Anatomical Study of Renovascular Variations
A Cadaveric Study from Central India

Shweta B Shambharkar¹, Tarkeshwar D Golghate², Shabana Borate³, Vinaram P Rukhmode¹

¹Department of Anatomy, Govt. Medical College, Gondia, Maharashtra, India.
²Department of Anatomy, Govt. Medical College, Nagpur, Maharashtra, India.
³Department of Anatomy, Grant Govt. Medical College, Mumbai, Maharashtra, India.

Corresponding Author: Tarkeshwar D Golghate
tarkeshwargolghate@gmail.com

ABSTRACT

Introduction: The knowledge of the accessory renal arteries has grown in importance with the increasing number of renal transplants and other uroradiological procedures and for surgeons in view of nephrectomy and segmental renal resections. Renal artery variations include their origin, number and course. The most common is the presence of additional vessels. There may be several renal arteries or veins on each side or the renal artery may divide close to its origin into several branches. Aim and Objective: To study morphological variations and anomalies in the renal vasculature of Kidney. Material and Method: In order to facilitate the clinical approaches, we studied renal vascular pattern in 50 embalmed cadavers during the period of two years to establish the incidence of additional renal vessels in human cadavers and to understand the abnormalities of anatomical and embryological variations. Results: In our study we found, renal artery passing anterior to renal vein. Study also showed that accessory renal arteries arising from aorta are passing few to the upper pole, few to the lower pole unilaterally and few showed the same variation bilaterally. Early segmental branches of renal artery before entering the kidneys were also found in our study. Renal vein passing behind the abdominal aorta in one case and two or more renal veins at the hilum of kidney were also found in our study. Conclusion: Total renovascular variations were found in 42.42% cadavers. Detailed review of the literature shows that variations of renal arteries are more common than the renal veins, but in present study we found variations of renal veins (27.27%) more than the renal arteries(12.12%). A detailed knowledge of variations of renal vessels is obligatory for the safe performance of endovascular, laparoscopic, uroradiological procedures, renal transplants, clamping of vessels during partial nephrectomy and abate the complications in various procedures.

Keywords: renal artery, renal vein, accessory renal artery, variations.
1. INTRODUCTION

The renal arteries are the lateral branches of abdominal aorta just below the origin of superior mesenteric artery. And these paired renal arteries are considered as end arteries and it takes 20% cardiac output. The right renal artery is longer and higher than the left renal artery. In 70% individuals a single renal artery is present but it often varies in disposition. Renal veins, one on each side drain into inferior vena cava. The left renal vein (7.5cm) is three times longer than the right renal vein (2.5cm) [1]. And for this reason, the left kidney is the preferred side for live donor Nephrectomy [2]. Variations are reported by many researchers. These variations are useful in radiological imagings, renal transplant, renal artery embolization, renovascular hypertension, radical renal surgery [3].

2. AIMS AND OBJECTIVES

- To study the normal renal vasculature of kidney from the cadavers.
- To study morphological variations and anomalies in the renal vasculature of Kidney.
- To correlate the findings of the present study with the findings of the previous workers.

3. MATERIAL AND METHOD

The present study was undertaken on 50 embalmed human cadavers allotted to MBBS students selected from medical colleges. Both male and female cadavers were included in the study. The cadavers were donated by relatives with consent and with death certificate. None of them had any pathological lesions, traumatic lesions or surgical procedures in the abdominal regions.

In the present study, amongst 50 cadavers 31 were male and 19 were female, 50 were right and 49 were left kidneys (one kidney was absent in a cadaver). As per the Cunningham’s Manual of Practical Anatomy Volume-2 (Thorax and Abdomen) [4] anterior abdominal wall and abdominal cavity was opened. All the abdominal organs were removed for exposure of the posterior abdominal wall. Details of the position and external appearance of kidney in situ were noted. The right and left kidneys and the surrounding tissues were removed en bloc with the adjacent part of aorta and inferior vena cava cleared and studied. Kidneys were removed from the abdomen along with renal artery, vein and pelvis. Renovascular structures were well identified and noted. The results were presented as mean and SD. The variations were analysed between male and female, right and left kidneys. The statistical significance was set at p<0.05. Analysis was performed by using the PRISM software.

4. RESULTS

The study of renovascular variations in arrangement of hilar structures and accessory renal vessels of kidney was an observational study in which 50 human cadavers (31 male and 19 female) were dissected in medical colleges. The structures passing through the hilum of kidney from before backwards are renal vein, renal artery and renal pelvis (VAP) [1]. Variations in the arrangement of hilar structures are commonly seen. Anomalies or accessory renal vasculature found in present study

The present study showed the occurrence of renal artery anterior to renal vein at renal hilum in 15 kidneys out of 99 (15.15%) and one cadaver demonstrated the same feature bilaterally (figure 1). It is also observed that, an accessory renal artery arising from the aorta entering the upper pole without passing to hilum is present in 12 kidneys amongst which one had 2 accessory renal arteries at upper poles one above the other (figure 2). An accessory renal artery arising from the aorta entering the lower pole found in 2 left kidneys in different cadavers (figure 3). Bilateral accessory renal arteries arising from aorta were found in 3 cadavers (figure 4).

