest pattern (98%) in the present study which correlates with 98% in Julius A (2010)[16]. Longer external arteries are more suitable for ligation in segmental resection of kidneys. Intrarenal division of renal artery was found to be 2% which correlates with the 2% of Julius A (2010)[16].

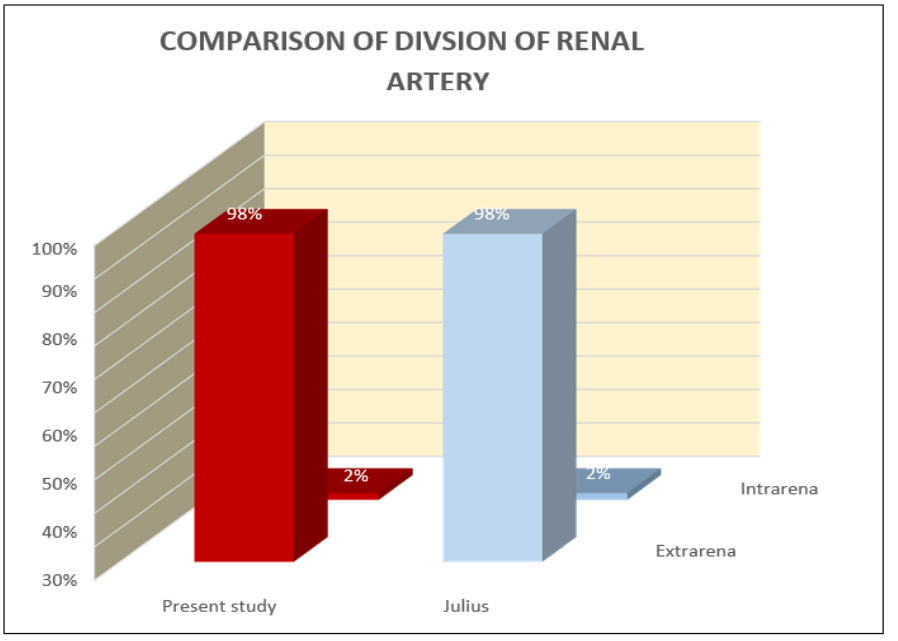

Chart: 22

VI Accessory renal arteries

a) Prevalence: The prevalence of accessory renal artery in present study was 28% which correlates with 28% in Ephraim study (2015)[9] and 27.7% in Sathyapal's (2001)[15]**.** Gayata Mehta (2010)[17], Mutyalapatti (2011)[18] and Vrinda & Sengupta (2013)[10] had a lower prevalence of 22%, 24% and 25% respectively.

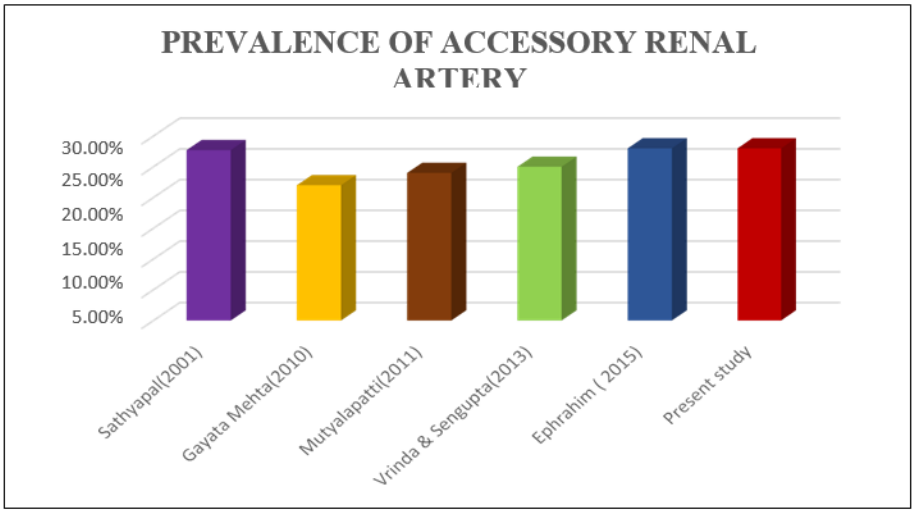

Chart: 23

a) Side of ARA: Left sided accessory renal artery is more common than right side.In the present study left sided ARA was seen in 32% of specimens and right side in 24% which correlates with Sathyapal[15] study of 32% and 23.3% respectively. Gayata Mehta (2010)[16] also proved that left sided ARA is commonthan right side.

