Original article

Anatomical variations of renal artery and its clinical correlations: a cadaveric study from central India

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Abstract

Background: Kidneys are retroperitoneal organs normally supplied by the paired renal arteries. The aim of present study is to determine prevalence of multiple renal arteries in Indian population and provide their embryological and clinical correlation. **Materials and Methods:** The formalin fixed forty two cadavers constituted the material for study. During routine abdominal dissection conducted for medical undergraduates at Department of Anatomy, kidneys along with their arteries were explored and the morphological variations of renal arteries were noted. **Results:** We observed multiple renal arteries originating from abdominal aorta in 54.7% cases which includes Double hilar arteries(22.6%), Three hilar arteries(11.8%), hilar and superior polar (13.1%), hilar and inferior polar artery (7.1%). **Conclusion:** Awareness of variations of renal artery is necessary for surgical management during renal transplantation; repair of abdominal aorta aneurysm, urological procedures and for angiographic interventions.

Keywords: renal artery, variations, cadavers.

1 Introduction

Each kidney is supplied by a single renal artery, which arises as a lateral branch of abdominal aorta, between the levels of L_1 and L_2 (BEREGI, MAUROY, WILLOTEAUX et al., 1999; OZKAN, OGUZKURT, TERCAN et al., 2006). However the classical description of the renal vasculature, formed only by one artery and one vein, occurs in less than 25% of cases (AWOJOBI, OGUNBIYI and NKPOSONG, 1983; CIÇEKCIBASI, ZIYLAN, SALBACAK et al., 2005). Most often encountered morphological variations of renal artery are its variable number and unusual branches originating from it (DHAR and LAL, 2005; RUSU, 2006; SHOJA, TUBBS, SHAKERI et al., 2008a). Most of these variations remained undiscovered until being noticed during any surgical procedure or found by forensic pathologist during autopsy (KRISHNASAMY, RAO, SOMAYAJI et al., 2010). Variations in renal arteries have been called aberrant, supernumerary, supplementary, accessory, among other terms. It is therefore necessary that the morphology and the nomenclature of these vessels are standardized. According to Sampaio and Passos (1992) these arteries should be called multiple, since they are segmental vessels for the kidneys, without anastomoses between themselves and they should be named according to the territory supplied by them as- hilar, superior polar and inferior polar. We followed the Sampaio and Passos (1992) nomenclature for our study and believe that awareness of these possible variations of renal arteries is necessary for surgical management during renal transplantation, repair of abdominal aorta aneurysm, urological procedures and angiographic interventions (OLSSON and WHOLEY, 1964; NATHAN and GLEZER, 1984; SATYAPAL, HAFFEJEE, SINGH et al., 2001).

2 Material and Methods

The formalin fixed forty two cadavers constituted the material for study. During routine abdominal dissection conducted for medical undergraduates at Department of Anatomy, kidneys along with their arteries were explored and the morphological variations of renal arteries were noted. During the course of dissection various abdominal viscera were removed and preserved as specimen for teaching purposes. We studied the arteries arising from the abdominal aorta and pre-hilar branches of the main artery, directed to the kidneys. The aortic branches of larger caliber were called renal arteries and there pre-hilar branches were those arising from renal arteries before they reach the hilum. The hilum limits were set by a line drawn between the two most medial points in the frontal plane of each kidney. The renal arteries were observed according to their number (sum of renal arteries originating from the aorta) and early segmental and extra hilar branches of the main renal artery on each kidney.

We used the nomenclature adapted by Sampaio and Passos in 1992: hilar artery- branch of aorta that penetrates the kidney in hilum; extra-hilar artery- branch of renal artery that presents an extra hilar penetration (in superior or inferior poles); superior polar artery- branch of aorta penetrates the kidney at the superior pole; inferior polar artey- branch of aorta that penetrates the kidney at the inferior pole.

3 Results

We observed cases of single renal artery in 18/42 (42.9%) on right side and 20/42 (47.6%) on left side, originating from abdominal aorta. Multiple renal arteries originating from abdominal aorta were present in 24/42 (57.1%) cases on right side and 22/42 (52.4%) cases on left side, these

arteries include double hilar arteries (DHA) (Figure 1), three hilar arteries (THA) (Figure 2), one hilar and one Superior polar artery (SPA) (Figure 3), one hilar and one Inferior polar artery (IPA) (Figure 2), there percentage distribution represented in Table 1.

