CASE REPORT

A rare representation of kidney vasculature – cadaveric case report

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Abstract

Understanding the nuances of renal vascular anatomy is paramount in the context of retroperitoneal surgeries and kidney transplant procedures. This case report describes the unique vascular variations observed in the right kidney of an adult male cadaver during dissection. The right kidney was supplied by three renal arteries: two through the hilum and an extra hilar superior polar branch, and one through the lower pole. Three renal veins emerged independently from the hilum, each opening separately into the inferior vena cava. Two of these veins emerged anterior to the renal pelvis, while the third emerged posterior to it. Notably, two veins terminated into the lateral aspect of the inferior vena cava, while one terminated into its posterior aspect.

Keywords: Multiple Renal veins, Multiple Renal Arteries, Abnormal Renal vasculature

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Introduction

The renal arteries arise bilaterally from the abdominal aorta, usually at the level of the L1-L2 intervertebral disc. After originating from the abdominal aorta, the renal arteries travel laterally toward each kidney. They pass posterior to the renal veins and run along the posterior surface of the kidneys. The left artery is shorter than the right; it crosses the left crus and psoas, behind the left renal vein, both being covered by the tail of the pancreas and the splenic vessels. The longer right artery crosses the right crus and psoas behind the inferior vena cava and the short right renal vein; these structures separate the artery from the head of the pancreas and bile duct and from the second part of the duodenum. Upon reaching the kidneys, each renal artery usually divides into five segmental arteries that enter the hilum of the kidney. They are distributed to different segments or areas of the kidney. Lobar arteries arise from each segmental artery, one for each renal pyramid. Before entering the renal substance, each lobar artery gives off two or three interlobar arteries. The interlobar arteries run toward the cortex on each side of the renal pyramid. At the junction of the cortex and the medulla, the interlobar arteries give off the arcuate arteries, which arch over the bases of the pyramids. The arcuate arteries give off several interlobular arteries that ascend in the cortex. The afferent glomerular arterioles arise as branches of the interlobular arteries.

Each kidney is drained by a single renal vein. The renal veins exit the kidneys and course anteriorly to the corresponding renal artery and join the vena cava at right angles, at the level of L2 vertebra. Each emerges from the hilum of the kidney as five or six tributaries which soon unite. The left renal vein is three times as long as the right (7.5 cm compared with 2.5 cm) and usually crosses in front of the aorta. The right renal vein is usually slightly shorter and more vertical than the left renal vein because of the positioning of the inferior vena cava on the right side. It receives the left suprarenal vein and left gonadal vein (testicular vein in males and ovarian vein in females) and possibly a left inferior phrenic vein. In contrast the shorter right renal vein usually drains only its own kidney. On the right side, the right renal vein directly connects to the inferior vena cava (IVC) (1,2).

Multiple renal arteries (MRA) are present in 20-30% of individuals (two in 22%, three in 1-2%, four in 0.1%) (3). Sampaio and Passos categorized the renal arteries according to their point of entry as follows: the Hilar artery, which originates as a branch from the aorta and enters the kidney through the hilum; the extra-hilar artery, a renal artery branching off the abdominal aorta and including additional branches to the poles; the superior polar artery (SPA), emerging from the aorta and entering the kidney through its upper pole; and the inferior polar artery (IPA), arising from the aorta and entering the kidney through its lower pole. While multiple renal veins are found in 16.7 % of individuals their occurrence on the left is significantly less (2.1%) compared to the right (16.6%) (4), attributed to the divergence in embryological development between the two sides. The origin of the left renal vein at its hilum occurs within a single stage of embryological development as compared to the right (5).

Case Report

During routine student dissections at the Department of Anatomy, General Sir John Kotelawala University, Ratmalana, anomalies with the vasculature of the right kidney were observed in an 86-year-old male cadaver of Sri Lankan origin, who passed away of natural causes. Observation and medical history investigations showed no signs of any scars or surgical intervention on the abdomen or lumbar regions.

The left kidney presented with a single renal artery (SRA) which bifurcates 22 mm from the abdominal aorta (Figure 1), with the inferior branch supplying to the hilum and the superior branch further bifurcating 10 mm from the initial bifurcation into three branches with the superior branch supplying the superior pole of the kidney and the middle and inferior branch supplying the hilum.

