VARIATIONS IN THE BRANCHING PATTERN OF RENAL ARTERY AND ITS CLINICAL IMPLICATIONS

S Trivedi, A Dixit, S Kotgiriwar, S Athavale, V Gupta, R Deopujari

Department of Anatomy, Peoples college of medical sciences and research centre, Bhopal

ABSTRACT

Renal artery arises from the aorta and divides into an anterior and posterior division. The anterior division further divides into 4 segmental arteries: apical, superior anterior, middle anterior and lower. The posterior division continues as posterior segmental artery. These segmental arteries serve as end arteries and supply a specified segment of the kidney. In the present study, variations in the branching pattern of the renal artery and vascular segmentation of the kidney was studied by dissection, corrosion cast and radiographic methods in 72 kidneys obtained from post-mortem cases of Forensic department. Five vascular segments were observed in all the kidneys studied. The anterior division of the renal artery showed considerable variations in giving segmental branches on the basis of which it was classified into 6 types; most common being anterior division dividing into an upper and a lower branch. The upper branch further divided into an apical and an upper segmental artery and the lower branch divided into middle and a lower segmental artery (29.19%). Knowledge of branching pattern of the renal artery is very important for the proper interpretation of radiographic interpretation of renal vasculature and planning surgical procedures in cases of renal trauma, renal transplantation, and partial nephrectomy.

KEYWORDS: Anatomical variations, Corrosion cast, Partial nephrectomy, Renal angiography, Segmental artery

INTRODUCTION:

The arterial supply of the kidney is segmental. Each segment is supplied by its own segmental artery acting as end arteries. The main stem of the renal artery branches at variable points between the aorta and the hilum into an anterior and a posterior division. The anterior division gives rise to the apical, superior (anterior), middle (anterior), and lower segmental arteries in the prehilar or hilar region. These segmental arteries further divide into lobar and then interlober arteries, which finally enter the kidney substance through renal column (Standring et al. 2005, Sinnatamby CS 2006, Romanes GJ 2003)[1,2,3].

Pre-operative depiction of the complete vascular anatomy is important for the surgical planning, especially prior to performing laparoscopic partial nephrectomy and nephron-sparing surgery. The fact that segmental arteries are present at the hilar or pre-hilar region makes them accessible for selective clamping during surgical procedures like partial nephrectomy (Weld et al. 2005)[4]. Since laparoscopic nephrectomy is performed with a limited field of view, knowledge of normal variants of vascular pattern reduces the chance of vascular injury and hemorrhage. Earlier studies on vascular segmentation of kidney and the number of segmental arteries have provided contradictory observations (Weld et al. 2005, Graves FT 1954, Fine and Keen 1966, Ajmani and Ajmani 1983, Longia et al. 1984, Sampaio et al. 1993, Sapte and Bordei 2005, Verma et al. 1961, Shoja et al. 2008, Ogeng'o et al. 2010)[4-13]. Various patterns and classification described in the literature add confusion for clinicians.

Present study was undertaken to study the branching pattern and arterial segments supplied by the branches of renal arteries, so as to be of clinical value in diagnostic studies and surgical procedures such as renal transplant surgeries, laparoscopic surgeries and Partial nephrectomy, which might be indicated in cases of renal tumors, renal calculus or renal trauma.

MATERIAL AND METHODS

The present study was carried out in 72 (40 right and 32 left) kidneys obtained from the medico-legal autopsies done in the department of Forensic medicine and Toxicology, G. M.C. Bhopal. Specimens were obtained along with vascular pedicle and the renal artery was cut as close as possible to the abdominal aorta. The specimens were subjected to one of the following methods of

Correspondence

DR. SOUMITRA TRIVEDI

Assistant professor, Department of Anatomy

P.C.M.S. & R.C., Bhopal.

