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Abnormal Origin of the Double Inferior Vena Cava with the Interiliac Vein and Anomalous Structure of the Left Renal Hilum in a Human Cadaver

Origen Anómalo de la Vena Cava Inferior Doble con la Vena Interilíaca y Estructura Anómala del Hilio Renal Izquierdo en un Cadáver Humano

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SUMMARY: This report presents a case of double inferior vena cava (DVIC), anomalous origin of the interiliac vein, and early branching of the left renal artery sandwiching double left renal veins in a single male cadaver. In the cadaver, DIVC and an interiliac vein with anomalous origin were identified: the latter collected blood from the right pelvic cavity, anastomosed with the right internal iliac vein and right common iliac vein to form a venous circuit, and finally drained into the left inferior vena cava. Additionally, anomalous structures at the left renal hilum were observed, mainly characterized by early branching of the left renal artery, with complex crossing relationships among the resulting segmental arteries, double left renal veins, and renal pelvis. This paper details these anatomical variations and discusses their possible embryological evolution mechanisms and relevant clinical significance. Since these anatomical variations affect the outcomes and prognosis of retroperitoneal space and pelvic surgical procedures, familiarity with the knowledge of renal vascular and inferior vena cava anomalies is crucial for surgeons.

KEY WORDS: Interiliac vein; Inferior vena cava; Renal artery; Renal vein.

INTRODUCTION

The inferior vena cava (IVC) drains structures below the diaphragm, formed by bilateral common iliac vein confluence slightly right of the 5th lumbar vertebra (angle 40°-120°, mean 76°). Its tributaries (beyond common iliac origins) divide into visceral (draining paired abdominal organs/liver: hepatic, right testicular/ovarian, renal, right suprarenal veins) and parietal (inferior phrenic, lumbar veins) branches; most (except hepatic veins) accompany corresponding arteries.

Renal vessels include renal arteries (RAs) and veins (RVs). Paired RAs arise at right angles from the lateral abdominal aorta, just inferior to the superior mesenteric artery, dividing into anterior (apical/superior/middle/inferior segmental arteries) and posterior (continuing as posterior segmental artery) trunks near the hilum. Common accessory (supernumerary/polar) RAs arise above/below the main RA, entering the hilum or supplying renal poles/parenchyma.

Extensive intrarenal venous anastomoses converge into 2-3 hilar trunks, uniting into a single RV that runs anterior to the RA and drains into the IVC at nearly a right angle. The right RV (RRV) has few extra-renal tributaries; the left RV (LRV) receives left suprarenal, inferior phrenic, capsular veins and an intermediate hemiazygos root (superiorly) plus left testicular, ovarian, ureteral veins (inferiorly), with anastomoses to surrounding veins.

Within the renal sinus, RV is typically anterior to RA. Anterior RA trunk branches pass anterior to RV and renal pelvis (RP) to supply renal segments; the posterior trunk runs posterior to RP, continuing as posterior segmental artery intra-renally.

IVC and renal vessel variations are clinically crucial for retroperitoneal surgeries. This report describes two unusual anatomical variations from routine dissection at

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Wuhan University of Science and Technology School of Medicine's Anatomy Department, enhancing understanding of renal vasculature and IVC anatomy and physiological imaging.

CASE REPORT

The anatomical variation described herein was identified during a routine dissection conducted as part of a clinically oriented regional anatomy course. The donor was an 84-year-old male cadaver obtained through the Body Donation Program of the Wuhan Red Cross Society at Wuhan University of Science and Technology. The recorded cause of death was lung cancer. The authors confirm that all applicable local and international ethical guidelines and laws governing the use of human cadavers for anatomical research were strictly adhered to. Additionally, the present analysis was approved by the Institutional Research Ethics Committee (Approval No.: 2025216).

1) Numerical variation of the inferior vena cava (Fig. 1)

During a routine dissection, a numerical variation of the inferior vena cava (IVC) was observed. Two distinct IVC channels were identified, ascending in parallel and converging to form a single vessel 21.9 mm inferior to the hepatic border. The resulting common IVC, with a flattened diameter of 36.8 mm, subsequently entered the liver. The left IVC (flattened diameter: 27.5 mm) coursed along the left side of the abdominal aorta. At the level of the first lumbar vertebra (L1), it crossed anterior to the aorta to join the right IVC on the contralateral side. The right IVC (flattened diameter: 23.4 mm) maintained its course along the right side of the abdominal aorta throughout its ascent.

