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Original Article

Variations in the Branching Pattern of Segmental Renal Arteries on 64 Slice MDCT

Authors
Anu Dogra[1], Anju P Kaundal[1], Randhir S Chauhan[1], Yogesh Diwan[1], Sanjiv Sharma[2], Deepa Diwan[1]
[1]Department of Anatomy, Indira Gandhi Medical College, Shimla
[2]Department of Radiodiagnosis, Indira Gandhi Medical College, Shimla
Corresponding Author
Dr Yogesh Diwan
Assistant Professor, Department of Anatomy, Indira Gandhi Medical College, Shimla-171001, H.P.-India
Tel: +919418477132, Email: *drydiwan@gmail.com*

ABSTRACT

Introduction: *Segmental arteries supplying the five vascular segments of the kidney are end arteries. Selective ligation of these arteries allows partial nephrectomy with minimal risk of injury to the remnant tissue. There exists great variability in the branching pattern of the renal artery. The aim of the present study was to illustrate these branching patterns and their frequency.*

Material and Methods: *This study was done on one hundred patients (86 males and age group 18-80 years) on whom aortofemoropopliteal or aortic MDCT angiography was done for various indications like peripheral vascular disease, aortic aneurysm, aortic stenosis, mesenteric ischaemia etc. and the branching pattern of the 200 renal arteries was studied. The data was statistically analysed using SPSS software.*

Result: *The division of main renal artery into anterior and posterior division was hilar in 75% and prehilar (early branching) in 25% of kidneys. The posterior division was constant and continued as posterior segmental artery. The anterior division showed variable pattern which was classified into 9 types. Type VII (19.02%) followed by type VIII (16.56%) and type IV (16.56%) were most frequent. The anterior division either directly divides into segmental arteries or first it divides to form presegmental and then segmental arteries.*

Conclusion: *Type VII did not correspond with any previously reported types. Any typical pattern of division could not be seen in the cases with accessory renal arteries. The number of vascular segments was four or five, but there was great variability in the branching pattern of anterior division of renal artery.*

Keywords: *Segmental renal arteries; 64 slice MDCT; Kidney.*

INTRODUCTION

With the advent of minimally invasive laparoscopic nephrectomy and conservative surgical procedures, the interest in renal arterial anatomy has revived. Pre-surgical comprehensive depiction of renal arterial supply helps to avoid potential complications. Selective ligation of segmental renal arteries allows partial nephrectomy with minimal ischaemic risk to the remnant renal tissue.[1]

Renal vascular segmentation was originally recognised by John Hunter in 1794, but the first internationally accepted detailed account of the primary pattern was given by Graves[2] in 1954.Five arterial segments have been identified-Apical, upper, middle, lower and posterior segments. The five arterial segments described by Graves were reduced to four in 46% kidneys due to absence of apical segment in 15%, fused upper and middle segments in 14% and fused middle and lower segments in 17% of kidneys.[3]

Each renal segment is supplied by its own segmental artery, an end artery, which originates from the anterior or posterior division of main renal artery. Max Brodel[4] (1901) Their careful clamping provides a bloodless access and minimises the risk of injury to the rest of kidney.[5] Renal artery may not divide into anterior and posterior divisions but continues as anterior division and divides into upper, middle and lower segmental arteries in 1% cases. The anterior division shows five different branching patterns.[6] Trivedi S et al.[7] (2012) observed that the most common branching pattern is anterior division dividing into upper and lower presegmental arteries and further division of upper branch into apical and upper segmental arteries and lower branch into middle and lower segmental arteries.

As 64-slice MDCT angiography provides the accurate evaluation of vascular anatomy[8], so this method was used to highlight the pattern of division of anterior division of renal artery due to their significance in the blood supply of renal segments as end arteries.

