International Journal Dental and Medical Sciences Research
Volume 4, Issue 2, Mar-Apr 2022 pp 527-532 www.ijdmsrjournal.com ISSN: 2582-6018

Study on Intra Renal Arterial Segmental Patterns of Human Kidney and Its Variations

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Submitted: 10-04-2022 Accepted: 22-04-2022

ABSTRACT
Background: The advent of more conservative methods in the renal surgery has necessitated a more precise knowledge of renal vascularization and its importance in partial and total renal transplantation surgeries. **Methods:** Totally 60 adult human kidneys were studied in the present work belonging to both sexes; Out of it 40 were procured from dissection cadavers in the Department of Anatomy, IGIMS, Patna. and Before removal of the kidneys from the bodies, possibilities of additional renal arteries from the common iliac, internal iliac, lumbar, sacral, superior mesenteric, hepatic and inferior suprarenal arteries were looked upon. The segmental arteries of the kidneys were studied by three methods. 40 by dissections, 10 by corrosion cast and 10 by radiological method. **Conclusion:** Much importance is given to the segmental artery which arises in common and divides within the renal parenchyma, as healthy renal tissue is often involved during partial nephrectomy of the affected part during ligating the specified segmental artery.
Keywords :Human Kidneys, Intrarenal, Arterial segmental patterns.

I. INTRODUCTION

The present work on Intrarenal arterial segmental pattern of human kidneys and its variations has been undertaken because of its urosurgical importance in making a relatively bloodless surgical approach to the kidneys and to save the healthy renal tissue in partial nephrectomy. The advent of more conservative methods in the renal surgery has necessitated a more precise knowledge of renal vascularization and its importance in partial and total renal transplantation surgeries. The renal vascular segmentation was originally recognized by John Hunter[1] in 1794 and wrote "The veins in the spleen and kidney anastamose in vary large trunks while the arteries do not at all" but the idea of segmental anatomy started with the discovery of bronchopulmonary segments in 1889 by William Ewart[2.] In 1901 Max Bordel[3] has advocated an incision on the posterior side of the lateral border of the kidney as this site was thought to be relatively avascular but however in practice most of the surgeons had found that this is by no means a bloodless area. In 1952 F. T. Graves[6,] came across two cases of nephrolithotomy which resultedin post operative persistent hematuria which compelled him to do total nephrectomy in order to save the life of the same patient. The loss of the normal kidney that has partially affected prompted him to investigate the arterial distribution in the kidney substance. Hence in 1954, he made an outstanding contribution to the renal surgeries by describing five segmental branches of the renal artery with little anastamosis of there neighboring branches for the establishment of an effective collateral circulation in cases of segmental infarction of the kidney. In 1960, Robert[10] stressed the necessity of knowing the variation in the vascular segmental patterns to prevent the avoidable loss of normal healthy renal tissue which occurs in total nephrectomy while removing the infarcted renal tissue. Thus from radical total nephrectomy to conservative partial nephrectomy. In 1963, D. Sykes said that surgeons should know all the possible variations and their incidence to make through search and take spot decision at the operation table as their vascular patterns in the kidneys are not same in all the kidneys or similar in the two kidneys of the same person. Thus, many workers especially endourological surgeons from time to time confirmed the clinical importance of the intrarenal arterial segmental patterns and its variations for adventing more conservative therapy or the surgeries.

II. OBJECTIVES

To study the intrarenal arterial segmental patterns and its variations in 60 human kidneys by

dissection, corrosion cast and radiological method. To help the endourologic surgeons to carry out safer surgeries on kidneys.

