FOLIA MEDICA CRACOVIENSIA
Vol. LXV, 4, 2025: 177–182
PL ISSN 0015-5616 eISSN 2957-0557
DOI: 10.24425/fmc.2025.156707

Bilateral extra hilar branching pattern of renal artery: Its embryological basis and clinical elucidation

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Abstract: Extra-hilar branching refers to the main renal artery dividing before reaching the hilum of the kidney into an anterior and posterior branch. Embryologically, initial segmentation of renal artery may occur due to ablation of renin cell precursors and mutations of the renin-angiotensin system or due to delay in communication between the constituents located within the mesenchyme of the vascular structures and those found in the mesenchyme of the metanephros, such as hepatocyte growth factor and glial-derived neurotrophic factor. The variations in renal vascular anatomy is of clinical relevance to surgeons and radiologists in cases of renal transplantation, vascular reconstruction and assessment of renovascular hypertension. The present case report involves the extra hilar branching of bilateral renal arteries with its embryological basis and clinical elucidation.

Keywords: renal artery, hilum, endothelial cell, renin cell, renal transplantation.

Submitted: 18-Sep-2025; **Accepted in the final form:** 30-Nov-2025; **Published:** 31-Dec-2025.

Introduction

The renal artery, one of the lateral branches of abdominal aorta terminates near hilum of the kidney by bifurcating into an anterior and a posterior division immediately prior to its ingress into the renal parenchyma, subsequently giving rise to several segmental vessels, specifically four originating from the anterior division and one from the posterior division. Extra-hilar branching refers to the main renal artery dividing before it reaches the hilum [1]. Prior studies have revealed that 51% of individuals who donate kidneys display variations in the anatomical structure of the renal artery; of this subgroup, 38% exhibit the presence of an accessory renal artery, whereas 13% show an earlier bifurcation of the renal artery. Consequently, it is imperative to recognize these anatomical variations through a thorough evaluation of the donors prior to the execution of renal transplantation, urological interventions, and angiographic procedures. Therefore, before undergoing these interventional procedures, it is imperative to assess the donors in order to identify any variations [2]. The present study involves the analysis of extra-hilar branching patterns of renal artery with its embryological basis and clinical significance.

Case report

During routine cadaveric dissection of an 85 years old male, extra hilar branching pattern of renal artery was noted bilaterally in the Department of Anatomy at All India Institute of Medical Sciences, New Delhi. The structures and their relationships in the hilar region were clearly defined after a thorough dissection. The formation of the renal pelvis was normal bilaterally but the variation is as reported below. Due to an unusual branching pattern of the renal artery, the arrangement of structures at hilum was disturbed. On the right side, the renal artery (RA) with its normal origin and course from abdominal aorta divided immediately into an anterior and posterior division. The anterior branch divided into two segmental branches- right anterior segmental artery (RASA1 & RASA2) as seen in Fig. 1A, C while the posterior branch entered as a segmental branch (RPSA) into the substance of the kidney. After leaving the hilum, the right renal vein (RRV) tributaries joined to form a single trunk, which then drained into the inferior vena cava (Fig. 1C). On the left side, RA divided into an anterior and posterior branch before reaching the hilum. The anterior branch is divided into three (LASA1, LASA2 & LASA3) and posterior into two (LPSA1 & LPSA2) segmental branches in the extra hilar region (Fig. 1B, D). Kidneys appeared lobulated on both sides. The distance of renal artery division from hilum (Table 1) and diameter of renal arteries along with its segmental vessels (Table 2) was measured using digital vernier calliper and rounded off to nearest millimetre.

Table 1. Distance (in mm) of renal artery division from hilum.

S. No.	Distance (in mm)	RRA	LRA
1	Anterior division from hilum	20	38
2	Posterior division from hilum	35	32

RRA — Right renal artery, LRA — Left renal artery

Table 2. Diameter (in mm) of bilateral renal artery and its segmental branches.

