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Original article:

Anatomical and Morphological Study On Renal Blood Vessel in A Tertiary Care Hospital of West Bengal

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Abstract:

Introduction: Each kidney is supplied by a single renal artery and a single renal vein, which accounts for about 20% of the cardiac output. Right renal artery is longer, often higher than left. Renal arteries divide into 4-5 segmental arteries supplying the renal vascular segments but the renal vein does not follow the segmental drainage pattern. However, variations in the form of level of origin and arrangement of renal arteries are so frequent.

Method: A descriptive study was conducted in Coochbehar Govt. Medical College where twenty-six cadavers were dissected and distribution of renal blood vessels, their origin and termination were noted. The distance between two renal veins was measured along the midline of IVC from the plane of lower border of higher vein to the plane of upper border of higher vein. The width of IVC was measured at the level of right and left renal veins individually. The length of renal veins, renal artery and any additional blood vessel was also measured.

Observation: The average age of the cadavers 70.7692±6.5563 years. Veins coming out of hilum of the kidney were 1-4. Segmental arteries entering into the kidney were 2-6. average length of right and left renal veins were 17.3046mm ± 2.2663 & 51.4323mm ± 4.9873. The average length of right and left renal arteries were 46.8138 mm ± 2.3662mm & 40.7069mm ± 4.2682mm. In 92.3% cases the average distance between right and left renal veins were 12.5871mm ± 0.6103mm where left renal vein is higher in position than that of right renal vein. average width of IVC at the level of left & right renal veins are 34.6mm ± 1.7070mm & 34.6715mm ± 1.6379mm respectively.

Conclusion: Appropriate knowledge of the variations in the origin, course, relations and branching pattern of renal vessels is very essential to perform surgical procedures including transplantation of kidneys during infancy, childhood and in adults.

Key words: Renal artery, Renal vein, Inferior vena cava

Introduction

The paired renal arteries, taking 20% of the cardiac output arise from the lateral aspect of the aorta just below the origin of the superior mesenteric artery[1]. The right renal artery is longer, often higher than left and passing posterior to right renal vein, inferior vena cava[1]. The left renal artery is a little lower and passes behind the left renal vein and more anteriorly the body of the pancreas and splenic vein[1]. In 70% of individuals a single renal artery divides into anterior and posterior divisions near the renal hilum and these divide into 4-5 segmental arteries supplying the renal vascular segments. In majority of the cases five arterial segments namely apical, superior, middle, inferior & posterior are identified, although there can be considerable variations from this pattern[1]. The initial branches of segmental arteries are lobar, usually one to each renal pyramid. Before reaching the pyramid they subdivide into two or three interlobar arteries, extending towards the cortex around each pyramid. At the junction of the cortex and medulla, interlobar arteries dichotomize into arcuate arteries which diverge at right angles. As they arch between cortex and medulla, each divides further, ultimately supplying interlobular arteries which diverge radially into the cortex. The terminations of adjacent arcuate arteries do not anastomose but end in the cortex as additional interlobular arteries. Though most interlobular arteries come from arcuate branches, some arise directly from arcuate or even terminal interlobar arteries. Interlobular arteries ascend towards the superficial cortex or may branch occasionally en route. Some are more tortuous and recurve towards the medulla at least once before proceeding towards the renal surface. Others traverse the surface as perforating arteries to anastomose with the capsular plexus[1].

Moreover, different vascular segments of the kidney are supplied by end arteries but larger intrarenal veins have no segmental organization and anastomose freely[1]. Many interlobular veins begin beneath the fibrous renal capsule by the convergence of several stellate veins, which drain the most superficial zone of the renal cortex and so are named from their surface appearance. Interlobular veins pass to the corticomedullary junction and also receive some ascending vasa recta before ending in arcuate veins (which accompany arcuate arteries), and anastomose with neighbouring veins. Arcuate veins drain into interlobar veins, which anastomose and form the renal vein[1].