III. REVIEW OF LITERATURE

John Hunter (1794) [1] said that the veins in spleen and kidneys anastamose but not the arteries and the search for segmentation in kidneys was made when William Ewart[2] discovered bronchopulmonary segments in lungs. Max Bordel [3] (1901) described a relatively avascular zone in the kidney cortex where the branches of anterior and posterior divisions of the renal artery end as functional end arteries. So he advocated an incision on the posterior side of the lateral border of the kidney to minimize bleeding. In 1950[4] Abehouse and Lerman also advocated the renal arteriography and determined the distribution of the segmental artery by noting the purplish discoloration produced by its compression which enables the surgeons regarding the amount of tissue to be resected. Robert More and Lyman Duff in 1951[5] denoted the independence of anterior and posterior major divisions supplying larger anterior about 2/3rd and smaller posterior about 1/3rd respectively. He named the five segments of the kidney as apical, upper, middle, lower and posterior. He termed the medial part of the kidney at its upper pole as the apical segment, a larger part at the lower pole as lower segment, posterior portion of the intervening theseparts as posterior segment, the anterior portion between apical and lower segments being divided into upper and middle segments. The apical, upper, middle and lower segments of him are supplied by anterior division of the renal artery and posterior segment by its posterior division. Bose P[9] (1955) observed the human renal arterial tree by preparing 46 methacryalate casts and said that the posterior division supplies the upper 2/3rd of the posterior surface and that if there were to be three anterior primary branches, they would supply upper, middle and lower thirds of the anterior surface. A few branches however from the anterior group were found to supply the posterior region after crossing the pelvisof the ureter. Robert J Merklin and Nicholas A Michels[10] (1958) reported various possibilitiesof origin of segmental renal arteries from inferior phrenic artery to apical or upper segmental, apical artery giving rise to inferior suprarenal artery, and origin of upper, middle or lower segmental arising directly from abdominal aorta. Donald F, McDonald and Johan M. Kennelly, JR. (1959)[11] done vinylite artery casts which reflected the condition of the vessels and said right renal arterial anomalies constitute 65% compared to left. Verma, Chaturvedi and Pathak (1961) studied casts of butyrate acetate of renal artery; of them, 83 cases showed extrahilar branches of the renal artery. They described a variation in which the anterior division of renal artery after entering the kidney was arching lateral wards like the posterior division and was giving four segmental branches from its convex side to the apical, upper, middle and lower segments.They also observed that in 16 specimens apical segmental artery was absent. Arne Ljungvist and Curt Lagergren (1962) detected that kidney depends upon the lumen of the segmental artery. Partial or complete blocking of any segmental artery in old age leads to decreased segmental perfusion and may lead to that segmental ischemia. David Sykes (1963) studied 82 kidneys. He noted three types of arterial segmental pattern (1) Typical arterial type was present in 59 casts corresponding to the description given by Graves, (2) Typical venous type present in 6 casts and (3) Dual arterial pattern in 17 casts. He was the first to describe the venous pattern of the renal arterial branching. Chatterjee S K and Dutta A K (1963) studied the segmental pattern in 59 kidneys by injecting neoprene latese under pressure of 150 to 160 mm of mercury into renal artery and also by arteriography. They named the upper segment of Graves as the upper middle and the middle as the lower middle segment. Julier Fourman (1972) says each of these segmental arteries are virtually end arteries since it supplies a definite segments of the kidney and does not anastomoses with the arteries of the adjacent segments except via very small capsular and pelvic branches which are quite unable to establish a collateral circulation. Harrison R.G. (1981)stated that during the initial development of kidneys within the pelvic cavity receives its blood supply from near by larger arteries and during its ascend towards its normal position these may disappear and it may be replaced either by median sacral, internal iliac, common iliac arteries or from the lower part of the abdominal aorta and some of them may persist as supernumerary or the aberrant arteries of the kidney. The kidney is originally at the level of upper sacral segment and receives its early arterial supply from the lateral sacral branches of the aorta. The ascent of the kidney from its original pelvic region to its final lumbar position takes place between the ends of fifth week and eighth week. During the ascent of the kidney, their intrinsic blood vessels receive their blood supply from the lateral stem arteries, which arise from the aorta at increasingly higher level until that of definitive renal arteries, at the second lumbar vertebra is reached. This definitive renal artery is the most caudal of three suprarenal arteries.

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IV. MATERIAL AND METHODS

Totally 60 adult human kidneys were studied in the present work belonging to both sexes; Out of it 40 were procured from dissection cadavers in the Department of Anatomy, Indira Gandhi Institute of medical sciences, Patna, Bihar. and Before removal of the kidneys from the bodies, possibilities of additional renal arteries from the common iliac, internal iliac, lumbar, sacral, superior mesenteric, hepatic and inferior suprarenal arteries were looked upon. The segmental arteries of the kidneys were studied by three methods. 40 by dissections, 10 by corrosion cast and 10 by radiological method. The segmental arteries of the kidneys were studied by three methods. Dissection method– 40 specimens, Corrosion cast method– 10 specimens, Radiological Method – 10 specimens. For all the three methods, after identifying the supernumerary renal arteries from the aorta, the kidneys of each pair were separated along the renal arteries by discarding the piece of aorta. Before removal of the kidneys from the bodies, possibilities of additional renal arteries from the common iliac, internal iliac, lumbar, sacral, superior mesenteric, hepatic and inferior suprarenal arteries were looked upon. Dissection method: Adult human kidneys from the dissection cadavers were washed in running tap water to remove the formalin. The capsule of each kidney was striped off and the parenchymatous tissue was removed in piece meal with forceps under water, tracing the segmental arteries as much as possible. The dissected specimens were numbered and allowed to dry for a time. The renal arterial segments were observed and photographed. Specimens were preserved in 5% formalin. Radological method, Fresh kidneys along with their capsule were washed in running tap water for about 30 min to 1 hour. The blood from arteries and veins were washed off by injecting warm saline till a clear fluid comes out of it. The washed kidneys were turned downwardsfor 2 hours to drain out the fluid completely.