2) Tributary anomaly of the left inferior vena cava (Fig. 1)

An anatomical variation was observed in the left iliac venous system, consisting of an interiliac vein (flattened diameter: 7.6 mm) that drained into the left

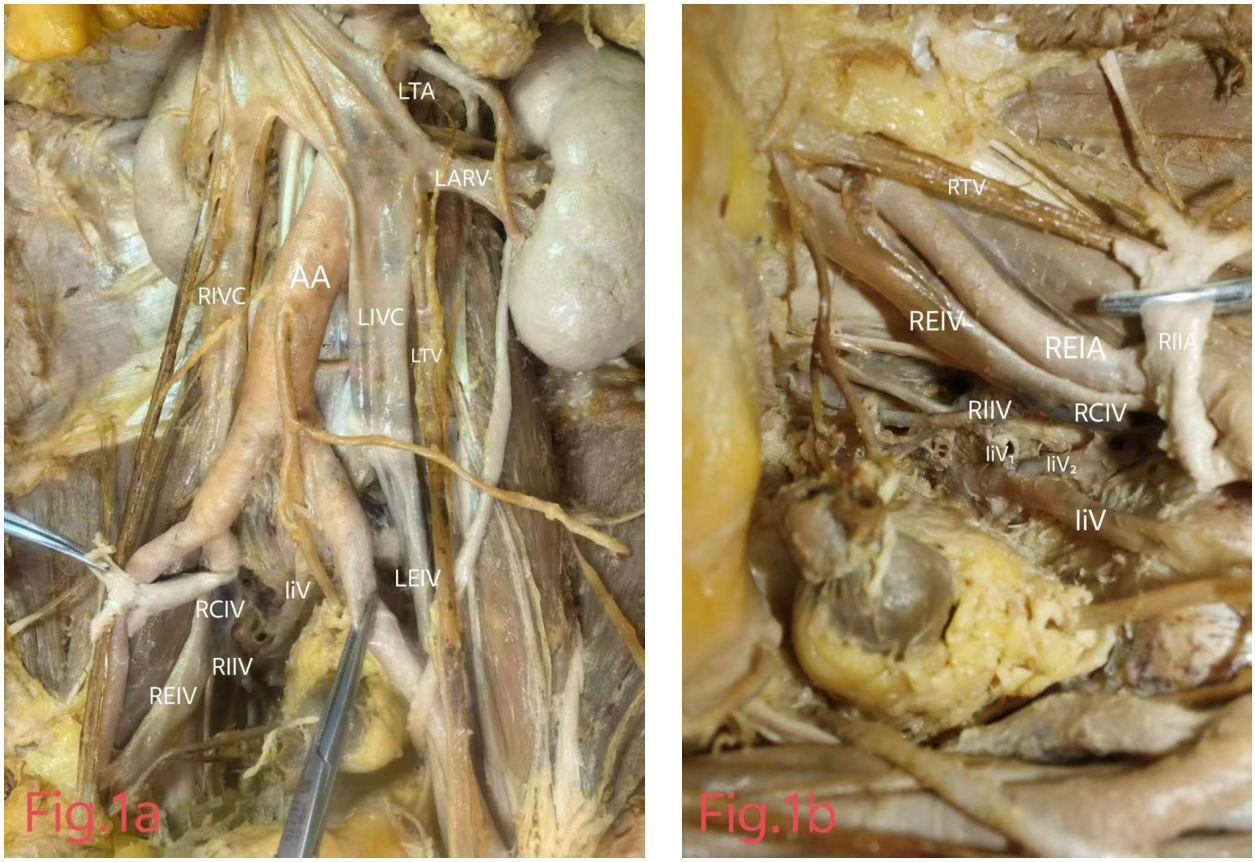


Fig. 1. Images 1a and 1b show the double inferior vena cava, as well as a variant iliac interstitial vein originating from the right pelvic cavity and anastomosing with the right internal iliac vein and right common iliac veins. RIVC:right inferior vena cava, LIVC:left inferior vena cava, AA:abdominal aorta, LTA:left testicular artery, LTV:left testicular vein, RTV:right testicular vein, LARV:left anterior renal vein, RCIV:right common iliac vein, RIIV:right internal iliac vein, RIIA:right internal iliac artery, REIV:right external iliac vein, REIA:right external iliac artery, IiV: interiliac vein, IiV1: branch 1 of interiliac vein, IiV2:branch 2 of interiliac vein, LEIV:left external iliac vein.

inferior vena cava 32.4 mm superior to the confluence of the left external and internal iliac veins. After collecting venous return from the right hemipelvis, this anomalous vessel ascended obliquely from a right inferior to left superior direction for 97.9 mm before terminating in the left inferior vena cava. Along its course, it gave off branches that anastomosed sequentially with the right internal iliac vein and the right common iliac vein, forming a distinct venous circuit.