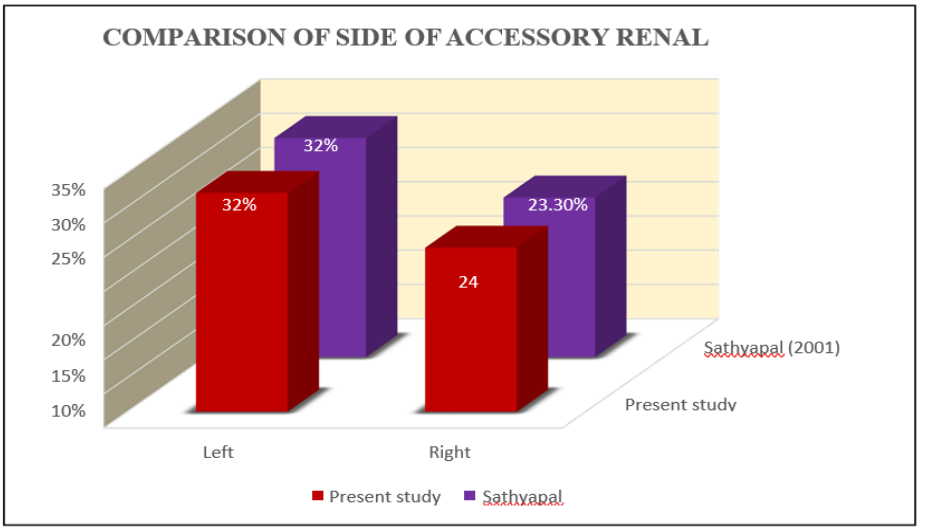

Chart: 24

IV Number of ARA

In Sathyapal's (2001)[15] study single accessory renal artery was seen in23.2% of specimens and double ARA in 4.5%. In present study single ARA was seen in 20% of specimens and doubleARA was seen in 4% of specimens which correlates with Sathyapal's(2001)[15].

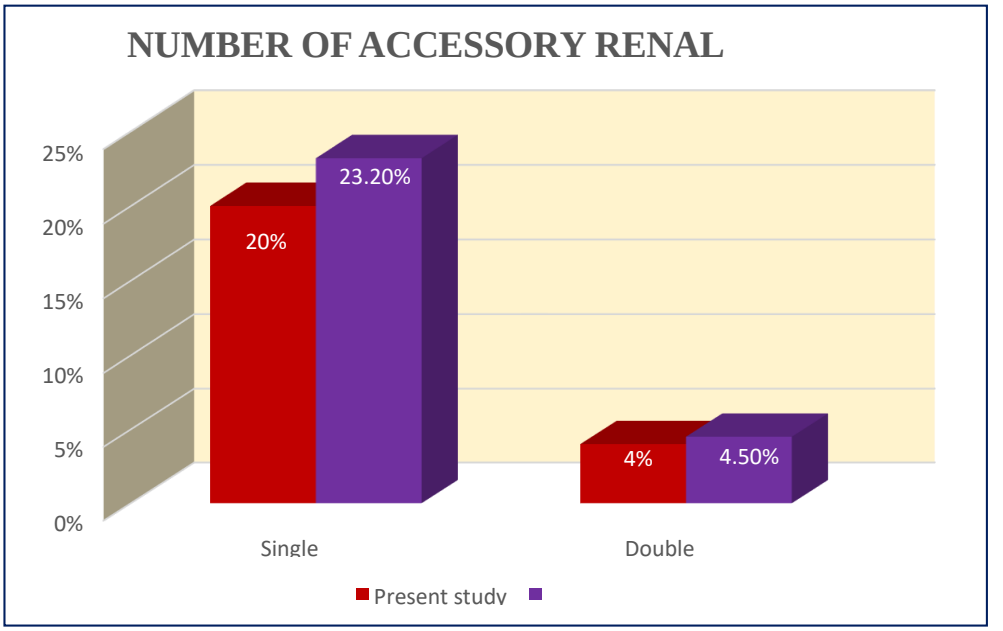

Chart: 25

IV Type of ARA

Three types of renal arteries observed in the present study are hilar, SPAand IPA. Present study had the hilar type of origin in 14% of specimens, SPA in4%, IPA in 8% and both SPA& IPA in 2%. In Olga kornafel's (2010)[19] study hilar type was seen in 7% of specimens,SPA in 4.7% which correlates with present study. IPA in 8.7% which correlates with present study. SPA & IPA in 0.3% of specimens which was much lower than present study. In Mutyalapatti's (2011)[18] study hilar type was seen in 14% of specimens which correlates with present study. SPA was found in 2% and IPA was found in 12%. In Vrinda & Sengupta's (2013)[10] study hilar type was found in 11.67%, SPA in 6.6% and IPA in 10%.