The large renal veins lie anterior to renal arteries and open into the inferior vena cava almost at right angles[1]. The left renal vein runs posterior to splenic vein, body of the pancreas and then crosses the aorta anteriorly just below the origin of superior mesenteric artery. Left gonadal vein enters into it from below and the left suprarenal vein, usually receiving one of the left inferior phrenic veins drains in it from above but nearer the midline. Finally, the left renal vein enters the inferior vena cava a little superior to right vein[1]. Interestingly, the longer left renal vein makes the left kidney the preferred side for live donor in transplant surgery[1]. The right renal vein is behind the descending duodenum and sometimes the lateral part of the head of the pancreas. It can be extremely short (<1 cm) such that safe nephrectomy may require excision of a cuff of the inferior vena cava[1]. Most of the variations of renal vessels remain unrecognized until being noticed during any surgical procedure, autopsy or arteriography.

Aims & Objectives

The aim of the present study was to explore the drainage pattern of renal blood vessels, the branching pattern of renal arteries, formation of renal veins and tributaries. The present study was also conducted to measure the length of different renal vessels and width of inferior vena cava.

Materials & Methods

A descriptive study with cross sectional design of data collection was conducted in Coochbehar Govt. Medical College & Hospital over a period of six months. Total twenty-six cadavers were dissected by following the standard procedure. The stomach, intestine and part of peritoneum were removed to get clear access to posterior abdominal wall structures like kidneys, associated blood vessels and nerves. After opening of the abdominal cavity the kidneys with ureters, renal blood vessels, abdominal aorta, Inferior vena cava (IVC) were dissected and exposed. The distribution of renal blood vessels, their origin and termination were noted. The distance between two renal veins was measured along the midline of IVC from the plane of lower border of higher vein to the plane of upper border of higher vein. The width of IVC was measured at the level of right and left renal veins individually. The length of renal veins, renal artery and any additional blood vessel was also measured. In both cases Digital Calipers was used for measuring the length. Thereafter, renal blood vessels were coloured and photographed. Finally, the collected data was tabulated in Microsoft spread sheet and was analysed by Epi-info 7.0 and SPSS 20.

Result & Analysis

Among the 26 dissected cadavers, 18 cadavers were male and rest were female. The average age of the cadavers 70.7692 years with standard deviation of 6.5563 years. The most common number of veins coming out of hilum of right & left kidney were 2 (Range: 1-2) and 1 (Range: 1-4) respectively. The most common number of segmental artery entering into the right & left kidney were 4 (Range: 2-5 and 2-6 respectively). The average length of right and left renal veins were 17.3046mm ± 2.2663 (SD) (Range=11.14-21.78mm) & 51.4323mm ± 4.9873 (SD) (Range=44.56-60mm). The average length of right and left renal arteries were 46.8138 mm (mean) ± 2.3662 (Range=42-51.1) & 40.7069mm ± 4.2682 (SD) (Range=33.63-48.56mm). The average length, standard deviation, range of right and left renal veins & arteries according to gender are depicted in **Table-I**. No significant difference in mean length of renal artery & vein was found between male & female. The average width of IVC at the level of left & right renal veins are 34.6mm ± 1.7070mm (SD) (Range= 27.24-36.87) & 34.6715mm ± 1.6379mm (SD) (Range= 27.62-36.76) respectively. The average width of IVC (at the level of left & right renal veins) according to gender is depicted in **table-II**. Moreover, no significant correlation was observed between width of IVC & age **(Table-III)**. No significant difference in mean width of IVC was found between male & female. In one case the both renal veins were at the same plane and in another case right renal vein as 10.2mm above the left renal vein. Among the rest of the cases, the average distance between right and left renal veins were 12.5871mm ± 0.6103mm (SD) (Range=11.78-14.12mm) where left renal vein is higher in position than that of right renal vein. Table-IV shows the mean distance between left & right renal vein according to gender where left renal vein was above the right renal vein but no significant difference was observed between male & female. No significant correlation was found between distance from left to right renal vein (where left renal vein was higher) and age **(Table-III).** Other veins in addition to main renal vein was found in three cases in the right side **(Fig-1)** and one case in the left side. The average length of right other veins was 32.92mm with standard deviation of 2.9416mm (Range=30.84-35mm) and the length of left vein were 28.8mm. Two accessory renal arteries were found in the right side and also in the left side **(Fig-1 & 2)**. The average length of right and accessory renal artery was 37.115mm & 37.055mm with standard deviation of 0.4738mm & 2.0011mm respectively. In one case left gonadal vein drained into the lower left renal vein **(Fig-2)** and in one case very short right renal vein was also present which was formed by union of two veins coming out of right hilum (**Fig-3)**.