Renal artery showed early branching before it reached to the hilum of kidney in 14/42 (33.3%) cases on right side (Figure 1, 2 and 3) and 12/42 (28.5%) cases on left side (Figure 1, 3 and 4). These early branches from main renal artery entered the kidney through hilum or had an extra hilar

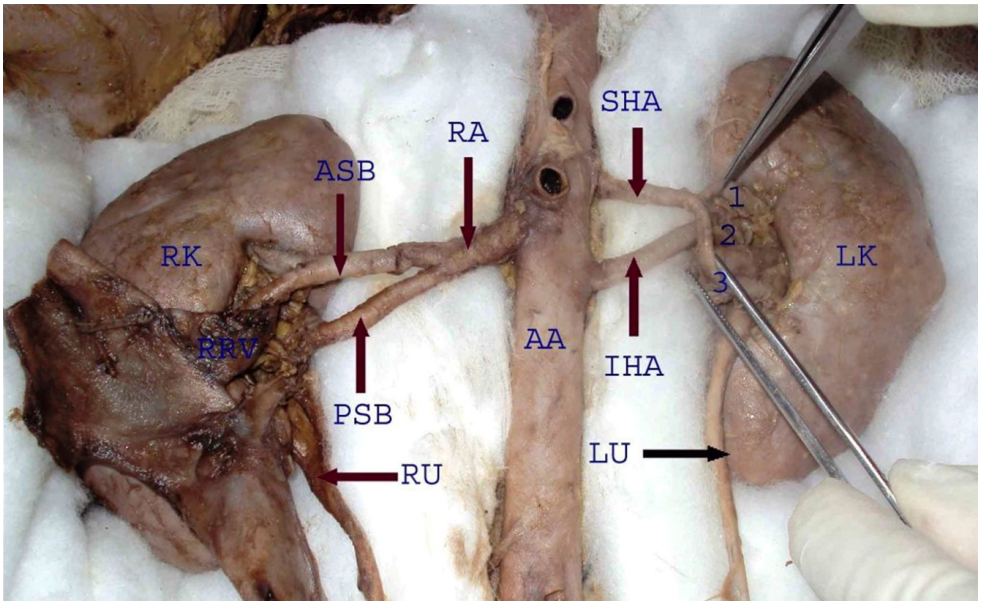

Figure 1. Photograph showing two hilar arteries on left side and early division of renal artery on right side. AA- abdominal aorta, SHA- superior hilar artery, IHA- inferior hilar artery, RA- renal artery, ASB- anterior segmental branch, PSB- posterior segmental branch, 1, 2, 3- Segmental branches on left side, RK-right kidney, LK- left kidney, RU- right ureter, LU- left ureter, RRV-reflected renal vein.