Email id: dr.somit@gmail.com

Phone: 0755-4055219, 09893815303

Fax No: 0755-4005221

study:

1. Dissection: -In 36 specimens (20 right and 16 left) renal artery was finely dissected then washed and painted with acrylic red colour.
2. Corrosion cast: - In 28 (14 right and 14 left) specimen renal artery was immediately catheterized after autopsy and fresh water was run through it for 2 hrs. followed by 2 liters of 0.9% NaCl solution, using gravity pressure, 1-2 drops of 1% HCl was added to remove the stubborn clots Subsequently, plastic resin (Butyrate acetate) in 100ml acetone was made to flow through the renal artery by gravity method for a period of about 18-20 hrs the catheter was then clamped and resin was allowed to dry and set completely for 5-6 hrs. Kidneys were completely submerged in 30% HCl acid for 1-6 days; this dissolved all the tissues of the kidney leaving behind the arterial cast. This arterial cast was washed under the slow running tap water.
3. Renal Angiography of Post Mortem Kidney: - Angiography was performed to substantiate the findings obtained from dissection and cast study. Eight (5 right and 3 left) post mortem kidneys were injected with dye, Trazograph 76% (Diatrizoate meglumine and Diatrizoate sodium) and radiograph was immediately taken before the radio opaque dye could diffuse.

Renal artery divides into presegmental and segmental branches. Presegmental arteries when traced towards the hilum further divide into respective segmental arteries. A segmental artery was defined as a primary or a secondary branch of renal artery that could be isolated in the prehilar, hilar regions or in the sinus of kidney (Fine and Keen 1966, Sampaio et al. 1993)[6, 9]. Branching pattern of renal artery upto the level of segmental arteries was studied by all three methods. Intrarenal arterial pattern was observed in corrosion casts and radiographs to study the number of renal arterial segments.

OBSERVATION:

The branching pattern of the renal artery till the level of segmental artery could be easily delineated by all the methods of study. Hence the observations on branching pattern were complied collectively. A constant bifurcation of renal artery into an anterior and a posterior division was observed in all the cases in the pre-hilar region.

The posterior division continued as posterior segmental artery was seen in all the cases; whereas, the anterior division showed great variation in its branching pattern to give rise to segmental arteries supplying the segments of the kidney.

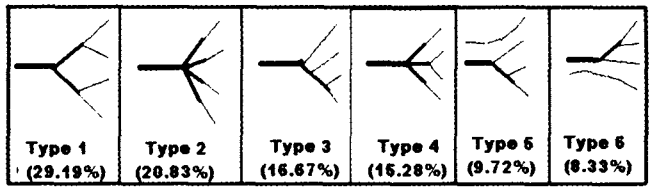

Fig. 1:- Shows the branching pattern of the anterior division into six types.