RRA (8)				LRA (7)				
RASA (6)			RPSA (5)	LASA (5)			LPSA (5)	
RASA1 (3)	RASA2 (4)	RASA3 (2)		LASA1 (3)	LASA2 (2.5)	LASA3 (2.5)	LPSA1 (4)	LPSA2 (2)

RRA — Right renal artery, LRA — Left renal artery, RASA — Right anterior segmental artery, RPSA — Right posterior segmental artery, LASA — Left anterior segmental artery, LPSA — Left posterior segmental artery

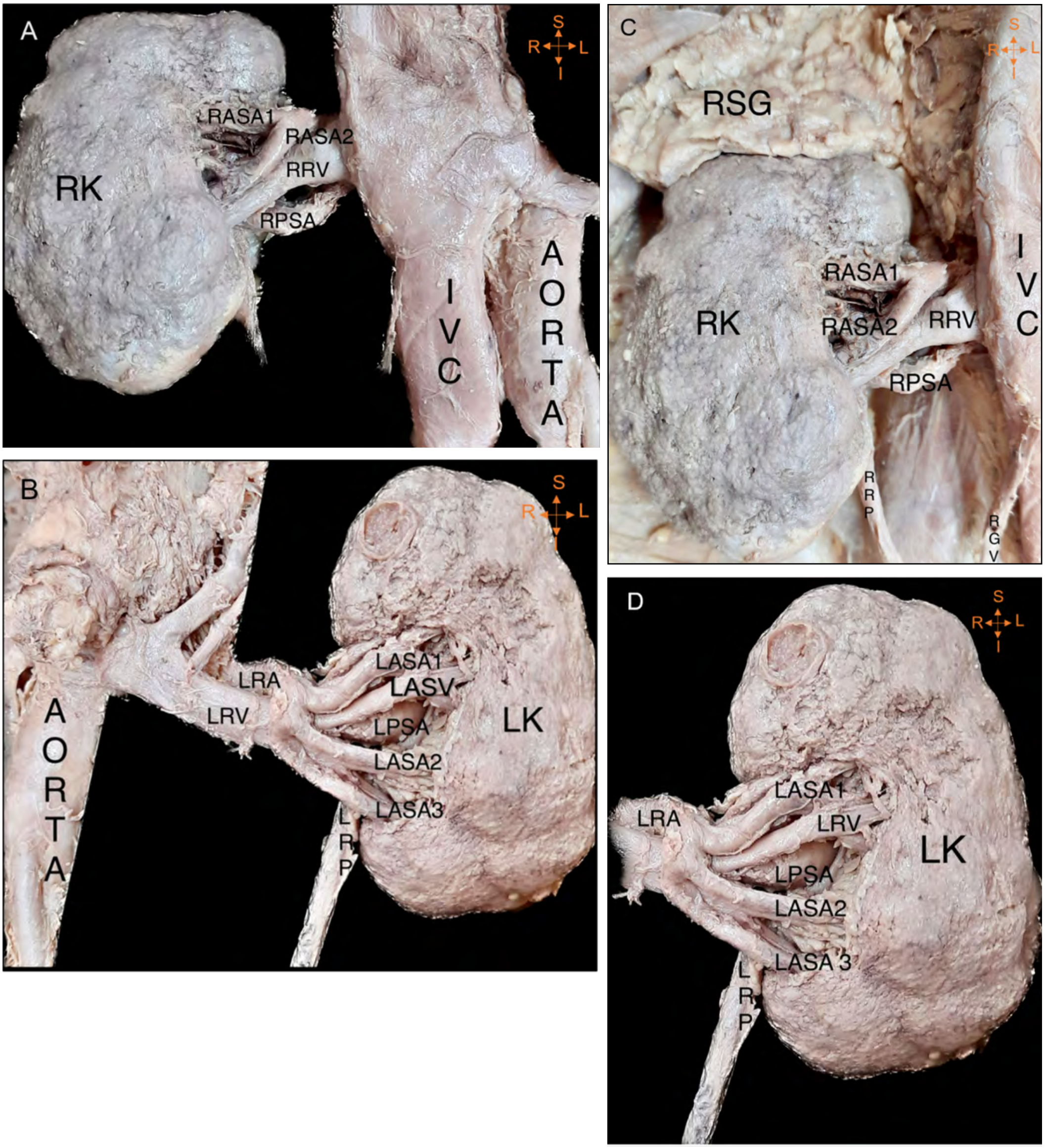

Fig. 1. Extra hilar segmentation of renal artery. **A, C.** Arrangement of structures in the extra hilar region of right kidney. **B, D.** Arrangement of structures in the extra hilar region of left kidney; S, superior; I, inferior; R, right; L, left; RK, right kidney; LK, left kidney; IVC, inferior vena cava; RRV, right renal vein; LRA, left renal artery; LRV, left renal vein; RASA, right anterior segmental artery; RPSA, right posterior segmental artery; LASA, left anterior segmental artery; LPSA, left posterior segmental artery; LASV, left anterior segmental vein; LRP, left renal pelvis; RRP, right renal pelvis; RGV, right gonadal vessel; RSG, right suprarenal gland.

Discussion

Previously, many variations pertaining to kidney shapes, positions, vascular variations have been reported earlier, there are no reports to the best of our knowledge on bilateral variation of the renal vessels mentioning embryological basis and clinical aspect as discussed in present paper. It has been well established that the genesis of the renal arteries and their morphological variations may be elucidated through the phylogenetic development of mesonephric arteries. These arteries are responsible for supplying blood to the kidneys, adrenal glands, and gonads bilaterally along the aorta, extending from the sixth cervical vertebra to the third lumbar vertebra, a territory referred as the rete arteriosum urogenitale. As the developmental process advances, these arteries experience a degenerative regression, culminating in the formation of a singular dominant mesonephric artery. Insufficient development of mesonephric arteries may give rise to the presence of multiple renal arteries [3]. The cellular composition of the renal vasculature include endothelial cells (ECs), vascular smooth muscle cells (SMCs), renin cells, pericytes, mesangial cells and the nerve fibers that innervate the vessels. During arteriolar development, pericytes stimulate EC proliferation and migration. In turn, ECs activate the pericyte precursor cell population. The paracrine