DIVERSITY IN ARTERIAL SUPPLY OF KIDNEY AND IT'S CLINICAL IMPLICATIONS–A CADAVERIC STUDY

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KEYWORDS
Renal artery, Multiple renal arteries, Superior polar artery, inferior polar artery, Prehilar branches.

ABSTRACT

Kidneys are excretory organs situated in the lumbar region in adult human. A pair of kidney label as right and left kidney, situated on eighter sides of abdominal aorta. Kidneys are supplied by a renal arteries which are the branches of abdominal aorta arises laterally at the level of L1 vertebral body, below the origin of superior mesenteric artery.

Variations in renal vasculature remain undiscovered until they noticed during cadaveric dissection, surgical procedures or radiological examinations of the patients. Hereby we are presenting variations found in routine cadaveric dissection of undergraduate students as variations in arterial supply of kidney.

In present study there were 50 specimens studied in 25 cadavers. In which 44 specimens with male and 6 are of female gender. There is more than one variation is seen in single specimen.14 % of them show multiple renal arteries. 12 % shows superior polar artery, 2% shows presence of inferior polar artery, and 22% are with prehilar baranches.24% shows more than one branch entering into the hilum. In present study all described renal arteries are the branches from abdominal aorta. There is no any bilateral sementery was found in any cadaver showing variation.

Awareness must be created about the vast variety of variations in arterial supply of kidney. The knowledge is required for the Surgeons, Radiologists and Urologist, kidney transplantation procedures to avoid fatal complications during various surgeries and to the physicians while dealing with patients like hypertension and hydronephrosis.

INTRODUCTION-

Renal arteries are the arteries arise from lateral side of abdominal aorta below the origin of superior mesenteric artery,at the level of L1 vertebra, Labeled as right and left renal artery supply to the right and left kidney respectively. Renal hilum is a vertical slit on the medial border of kidney through which structures enter and leave. Anterio posterioly the arrangement is as renal artery-renal vein, renal pelvis. [1]

As per the literature,

1564, Eustachi [2] describe Accessory renal arteries as these arteries are end arteries, they do not form anastomotic connections once they enter the kidney.

1956, Graves [3] introduces term Multiple-It could describe any additional vessel entering the kidney, originating from aorta or main renal artery.

1958, According to Merklin and Michels [4] They classify accessory renal artery according to their origin as accessory renal arteries originating from aorta, from main renal artery, from other sources, and they use terminologies polar arteries

1962, Geyer and Poutasse[5] according to them additional renal artery as supernumerary, accessory or aberrant.

1969, Poisel and Spangler [6] describe additional renal artery, accessory, supernumerary, supplementary enter through hilum while aberrant are the arteries which penetrate the area of kidney other than the hilum

Sampaio and Passos[7] took following terms into consideration, as Hilar-as aortic branch penetrating the hilum. Extra hilar branch of renal artery with extra hilar penetration. Superior polar-aortic branch penetrate superior pole. Inferior polar-branch of aortic or common iliac penetrate inferior polar.

These terms should be denominated as multiple because they are segmental end arteries. So in present study the multiple renal arteries is the terminology is used. In recent studies multiple renal arteries is the terminology used by various authors.

Vast variety of variations were observed, during the study are reported and its clinical correlations are discussed in present study.

MATERIAL AND METHOD-

The variations describe here are found in routine cadaveric dissection of undergraduate students in department of anatomy. Study was conducted In 25 formalin fixed cadavers. 50 formalin fixed adult human kidneys is the sample the present study. In which 6 were from female cadavers and 44 were male cadavers.

Ethics committee's permission was taken prior the conduction of study.

All the specimens available in 2023-24 year, irrespective of age and sex are included in the study.

Kidneys with major congenital anomalies are the exclusion criteria.

Dissection was performed as per the Cunningham's manual for anatomy dissection

To see the branches of aorta and renal artery variations, the inferior vana cava and renal veins are carefully dissected and reflected wherever necessary for the better field of vision.

Variations are described and results are expressed in percentages (%). Variations with its clinical correlation are described in discussion.

RESULTS-

Study was conducted in 25 formalin fixes cadavers in which 50 specimens were studied.There were3 female cadavers and 22 were male cadavers.

Table 1 Given table describe the findings in right and left side of specimens in which variations were noticed and similar we can seen in figures. Remaining specimens shows normal findings.

Table 1 - Variations in renal arteries.