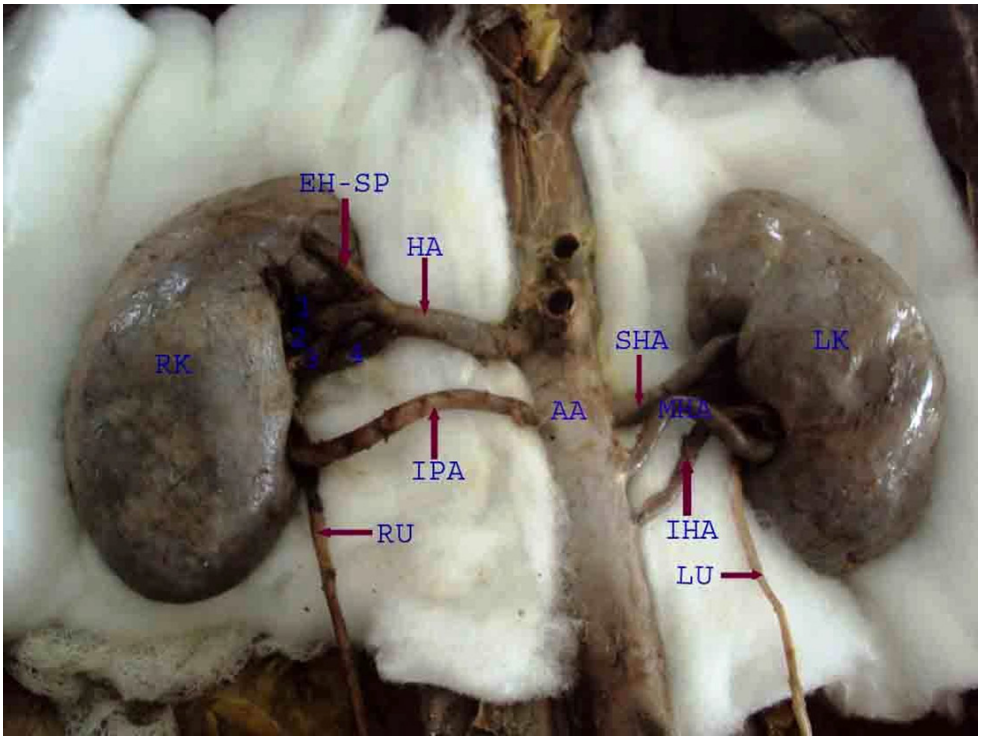

Figure 2. Photograph showing three hilar arteries on left side and one hilar and one inferior polar artery on right side. AA- abdominal aorta, SHA- superior hilar artery, MHA- middle hilar artery, IHA- inferior hilar artery, HA- hilar artery, IPA- inferior polar artery, 1, 2, 3, 4- Segmental branches on right side, RK-right kidney, LK- left kidney, RU- right ureter, LU- left ureter, EH-SP- extra hilar superior polar branch of hilar artery on right side.

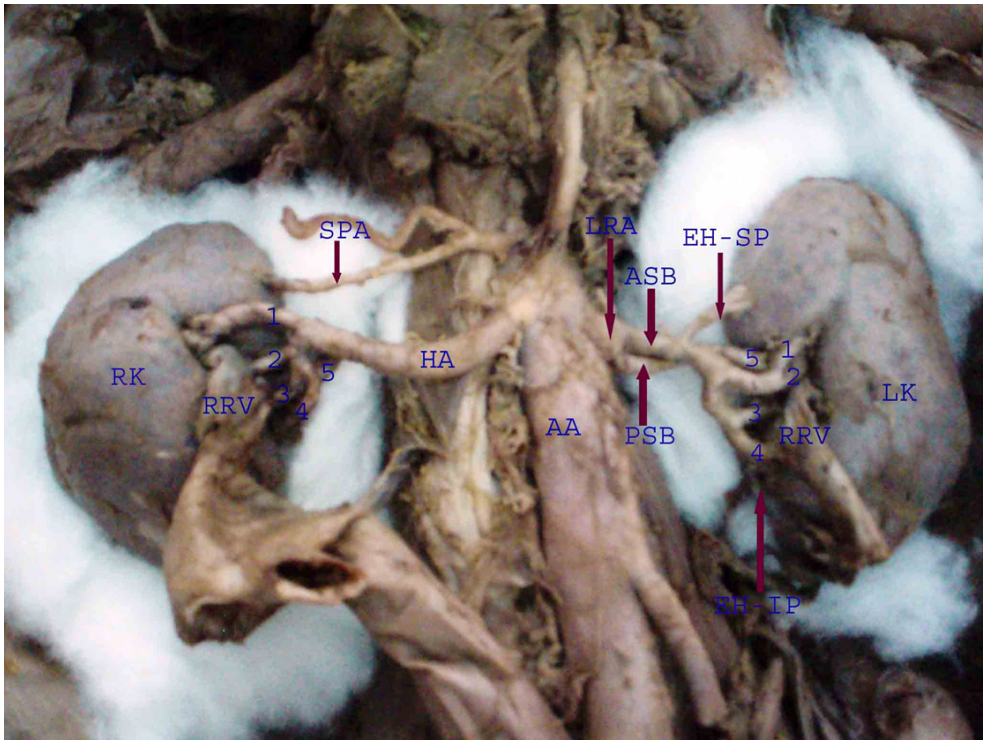

Figure 3. Photograph showing one hilar and one superior polar artery on right side and early division of renal artery on left side. AA- abdominal aorta, HA- hilar artery, SPA- superior polar artery, LRA- left renal artery, ASB- anterior segmental branch, PSB- posterior segmental branch, 1, 2, 3, 4, 5- Segmental branches on left and right side, RK-right kidney, LK- left kidney, EH-SP- extra hilar superior polar branch, EH-IP-extra hilar inferior polar branch, RRV-reflected renal vein.

Table 1. Percentage distribution of renal arteries for right and left kidney.

Arterial features	Right kidney	Left kidney	Total
Single renal artery	18/42(42.9%)	20/42 (47.6%)	38/84(45.2%)
Multiple renal arteries	24/42 (57.1%)	22/42 (52.4%)	46/84 (54.7%)
Double hilar arteries	9/42 (21.4%)	10/42 (23.8%)	19/84 (22.6%)
Three hilar arteries	4/42 (9.5%)	6/42(14.2%)	10/84 (11.8%)
Hilar and superior polar artery	7/42 (16.6%)	4/42 (9.5%)	11/84 (13.1%)
Hilar and inferior polar artery	4/42 (9.5%)	2/42 (4.7%)	6/84 (7.1%)

presentation by entering through one of its pole (Figure 2, 3 and 4). Extra hilar distribution of renal artery represented in Table 2.