### Table 1: Variation found at Hilum in Present Study

<table>
<thead>
<tr>
<th>Variation</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>Present</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Absent</td>
<td>57</td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>12</td>
</tr>
<tr>
<td>Variation towards</td>
<td>Right</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Left</td>
<td>21</td>
</tr>
</tbody>
</table>

Early segmental branches of renal artery before entering the kidney were found in 14 cadavers on left and 13 cadavers on right side (27.27%) (figure 5).

In one cadaver we found a rare variation. After receiving two tributaries from left kidney at hilum which joined to form a single renal vein, it passed behind the abdominal aorta (retroaortic renal vein) and drained into inferior vena cava (figure 6).

Two or more renal veins at the hilum of kidney were found in 14 left kidneys and 13 right kidneys, of which 9 cadavers had shown bilateral variations (figure 7).

Fig. 6. Left renal vein after passing behind the aorta (Retroaortic)

Fig. 7. Bilateral multiple renal veins at the hilum

5. DISCUSSION

The structures passing through the hilum of kidney from before backwards are renal vein, renal artery and renal pelvis (VAP)1. Variations in the arrangement of hilar structures are a common finding. The vascular patterns of the kidneys are inevitable to understand in order to perform various procedures for treatment. The abnormalities in the renal arteries are mainly due to the various developmental positions of the kidney (Moore et al) [5]. The objective of this study is to bring awareness to the clinicians about the variations in the renal vascular region and their hilar relation. This study may also be helpful to clinicians in performing invasive techniques and to urologists performing nephrectomy and renal transplantation.

Poonam Verma (2012) [6] studied the renal hilar structures and observed their anomalous arrangement. She observed that there were three renal arteries on left side. The left main renal artery took origin from the anterior aspect of abdominal aorta. The other two arteries took origin from a common trunk coming out of the lateral aspect of abdominal aorta inferior to the main renal artery. The renal vein was found posterior to the main renal artery. In present study too, occurrence of renal artery anterior to renal vein at hilum of kidney was found in 15.15%.

Bulic et al (1996) [7] reported that the right kidney received two renal arteries arising from aorta entering through hilum. The left kidney had three arteries originating from aorta, one at its usual hilar position and the other two entering the renal cortex one at its upper pole and other at its lower pole. Budhiraja et al (2010) [8] in its study on anatomical variations of renal artery observed multiple renal arteries arising from abdominal aorta in 54.7% cases which includes double hilar arteries (22.6%), three hilar arteries (11.8%), hilar and superior polar arteries (13.1%), hilar and inferior polar arteries (7.1%). Ammar Mohammed Ali Mohammed et al (2012) [9] observed during a gross anatomy dissection of the abdomen of a 55 year old male cadaver that, the right kidney received two (superior and inferior) renal arteries of which one took origin from the lateral aspect of the abdominal aorta just at the level and one below the origin of superior mesenteric artery. Both arteries were equal in size and reach the kidney through the hilum, superior lied anterior to renal vein and inferior behind the renal vein. Praveen Kumar et al (2012) [10] studied 12 cadavers and 10 abortuses and found that two cadavers showed the accessory renal arteries on the right side arising from the abdominal aorta entering the lower pole of the kidney in front of the ureter.

In present study also it was observed that, accessory renal arteries arising from the aorta entering the upper pole without passing to hilum were present in 12 kidneys amongst which one had 2 accessory renal arteries at upper poles one above the other. Accessory renal arteries arising from the aorta entering the lower pole were found in 2 left kidneys in different cadavers. Bilateral accessory renal arteries arising from aorta and entering the upper pole were found in 3 cadavers. Right kidney showing presence of accessory renal artery was found in 6 cadavers. Left kidney showing presence of accessory renal artery was found in 6 cadavers.
Sharmila Aristotle et al (2013) [11] noted the vascular anatomy of kidney on 15 cadavers and observed the following anatomical findings:

- Accessory renal arteries
- Presegmental arteries
- Upper polar arteries
- Lower polar arteries
- Inferior suprarenal artery from accessory renal artery and
- Accessory renal vein.

In present study too, early segmental branches of renal artery before entering the kidney were found in 14 cadavers on left and 13 cadavers on right side (27.27%).