Cadaver	Gender	Side	Branches from abdominal aorta	Single/multiple renal artery (MRA)	Number of prehilar branches	Branches entering into hilum	Superior polar	Inferior polar
1 Fig 1	M	Right	2	MRA	3	2	Direct1	0
1 Fig 1		Left	1	1	2	2	0	0
2 Fig 2	M	Right	1	1	4	3	Early division1	0
2 Fig 2		Left	1	1	4	4	0	0
3 Fig3	F	Right	2	MRA	3	3	0	0
3 Fig3		Left	2	MRA	0	1	0	Direct1
4 Fig4	M	Right	1	1	2	2	0	0
4 Fig4		Left	3	MRA	0	2	Direct1	0
5 Fig5	M	Right	1	1	4	4	0	0
5 Fig5		Left	2	MRA	0	2	0	0
6 Fig 6	M	Right	2	MRA	3	3	0	0
6 Fig 6		Left	2	MRA	4	3	Early division1	0
7 Fig 7	M	Right	1	1	3	2	Early division 1	0
7 Fig 7		Left	1	1	2	1	Early division 1	0
				7/50	11/50	12/50	6/50	1/50
				14%	22%	24%	12%	2%

(Fig-Figure, M-Male, F-Female, MRA-Multiple renal arteries.)

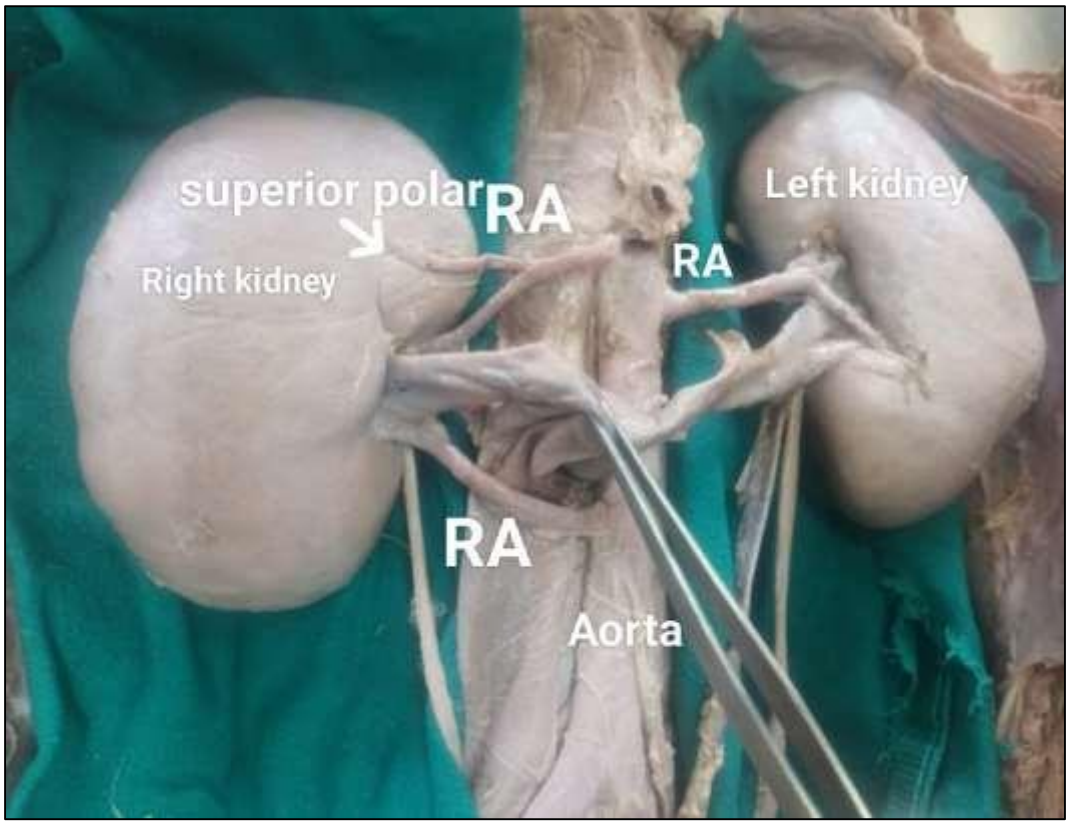

Figure 1-Variations in renal arteries.
(RA-Renal Artery)