MATERIAL AND METHOD

The study was conducted in the department of Anatomy in collaboration with the department of Radio-diagnosis at a tertiary care centre in North India. The subjects were the patients whose aortic or aortofemoropopliteal CT angiography was done for various clinical indications like aortic aneurysm, aortic stenosis, peripheral vascular disease, mesenteric ischaemia, abdominal trauma, gastrointestinal bleeding etc. There were 86 males and 14 female patients in the age group of 18 to 80 years. Hence two hundred kidneys of hundred patients were analysed.

Multidetector computed tomography angiography was done on GE light speed VCT Xte 64 slice MDCT scanner. A non ionic water soluble radiographic contrast medium IohexolN,N-Bis(2,3-dihydroxypropyl)-5-[N-(2,3-dihydroxypropyl)-acetamide]-2,4,6-iodoisophthalamide(omnipaque) was injected with automatic pressure injecter (Madrad). 90-100 ml (1.5 mg/Kg body weight) contrast medium was given at the rate of 4-5ml/sec.

After the completion of CT, contiguous 5mm slices were reconstructed and these images were transferred to a real time interactive 3D workstation: Advantage window version 4.5, GE healthcare for further analysis using vessel analysis software. Coronal 3D display was used to delineate segmental branching pattern. Cases with accessory or ectopic renal arteries were excluded. The data thus collected was then analysed using SPSS software.

RESULTS

The study was conducted on 100 patients with the mean age of 50.50±20.69 years. Thus, the segmental arterial branching pattern of 200 kidneys was analysed. Accessory arteries were present in 20 cases on the right side and 16 cases on the left side. In one patient, the left main renal artery was stenosed. In these cases, typical segmental pattern of division could not be seen. These 37 cases were excluded.

The main renal artery branched into anterior and posterior division in all cases. Any branch within 2.0 cm from the aorta was classified as prehilar. The right main renal artery showed hilar pattern of division in 73% and prehilar in 27% cases and the left main renal artery showed hilar pattern in 76% and prehilar in 23% cases. Thus, hilar pattern was seen in 75% and prehilar in 25% kidneys.

The posterior division continued as posterior segmental artery and supplied the posterior segment. A variable branching pattern was

observed for anterior division. It divided directly into segmental arteries or first presegmental and then further segmental arteries. Their pattern of division was classified into nine different types.

- Type I – The anterior division divides into upper presegmental and lower segmental artery. The presegmental artery further divides into upper and middle segmental arteries. (Right 7.5%, Left 9.64%)
- Type II- The anterior division divides into upper segmental and lower presegmental artery. The presegmental artery further divides into middle and lower segmental arteries. (Right 2.5%, Left 12.05%)
- Type III- The anterior division divides to form upper, middle and lower segmental arteries which originate from a common point. The apical artery is absent. (Right 15%, Left 18.07%)
- Type IV- The anterior division divides into upper apical and lower presegmental artery. The presegmental artery divides to form upper, middle and lower segmental arteries. These may originate from a common point or sequentially. (Right 11.25%, Left 7.22%)
- Type V- The anterior division divides to form upper presegmental and lower segmental artery. The presegmental artery further divides to form apical, upper and middle segmental arteries. These may originate from a common point or sequentially. (Right 6.25%, Left 10.84%)
- Type VI- The anterior division sequentially divides to form apical, upper, middle and lower segmental arteries. (Right 5%, Left 6.02%)
- Type VII- The anterior division divides to form upper presegmental and lower middle segmental artery. The presegmental artery divides to form apical and then upper and lower segmental arteries. The middle segmental artery passes in front of presegmental artery to supply the middle segment. (Right 26.25%, Left 12.05%)
- Type VIII- The anterior division divides to form upper and lower presegmental arteries. The upper presegmental artery divides to form apical and upper segmental arteries and lower presegmental artery divides to form middle and lower segmental arteries. (Right 16.25%, Left 16.86%)
- Type IX- The anterior division divides to form apical and lower segmental arteries and middle presegmental artery. The presegmental artery further divides to form upper and middle segmental arteries. (Right 10%, Left 6.02%)

On the rightside majority of cases were of type VII followed by type VIII and type III whereas on the left side it is type III and type VIII. Overall types III, VII and VIII constitute 52.14% of cases.