Satyapal K.S. et al (1999) [12] studied 1008 cases and revealed that retroaortic left renal vein were present in 0.5% of cases and additional renal vein in 0.4% of cases. Malcic Gurbuz J et al (2002) [13] observed multiple renal anomalies during dissection of the posterior abdominal wall in a 65 year old male cadaver. He found that left renal vein coursed posterior to the aorta and gave off three branches; the superior branch coursed on the vertebral column and drained into azygous vein while the inferior branches drained into the IVC. The right renal vein was double and both drained into the IVC separately. Syed Ali Anjamrooz et al (2012) [14] observed during dissection of the retroperitoneal region of the cadaver of a 50 year old Indian male, that on his left side, three veins arise from the hilum of the kidney and they subsequently joined to form the beginning of the renal vein. The left renal vein then passed downwards and medially for approximately 65 mm and bifurcated after crossing the psoas muscle. The two branches passed behind the aorta and subsequently terminated in IVC on the vertebral column. Praveen Kumar et al (2012) [10] studied 12 cadavers and noted that left renal vein was retroaortic in one cadaver.

In present study we observed in one cadaver that two renal veins arising at the hilum of the left kidney joined to form a single renal vein which passed behind the aorta (retroaortic) and drained into IVC. We also observed that two or more renal veins at the hilum of kidney were found in 14 left kidneys and 13 right kidneys, of which 9 cadavers had shown bilateral variations.

Graves [15] first described the vascular segments of the kidneys into five: apical, superior, inferior, middle and posterior. Each segment receives blood supply by the branches from the main renal artery. According to Graves, apart from main renal artery, artery arising from aorta should be named accessory and from other sources should be called aberrant. Accessory arteries arise either above or below the main artery. If crossed anterior to ureter can cause obstruction and could be the cause of hydronephrosis [16]. Embryological explanation of these variations are discussed by Keibel and Mall [17]. Anomalies of renal arteries are said to occur more frequently than anomalies of any other large vessels and also the anomalies of renal veins (Gillaspie, Miller and Baskin) [18]. But in the present study, multiple renal veins are found in 27 kidneys (27.27%), out of which 14 were on left side and 13 on right side in contrast to 12 kidneys (12.12%) showing accessory renal arteries.

In an extensive study by Pick and Anson19 40.5% of all kidneys examined had more than 2 vessels; that are more than a single artery and a single vein. For most parts of the body, variations or anomalies of veins are far more frequent than those of arteries, but this is not true of the vascular pedicle of kidney. Anomalies of renal arteries are more common than anomalies renal veins (Gillaspie and Co-workers) [17].

**Embryological explanation for variations in renal vasculature**

The gonads, mesonephros and metanephros are supplied by arterial segments from rete arteriosum urogenital which is the network formed by mesonephric arteries, later some of the roots of this network degenerate and blood supply to the area are replaced by the neighbouring root. This describes why the segmental branches have variation in their point of origin (Praveen Kumar) [10]. The occurrence of variations of renal vein can be explained on the basis of embryologic development. The development of the veins is a part of a complex developmental process of the inferior vena cava. The processes start of the 4th week and ends at the 8th week of conception. Three pairs of parallel veins formed, they are posterior cardinal vein, sub cardinal vein and suprachordal vein. Renal veins are formed by the anastomoses of sub cardinal and suprachordal veins. Initially two renal veins are formed i.e. Dorsal and ventral vein. The dorsal vein usually degenerates, ventral vein forms the renal vein. Persistence of these two veins results in additional renal vein on the right side (Praveen Kumar) [10].

If dorsal vein persists and ventral degenerates, or there is persistence of retroaortic anastomosis (Shubhra Mandal) [2], there is occurrence of retroaortic left renal vein.
6. CONCLUSION

From the present study, we come to the conclusion that total hilar renovascular variations out 50 dissected cadavers (99 kidneys) was found to be 42.42% kidneys; occurrence of renal artery anterior to renal vein in 15.15% kidneys; accessory renal artery passing to upper pole in 12.12% kidneys and that passing to lower pole in 2.02% kidneys; bilateral accessory renal arteries passing to the upper pole in 3.03% kidneys and no bilateral accessory arteries to lower pole; early segmental renal arteries in 27.27% kidneys; retroaortic left renal vein in one kidney; multiple renal veins in 14.14% on left side, 13.13% on right side and 9.09% bilaterally.

Normal renovascular information is useful for planning and performing of endovascular, laparoscopic, angiographic, uroradiological procedures and renal transplants. A detailed knowledge of variations of renal vessels is obligatory for the safe performance of endovascular procedures, clamping of vessels during partial nephrectomy and abate the complications in various surgical procedures. Hence this study will serve as a useful guideline for doing above mentioned procedures.

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REFERENCES