4 Discussion

It is not very uncommon to find accessory renal artery (or arteries). The various types of accessory renal arteries, their positions, method of entry to the kidney and its segmentation were studied extensively by Sykes (1963). When there are two or more renal vessels, the vessels do not anastomose within the substance of kidney. Each artery supplies a separate part of kidney; hence none of the multiple arteries can be regarded as accessory. Obstruction of any renal artery leads to cessation of function and death of the part of kidney supplied by it; hence the term accessory is misleading because they are not extra but essential tissue sustaining arteries without anastomosis between them, which correspond to the segmental branches of a single renal artery (SAMPAIO and PASSOS, 1992; MADHYASTHA, SURESH and RAO, 2001). We therefore used the term hilar, superior polar and inferior polar renal artery, depending upon its entrance into the kidney.

There are reports of additional renal arteries in literature (KRISHNASAMY, RAO, SOMAYAJI et al., 2010; ILKE, AYSIN, OZCAN et al., 2009; PATASI and BOOZARY, 2009). Bordei, Sapte and Iliescu (2004) reported 54 cases of double renal arteries supplying one kidney originating from aorta. Out of 54 cases, 6 cases were bilateral. In about 28 cases supplementary renal artery entered the kidney through the hilum, in 16 cases it was inferior polar and in 5 cases it was superior polar. We compared our results with previous studies (Table 3) and found wide variability in variations of renal arteries among different population group. Our results present a significant high variation in occurrence of different forms of multiple renal arteries in Indian population in comparison to Turkish, Caucasians, Thai, American, Bosnian and Colombian population (Table 3).

Early division of renal artery before it reaches the hilum reported earlier as 75% (SARFRAZ, TAHIR and SAMI,

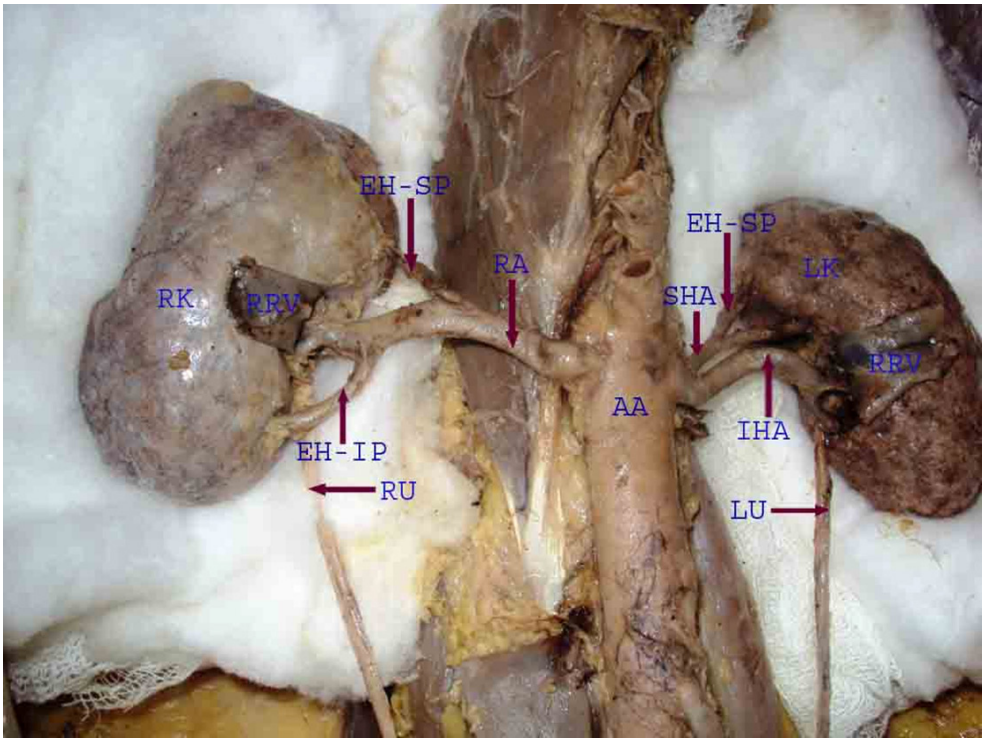

Figure 4. Photograph showing two hilar arteries on left side and early division of renal artery on right side. AA- abdominal aorta, SHA- superior hilar artery, IHA- inferior hilar artery, RA- renal artery, RK-right kidney, LK- left kidney, RU- right ureter, LU - left ureter, EH-SP- extra hilar superior polar branch, EH-IP-extra hilar inferior polar branch, RRV-reflected renal vein.