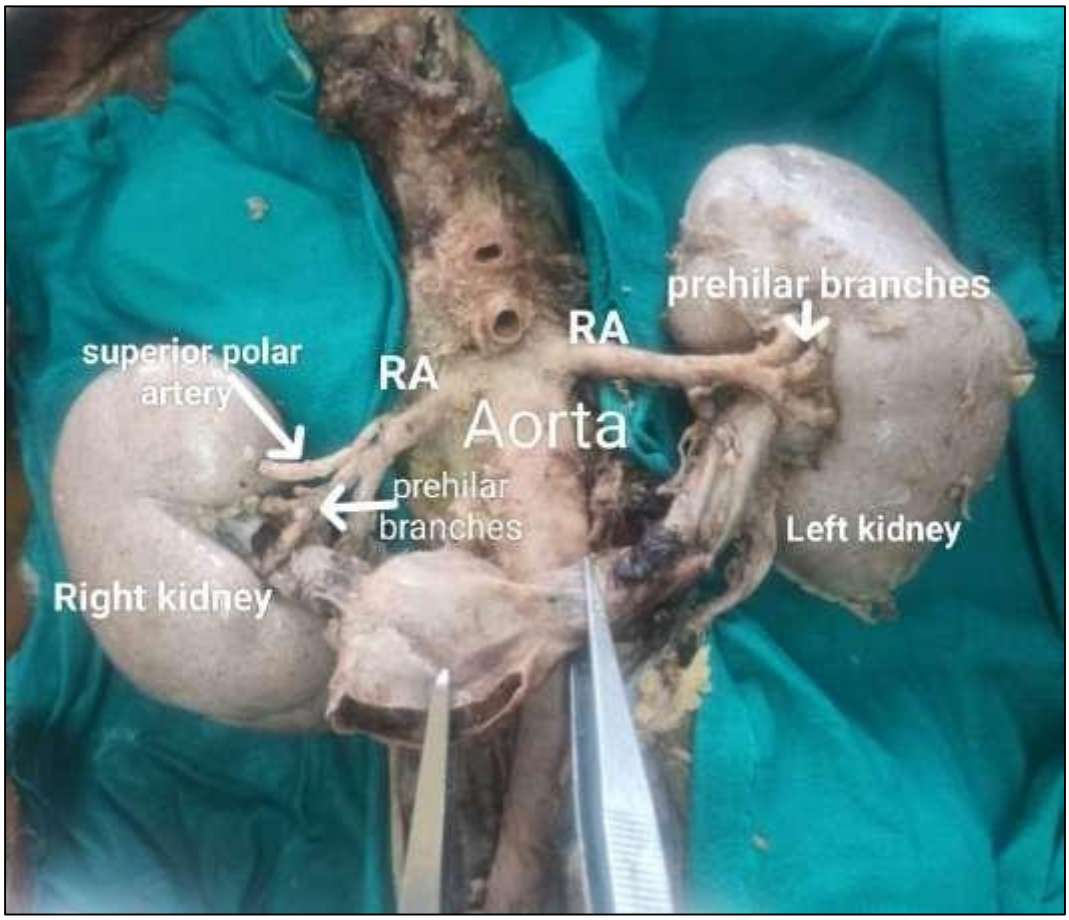

Figure 2 -Variations in renal arteries.
(RA-Renal Artery)