Table-I: Average length, standard deviation, mode & range of right and left renal veins & arteries according to gender. (n=26)

Parameters		Mean (mm)	Standard Deviation (mm)	Mode (mm)	Range (mm)	Test of significance
Right renal vein	Male (n=18)	17.2456	2.4840	16.0	11.14-21.78	P-value = 0.84669
	Female (n=8)	17.4375	1.8245	18.0	15.34-21.2	
left renal vein	Male (n=18)	50.4656	5.2196	58.24	44.56-59.46	P-value = 0.14131
	Female (n=8)	53.6075	3.8548	47.78	47.78-60.0	
Right renal artery	Male (n=18)	47.1061	2.3419	44.6	42.46-51.1	P-value = 0.35527
	Female (n=8)	46.1563	2.4418	49.2	42.0-49.2	
left renal artery	Male (n=18)	40.3489	3.9533	36.46	33.63-48.56	P-value = 0.53217
	Female (n=8)	41.5125	5.1027	34.0	34.0-48.12	

Table-II: Average width of IVC (at the level of left & right renal veins) according to gender (n=26)

Parameters		Mean (mm)	Standard Deviation (mm)	Mode (mm)	Range (mm)	Test of significance
Left renal vein	Male (n=18)	34.3539	1.9171	34.5	27.24-36.24	P-value = 0.27895
	Female (n=8)	35.1538	0.9870	33.67	33.67-36.87	
Right renal vein	Male (n=18)	34.4867	1.8444	34.68	27.62-36.76	P-value = 0.39898
	Female (n=8)	35.0875	1.0172	35.42	33.34-36.22	

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Table-III: Regression equation & correlation coefficient of Width of IVC at the level of left & right renal veins with age.

Parameters	**Age**	
Width of IVC at the level of left renal vein ***(n=26)***	**r**=0.17	**r**^{2}=0.03
	=48.526+0.643×Width of IVC at the level of left renal vein	
Width of IVC at the level of right renal vein ***(n=26)***	**r**=0.14	**r**^{2}=0.02
	=48.975+0.629×Width of IVC at the level of right renal vein	
Distance between left & right renal vein ***(n=24)***	**r**=0.26	**r**^{2}=0.07
	=36.238+2.755× Distance between left & right renal vein	

Table-IV: Average distance between left & right renal vein with standard deviation, mode & range according to gender where left renal vein was above the right renal vein. (n=24)

		Mean (mm)	**Standard Deviation (mm)**	**Mode (mm)**	**Range (mm)**	**Test of significance**
Distance between left & right renal vein	Male (n=16)	12.6775	0.6869	11.86	11.86-14.12	P-value = 0.31529
	Female (n=8)	12.4063	0.3959	12.44	11.78-13.12	

Fig-1: Oblique right renal vein

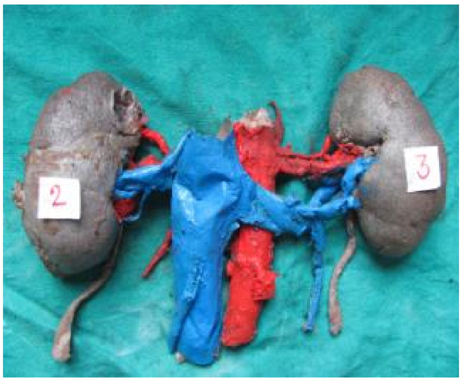
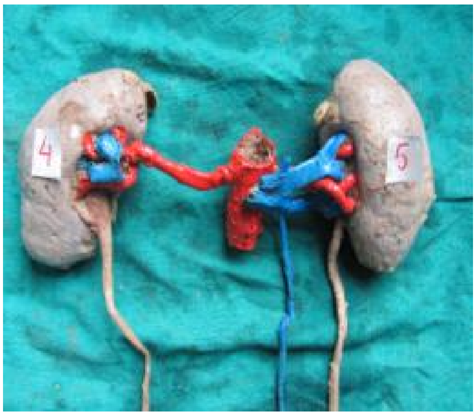