Table 1 Comparison of incidence of prehilar renal arteries

S No.	Author	Incidence of prehilar arteries	Method of study
1	Patil et al. (2001)[9]	10%	Helical CT angiography
2	Kawamoto et al. (2003)[10]	19%	MDCT Angiography
3	Ozkan et al. (2006)[11]	8%	Digital Subtraction Angio
4	Ayuso et al. (2006)[12]	11.8%	CT Angiography
5	Kornafel et al. (2008)[13]	11.9%	64 Slice MDCT Angiography
6	Saldarriaga et al. (2008)[14]	12.95%	Dissection
7	Gumus et al. (2012)[15]	26.7%	MDCT Angiography
8	Doescu et al. (2012)[16]	20%	Corrosion cast method
9	**Present study**	25%	64 Slice MDCT Angiography

Table 2 Comparison of present study on branching of anterior division of renal artery with earlier studies

S.No.	AUTHOR	TYPE I	TYPE II	TYPE III	TYPE IV	TYPE V	TYPE VI	TYPE VII	TYPE VIII	TYPE IX
1.	Graves (1954)[2]	33.33%	30%	16.6%	-	-	-	-	-	-
2.	Kher et al.(1960)[22]	33.33%	38.8%	27.3%	-	-	-	-	-	-
3.	Verma et al.(1961)[20]	Observed	Observed	Observed	-	-	Observed	-	-	-
4.	Trivedi et al. (2012)[7]	-	-	16.67%	-	-	-	-	29.19%	15.28%
5.	Chandragirishet al. (2014)[23]	31%	19%	20%	8%	-	16%	-	-	-
3.	Kumar U andPrabhaR (2016)[24]	43.06%	33.33 %	23.61%	-	-	-	-	-	-
5.	**Present study**	8.59%	7.36%	16.56%	9.20%	8.59%	5.52%	19.02%	16.56%	7.98%