interactions between these two cell types involve mainly sphingosine 1 phosphate (S1P) signalling pathways and vascular endothelial growth factor (VEGF) [4]. S1P signalling pathway serves as a pivotal regulator of endothelial cell (EC) migration and proliferation. S1P, activates a family of five G-protein coupled receptors, and it has been demonstrated that the genetic ablation of S1P1 in murine models lead to embryonic lethality occurring between embryonic days 12.5 and 14.5, attributing to anomalous vasculature development. This is potentially stemming from impaired migration and/or differentiation of vascular smooth muscle cells (SMCs), demonstrating the critical role of S1P1 in vascular maturation [5].

According to a previous study, the renal arterial tree branching and elongation have been linked to renin-expressing cells. The emergence of renin-expressing cells at the branching site precedes the development of a new arterial branch. This is followed by the elongation and outpouching of a new arteriole that is nearly entirely covered in renin cell progenitors. Renin cells develop into mesangial cells and SMCs as the vessels get mature. These studies suggest renin cells either directly or indirectly control the renal arterial tree branching and elongation by producing angiotensin locally [6]. Gene profiling indicates that renin cells are capable of producing more than 14 different well known angiogenic and trophic factors, including VEGF, angiopoietin, and autotaxin, among others [7]. Where there is an absence of angiotensin II actions in the presence of renin cell hyperplasia, ischemia, or exogenous activation of renal vasoconstrictors, it may contribute to the branching and elongation of the renal arterial tree and in pathologic conditions to aberrant, circumferential growth of the renal arterioles. An alteration in the formation of kidney vasculature can lead to major developmental abnormalities in both humans and animals. Ablation of renin cell precursors and renin-angiotensin system mutations cause early arterial abnormalities, which are followed by a deterioration in kidney structure and function [8]. Another study suggests that the initial segmentation of renal artery may arise from delay in communication between the constituents located within the mesenchyme of the vascular structures and those found in the mesenchyme of the metanephros, such as glial-derived neurotrophic factor and hepatocyte growth factor [9].