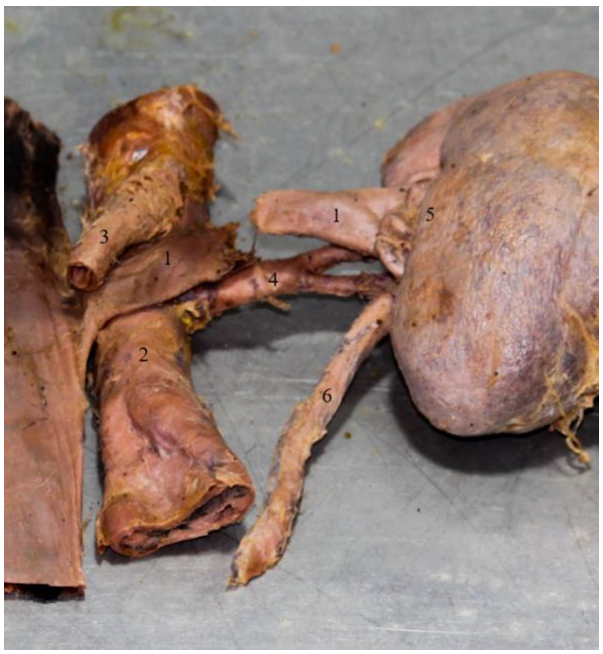

Figure 1: Renal vasculature of the Left Kidney
(1 – Dissected Left Renal Vein, 2 – Abdominal Aorta, 3 – Detached Superior Mesenteric Artery, 4 – LRA – Left Renal Artery, 5 – Kidney hilum, 6 – Left ureter)

Figure 2: MRA arrangement in the Right Kidney from Abdominal Aorta
(1 – Abdominal Aorta, 2 – Detached Superior Mesenteric Artery, 3 – LRA – Left Renal Artery, 4 – IVC – Inferior Vena Cava, 5 – LRV – Detached Left Renal Vein, 6 – SRV – Right Superior Renal Vein, 7 – Kidney hilum, 8 – HA – Right Superior Hilar Artery, 9 – EHA – Right Middle Extra-hilar artery, 10 – IPA – Right Inferior Polar Artery)

The right kidney was seen to present with multiple renal arteries (MRA), where triple renal arteries (TRA) were observed branching separately from the abdominal aorta (Figure 2.), the superior renal artery which is a hilar artery (HA) originates anterolateral from the abdominal aorta surface and observed to directly course towards the hilum. The middle renal artery is identified as an extra-hilar artery (EHA) which originates at the lateral surface of the abdominal aorta and bifurcates 20 mm from the branching point of the abdominal aorta. The superior branch of the EHA bifurcates 16 mm from the initial branching point and supplies the superior pole of the kidney, whereas its inferior branch directly

supplies the superior aspect of the hilum of the kidney with the inferior and superior branches having a 10 mm distance apart from each other. The inferior renal artery which is an inferior polar artery (IPA) originates anterolateral and directly supplies the inferior pole of the kidney. The right renal vein (RRV) was observed to present with a triple right renal vein (DRRV) (Figure 3) originating from the hilum of the kidney and draining into the Inferior Vena Cava (IVC). The superior RRV is 35 mm in length from the kidney to the IVC and the middle RRV is 29 mm in length from the kidney to the IVC, with the two veins being 7 mm apart from each other. The third inferior vein originating from the hilum posterior to renal arteries and 51mm in length to IVC and draining on the posterior surface of the IVC.

Figure 3: Double Renal Vein arrangement from hilum of the right kidney to IVC
(1 – Right kidney, 2 – IVC – Inferior Vena Cava, 3 – Abdominal Aorta, 4 – Detached Superior Mesenteric Artery, 5 – SRV – Right Superior Renal Vein, 6 – MRV – Right Middle Renal Vein, 7 – MRA - Multiple Renal Arteries, 8 – Right ureter, 9 – Kidney hilum)

Discussion

Multiple renal arteries (MRA) are present in 20-30% of individuals (two in 22%, three in 1-2%, four in 0.1%) (3). In study done in India found 2 TRA in 100 kidney donors and it was observed that out of 2 incidences, one comprised a hilar-superior polar-inferior polar arterial arrangement whereas other was organized on a 2 hilar-inferior polar structure (3). Sampaio and Passos analyzed the renal vasculature of 266 kidneys by dissection and reported two hilar with one superior polar extra-hilar branch in 3.4% while triple hilar artery in 1.9% (6). In this study, it was observed triple renal arteries (TRA) branching separately from the abdominal aorta (Figure 2.), the superior renal artery which is a hilar artery (HA), the middle renal artery is identified as an extra-hilar artery (EHA) which originated at the lateral surface of the abdominal aorta and bifurcates 20 mm from the branching point of the abdominal aorta, the superior branch of the EHA bifurcates 16 mm from the initial branching point and supplied the superior pole of the kidney, whereas the inferior branch directly supplied the superior aspect of the hilum of the kidney. The inferior renal artery which is an inferior polar artery (IPA) originates anterolateral and directly supplies the inferior pole of the kidney which is a totally different arterial arrangement compared to previous case studies we referred.