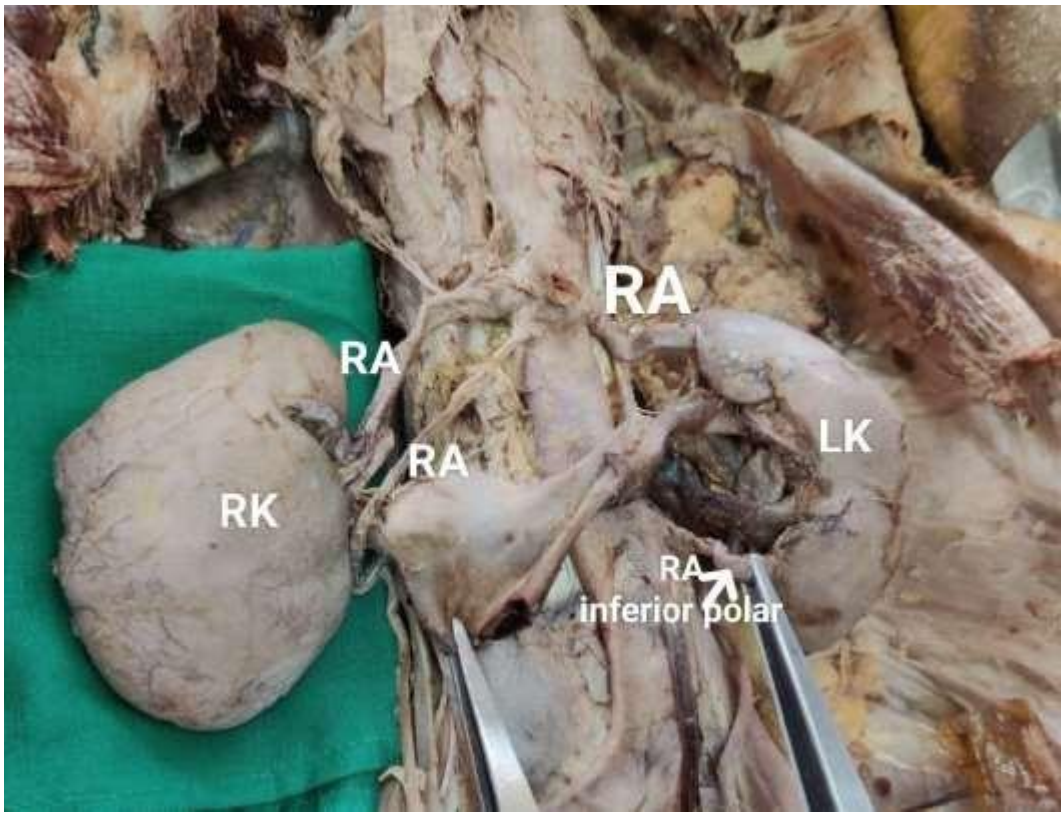

Figure 3- Variations in renal arteries.
(RK-Right Kidney, LK-Left Kidney, RA-Renal Artery)

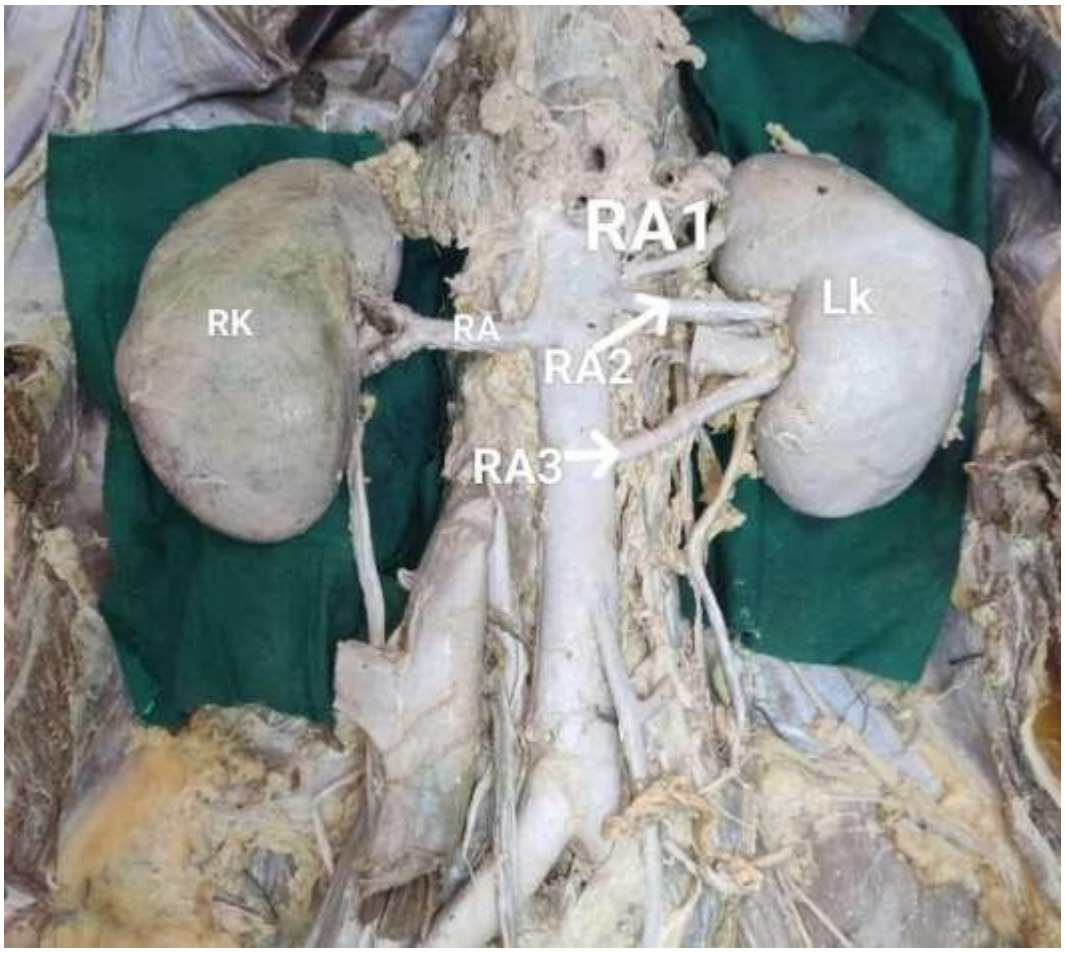

Figure 4- Variations in renal arteries.