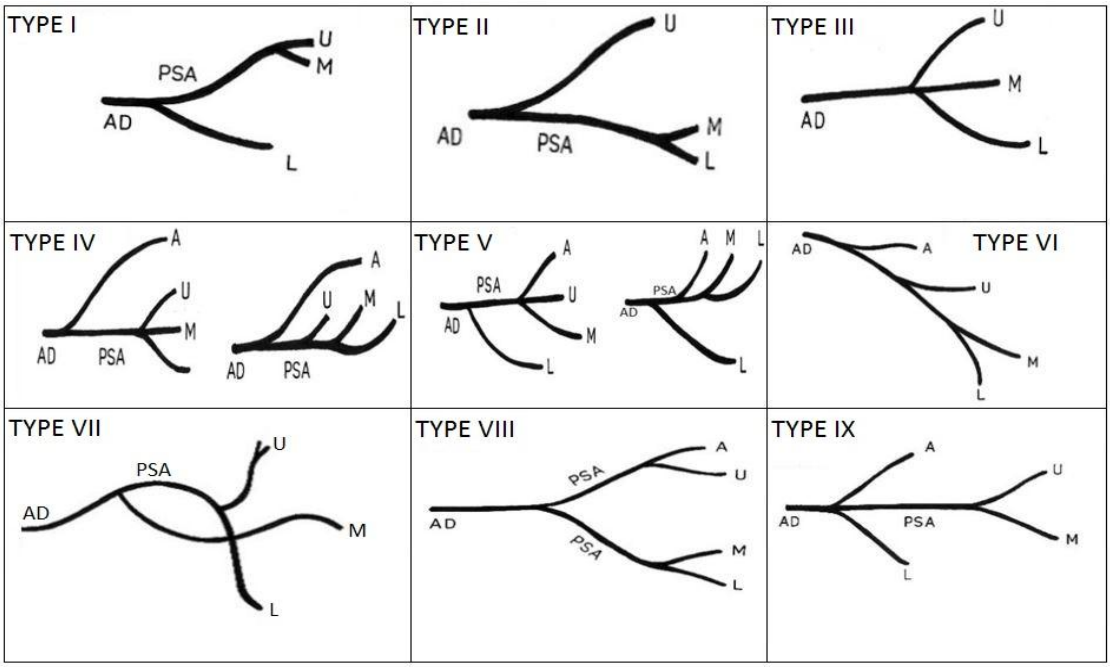

Fig. 1 Line diagram of variant branching pattern of anterior division of renal artery observed in the present study. AD-Anterior division, PSA-Presegmental artery, A-Apical segmental artery, U-Upper segmental artery, M-Middle segmental artery, L-Lower segmental artery.

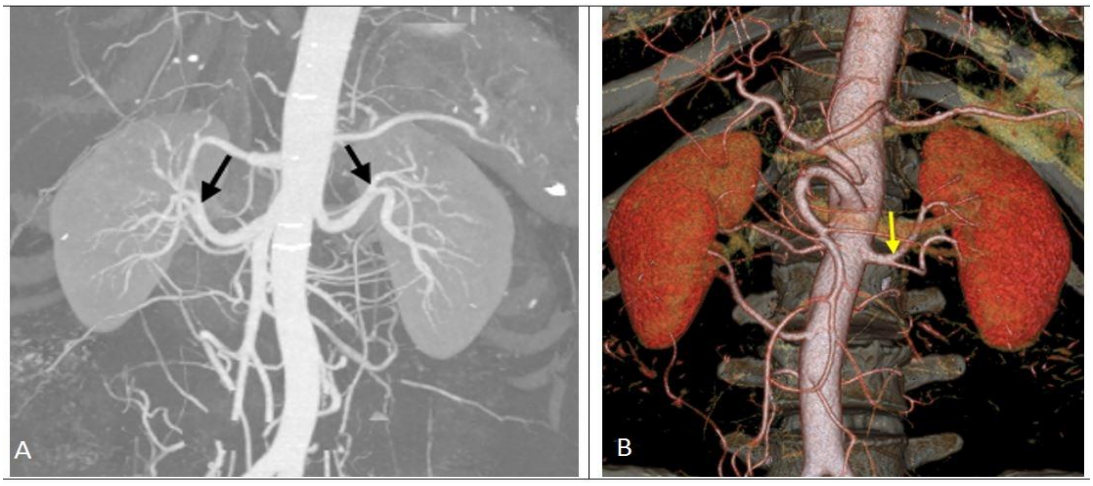

Fig.2 A-MIP coronal image for bilateral hilar division of main renal arteries. B-VR coronal image for prehilar division of left main renal artery.

