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Case Report

Retroaortic left renal vein – developmental and clinical implications

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Abstract

Normal renal vascular anatomy has renal veins draining deoxygenated blood from the kidneys into the inferior vena cava (IVC). Since the IVC is situated to the right of the midline, the left renal vein typically runs anterior to the abdominal aorta and drains into it. Routine dissection of the posterior abdomen of a 76-year-old male donor, presented a variant left renal vein. In contrast to the expected anatomy, the left renal vein displayed a retroaortic course. An understanding of normal renal vasculature aids in diagnosis of vascular variations in the posterior abdomen, and hence the dissection team proceeded to document the variation using digital photography. Additionally, a thorough literature review was carried out to understand the developmental basis of the variation, pathogenesis, mechanisms, treatment options and clinical implications in patients. The findings of the dissection are presented along with a comprehensive review of the development of renal vasculature.

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Introduction

Passage of the left renal vein posterior to the abdominal aorta is referred to as a retroaortic left renal vein (RLRV), and is a known anatomical variation associated with the inferior vena cava (IVC). Incidence of RLRV has been reported to be 0.5% to 3.7% in the healthy population [1-5] , with incidence rates of 1.7% and 1.6% in men and women respectively. Although RLRV is a relatively uncommon presentation, its presence has been linked to various renal pathologies, including, but not limited to, pelvic varices, varicoceles, pelvic congestion syndrome, left renal vein thrombus formation, adrenal adenomas, renal vein hypertension and hematuria [6-12]. In addition, an understanding of vascular variations is critical in cases of renal transplantation, renal surgery, uroradiology, Doppler imaging, surgeries of the abdominal aorta and gonadal surgery.

During routine dissection of the posterior abdominal region of a 76-year-old male donor, the dissection team noticed that the left renal vein was not located in the normal expected anterior location in relationship to the abdominal aorta. Instead, the left renal vein was located posterior to the abdominal aorta, and its connection to the inferior vena cava was not directly visible. The team proceeded to complete a thorough dissection of the region of interest, documented the variation by digital photography, and carried out a thorough literature review to understand the developmental basis of variations in renal vasculature and the clinical implications in patients presenting with such anatomical variations.

Case Report

During routine dissection in the gross anatomy laboratory, the dissection team identified a retroaortic presentation of the left renal vein (Figure 1a). The branches of the abdominal aorta, including the celiac trunk and the superior mesenteric artery (SMA) were dissected (Figure 1a). The left renal vein, instead of passing deep to the superior mesenteric artery and anterior to the main trunk of the abdominal aorta, ran a course posterior to the abdominal aorta. The inferior vena cava was located to the right of the abdominal aorta.

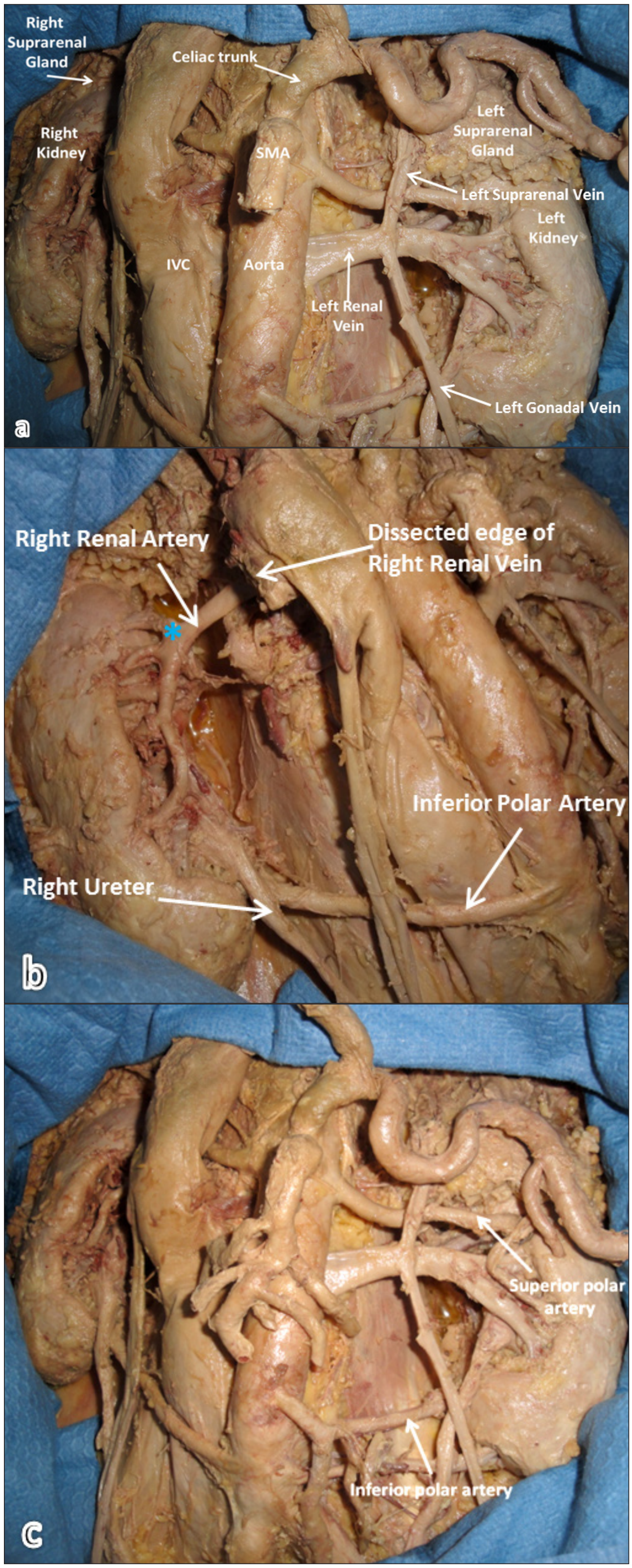
In addition to the retroaortic left renal vein, the dissection team also noted the presence of additional variations of the renal vasculature. As expected, the right renal artery was located higher than the left renal artery, and branched off the abdominal aorta, passing posterior to the inferior vena cava. The right renal artery was also located deep to the right renal vein (dissected edge of the right renal vein is indicated in Figure 1b). The right renal artery exhibited multiple segmental arteries as it entered the renal hilum. Interestingly, all segmental branches did not enter at the hilum; it was noted that one segmental branch entered the right kidney at the superior pole, and could be considered to be a superior renal polar artery (Figure 1b – blue star). Additionally, a distinct inferior renal polar artery ran superolaterally from the abdominal aorta, anterior to the inferior vena cava and posterior to the right gonadal vein, to enter the inferior pole of the right kidney (Figure 1 b).