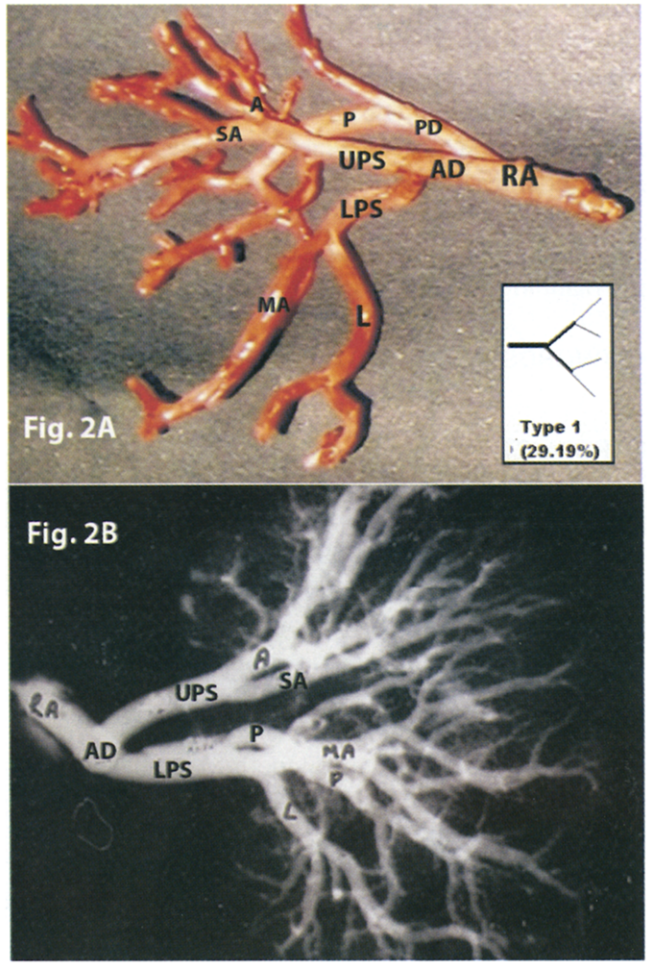

Fig. 2:- 2A corrosion cast showing type 1 branching pattern. Anterior division divided into upper and lower presegmental branches. Upper branch further divided into apical and superior segmental artery and lower branch divided into middle and lower segmental artery.

2B shows radiograph having similar type 1 branching pattern.

(RA- Renal artery, AD Anterior division, PD Posterior division, UPS Upper presegmental artery, LPS Lower presegmental artery, A Apical segmental artery, SA Superior anterior segmental artery, MA middle anterior segmental artery, L Lower segmental artery P posterior segmental)

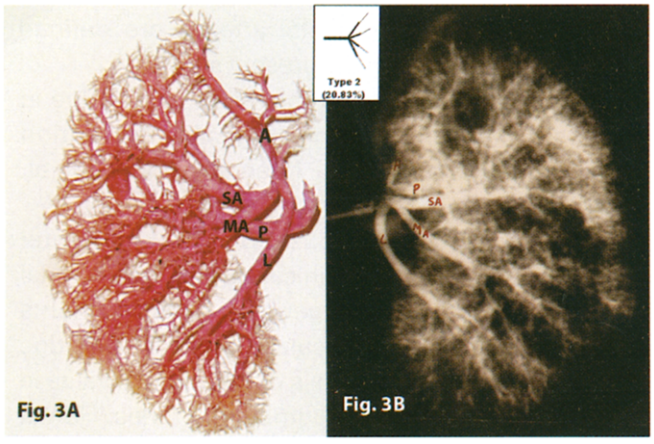

Fig. 3:- 3A corrosion cast showing type 2 branching pattern where anterior division divided more or less at one common point into 4 segmental arteries.

3B shows the radiograph having similar type 2 branching pattern.

(A Apical segmental artery, SA Superior anterior segmental artery, MA middle anterior segmental artery, L Lower segmental arterv P posterior segmental)

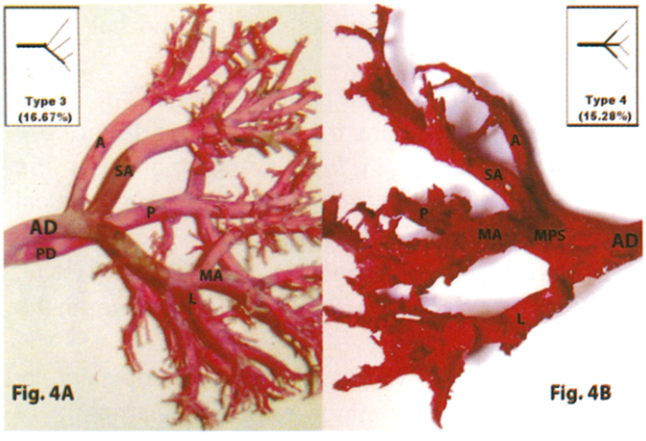

Fig. 4:- 4A shows corrosion cast showing type 3 branching pattern in which anterior division divided into a segmental and a presegmental branch. The segmental branch coursed towards the superior pole as apical segmental artery. The presegmental branch coursed towards the lower pole and sequentially gave superior middle and lower segmental arteries.