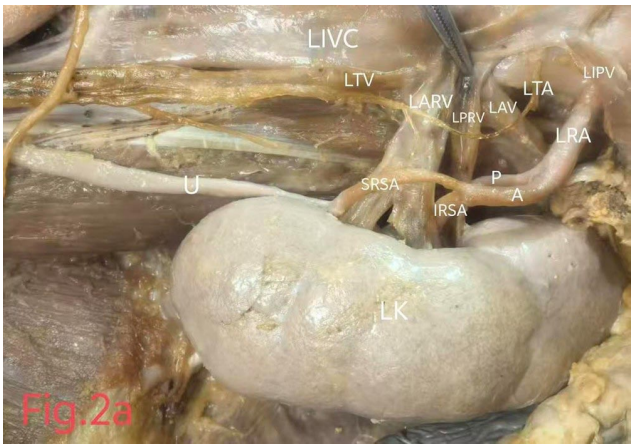
3) Numerical and tributary anomalies of the left renal vein (Fig. 2).

The intrarenal veins of the left kidney converged at the hilum to form two distinct left renal veins—anterior left renal vein (LARV) and posterior left renal vein (LPRV)—that drained independently into the left IVC. The LARV (flattened diameter: 10.9 mm) entered the IVC 32.6 mm inferior to the junction of the left and right IVCs. The LPRV (flattened diameter: 7.6 mm) inserted 2.9 mm superior to the LARV. The left testicular vein (flattened diameter: 3.7 mm) drained into the venous angle formed by the confluence of the LARV and the left IVC. Of particular note, the left adrenal vein (flattened diameter: 5.2 mm) did not terminate in the left renal vein but shared a common ostium with the LPRV to empty directly into the left IVC.In contrast, the right renal vein exhibited a normal course and tributary pattern; however, it joined the right IVC at an acute angle of 43 degrees.

4) Variant structural arrangement of the left renal hilum (Fig. 2)

The left renal artery (RA) originated high from the left lateral wall of the abdominal aorta, with its ostium nearly level with the superior pole of the left kidney, and exhibited early branching. Its proximal segment (diameter: 5.8 mm) coursed inferolaterally for 17.9 mm before bifurcating into anterior and posterior divisions. The anterior division (diameter: 4.1 mm) extended 16.1 mm before further dividing into a superior segmental artery (3.3 mm) and an inferior segmental artery (2.3 mm). These segmental arteries adopted an anteroposterior orientation, coursing around the LARV approximately 10.1 mm anterior to the renal hilum. The superior artery entered the hilum proper, whereas the inferior artery penetrated the renal parenchyma directly below it. The posterior division (diameter: 4.2 mm) entered the kidney posterior to the left posterior renal vein. Together with the superior segmental artery (from the anterior division), it formed a vascular collar around the LPRV. Thus, the sequence of structures within the left renal hilum, from anterior to posterior, was: the left anterior renal vein, the superior segmental artery (anterior division of the left RA), the renal pelvis, the left posterior renal vein, and the posterior division of the left RA.

Additionally, a left testicular artery with a high origin (1.0 mm in diameter) was identified. It originated 10.0 mm below the left renal artery on the anterolateral aortic wall, crossed anterior to the left anterior renal vein, and ran parallel to the right testicular vein.