The left kidney showed the presence of a superior renal polar artery, a branch from the left lateral aspect of the abdominal aorta, given off approximately between the celiac trunk and the superior mesenteric arteries (Figure 1c). The superior renal polar artery ran superior to and almost parallel to the left renal vein, to enter the superior pole of the left kidney (Figure 1c). A left inferior renal polar artery, supplying the inferior pole of the left kidney, was also dissected. Unlike the left superior renal polar artery, the left inferior renal polar artery was not a direct branch of the abdominal aorta. Instead, a single common branch of the abdominal aorta divided into the left inferior renal polar artery, which ran superolaterally to enter the inferior pole of the left kidney, and a left gonadal artery that ran inferiorly and parallel to the abdominal aorta (Figure 1c). Similar to that seen in the right renal artery, there were 2 to 3 small, segmental branches of the left renal artery that entered the left kidney at the hilum, posterior to the left renal vein. The dissection team also noted the presence of the left suprarenal vein running superolaterally, and the left gonadal vein running inferolaterally, both branches of the left renal vein.

Discussion

Developmental Pattern and Normal Anatomy of the Inferior Vena Cava

In the adult, the inferior vena cava (IVC) is a composite vascular structure which develops in the posterior abdominal wall during the 6th to 10th week of gestation. The development of the IVC is a complex phenomenon that involves a temporally sequenced appearance and regression of three paired veins, the posterior cardinal veins, subcardinal veins



➤ **Figure 1.** Photographs of dissected posterior abdomen. **a)** Retroaortic presentation of the left renal vein, draining the left kidney, is clearly visible. The celiac trunk and dissected edge of the superior mesenteric artery is also seen branching from the abdominal aorta. The left suprarenal and gonadal veins, branches of the left renal vein are indicated. **b)** Dissection of the right kidney shows the dissected edge of the right renal vein draining into the inferior vena cava. The right renal artery, located posterior to the right renal vein, is seen entering the renal hilus. A right inferior renal polar artery is visible. **c)** In addition to the retroaortic left renal vein, the left kidney also shows the presence of left superior renal polar artery and a left inferior renal polar artery.

and supracardinal veins [13, 14]. Disturbed developmental processes may result in numerous anomalies and variations of the IVC, chief among them being, duplicate IVC, transposed IVC, retroaortic left renal vein and circumaortic left renal vein [15].

During early development, the body wall cranial to the developing heart is drained by paired precardinal veins, while the body wall caudal to the developing heart is drained by paired postcardinal veins. The pre and postcardinal veins on each side, drain into a short common cardinal vein, and finally into the sinus venosus. In order to support the rapidly growing embryo, precardinal veins undergo remodeling, while postcardinal veins receive supplemental drainage via newly formed subcardinal, supracardinal, azygos, subcentral and precostal veins.

