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VARIATIONS OF RENAL ARTERIES AND
VEINS: A CADAVERIC STUDY WITH
CLINICAL SIGNIFICANCE

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ABSTRACT

Background: Variations in the vascular anatomy of the kidneys are frequently encountered and hold considerable importance in surgical and radiological practice. Renal arterial anomalies are more common than venous variations and include accessory renal arteries, polar arteries, and early branching patterns. Venous anomalies commonly involve multiple renal veins and altered drainage patterns. Knowledge of these variations is essential during renal transplantation, nephrectomy, urological procedures, and interventional radiology to prevent vascular injury and postoperative complications.

Case Presentation: During routine cadaveric dissection, several unusual variations of renal vessels were observed, including accessory renal arteries, superior polar arteries, early division of renal arteries, and multiple renal veins. The present study highlights these variations and discusses their embryological basis and clinical relevance. Awareness of such anatomical differences is crucial for accurate surgical planning and successful radiological interventions involving the kidneys. Keywords-renal artery, renal vein, case report, anatomical variation.

Conclusion: The case highlights clinically important renal vascular variations and the need for awareness during renal surgical and radiological procedures.

Keywords: renal artery; renal vein; anatomical variation; accessory renal artery; polar artery; cadaveric study

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INTRODUCTION:

The kidneys are paired, bean-shaped retroperitoneal organs that play a vital role in maintaining the internal homeostasis of the human body. They are situated on either side of the vertebral column, extending approximately from the twelfth thoracic (T12) to the third lumbar (L3) vertebral levels, with the right kidney positioned slightly lower than the left due to the presence of the liver. Each adult kidney measures approximately 10–12 cm in length, 5–7 cm in width, and 2.5–3 cm in thickness, weighing about 120–170 g.

Each kidney is supplied by a single renal artery arising from the abdominal aorta at the level of the first and second lumbar vertebrae, just inferior to the origin of the superior mesenteric artery. Near the renal hilum, the artery divides into anterior and posterior branches. The renal vein lies anterior to the artery and drains into the inferior vena cava. The left renal vein is usually longer and passes between the abdominal aorta and superior mesenteric artery before draining into the inferior vena cava, whereas the right renal vein is shorter and enters the vena cava directly.¹⁻³

However, variations in the number, origin, branching pattern, and course of renal vessels are common. Accessory renal arteries are the most frequently encountered arterial anomaly. Venous variations, though less common, include multiple renal veins and variations in venous drainage. These anatomical differences are clinically significant in renal transplantation, nephrectomy, angiography, and reconstructive urological procedures.¹⁻³

The embryological development of kidneys explains many of these vascular variations. During foetal life, the kidneys develop in the pelvic region and gradually ascend to the lumbar region. As they ascend, they receive blood supply from successive branches of the abdominal aorta. Normally, the lower vessels regress while new superior vessels persist. Failure of regression of these embryonic vessels results in accessory or aberrant renal arteries.⁴

The present study reports unusual bilateral variations in renal arteries and veins observed during cadaveric dissection, including accessory renal arteries, superior polar arteries, early branching patterns, and multiple renal veins.

CASE PRESENTATION

Patient Information

A 70-year-old male cadaveric specimen was examined during routine cadaveric dissection for first-year medical students at Shri Dharmasthala College of Ayurveda and Hospital, Hassan, in 2025.

Clinical Findings

Not applicable; this was a cadaveric anatomical case.

Diagnostic Assessment

The renal vessels were identified and assessed by detailed cadaveric dissection. The source report documents bilateral renal arterial branching variations, an accessory renal artery, a superior polar artery, and two right renal veins.

Therapeutic Intervention

Not applicable; this was a cadaveric anatomical case.

FOLLOW-UP AND OUTCOMES

Not applicable. The anatomical variations were documented during dissection.

CASE DETAILS

The study was conducted during routine cadaveric dissection for first-year medical students at Shri Dharmasthala College of Ayurveda and Hospital, Hassan, in 2025. The specimen was obtained from a 70-year-old male cadaver.

During dissection, an accessory renal artery was identified on the left side. This vessel originated from the left lateral aspect of the abdominal aorta just below the superior mesenteric artery. It coursed superiorly and parallel to the left renal artery before reaching the upper pole of the left kidney. Near the kidney, it bifurcated into two branches that entered the anterior surface of the upper pole.

Further dissection revealed bilateral early branching and multiple divisions of the renal arteries. The renal arteries arose from the abdominal aorta approximately at the level of the second lumbar vertebra.

On the right side, the renal artery divided into upper and lower divisions about 4 cm proximal to the hilum. The upper division further subdivided into upper, middle, and lower branches. Some branches entered the kidney through the hilum, while others entered through the upper and lower parts of the medial border. One branch passed anterior to the renal vein. Two right renal veins draining separately into the inferior vena cava were also observed.

On the left side, the renal artery bifurcated into upper and lower divisions about 3 cm before the hilum. The upper division produced three branches that entered the hilum anterior to the left renal vein, while the lower division passed posterior to the vein. In addition, a superior polar artery arose directly from the abdominal aorta above the origin of the left renal artery and entered the upper pole of the kidney after dividing into two branches.