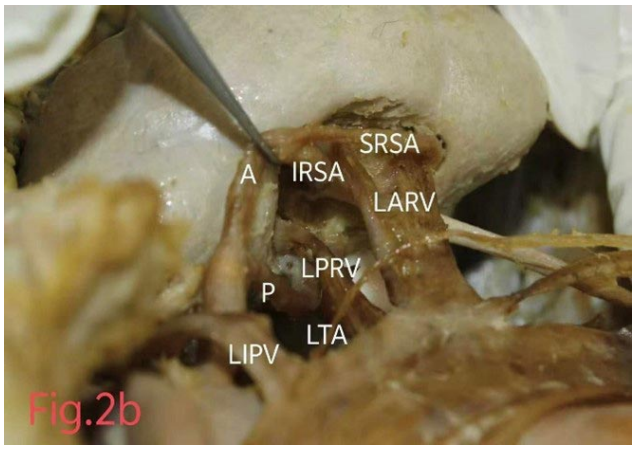


Fig. 2. Images 2a and 2b show the structural and positional abnormalities of the left renal hilum. LIVC:left inferior vena cava, LTV:left testicular vein, LTA:left testicular artery, LARV:left anterior renal vein, LPRV:left posterior renal vein, LIPV:left inferior phrenic vein, LRA:left renal artery, P:posterior branch, A:anterior branch, LAV:left adrenalvein, SRSA:superior branch of renal segmental artery, IRSA: inferior branch of renal segmental artery, U:ureter, LK:left kidney.

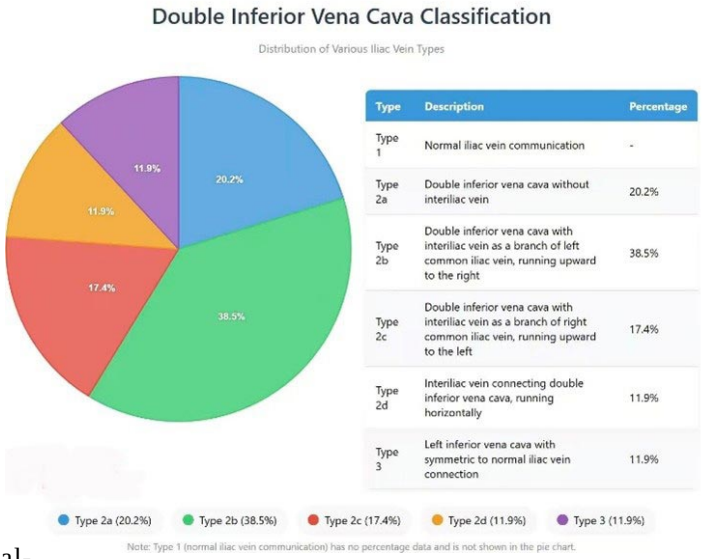
DISCUSSION

Double inferior vena cava (DIVC), first described by Lucas in 1916 (Eldefrawy *et al*., 2011), is frequently encountered clinically (Evans *et al*., 2001; Shaw *et al*., 2003; Anne *et al*., 2005) and the most common IVC variation with

an incidence of 0.2%–3% (Bass *et al.*, 2000). Its variations mainly involve the drainage sites of the left and right IVCs.

The development of the human embryonic IVC was elaborated by McClure and Butler (Malaki *et al.*, 2012). The IVC and its tributaries derive from three pairs of primitive parallel veins: posterior cardinal, subcardinal, and supracardinal veins. The left supracardinal vein regresses, while some left supracardinal-subcardinal anastomotic branches persist in the left renal vein. The cephalic parts of paired supracardinal veins drain into subcardinal veins, and the posterior aorta gradually regresses into common iliac veins. Thus, the IVC from inferior to superior comprises: common iliac veins, a short segment of the right posterior cardinal vein, posterior-supracardinal anastomoses, part of the right supracardinal vein, right supracardinal-subcardinal anastomoses, right subcardinal vein, and hepatic segment of the IVC (Mathews *et al.*, 1999). Multiple embryological theories explain DIVC occurrence: the left IVC may result from failure of regression of the left supracardinal vein's caudal segment or lack of anastomoses between primitive cardinal veins (Ohwada *et al.*, 2007).