Fig-2: Gonadal vein draining into the lower left renal vein



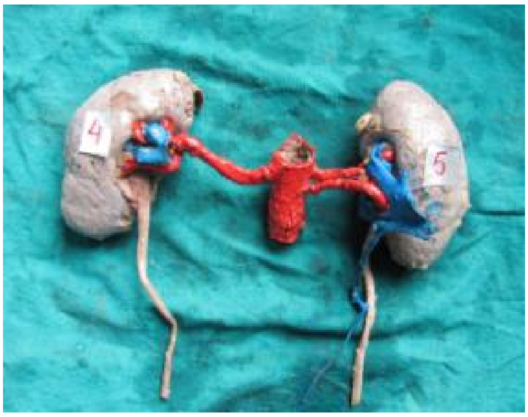
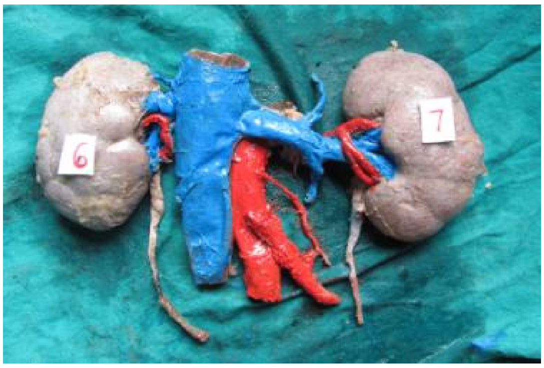


Fig-3: Short right renal vein



Discussion:

Proper knowledge of the variations in the origin, course, relations and branching pattern of renal vessels is very essential to perform surgical procedures including transplantation of kidneys during infancy, childhood and in adults. In 70% of the individuals, each kidney is supplied by a single renal artery and in 30% of individuals, accessory renal arteries are common and usually arise from the aorta above or below the main renal artery and follow it to the renal hilum. They are regarded as persistent embryonic lateral splanchnic arteries[2]. Renal veins variations are not as common as arteries (incidence – 0.8 to 6 %). Presence of additional renal vein has been reported to occur in 14% cases [3,4] . Satyapal (1995) has named any extra vein other than renal vein emerging out of kidney and draining separately in the inferior vena cava as 'additional' renal vein and classified these kidneys as type-3, using the drainage pattern of primary renal vein tributaries and renal vein proper as a basis[4]. The renal vascular segmentation was discovered by John Hunter in 1794, but a detailed account was given in 1950's by Corrosion Cast studies. There are five defined arterial segments: apical, superior, middle, inferior and posterior. The anatomical knowledge of these segments is important while performing nephrectomies[5]. According to Hollinshead (1958), the level of origin of renal artery is important topographically as right renal arteries which arise at a lower level typically pass in front of the inferior vena cava instead of behind it. He also gave a developmental explanation that the inferior vena cava below the level of kidney usually develops from a dorsally placed supracardinal system of veins while that at the level of kidney develops from a ventrally placed subcardinal system of veins. Thus, inferior vena cava is placed ventral to the right renal artery at a higher level and dorsal to it at a lower level[8]. The renal veins are interconnected within the kidney and if one renal vein is occluded; the remaining renal vein will continue to drain the entire kidney. Unlike the arteries, the venous tributaries anastomose within the kidney and there are minor anastomosis throughout the fibrous capsule with veins that are not tributaries of renal veins, but due to insufficiency of anastomosis, sudden occlusion of a vein may cause necrosis of the whole kidney[9]. Mandal et al., 2013 and Moore and Persaud (2002) reported emergence of two renal veins at the hilum of right kidney, which drained separately into inferior vena cava which is quite similar to our study[10,11]. In our study we found in one case left gonadal vein drained into the lower left renal vein and in one case very short right renal vein was also present which was formed by union of two veins coming out of right hilum. Satypal (1995), classified the drainage patterns of the renal veins. In the present study, we classified the renal veins according to their number, origin, and destination. A correlation was planned to establish in gender variation and difference in drainage between right and left. This classification differs from Satyapal's classification[12], where he described three types of renal venous drainage patterns (types IA, IB, IIA, IIB, and III) depending on the number of primary tributaries of the renal vein, the presence or absence of a posterior primary tributary, and the presence of an additional renal vein. The accessory renal vein described in the present study corresponds to type III described by Satyapal[12].