DISCUSSION

Renal vascular variations are primarily developmental in origin. During embryogenesis, kidneys ascend from the pelvic cavity to the lumbar region while receiving blood supply from transient branches of the abdominal aorta. Persistence of these embryonic vessels results in accessory renal arteries or aberrant branches.

Accessory renal arteries were first described by Bartolomeo Eustachi in 1564. These arteries are often referred to as aberrant, supernumerary, or additional renal arteries. Since they are end arteries without significant collateral circulation, accidental injury or ligation may lead to ischemia of the supplied renal segment.^{5,6}

Early branching of the renal artery is another important variation. In such cases, the renal artery divides close to its origin from the abdominal aorta rather than near the hilum. This variation increases surgical complexity during renal transplantation and partial nephrectomy because multiple arterial branches require careful dissection and vascular anastomosis.^{7,12}

Previous anatomical studies have reported varying incidences of renal vascular anomalies. Ramesh Rao et al. observed renal arterial variations in approximately 30% of individuals. Lippert et al. reported accessory renal arteries in 26% of cases⁸. Archana Srivastava and colleagues documented accessory renal arteries in nearly one-fourth of examined kidneys. Karmalkar et al. found duplicated renal arteries more frequently on the right side.⁹

In the present study, bilateral multiple renal arterial branching and accessory arteries were identified. A superior polar artery arising directly from the abdominal aorta was also observed. Such vessels are clinically significant because polar arteries may compress the ureter and contribute to hydronephrosis.^{10,11}

Venous variations are less common than arterial anomalies but are equally important during surgical procedures. Multiple renal veins, especially on the right side, are among the most frequent venous variations¹³. In the present case, two right renal veins draining separately into the inferior vena cava were identified.

The embryological basis of renal venous variations is associated with the complex development of the inferior vena cava and its tributaries. Failure of regression or persistence of embryonic venous channels may produce supernumerary renal veins or anomalous venous drainage patterns¹³.

Understanding these vascular variations is essential in renal transplantation, nephrectomy, angiography, and other urological procedures. Preoperative identification of such anomalies helps prevent haemorrhage, vascular injury, ischemic complications, and technical difficulties during surgery.

Knowledge of renal vascular variations is important in several clinical situations:

Renal transplantation: Multiple arteries or veins increase the complexity of vascular anastomosis and may influence graft survival.

Nephrectomy: Accurate identification of all vascular branches is necessary to avoid bleeding and preserve renal function.

Urological surgeries: Polar arteries may compress the ureter and contribute to obstructive conditions.

Interventional radiology: Procedures such as angiography, embolization, and stenting require precise understanding of renal vascular anatomy.