In a case report and literature review on double inferior vena cava accompanied by an intersubiliac vein, Chen *et al.* (2012) proposed a subclassification of this anomaly based on the branching pattern of the intersubiliac vein (Fig. 3). However, the present case is unique: here, the main trunk of the intersubiliac vein originates from the right pelvis and courses to drain into the left inferior vena cava. Along its path, it sequentially gives off branches that anastomose with the right internal iliac vein and the right common iliac vein, thereby forming a venous loop. This distinctive anatomical configuration underscores the rarity and clinical significance of the present case. Studies have established that double inferior vena cava is associated with an increased risk of deep vein thrombosis (DVT) and venous thromboembolic disease (Garg *et al.*, 2019). In interventional venous radiology, congenital inferior vena cava anomalies are recognized risk factors for DVT, where the specific anatomy of the intersubiliac vein often critically influences therapeutic planning (Chen *et al.*, 2012). During retroperitoneal surgeries, such as anterior lumbar interbody fusion (Inamasu & Guiot, 2005), the intersubiliac vein may be inadvertently injured, leading to intraoperative hemorrhage. Furthermore, during interval debulking surgery for advanced ovarian cancer involving retroperitoneal lymphadenectomy, failure to recognize such anatomical variations—and subsequent adherence to conventional surgical approaches—can readily lead to intersubiliac vein injury and significant hemorrhage (Matsuoka *et al.*, 2018).



Type	Description	Percentage
Type 1	Normal iliac vein communication	-
Type 2a	Double inferior vena cava without interiliac vein	20.2%
Type 2b	Double inferior vena cava with interiliac vein as a branch of left common iliac vein, running upward to the right	38.5%
Type 2c	Double inferior vena cava with interiliac vein as a branch of right common iliac vein, running upward to the left	17.4%
Type 2d	Interiliac vein connecting double inferior vena cava, running horizontally	11.9%
Type 3	Left inferior vena cava with symmetric to normal iliac vein connection	11.9%

Fig. 3: Classification of double inferior vena cava.

Renal veins (RVs) are a key aspect of complex IVC development, briefly addressed in the aforementioned embryonic discussion. During embryogenesis, subcardinal and supracardinal veins form a complex periaortic venous plexus in the mid-renal region, termed the periaortic renal venous ring. Typically, the plexus's dorsal parts regress, while ventral parts persist and develop into left and right RVs. If ventral parts regress and dorsal parts persist, the left renal vein (LRV) lies posterior to the aorta (retroaortic LRV [RLRV] types 1-2-4). Preservation of both ventral and dorsal parts forms type 3 periaortic LRV (RLRV).

RVs play a critical role in the complex embryological development of the IVC, the basis of which has been outlined previously. Between the sixth and eighth weeks of embryonic development, the subcardinal and supracardinal veins give rise to a complex venous plexus surrounding the aorta in the mesonephric region, known as the circumaortic renal venous collar. Typically, the dorsal limb of this plexus regresses, whereas the ventral limb persists and differentiates into the right and left renal veins. Variations in this developmental sequence result in distinct anatomical outcomes. Regression of the ventral anastomosis, coupled with persistence of the dorsal anastomosis, results in a LRV that courses posterior to the aorta, corresponding to types 1, 2, or 4 of RLRV. Persistence of both the ventral and dorsal segments leads to the formation of a type 3 RLRV, also known as a circumaortic renal vein. The RLRV, characterized by the LRV passing between the aorta and the vertebral column, is an anatomical variant with four recognized subtypes: Type 1: The LRV courses posterior to the aorta and drains into the IVC at the typical anatomical site. Type 2: The LRV joins the IVC at a more caudal level, typically corresponding to the L4-L5 vertebrae. Type 3: Representing the circumaortic variant,

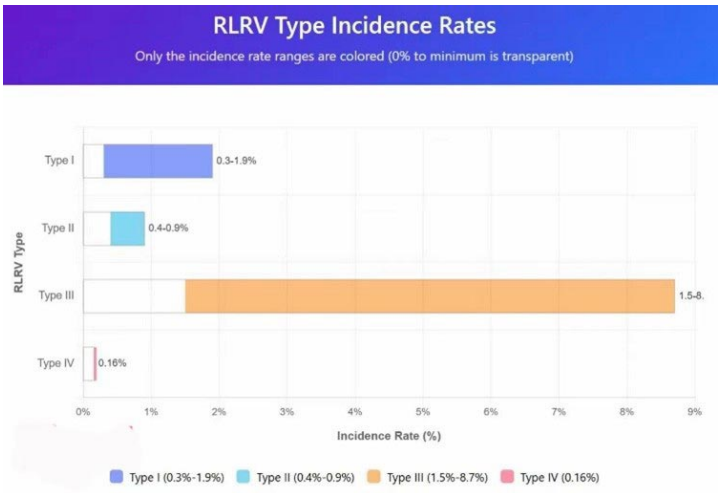


Fig. 4. Retroaortic left renal vein type.

this type comprises both an anterior and a retroaortic venous limb that converge before entering the IVC. Type 4: The LRV descends from the renal hilum and terminates in the left common iliac vein at the L4-L5 vertebral level (Yaman & Arslan, 2025) (Fig.4).