V. RESULTS

The nomenclature of the renal segments approved at the 8th International Congress of Anatomists held in Wiesbaden, Germany in 1965 is as superior (apical of Graves), anterior superior (upper of Graves), anterior inferior (middle of Graves) and posterior segments (posterior of Graves). The classification adapted here is based mainly on the classification of the various types of renal segmental arteries made by Graves. He described four types of the apical segmental arteries according to its mode of origin and three of the anterior division of the renal artery based on its mode of termination Kher[12] et al modified the grouping of the Graves. They grouped the other arteries also formerly omitted by Graves. They classified (1) Six types of the apical segmental arteries instead of four types described by Graves and (2) Four types of the lower segmental artery not typed by Graves. Verma et al further modified the classification. They grouped (1) Four groups of anterior division of the renal artery instead of the three groups described by Graves (2) Three types of the posterior division not typed by the previous workers.

Sl. No.	Side	Method	Specimens No.	Total
1	Right	Dissection	27	1
2	Left	Dissection	12,22,30,46	4
3	Right	Cast	-	0
4	Left	Cast	-	0
5	Right	Radiological	-	0
6	Left	Radiological	54	1
Total Percentage = 10%			**Total Specimens**	**6**

The anterior division terminates as the middle and lower segmental arteries after giving off the upper segmental artery.

Sl. No.	Side	Method	Specimens No.	Total
1	Right	Dissection	1,3,7,11,13	5
2	Left	Dissection	-	0
3	Right	Cast	-	0
4	Left	Cast	-	0
5	Right	Radiological	-	0
6	Left	Radiological	34,47	2
Total Percentage = 11.66%			**Total Specimens**	**7**

Anterior division divides and terminates either in combination with twosegmental arteries in common i.e. apical

International Journal Dental and Medical Sciences Research
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with upper, middle with lower and apical with middle segmental arteries much before the hilum or within the hilum.

Sl. No.	Side	Method	Specimens No.	Total
1	Right	Dissection	19,37,43,45	4
2	Left	Dissection	20,26,40,42	4
3	Right	Cast	48	1
4	Left	Cast	-	0
5	Right	Radiological	56,57	2
6	Left	Radiological	58	1
Total Percentage = 20%			**Total Specimens**	**12**

In 10% of the anterior division, it terminates as the upper and middle segmental arteries after giving off the lower segmental artery much before the hilum. In 11.66%, the anterior division terminates as the middle and lower segmental arteries after giving off the upper segmental artery or may along with apical segment. In 13.33%, the anterior division gives rise to the apical segmental artery before or much before the hilum and then to three terminal branches upper, middle and lower segmental arteries In 16.66%, the anterior division gives off three terminal branches viz., apical, upper and middle after giving off lower segmental artery much before the hilum Only 6.66%, the anterior division runs downwards, in front of the pelvis of the ureter with an outward convexity from which the apical, upper, middle and lower segmental arteries arise in single or small more than one. The posterior division gives off (a) apical or (b) middle or (c) lower segmental artery or any two of them which are all usually branches of anterior division. It supplies the posterior segment before or after giving the above said branches.

Sl. No.	Side	Method	Specimens No.	Total
1	Right	Dissection	9,13,17	3
2	Left	Dissection	20,22,42	3
3	Right	Cast	50	1
4	Left	Cast	33,49	2
5	Right	Radiological	-	0
6	Left	Radiological	36	1
Total Percentage = 16.66%			**Total Specimens**	**10**

In 16.66% of the cases, the posterior division may gives off one or two anterior divisional branches which may replace either apical or middle or lower segmental artery or any two of them which are all normally branches of anterior division. It supplies the posterior segment before or after giving the above said branches. Sometimes there maybe additional branch to these anterior segmental areas. Posterior segmental or the division may arise directly from the abdominal aorta as accessory artery in 3.33%. Some times it even replaces lower segmental artery. THE SEGMENTAL TYPE is seen only in 4 specimens in which a single accessory renal artery arises directly from the aorta and it replaces one or two of the segmental branches of the anterior division of the renal artery which accounts for 6.66%. If present it is usually arises superior to the normal renal artery or it may arise in close to it. During its course to supply the renal tissue it may even cross the other segmental branches.