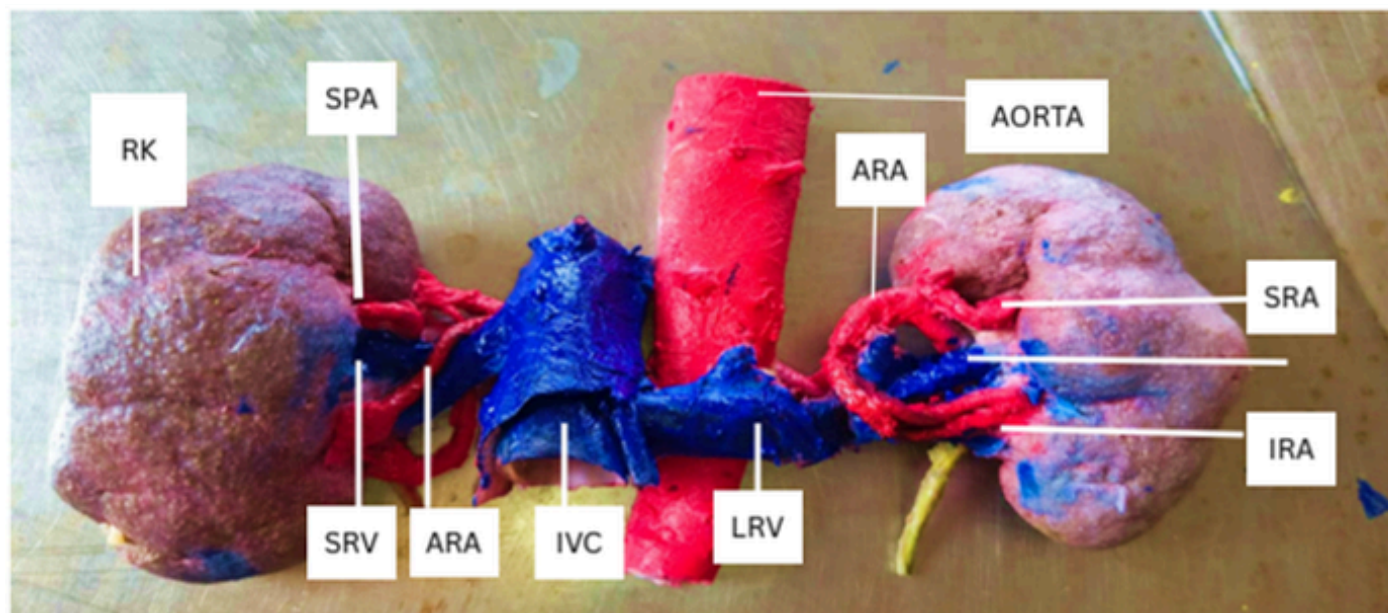


FIGURE 1. ANTERIOR VIEW-

RK-RIGHT RENAL ARTERY, RRV-RIGHT RENAL VEIN, IVC-INFERIOR

VENA CAVA, IPV-INFERIOR RENAL VEIN, ARA-ACCESSORY RENAL ARTERY, PEA-PREILIOIC

ARTERY, SRV-SUPERIOR RENAL VEIN, LRV-LEFT RENAL VEIN, LK-LEFT KIDNEY, IPA-INFERIOR
POLAR ARTERY

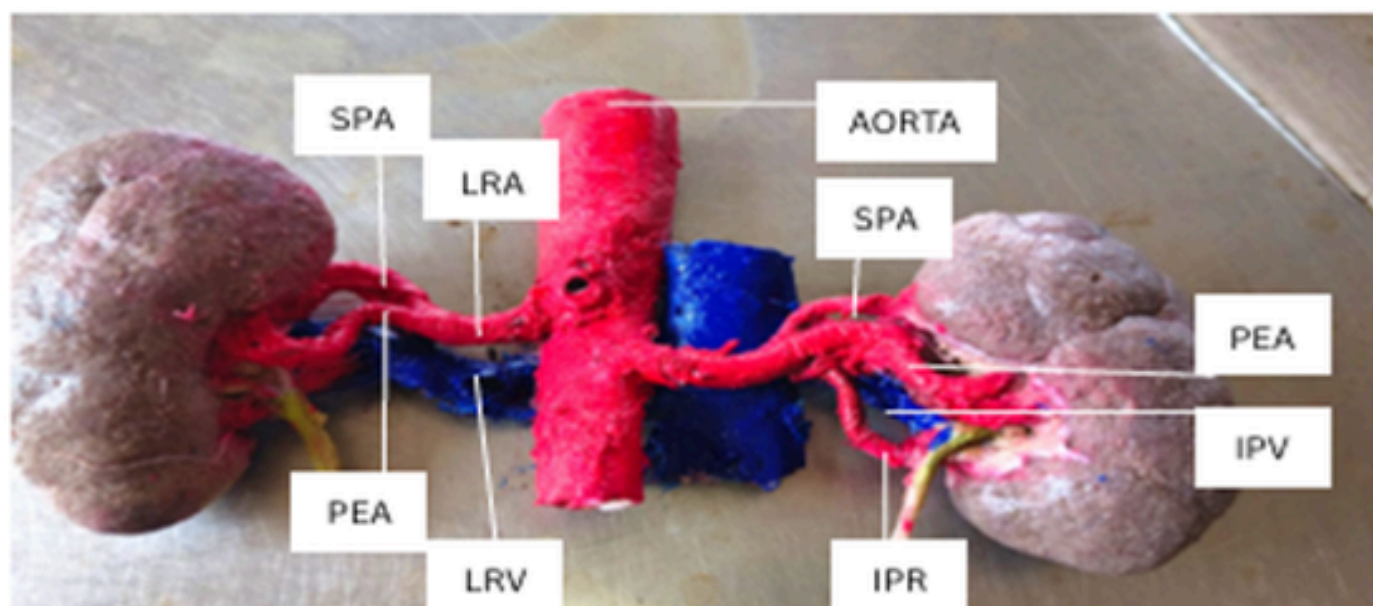


FIGURE 2. POSTERIOR VIEW.

SPA-SUPERIOR RENAL ARTERY, LRV-LEFT RENAL VEIN, IVC-INFERIOR VENACAVA,

IPV-INFERIOR RENAL VEIN, ARA-ACCESSORY RENAL ARTERY, SRV-SUPERIOR RENAL

VEIN, LRV-LEFT RENAL VEIN, IPA-INFERIOR POLAR ARTERY

CONCLUSION

Renal vascular variations are common and clinically important. Arterial variations occur more frequently than venous anomalies, with accessory renal arteries representing the most common finding. Early branching patterns and polar arteries are also significant because of their surgical implications. Venous variations commonly involve multiple renal veins.

The present cadaveric study demonstrated bilateral renal arterial branching anomalies, accessory polar arteries, and multiple renal veins. Thorough knowledge of these anatomical variations is essential for surgeons, radiologists, and clinicians performing renal interventions, as careful preoperative assessment can reduce operative complications and improve patient outcomes.

PATIENT PERSPECTIVE

Not applicable to this cadaveric anatomical study.

INFORMED CONSENT

Not applicable to a cadaveric anatomical study. Any institutional permissions or donor-related documentation should be added according to the institution's requirements.

ETHICAL CONSIDERATION

The study was conducted during routine cadaveric dissection at Shri Dharmasthala College of Ayurveda and Hospital, Hassan. Any institutional ethical approval or body-donation documentation should be stated if applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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