4B shows dissected renal artery with type 4 branching pattern in which the anterior division after giving apical and lower segmental arteries continued as middle presegmental branch, which further divided into superior and middle segmental arteries.

(AD Anterior division, PD Posterior division, MPS Middle presegmental branch, A Apical segmental artery, SA Superior anterior segmental artery, MA middle anterior segmental artery, L Lower segmental artery P posterior segmental)

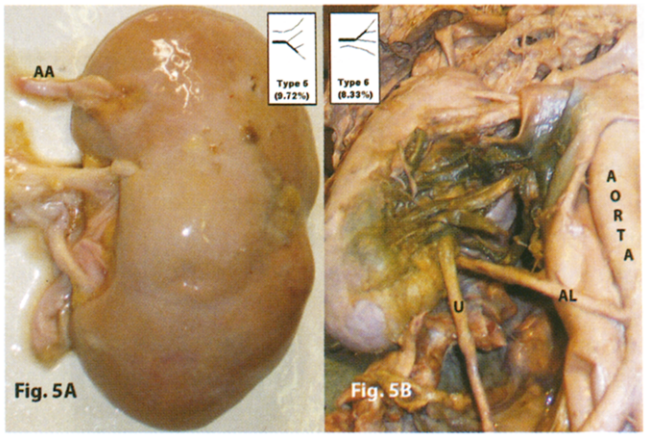

Fig. 5:- 5A - Photograph of left kidney showing presence of an accessory renal artery coursing towards the apical segment (type 5 branching pattern).

5B - Photograph of right kidney showing presence of an accessory renal artery to the lower segment seen arising from the aorta (type 6 branching pattern).

(AA- Accessory apical segmental artery, AL Accessory lower segmental artery, U Ureter)

The variable branching pattern of the anterior division of renal arteries was classified into 6 types(Fig. 1):

Type 1: The anterior division divided into an upper and a lower presegmental branch. The upper branch further divided into apical and superior segmental artery and the lower branch divided into middle and lower segmental artery (29.16%) (Fig. 2).

Type 2: The anterior division divided more or less at one common point into 4 segmental arteries (20.83%) (Fig. 3).

Type 3: The anterior division divided into a segmental and a presegmental branch. The segmental branch coursed towards the superior pole as apical segmental artery. The presegmental branch coursed towards the lower pole and sequentially gave superior middle and lower segmental arteries (16.67%) (Fig. 4A).

Type 4: The anterior division after giving apical and lower segmental arteries, continued as middle presegmental branch, which further divided into superior and middle segmental arteries (15.28%) (Fig. 4B).

Type 5: The anterior division continued to the lower pole and gave superior, middle and lower segmental arteries whereas the apical artery gains origin directly from renal artery or from aorta (9.72%) (Fig. 5A).

Type 6: The anterior division gave apical, superior and middle segmental arteries whereas the lower segmental artery gains origin directly from renal artery

or from aorta (8.33%) (Fig. 5B)

A single case of Type 1 was seen in which posterior segmental artery was seen arising from inferior aspect of renal artery, spiraling between the two presegmental arteries of the anterior division.

A single variant case of Type 6 was seen in an which acessory renal artery of equal calibre was seen arising below the renal artery. It supplied the middle anterior segment in addition to lower segment.

Although variable branching pattern was observed, the number of segmental arteries remained constant (five in number). Similarly, five arterial segments were observed by corrosion cast and radiographs in all the cases.