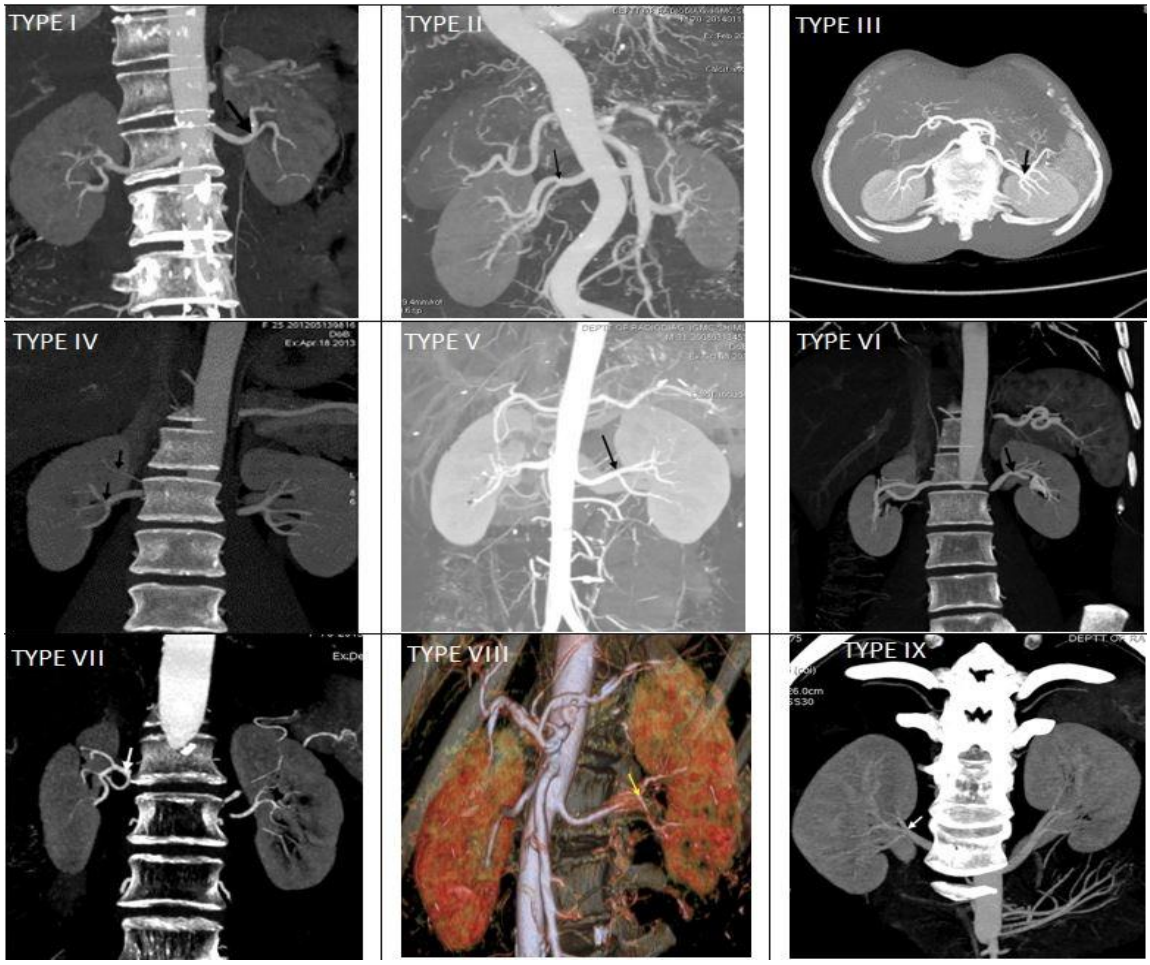

Fig. 3 MDCT images of variant branching pattern of anterior division of renal artery observed in the present study. Type I and IX are MIP oblique coronal images, Type II, IV, V, VI and VII are MIP coronal images, Type III is MIP axial image and Type VIII is VR coronal image.

DISCUSSION

Pre hilar or early branching pattern is a normal variant in which the main renal artery divides into segmental branches at a more proximal level than the renal hilum. Any branch that diverges within 1.5 to 2.0 cms from the lateral wall of the aorta is pre hilar.Pre operativedepiction of prehilar arteries is critical as it represents an exclusion criteria for laparoscopic nephrectomy. In renal transplant-tation, at least 2 cm of donor artery is required for anastomosis with recipient's artery. Table 1 shows the comparison of incidence of prehilar arteries in previous studies with the present study. In our study, there were 27% prehilararteries on right and 23% on the left side. In one case the left main renal artery was stenosed. The pattern was unilateral in 22% and bilateral in 14%.The total incidence of 25% is significantly high. It endorses the need for pre operative evaluation

Variable branching pattern of renal arteries and vascular segmentation has been reported in literature. Grave's (1954) description of five vascular segments and their independent blood supply with no collateral circulation is internationally accepted.[2] However, some studies have suggested three to five segments.[6,17-19] In our study the number of segments was four in types I, II, IV and VII (51.53%) whereas it was five in types III, V, VI,VIII and IX (47.85%).