VI. DISCUSSION

The description of Brodel`s line in 1901 revolutionized renal surgery[3]. Since that time, a variety of complex renal reconstructive procedures have evolved for renal parenchyma preservation as an alternative to simple or radical nephrectomy. As a result, the urologic surgeons and anatomist may be called upon to perform these complex renal preservation procedures in the presence of trauma, neoplasia and urolithiasis. This bold approach and new technique evolved when Graves made a definite announcement about the existence of 5 arterial segments in the kidney in the year 1952. The new techniques employed in renal surgery mainly depend upon the segmental resection, namely wedge–type resections, if the disease affects upper or lower segments. But for the mid-portion lesions, either enucleation technique or the

partial nephrectomy is indicated although obviously limited to tumors, may be employed in other conditions with minimal loss of renal functions. The most commonly seen complication encountered after partial nephrectomy is bleeding. Life was threatened by post-operative complications such as severe bleeding prior to the advent of the conservative segmental resections. Later, the profound knowledge of variations of the mode of origin of the segmental arteries reduced the mortality rate. The attention to haemostasis and the use of cold ischemia have reduced the complication rate considerably. The lack of arterial anastomosis in the neighboring segments will affect only the affected segment and will neither produce ischemia nor interfere with blood supply of neighboring segments. This lack of arterial anastomosis will render the technique of resection easier, since the field of operation will be relatively bloodless following the ligation of the segmental artery supplying the area of the operation. It should be remembered that the origins of the segmental arteries are accessible. In the majority of cases, they are easily seen in the hilum and often at the points nearerthe aorta. This is of practical value, since segmental resection is best carried out from the hilum towards the periphery. Accessory renal arteries to the lower aspect of the renal hilum are often found in close relation to the ureteropelvic junction or upper part of the ureter. Their presence accentuates the obstruction leading to hydronephrosis. Hence, they cannot be ignored. In majority of the cases (55%) or normally, the middle segmental artery arises from the anterior division of the renal artery along with most of the other segmental arteries which is similar to Verma et al of 72%. In 13.33% of the cases i.e. it arises from or along with the upper segmental artery and divides into upper and middle within the renal parenchyma or within the hilum which is similar to the findings of H. Fine et al (14.77%) and its clinical importance is as discussed in anterior division and in apical segmental variations. Middle segmental artery usually arises from or in common with the lower segmental artery in around 28.33% next to type I. If the upper and lower calyces are large, and there is no middle segment, then, its branches are correspondingly small or absent as shown in 18% of the cases, as reported by Marklin and Michels (1958). where in the lower segmental artery is a direct branch from the aorta was noted in 28.33% of cases but along with the middle segmental artery. In this type IV pattern, one has to be aware of the gonadal artery arising in turn from the lower segmental artery, sometimes quite near the kidney. Ligation of the latter must therefore be made after the artery to the gonad has originated, as otherwise testicular atrophy will eventually develop (Graves). However such variations were not seen in the present study. In 10% of the cases, the lower segmental artery is given off directly from the renal artery much before the hilum. But others findings varies like 1% of Kher et al, 3% of Verma et al and 41% of H. Fine et al. In 28.33%, the posterior division runs downwards behind the ureteric pelvis with a lateral convexity and from the convexity, three or more branches arise to supply the posterior segment of the kidney similar to Kher et al. But others have reported 62% (Verma et al) and 50% (H. Fine). In majority of the cases, i.e. 51.66% of type II in present work revealed that the posterior division terminates by bifurcating or trifurcating giving a cruciate appearance and then supplies the posterior renal segment.

VII. CONCLUSION

The advent of more and more conservative methods in the renal surgery has necessitated a more precise knowledge of renal vascularization and its importance in partial and total renal transplantation surgeries. Therefore the valuable contribution of anatomical knowledge to operative surgery, particularly in partial or segmental resection of kidneys, will help further development of different techniques for the removal of calculi or affected part of kidneys and also helps in partial renal transplantation surgeries with end to end anstamosis of the resected part of the kidney. The presence of the arterial segments within the substance of kidney does not change, but there is a lot of variation in the course and exact point of origin from the renal artery or aorta of these segmental vessels outside the substance of the kidney.

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