Furthermore, Satyapal *et al*. (1995) defined an "additional renal vein" as a distinct vessel originating clearly from the renal hilum and draining independently into the IVC. They reported that a single additional renal vein on the left side is relatively uncommon; with an incidence of approximately 2.6%. This report describes a complex left renal venous variation associated with a duplicated inferior vena cava, characterized by two independent left renal veins. Embryologically, this pattern appears to originate from a circumaortic renal vein (type 3 RLRV). Unlike the classic configuration, the presence of a left-sided IVC may alter the developmental trajectory, potentially preventing the dorsal component (retroaortic portion) from passing behind the aorta. As a result, both the dorsal and ventral (preaortic) components drain separately and directly into the left-sided IVC.

The anatomical configuration of the renal veins carries significant clinical relevance in abdominal surgical procedures, including nephrectomy and donor nephrectomy for renal transplantation (Hostiuc *et al*., 2019). Preoperative identification of anatomical variants is essential to prevent intraoperative venous injury and related hemorrhagic complications (Karkos *et al*., 2001; Ayaz & Ayaz, 2016). For example, during vascular reconstruction utilizing a left renal vein graft in oncology patients (Ohwada *et al*., 2007), unrecognized variations can result in inadvertent vascular injury and subsequent significant hemorrhage.

Moreover, in the present case, an early-branching left renal artery (Raman *et al*., 2007; García-Barrios *et al*., 2024) was noted to traverse and potentially compress both renal veins. Although the compressive mechanism differs from that observed in classic Nutcracker Syndrome (NCS), it should be emphasized that any anatomical structure exerting extrinsic compression on the renal vein may give rise to the clinical features of secondary NCS.

CONCLUSIONS

This report documents a rare combination of vascular anomalies involving the inferior vena cava (IVC) and the left renal hilum. The specific findings include duplicate IVCs ascending in parallel before converging, an anomalous interiliac vein connecting the right hemipelvis to the left IVC, a unilateral duplication of the LRV with independent drainage, and an early-branching renal artery forming an entrapment configuration around these venous structures. To our knowledge, this specific combination of vascular variants has not been previously described in the literature. The unique anatomical architecture observed herein provides critical morphological insights for retroperitoneal and pelvic surgeries, with significant implications for minimizing iatrogenic vascular injury in these regions.

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CUI, C.; ZHAO, Q.; ZHOU, Z.; CHENG, J.; ZHANG, C.; LIU, X. & LI, M. Origen anómalo de la vena cava inferior doble con la vena interilíaca y estructura anómala del hilio renal izquierdo en un cadáver humano. *Int. J. Morphol., 44(2)*:654-659, 2026.

RESUMEN: Este informe presenta un caso de vena cava inferior doble (VCID), en un cadáver masculino, con origen anómalo de la vena interilíaca y ramificación precoz de la arteria renal izquierda que rodea las venas renales izquierdas dobles. En el cadáver, se identificaron la VCID y una vena interilíaca de origen anómalo: esta última recogía sangre de la cavidad pélvica derecha, se anastomosaba con la vena ilíaca interna derecha y la vena ilíaca común derecha para formar un circuito venoso y, finalmente, drenaba en la vena cava inferior izquierda. Además, se observaron estructuras anómalas en el hilio renal izquierdo, caracterizadas principalmente por una ramificación precoz de la arteria renal izquierda, con complejas relaciones de cruce entre las arterias segmentarias resultantes, venas renales izquierdas dobles y pelvis renal. Este artículo detalla estas variaciones anatómicas y analiza sus posibles mecanismos de

evolución embriológica y su relevancia clínica. Dado que estas variaciones anatómicas afectan los resultados y el pronóstico de los procedimientos quirúrgicos retroperitoneales y pélvicos, es fundamental que los cirujanos conozcan las anomalías vasculares renales y de la vena cava inferior.

PALABRAS CLAVE: Vena interilíaca; Vena cava inferior; Arteria renal; Vena renal.

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