The advent of advanced conservative methods of surgery like laparoscopic partial nephrectomy has necessitated the precise anatomical knowledge of renal vascular pattern. For selective segmental or non-selectivepresegmental arterial clamping it is essential to depict the distribution of segmental arteries before surgery. This aids in planning the feasibility of the procedure and minimises the risk of ischaemic injury.[1]

In the present study, the posterior division continues as posterior segmental artery in all the cases where as its variable branching pattern has been observed by some workers.[6,17,20]

The branching pattern of anterior division of renal artery is characterised by high morphological variability and has been classified into five types by Ajmani ML and Ajmani K (1983)[6] and Longia et al. (1984).[17]Shoja et al. (2008)[21] observed Ladder pattern (sequential branching) in 7.4% and Fork pattern (common branching point) in 92.6%. In our work nine types have been described. Table 2 compares the earlier studies of the variant pattern of anterior division of renal artery with the present study. OurType I, II and III correspond to group I, II and III of Grave's (1954)[2], Kher et al. (1960)[22], Kumar U and Prabha R (2016)[24] and type I, II and IV of Chandergirish et al. (2014).[23] Type III, VIII and IX are same as type 2,1 and 4 respectively as seen by Trivedi et al. (2012).[7] Type VI tallies with group IV observed by Verma et al. (1961)[20] and type VI by Chandragirish et al. (2014).[23] Type VII in which the anterior division divides into middle segmental artery and presegmental artery which further divides into upper and inferior segmental artery, has not been reported as per our knowledge. It was present in 26.25%% cases on the right side and 12.05% on the left side.

In our study the incidence of type I branching is 8.59% which is very low compared to 33.33% seen by Graves (1954)[2], Kher et al. (1960)[22] and 31% by Chandergirish et al. (2014)[23], as we have identified another similar pattern i.e. type V (8.59%) in which the lower segmental artery is the first branch as in type I but the presegmental artery gives origin to apical artery in addition to upper segmental artery. The origin of lower segmental artery is significant as it is ligated in hydronephrosis if the length is sufficient.

Type II branching pattern was seen by earlier workers. Graves (1954)[2] observed type II branching pattern in 30% cases, Kher et al. (1960)[22] in 38.80% and Chandergirish et al. (2014)[23] in 19%. In present study 7.36% cases were found, but we also identified 16.56% cases of type VIII, where the upper segmental artery which is the first branch of anterior division also gives origin to apical segmental artery. Trivedi et al. (2012)[7] found maximum cases of this pattern and grouped them as type1 (29.16%). The incid-ence of type III (16.56%) is almost in the same range (16%-27%) as observed in previous studies.

The apical segmental artery is the first branch of anterior division in type IV (9.20%). This pattern was also seen by Chandergirish et al. (2014)[23] in 8% and Trivedi et al. (2012)[7] in 16.67% cases, grouped as type3. The ligation of apical segmental artery produces bloodless field in conditions like solitary cyst, trauma, localised tumours and urolithiasis. If type VIII and type IV are not differentiated then accidental ligation of upper presegmental artery in type VIII can produce ischaemic injury in apical and upper segments.

Mishra GP et al. (2014, 2015)[25,26] studied the variations of upper and lower segmental arteries individually. It is difficult to match their classification with ours as they have not commented on other segmental arteries. Ours is a comprehensive study of all the segmental arteries arising from anterior division.

In the absence of constant vascular pattern, it may not be possible to forecast beforehand the type of surgery that can be safely performed in a particular case. Therefore, pre-operative MDCT angiography is of great value in diagnosing and planning surgical intervention.

CONCLUSION

Nine types of branching pattern of anterior division of renal artery is present in North Indian population and Type VII does not fall into any of the previously reported categories. MDCT angiography is the preferable imaging tool for screening renal vascular anatomy, which is of paramount importance for radiologists performing various interventional procedures, surgeons performing renal transplantation, laparoscopic nephrectomy and other retroperitoneal surgeries and vascular surgeons.

Conflict of Interest: Authors have none to declare.

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