(RK-Right Kidney, LK-Left Kidney, RA-Renal Atrery,RA1-Renal Artery 1,RA2-Renal Artery2,RA3-Renal Artery 3)

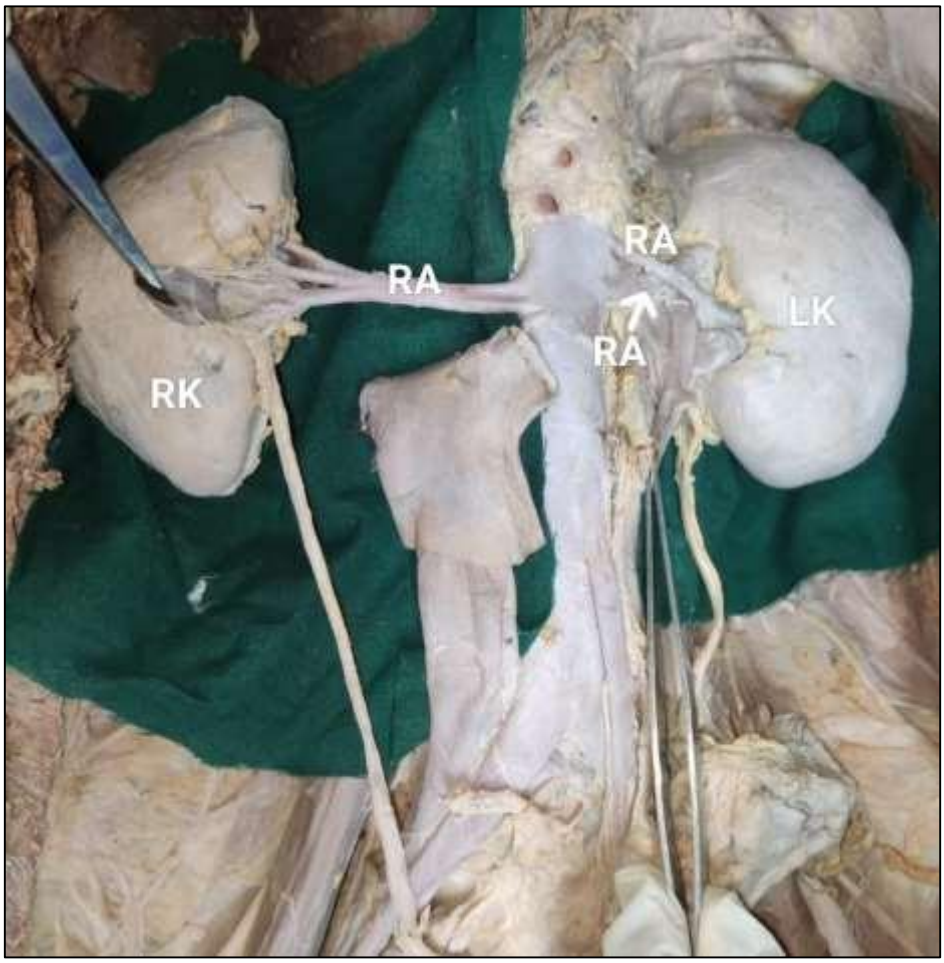

Figure 5 - Variations in renal arteries.
(RK-Right Kidney, LK-Left Kidney, RA-Renal Artery)