Subcardinal veins develop ventromedial to the postcardinal veins and ventrolateral to the aorta, and receive majority of the vascular drainage from the lower half of the body. Supracardinal veins receive majority of the drainage from the upper half of the body. The right subcardinal vein is intimately associated with the liver. As the cranial end of the right subcardinal vein grows, it becomes confluent with the caudally growing right vitelline hepatocardiac (common hepatic) vein. Thus, the cranial aspect of the right subcardinal vein forms the suprarenal aspect of the IVC. The cranial aspect of the left subcardinal vein forms the left suprarenal/adrenal vein. The right supracardinal vein enlarges and forms the infrarenal segment of the IVC, and its cranial end forms the azygos vein. The right and left subcardinal veins also form anastomoses with the right and left supracardinal veins to form a renal collar on each side. The dorsal portion of the renal collar eventually degenerates and the ventral portion persists to form the renal vein on each side [16]. The caudal ends of the postcardinal veins persist as the common iliac veins and the caudal extent of the subcardinal veins form the gonadal veins. Thus, the adult IVC develops in a caudal to cranial direction by the common iliac veins, sub-supracradinal anastomoses, small portions of the right sub and supracardinal veins, and suprarenal aspect of the IVC.

Variant Anatomy of the Inferior Vena Cava

Developmental aberrations of the IVC can result in multiple presentations, depending on which venous segments are affected. Variations of the supracardinal veins can result in formation of left –sided vena cava or double vena cava. Circumaortic renal veins are variants resulting from persistence of the renal collar/sub-supracardinal vein anastomoses, while retroaortic left renal veins are formed when the dorsal portion of the renal collar persists in the adult, instead of the ventral portion.

Retoaortic left renal vein variations are classified into four types based on the level at which it drains into the IVC: Type I – enters the IVC at the orthotopic position; Type II – enters the IVC at the level of L4-L5; Type III – enters the IVC at the orthotopic position, but as part of the circumaortic venous ring/renal collar; Type IV – enters the left common iliac vein, which then drains into the IVC.

Clinical and Surgical Implications

Variations of renal arteries and veins can result in different symptoms, based on the type, extent and pattern of the vasculature. Retroaortic left renal veins can be compressed between the aorta and the vertebra, referred to as the "posterior nutcracker phenomenon". The compression can elevate pressure within the left renal vein, leading to hematuria, and resultant congestion of the left kidney [7, 17-19]. In addition, compression of a retroaortic left renal vein can also result in varicocele formation and ureteropelvic junction obstruction [20]. Congenital renal vascular variations can cause renal vascular congestion, that clinically manifests as hematuria, left flank pain and pelvic congestion [5, 13, 21-24].

Retroaortic presentation of the left renal vein is often asymptomatic, but is of particular relevance before, during and after renal surgeries. Vascular anomalies are predisposed to form dilations and can easily be injured during surgical procedures, thus making preoperative recognition of variations critical for surgical success [25]. Advances in imaging technologies, such as computed tomography and magnetic resonance imaging, have ensured timely identification of such variations, thereby preventing intraoperative hemorrhage [25, 26].

Concomitant with variations of the left renal vein, surgeons can also encounter variations and/or anomalies of the lumbar veins and associated vena caval variations. In addition, anatomical relationships of the ureters to the renal vasculature may also be altered [26-29]. In patients with renal cell carcinoma or testicular carcinomas, tumor extension into the retroaortic renal vein has been reported [30-33]. Preoperative surgical planning is extremely critical in such situations to identify not only the vascular variations, but also the associated lymphatic variations. In patients with both vascular and lymphatic variations, it is recommended to carry out an extended lymph node dissection [33].

Variations in the normal anatomy of the renal vasculature can be life threatening if not recognized prior to surgical interventions. A thorough understanding of possible variations helps in the diagnosis and management of patients who present with such vascular variations. Computed tomography is well accepted as the imaging modality of choice for kidneys and the retroperitoneal region, and 3D CT angiography can be used for diagnosis of vascular variations associated with the posterior abdominal region, prior to surgical interventions. Studies indicate that about 1.5% to 3.2% of abdominal CT examinations reveal the presence of left renal vein anomalies [34-36]. Information acquired via such imaging modalities is of particular importance before and during extensive surgical procedures such as lymphadenectomy and tissue resections consequent to tumor invasion [37]. Surgeons prefer the left kidney for transplants, and therefore, early detection of vascular variations associated with the left kidney is especially critical for pre-operative treatment planning [38].

Clinical Management

Recommended clinical management of patients with chronic renal disease includes, monitoring blood pressure continuously during treatment, monitoring for signs of metabolic acidosis (hyperventilation), and employing stress-reducing measures like nitrous oxide, oxygen, and "profound local anesthesia" for minor procedures [39]. Local anesthesia is considered safe [40], but vasoconstrictors should be used conservatively [39]. Sedation requires close monitoring and should be restricted to inpatient settings. Drug clearance is an issue for renal patients and renal dosing should be performed. Potassium salts of penicillin should be avoided and alternate drugs that are metabolized through the liver, such as clindamycin or erythromycin, should be used. NSAIDs and narcotics should be avoided owing to their nephrotoxicity [39].

In conclusion, timely diagnosis of vascular variations associated with the inferior vena cava and its branches are critical for successful surgical procedures in the posterior abdominal area.

Conflict of Interest

The authors state that they have no conflicts of interest.

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