Table 2. Percentage distribution of extra-hilar branch of renal artery for right and left kidney.

Arterial features	Right kidney	Left kidney	Total
Extra-hilar superior polar	9/42 (21.4%)	8/42 (19%)	17/84 (20.2%)
Extra-hilar inferior polar	5/42 (11.9%)	1/42 (2.4%)	6/84 (7.1%)

Table 3. Comparison of data of multiple arteries in different population groups.

Authors	Population	DHA	THA	SPA	IPA
		Group			
Sampaio and Passos (1992)	Caucasians	7.9%	1.9%	6.8%	5.3%
Khamanarong, Prachaney, Utraravichien et al. (2004)	Thai	7.0%	1%	7%	3%
Çiçekcibasi, Ziylan, Salbacak et al. (2005)	Turkish	11.1%	-	3.3%	10.5%
Weld, Bhayani, Belani et al. (2005)	American	12.3%	-	9.6%	15.1%
Talovic, Kulenovic, Voljevica et al. (2007)	Bosnian	9%	1%	2%	10%
Saldarriaga, Perez and Ballesteros (2008)	Colombian	12.1%	-	4.3%	10.8%
Palmieri, Petroianu, Silva et al. (2011)	Brazilian	45.5%	18.8%	9.4%	3.2%
Present study (2012)	Indian	22.6%	11.8%	13.1%	7.1%

2008) and 81.67% (DAESCU, ZAHOI, MOTOC et al., 2012) respectively. In the present study we observed early division of renal artery before it reaches hilum in 33.3% and 28.5% for right and left kidneys. We also observed the extra hilar penetration of these branches and compared our results with similar studies (Table 4) and found that extra hilar penetration is more common at superior pole of kidney.

Embryological explanation of these variations has been presented and discussed by Felix (1912) In an 18 mm fetus, the developing mesonephros, metanephros, suprarenal glands and gonads are supplied by nine pairs of lateral mesonephric arteries arising from the dorsal aorta. Felix divided these arteries into three groups as follows: the 1st and 2nd arteries as the cranial; the 3rd to 5th arteries as the middle, and the 6th to 9th arteries as the caudal group. The middle group gives rise to the renal arteries. Persistence of more than one artery of the middle group results as multiple renal arteries (FELIX, 1912). Thus the multiple renal arteries in our study are a result of persisting lateral mesonephric arteries from the middle group.

Extra hilar polar arteries originating from renal arteries, directed towards superior or inferior pole have vertical

Table 4. Comparison of extra hilar penetration of branches of renal artery in Right Kidney (RK) and Left Kidney (LK).

Author's	Extra hilar superior polar		Extra hilar inferior polar	
	RK	LK	RK	LK
Talovic, Kulenovic, Voljevica et al. (2007)	10%	2%	2%	0%
Palmieri, Petroianu, Silva et al. (2011)	28.6%	11.6%	0%	1.4%
Present study	21.4%	19%	11.9%	2.4%

trajectory in comparison to polar arteries taking origin from aorta and they can leads to polar infarction (BEYER and DAILY, 2004), these superior and inferior polar extra hilar branches can be injured during mobilization and other surgical procedure (SAMPAIO and PASSOS, 1992). Inferior polar arteries can be a cause of ureteropelvic junction obstruction (SHOJA, TUBBS, SHAKERI et al., 2008b). Now a day allograft with multiple renal arteries has become a necessity to maintain donor pool (KADOLANI, OKAMOTO, NOBORI et al., 2005), but its outcome is still a matter of discussion. In opinion of some authors it has chances of rejection and poor graft functions (BRANNEN, BUSH, CORREA et al., 1982; GUPTA, KOTGIWAR, TRIVEDI et al., 2010), but Benedetti, Troppmann, Gillingham et al. (1995) did not find significant difference with regard to acute rejection rate in grafts with single or multiple arteries, however allograft with multiple renal artery have risk of renal artery stenosis (KAMALI, ABBASI, ANI et al., 2012) and technical difficulties for surgeon performing transplant operation (SHAKERI, TUBBS, SHOJA et al., 2007; SHOJA, TUBBS, SHAKERI et al., 2007).

Our results indicate that there are a large number of anatomical variations in the vascularization of the kidney. The most often incidence is the occurrence of multiple renal arteries. We believe that awareness of variations is necessary for surgical management during renal transplantation, repair of abdominal aorta aneurysm, urological procedures and for angiographic interventions.

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Received January 7, 2013
Accepted November 12, 2013