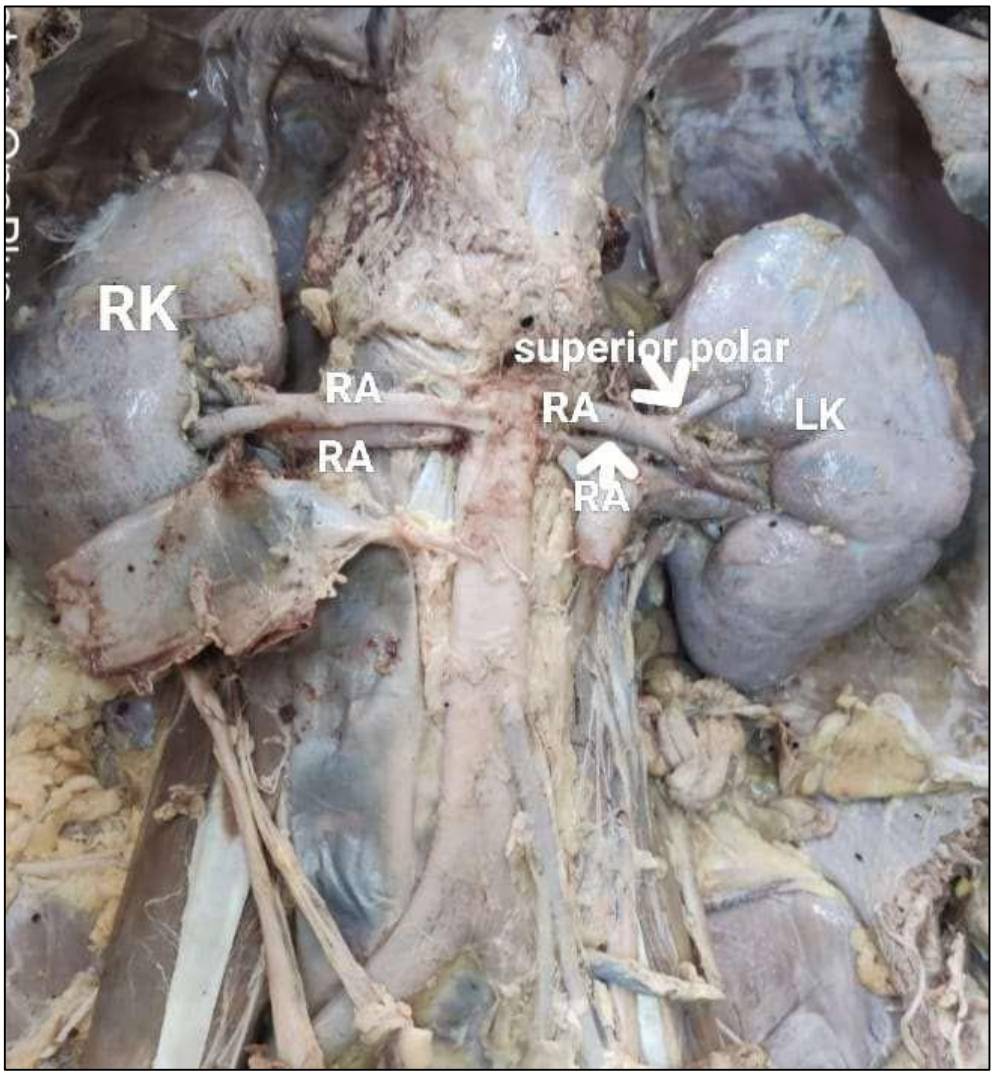

Figure6- Variations in renal arteries.
(RK-Right Kidney, LK-Left Kidney ,RA-Renal Aretry)