According to Gray's anatomy[1], one or two accessory renal arteries are frequently found, more especially on the left side they usually arise from the aorta, and may come off above or below the main artery, the former being the more common position. Instead of entering the kidney at the hilum, they usually pierce the upper or lower part of the organ. In our study, this fact is inconclusive. Budhiraja et al., 2010 observed pre-hilar multiple branching of renal arteries in 11 (11.66%) cases, duplication of renal arteries in eight cases (8.33%), superior polar arteries in seven cases (6.66%). Pre-hilar branches were directed towards apical, superior, middle, inferior and posterior vascular segment of kidney[6]. In the present case, inferior renal artery on the right side was seen to pass deep to inferior vena cava after taking origin from the lateral part of aorta at the level of L3. Almost a similar case was observed by Rajesh and Mane (2013)[7]. As per Lee Mc Gregor's synopsis of surgical anatomy, there is more than one renal artery in 15-20% of cases on the right and left sides respectively[13] and in a study conducted by Dhar and Lal (2005)[14], accessory renal arteries were observed unilateral in 15% cases and bilateral on 5% of cases. We found 7.7% accessory renal artery on right side as well as on left side. As the demand for kidney donation has rapidly increased, so it is essential to be aware of the possibility of donors with multiple renal arteries[15,16,17] and accessory renal artery especially the inferior accessory renal arteries are associated with hydronephrosis so it has clinical importance. This artery usually cross anteriorly to the ureter and may cause ureter hydronephrosis by obstruction. The reported incidence of additional renal arteries has a wide range (from 8.7%to 75.7%) and they, too, can cause hydronephrosis by obstruction[17, 18]. In this study of renal vasculature we found accessory renal arteries in 4 cases (7.7%) and in 2 cases we found variations in drainage of renal veins. This was a quite low frequency when compared to De Virgilic et al., 1995 (75%)[19], Graves et al., 1956 (50%)[20], 42 % in Brodie et al., 2004[21]. Chugh et al., 1993 & Singh et al., 1998 observed 36 % and 30-35 % of accessory renal arteries respectively[22,23]. Park et al., 1998 found 30% of aberrant renal arteries[24], whereas Dhar et al., 2005 observed 20%[14]. Satyapal et al., 2003 found 18% on right side, 27.6% on left side[24]. Karmacharya et al., 2006 found a very low incidence of 6.6 %[25] which was almost at same frequency when compared with our study. There were also single cases of accessory renal arteries reported by

Morishima et al., 1996[26]; Mohanty et al., 2002[27]; Bayramogulu et al., 2003[28]; Vaniya et al., 2004[29]; Tae et al., 2004[30] & Loukas et al., 2005[31].

Conclusion

Appropriate anatomical knowledge of renal vessels is very much essential for performing surgical procedures like stenting, stone extraction even in lithotripsy and moreover transplantation of kidneys during infancy, childhood and in adults. This anatomical knowledge will enrich and enhance the idea and confidence of surgeon during emergency procedures like renal injury. Concept of variation in origin, course, drainage and distribution of these vessels not only help the field of surgery but also they promote the decision made by clinician to start any new drugs like ACE inhibitors, ARB's, other diuretics. Proper knowledge of inferior vena cava (IVC), it's diameter and position will definitely guide the surgeons as well as critical care specialists to check the hydration status by calculating the collapsing index.

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