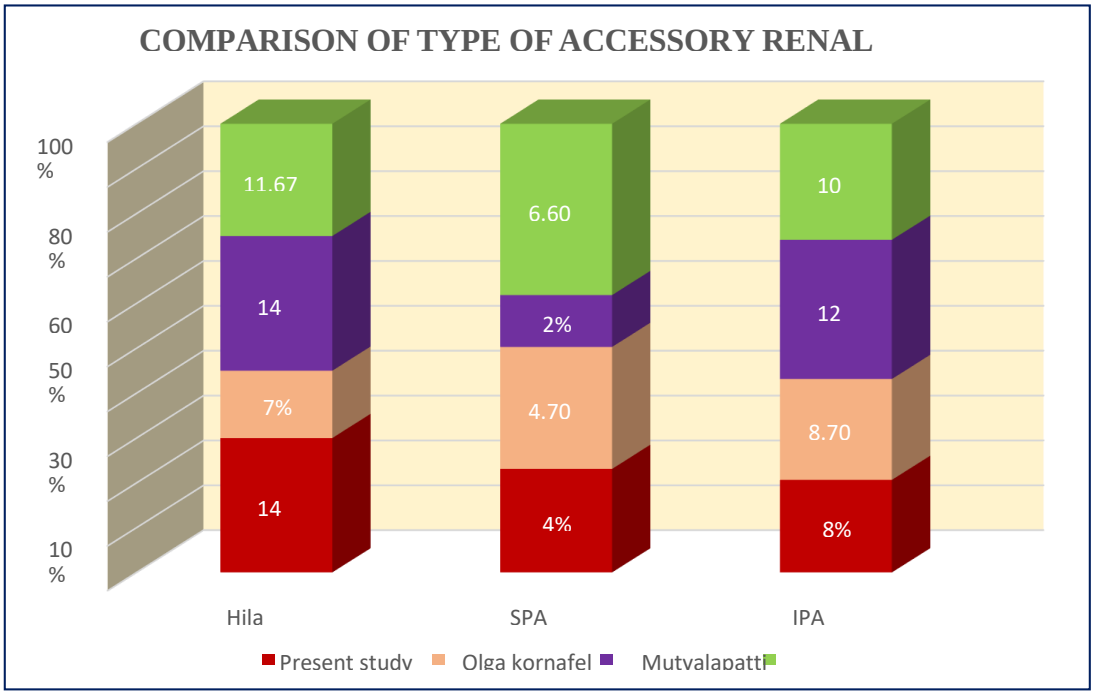

Chart: 26

V Symmetry of ARA

Vrinda & Sengupta's(2013)[10] study had unilateral ARA in 11.67% and bilateral in 6.67%. Ephraim (2015)[9] had unilateral ARA in 15.6% and bilateral ARA in 6.2%. Dhar P & Lal K[13] had unilateral ARA in 15% and bilateral ARA in 5% of specimens. In present study unilateral was seen in 12% of specimens which correlates with Vrinda[10] study and Bilateral in 6% which correlates with Vrinda[10] and Ephraim[9] study.

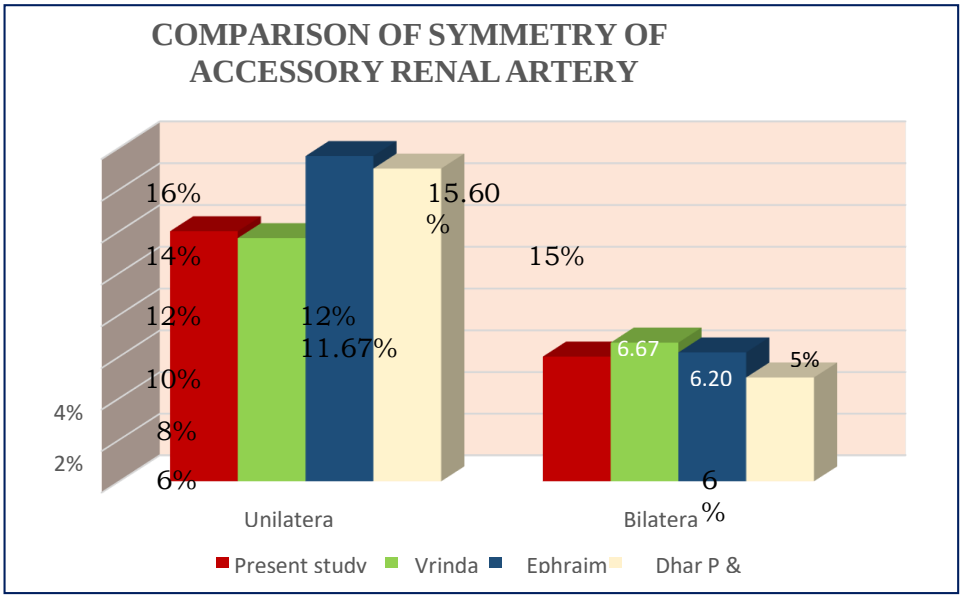

Chart: 27

Conclusion

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. 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. Multiple renal arteries in present study was found to be 24%. 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.

The arterial pattern of kidneys show 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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