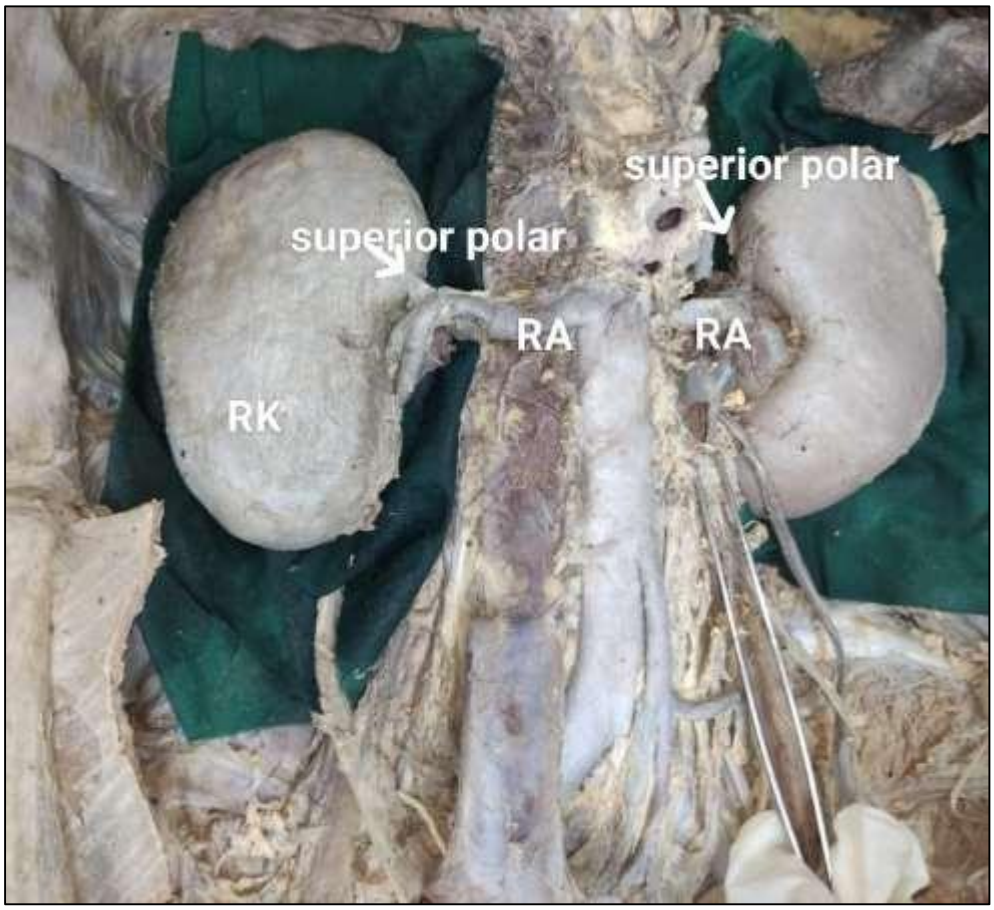

Figure7- Variations in renal arteries.
(RK-Right Kidney,LK-Left Kidney,RA-Renal Aretry)

There are more than one variation is seen in single specimen.14% of them shows multiple renal arteries.22% shows pre hilar branches.24% shows more than one branch entering into the hilum of kidney.12% shows superior polar artery in which 4% are direct polar arteries,2%shows inferior polar artery which is direct branch from abdominal aorta.72% of specimens shows normal findings that is single renal artery originating from abdominal aorta without any prehilar branch it enter in to kidney through the hilum.

In cadaver 1 (figure 1 ,table 1) on right side there were 2 renal arteries arise from abdominal aorta superior artery gives 2 branches one is early division superior polar and other enter the hilar of kidney and Lower artery arises from abdominal aorta and without any branching it enter into hilum of kidney. Consider as main hilar renal artery.

In Cadaver 1(figure 1, table 1) on left side artery originated from abdominal aorta entering in to the hilum of kidney gives 2 pre hilar branches

In Cadaver2 (2 Figure,Table2) on Right side there is single renal artery orginated from abdominal aorta it gives 4 prehilar branches in which one is very early branch of it and is penetrate the substance of kidney towards superior pole as early division superior polar and remaining 3 enters the hilum of kidney.

In Cadaver 2 (figure 2,table1) Left side there is single renal artery arises from abdominal aorta gives 4 prehilar branches and all of them entering into the hilum of kidney.
Cadaver3(This is female cadaveric findings) (figure 3,table1) on right side there are 2 renal arteries arises from abdominal aorta upper one give rise 3 prehilar branches and the enter the hilum of kidney and Lower artery enter into the hilum without branching.
Cadaver 3 (figure 3,table1) Left side- there are 2 renal arteries arises directly from andominal aorta upper entering the hilum of kidney and another enter in within substance of kidney at inferior pole, without any branching considered as direct inferior polar artery.
Cadaver 4 (Figure 4 ,table 1) On right side there is single renal artery arise from aorta gives 2 prehilar branches and both enters into hilum of kidney.
Cadaver 4 (Figure 4 ,table 1) On left side three renal arteries are there, all are arises from aorta. RA 1 is direct superior polar, RA2 and RA3 enter the hilum of kidney without prehilar branches.
Cadaver 5 figure 5 table 1 on right side there is single renal artery arises directly from aorta and gives 4 prehilar branches and all enter into hilum.
Cadaver 5 figure 5 table 1 on left side there two renal arteries arises from abdominal aorta and without branching they enter into hilum of kidney.
Cadaver 6 (Figure 6 Table 1) on Right side there are two renal arteries from abdominal aorta origin is close to one another upper one gives 2 prehilar branches so total 3 branches entering into the hilum of kidney.
Cadaver 6 (Figure 6 Table 1) on Left side there are two renal arteries arises from abdominal aorta upper gives 4 prehilar branches amongst one is early division superior polar and remaining are hilar.
Cadaver 7 Figure 7 table 1 on right side there is single renal artery from aorta gives 3 prehilar branches one of them is early division superior polar and remaining are hilar.
Cadaver 7 Figure 7 table 1 on left side there is single renal artery from aorta 2 branches one is early division superior polar and remaining is enter in into the hilum.

The remaining 36 specimen shows single renal artery arise from abdominal aorta entering into hilum of kidney without prehilar or polar branching So in total 72% specimens were normal. Bilateral variations were there in the result.