Multiple renal veins were reported in previous studies in the region and worldwide. In scholarly literature, a considerable prevalence of variations in the anatomical structure of the left renal vein (approximately 92%) has been documented. Additionally, the occurrence of

having multiple right renal veins (more than 2 vessels) was observed in approximately 8.0 to 9.7% of cases (7). In a case study in Japan found 4 right renal branches (8) while Brazil reported 29% (9/31) double right renal veins and 9.7% (3/31) triple or more renal veins in 342 living kidney donors (7). Another case study done in India also reported a double renal vein observation on right kidney (8). Another case was reported in Sudan where equal sized double renal veins in the right kidney (9). Another case reported in Brazil also reported having triple right renal vein arrangement where 3 calibrous veins (10). In our study right renal vein (RRV) was observed to present with a triple right renal vein (TRRV) (Figure 4.) originating from the hilum of the kidney and draining into the Inferior Vena Cava at independent courses (IVC).

Previous study done in Sri Lanka found that 25.7% of patients with multiple renal arteries and early branching have associated multiple renal veins (4) which also repeatedly patterned in some studies (5,11,9). The left kidney was presented with a kidney cyst on the lateral surface. (Figure 4.) The specimen was observed in a body of a male elderly person of Sri Lankan origin who was reported to passed away at the age of 86 from a natural cause which exceed the life expectancy of Sri Lanka which averages around 76.39 years (12). No patient history or the cause of death were reported related to kidney function and with no observable surgical or injury scaring on the body which lead to the believe that the cyst as well as the abnormal kidney vasculature must have gone undetected throughout his life.

Figure 4A

Figure 4B

4A Ensemble anterior view of dissected left and right kidney with vascular variations.
4B Ensemble posterior view of dissected left and right kidney with vascular variations.
(1 – Right kidney, 2 – Left kidney, 3 – IVC, 4 – Abdominal aorta, 5 – Detached Superior Mesenteric artery, 6 – Superior Right renal vein, 7 – Middle Right renal vein, 8 – Detached Left renal vein, 9 – Left Renal vein, 10 –Right Superior hilar renal artery, 11 – Right Middle extra-hilar renal artery, 12 – Right Inferior polar renal vein, 13 – Inferior Right renal vein, 14 – Ureters, 15 – Renal Cyst on left kidney)

Proper understanding of anatomical variations in renal vasculature is crucial in surgical and diagnostic procedures. Before performing a kidney donor nephrectomy, a routine angiographic assessment of the kidney's arterial supply is crucial to identify any anomalies or unexpected conditions.

Selective angiography should be conducted for each artery when multiple arteries are present to accurately detect potential kidney issues or artery-related problems. While the left kidney is preferred for donation due to its longer renal vein, anatomical differences often lead to choosing the right kidney in many cases. An early branching single renal artery is treated similarly to having multiple blood sources. A main renal artery of at least 1 cm length is necessary for safe ligation and anastomosis. Presence of a single anatomical variation during radiography can lead to misdiagnoses. The naked calix sign indicates multiple arteries in selective angiography. Multiple renal arteries should be considered during vascular trauma assessment. Selective renal angiography aids in diagnosing issues like hydronephrosis. Arteriography might be needed before radical nephrectomy with multiple arteries. Multiple renal arteries might be linked to unusual renal development (6).

The presence of multiple renal veins within a single kidney can give rise to various clinical complications. Surgical procedures become more complex, requiring careful access and manipulation to avoid bleeding or damage. Blood clot formation (venous thrombosis) in these veins can obstruct blood flow, potentially leading to kidney dysfunction or tissue death. Elevated pressure within kidney vessels (renal hypertension) and reduced kidney function (renal insufficiency) can result from compromised venous drainage. Additionally, the risk of varicocele formation increases, and diagnostic imaging becomes more challenging. Kidney transplantation and donation pose increased complexities, and misinterpretation during radiological imaging is possible. Vigilant monitoring is necessary for timely management of potential complications in individuals with multiple renal veins.

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Conflicts of Interest: None

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