The anatomical variations pertaining to the renal artery (including supernumerary arteries and extra hilar branching) have the potential to significantly influence surgical interventions such as renal transplantation, percutaneous biopsy, aortic aneurysm repair and angiographic procedures. Venous compression syndromes can present with clinical symptoms and are amenable to diagnosis through a comprehensive assessment of radiological characteristics [10]. The identification of extra-hilar branching is of paramount significance for radiologists when evaluating patients who are being considered as prospective renal donors. The existence of extra hilar branching may disqualify a candidate from serving as a renal donor, given that the length of the donor renal artery is generally required to be no less than 1 cm to adequately construct the primary renal artery anastomosis between the donor and recipient [11]. Understanding the vascular anatomy and segmental distribution of the human kidney is crucial for performing partial resections and transplantation, as effective management of bleeding is essential. Since the identification of renal segments, the urological complications that typically followed partial nephrectomy have notably diminished [12].

Acknowledgements

The cadaver was donated for educational and research purpose in Department of Anatomy at AIIMS, New Delhi, India.

Author contributions

Analysis or interpretation: A.S., H.H.H.N., P.P. Drafting of the manuscript: A.S. Critical revision of the manuscript: S.S. Approval of the final version of the manuscript: all authors.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

Funding

None declared.

References

1. *Rao N.S., Kishore K., Sujatha K., Rao H.R.K.*: Extra Hilar Branching of Renal Arteries: An Anatomical Study. Int J Anat Res. 2015; 3 (4): 1568–1572.
2. *Munnusamy K., Kasirajan S.P., Gurusamy K., et al.*: Variations in Branching Pattern of Renal Artery in Kidney Donors Using CT Angiography. J Clin Diagn Res. 2016; 10 (3): AC01–AC03.
3. *Felix W.*: The development of the urogenital organs. In: Keibel F., Mall F.P. (eds.) Manual of Human Embryology. Philadelphia: J.B. Lippincott Company 1912; 752–880.
4. *Jeansson M., Gawlik A., Anderson G., et al.*: Angiopoietin-1 is essential in mouse vasculature during development and in response to injury. J Clin Invest. 2011; 121 (6): 2278–2289.
5. *Liu Y., Wada R., Yamashita T., et al.*: Edg-1, the G protein-coupled receptor for sphingosine-1-phosphate, is essential for vascular maturation. J Clin Invest. 2000; 106 (8): 951–961.
6. *Reddi V., Zaglul A., Pentz E.S., Gomez R.A.*: Renin-expressing cells are associated with branching of the developing kidney vasculature. J Am Soc Nephrol. 1998; 9: 63–71.
7. *Brunskill E.W., Sequeira-Lopez M.L.S., Pentz E.S., et al.*: Genes that confer the identity of the renin cell. J Am Soc Nephrol. 2011; 22 (12): 2213–2225.

8. *Ferrara N.*: Role of vascular endothelial growth factor in the regulation of angiogenesis. Kidney Int. 1999; 56 (3): 794–814.
9. *Gomez R.A., Sequeira-Lopez M.L.*: Vascular development of the kidney. In: Tomanek R.J. (ed.) Assembly of the vasculature and its regulation. Boston: Birkhauser 2002; 193–210.
10. *Leckie A., Tao M.J., Narayanasamy S., et al.*: The Renal Vasculature: What the Radiologist Needs to Know. RadioGraphics. 2021; 41 (5): 1531–1548.
11. *Kang W.Y., Sung D.J., Park B.J., et al.*: Perihilar branching patterns of renal artery and extrarenal length of arterial branches and tumour-feeding arteries on multidetector CT angiography. Br J Radiol. 2013; 86 (1023): 20120387.
12. *Rani N., Singh S., Dhar P., Kumar R.*: Surgical importance of arterial segments of human kidneys: an angiography and corrosion cast study. J Clin Diagn Res. 2014; 8 (3): 1–3.