DISCUSSION-

The developing mesonephros, metanephros, suprarenal gland and gonads are supplied by nine pairs of lateral mesonephric arteries originated from dorsal aorta. They are grouped as Cranial (1^{st} and 2^{nd}), Middle (3^{rd} , 4^{th} ,5^{th} and 6^{th})and caudal group as(7^{th} , 8^{th} and 9^{th}) amongst them third and fifth pair in middle group give rise to renal arteries. On further development these arteries degenerate and only one mesonephric artery on each side persist as definitive renal artery.[8] Persistence of more than one renal arteries of middle group results in multiple renal arteries.
This can be the embryological explanation about variations found in present study. Regarding various terminologies used for arterial system, there are Supernumerary,
multiple, aberrant, additional, accessory, early division, direct, superior polar, inferior polar, hilar and so on. These terminologies are till confusing and controversial.
Artery originated from the aorta or main renal artery is called as accessory, artery arise from any other source should be consider as Aberrant renal artery. [9]
In present case there is no any aberrant renal artery as all are originated from aorta.

So in present study we follow simple naming to these arteries as Multiple renal arteries (MRA), arise from abdominal aorta and enter within substance of kidney. Polar artery as arises from direct branch of abdominal aorta or early division of main renal artery.
Racial, ethnic, and social differences were highlighted by frequency of ranal artery changes, with variations in the artery's branching pattern being more common in African and less common in Indians. [10]
Multiple renal arteries studied by various Indian authors in Indian population it was found that, Aistotle et al.[11] 2013 found 13.3%,Budhiraja et al.[12] (2010) obsversed 15% ,Gupta et al.[13] 2011 found 28.3% and Budhiraja et a.l [14] 2013 found 59.5% ,Shinde Amol .et al [15] 2018 found 11.80% where in present study in Indian population, there are 14% of multiple renal arteries observed.
Mendelsohn [16] in his study claims that person with accessory renal artery constitute 27% with resistant hypertension, and he underlined the importance of denervation of MRA if present as a treatment of persistent hypertension. He reported drop of systemic blood pressure in the patient with MRA by 21 mm of Hg in 6 months.
So the physician must keep in mind about MRA can be the one of the cause behind Hypertension.
Shinde Amol et al.[15] in his study noted 6.94% of inferior polar arteries while in present study we found 2% and found in female cadaver on left side.
Inferior polar artery passing in front of ureter causes compression of ureter give rise to hydronephrosis reported by Berman RA et. al. [17] in his study and said can be corrected by surgery.
In present study we found 12% of superior polar arteries eighter as direct branch or prehilar branch of main renal artery. In surgical terms superior polar artrery is a major risk because it is located high up in the kidney, in most cases surgeons may mistake it for surrounding connective tissue and unknowingly cut through it, causing massive hemorrhage.[5]
Ashraf HS et al. 2013 [18] concluded that renal transplantation in patients with MRA is as safe as patients with single renal artery and supported by various authors.
Guan et al [19] found that MRA is feeder arteries to the Renal cell carcinoma. laproscopic nephrectomy is one of the fundamental procedure to treat RCC ,surgeon must be aware of MRA in patients with RCC
Patil N and Dhapate SS (2019) [20] found 16.6% of early branching renal artery, Chandrika P and jakka L 2021 [21] found 12.5% of EBR , Vaishali anturlikar et al 2022 [22] found 4.2% of ERB and present study found 22% of prehilar branches of renal arteries.
Ferrara N. [23] mentions that a communication delay caused by glial derived neutrotropic factor and hepatocytic growth factor in mesenchyme of blood vessel and mesenchyme of metanephrons may contribute in early division.
Surgeons must be aware of such variation founding branching pattern of renal artery before entering hilum to avoid complications during endoscopic surgeries.
Sequeira-Lopez ML et al.2014 [24] in their study on role of progenitors in kidney vascular development said that, several putative progenitors marked by expression of eighter winged-fork-head transcription factor 1(Foxd 1+progenitor),Aspartile-Protease rennin(Ren+ progenitor)and or hemangioblast (Scl+ progenitor) are differentiate cells of renal arterial tree can be a trigger in the process of developing MRA.
The incidence of MRA may vary in the same geographical region itself depending on the differences in environmental factors that influence the organogenesis period [25].

According to Natsis [26] there is no any statistical significant difference in the variations of renal artery on the basis of gender. But many authors explained high prevalence in male [21, 27] .In present study we have got very few numbers of female cadavers so comparison will not give the justice to the result.
In recent some years authors describing arteries as MRA, Early branching and polar as terminologies to describe renal arteries.

CONCLUSION- as we seen that there are vast variety of variations in the arterial supply of kidney and they are associated with various kidney disorders as hypertension, hydronephrosis, renal cell carcinoma, graft rejection after kidney transplantation procedure. Physician must be aware of such variations and disorders related while treating patients. Surgeons must think of variation before surgical intervention to avoid fatal complications.

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ABBREVIATIONS

MRA-Multiple renal artery
RA-Renal artery
Fig-Figure
M-Male
F-Female
RK-Right kidney
LK-Left Kidney