DISCUSSION:

Vascular segmentation of the kidney has been a topic of investigation since long. Graves' suggested that five arterial segments exist in the kidney. This is the most widely accepted view and is adopted internationally (Graves FT 1954)[5]. However, some other studies have emphasized the great variability in the number of vascular segments, ranging from three to five (Fine and Keen 1966, Ajmani and Ajmani 1983, Longia et al. 1984, Sampaio et al. 1993, Sapte and Bordei 2005)[6-10]. The findings in the present study suggest that the number of segmental arteries and the number of vascular segments remain constant i.e. five. However, there exists great variability in the branching pattern of the renal artery which gives rise to segmental artery in the hilar or prehilar region.

The variable branching pattern of the renal artery has been studied by few workers. Ajmani and Ajmani (1983)[7] and Longia et al. (1984)[8] have suggested similar classifications and have divided the branching pattern of the anterior division into five types. The branching pattern has also been classified into fork and ladder type by Shoja M et al. (2008)12 and Ogeng'o et al. (2010)[13].

Contrary to the observations of present study of relatively constant posterior division, few workers have reported variable branching pattern of posterior division. (Ajmani and Ajmani 1983, Longia et al. 1984, Verma et al. 1961)[7,8,11].

Authors believe that the variable findings of different studies are a result of ambiguity about the origin and extent of segmental arteries. Variable interpretations are likely if the branching pattern is not traced upto the sinus of the kidney and/or presegmental branches are interpreted as segmental arteries. Such misinterpretation can be avoided if the position, origin and termination of segmental arteries are defined precisely as was done in the present study.

Pre-operative renal angiography is of great value in diagnosing and planning surgical intervention (Breton and Malone 1999, Khamanarong K et al. 2004)[14,15].

Successful embolization of segmental arteries has been reported in cases of pediatric renal hypertension, palliative surgeries in renal carcinoma and post surgical renal vascular injuries. Knowledge of arterial branching pattern is of therapeutic value in selective embolization of segmental arteries. (Tan et al. 2008, Massulo-Aguiar et al. 2006, Teigen et al.1992, Soo et al.1981)[16,17,18,19].

Similarly, in cases of renal transplantation, presence of accessory renal artery in the donor complicates the picture. Operating surgeon should take care to anastomose the accessory artery to the recipient circulation. In the present study accessory arteries were observed in 18.05%. High percentage of accessory renal artery (upto 31%) has also been reported by previous workers (Dhar and Lal 2005, Coen and Raftery 1992)[20,21].

In the type 6th pattern where the lower segmental artery arises from the renal artery or the aorta. It may cross in front of the pelvis or the pelviureteric junction and can cause mechanical obstruction to the flow of urine leading to hydronephrosis (Stephens FD 1982, Byoung et al. 2003)[22,23]. It was observed in 8.33% of the cases in the present study.

Findings of the present study can be gainfully utilized in contemplating selective clamping of segmental arteries which are easily accessible in the hilar or prehilar region instead of clamping renal artery as is the common practice in partial nephrectomy.

CONCLUSION:

- Five vascular segments were found in all the kidneys
- Renal artery showed consistent branching into anterior and posterior division in the prehilar region
- Posterior division was constant and supplied posterior arterial segment in all the cases
- Anterior division showed variable branching pattern which were classified into 6 types
- The findings of the present study shall be of help in planning and execution of surgical intervention in cases of renal transplantation, selective

clamping for partial nephrectomy and selective embolization of vessels in renal vascular injuries following surgeries.

REFERENCES:

1. Standring S; Gray's anatomy: the anatomical basis of clinical practice in urinary system, 39th edition, Elsevier-Churchill Livingstone, London 2005, pp 1274-1276
2. Sinnatamby CS; Last's anatomy: regional and applied in abdomen, 11th edition, Elsevier-Churchill livingstone, London 2006, pp 294
3. Romanes GJ; Cunningham's manual of practical anatomy in thorax and abdomen, 15th edition, vol.2, oxford medical publication 2003, pp 171
4. Weld K.J., Bhayani S.B., Belani J., Ames C.D., Hruby G., Landman J., Extrarenal vascular anatomy of kidney: assessment of variations and their relevance to partial nephrectomy, Urology 2005; 65(5):985-989
5. Graves F.T. Anatomy of the Intrarenal Arteries and its application to segmental resection of Kidney. British journal surgery 1954; 42: 132-139.
6. Fine H. and Keen E. N.. The arteries of the human kidney. Journal Anatomy 1966; 100: 881-894.
7. Ajmani M.L. and Ajmani K.. To study the intrarenal vascular segments of human kidney by corrosion cast technique. Anat Anz. 1983; 154(4):293-303.
8. Longia G.S. , Kumar V. , Gupta CD.. Intrarenal arterial pattern of human kidneycorrosion cast study. Anat Anz. 1984; 155(1-5):183-194.
9. Sampaio F.J. , Schiavini J.L. , Favorito L.A.. Proportional analysis of the kidney arterial segments. Urol Res.1993; 21(6):371-374
10. Sapte E. , Bordei P.. Anatomical considerations on the renal arterial segmentation. Rev Med Chir Soc Med Nat Iasi. 2005; 109(3): 597-602
11. Verma M. , Chaturvedi R.P. , Pathak R.K.. Anatomy of renal vascular segments. J of Anat Soc of Ind. 1961; 10: 12-19.
12. Shoja M.M. , Tubbs R.S. , Shakeri A. , Loukas M. , Ardalan M.R. , Khosroshahi H.T. , Oakes W.J.. Prehilar branching pattern and morphologies of renal artery: a review and anatomical study. Surg Radiol Anat. 2008; 30(5): 375-382.
13. Ogeng'o J.A. , Masaki C.O. , Sinkeet S.R. , Muthoka J.M. , Murunga A.K.. Variant anatomy of renal artery in a Kenyan population. Ann Transplant 2010; 15(1):40-45.
14. Breton P.N. , Malone M.J.. Complex renal reconstruction. Urol Clin North Am 1999; 26(1): 201-217
15. Khamanarong K. , Prachaney P. , Utraravichien A. , Tong-Un T. , Sripaoraya K.. Anatomy of renal arterial supply. Clin Anat. 2004; 17(4):334-336.
16. Tan T.J. , The H.S. , Pua U. , Ho S.H.. Endovascular management of renal vascular injury complicating percutaneous nephrolithotripsy: role of renal angiography and superselective coil embolization. J HK Coll Radiol.2008; 11: 103-107.
17. Massulo-Aguiar M.F. , Christiane M.C. , Rodrigues-Netto Jr. N.. Intrarenal pseudoanurysm after Percutaneous Nephrolithotomy. Angiotomographic assessment and endovascular management. International Braz J Urol. 2006; 32(4): 440-444.
18. Teigen C.L. , Mitchell S.E. , Venbrux A.C. , Christenson M.J. , McLean R.H.. Segmental renal artery embolization for treatment of pediatric renovascular hypertension. Journal of Vascular and Interventional Radiology, 1992; 3(1): 111-117.
19. Soo C.S. , Chuang V.P. , Wallace S. , Charnsangavej C. , Bowers T.A.. Segmental renal artery embolization in solitary renal carcinoma. Urology, 1981;18(4): 420-442.
20. Dhar P. and Lal K.. Main and accessory renal arteries a morphological study. Ital J Anat Embryol. 2005; 110(2): 101-110
21. Coen L.D. , Raftery A.T.. Anatomical variations of the renal arteries and renal transplantation. Clin Anat. 1992; 5: 425432.
22. Stephens F.D. , Ureterovascular hydronephrosis and the "aberrant" renal vessels. J Urol. 1982; 128(5):984-987.
23. Byoung S.P. , Taek K.J. , Seong K.M. , Soo W.K. , Nam H.K. , Ki C.C. , Yong Y.J.. Hydronephrosis by an aberrant renal artery: a case report. The Korean journal of Internal Medicine. 2003; 18: 57-60