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Anatomical Study of Retro-Aortic Left Renal Vein

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ABSTRACT

The renal vein normally is located in front of the aorta. However may course posterior to the aorta. This variation is of importance during procedures in the retroperitoneal region. The objective of this study was to investigate the incidence of the retro – aortic left renal vein. A total of 13 cadavers and 10 visceral blocks were used for the study in the laboratory of Morphology of the University of Pamplona. In two cadavers, three renal veins were found to bind and give rise to a common venous trunk corresponding to the left renal vein passing behind the aorta abdominal (retro-aortic) and ending at the inferior vena cava at the level of the fourth vertebra lumbar. Knowledge of anomalies of left renal vein is essential for radiologists, endocrinologists, fertility specialists, urologists and surgeons, in determining the feasibility of complication-free surgical interventions

Keywords: Anatomical variation, inferior vena cava, left renal vein, retro-aortic renal vein,

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INTRODUCTION

Variant patterns of arteries and veins are seen more frequently in abdomen than in any other part of the body. A knowledge of different types of variations depicted by renal and suprarenal veins is extremely important in exploration and treatment of renal trauma, renal transplantation, renovascular aneurysm and conservative or radical renal surgery [1–3]. A left renal vein passing behind the abdominal aorta is termed a retroaortic left renal vein (RLRV), and this anomaly is a relatively uncommon condition. Recent advances in computed tomography and magnetic resonance imaging techniques make it possible to visualize the vascular structures in detail. Additionally, the congenital anomalies of the inferior vena cava (IVC) and its tributaries have become more frequently encountered in asymptomatic patients. RLRV anomalies, although usually overlooked, are not rare [4,5]. However, only a few cases showing clinical symptoms with this anomaly have been reported [6]. It is also of surgical importance when a left renal surgery is considered. Failure to recognize these anomalies may lead to severe hemorrhage and severe renal damage [7]. Compression of the RLRV between the aorta and the vertebra is known to be the cause of urological problems such as hematuria, varicocele, and ureteropelvic junction obstruction (UPJO) [8]. Knowledge of anatomic and morphologic variations and the practical importance of such variations is essential in renal transplantation, renal and gonadal surgeries, uroradiology, gonadal color Doppler imaging and other retroperitoneal, therapeutic and diagnostic procedures. In view of its anatomical, embryological, clinical and surgical importance, the present study was undertaken for investigate the incidence of the RLRV.

EXPERIMENTAL SECTION

A total of 13 cadavers of both sexes (12 men and 1 women) with different age group and and 10 visceral blocks (46 renal veins) were used for the study in the Morphology Laboratory of the University of Pamplona. The history of the individual and the cause of death are not known. The specimens for the study of retro-aortic left renal vein were obtained from cadavers and permission was obtained from the Institutional Ethics Committee. Anterior abdominal

wall was opened by giving the following incisions and both the kidneys were exposed as per the guidelines given in the Cunningham's manual of practical anatomy [9].

Incisions:
1. A vertical incision from xiphoid process to the symphysis pubis surrounding the umbilicus.
2. A transverse incision from umbilicus to the right side and to the left side of the abdomen.

Steps
• The two upper skin flaps of the abdominal wall were reflected upwards and laterally and the lower two skin flaps were reflected downwards and laterally.
• The various viscera in the abdomen were removed to expose the kidneys.
• The abdominal viscera and the intestines were removed to expose the kidney on the posterior abdominal wall.
• Right and left kidneys were separated from the perirenal fat and fascia using fingers.
• The suprarenal glands were separated from the kidneys carefully by inserting the fingers between them.
• The gross anatomy of both kidneys was studied in particular to their arterial and venous supply.

RESULTS AND DISCUSSION

Out of 13 cadavers and 10 visceral blocks of the present study a standard text book pattern of renal veins was observed in 21 (91,3%) cases. In the rest of 2 (8,7%) cases the left renal vein instead of passing in front of aorta, passed behind it to drain into the IVC –defined as a retro-aortic left renal vein (RLRV). Instead of passing horizontally, it coursed obliquely downwards and joined inferior vena cava at the level of of the fourth vertebra lumbar.

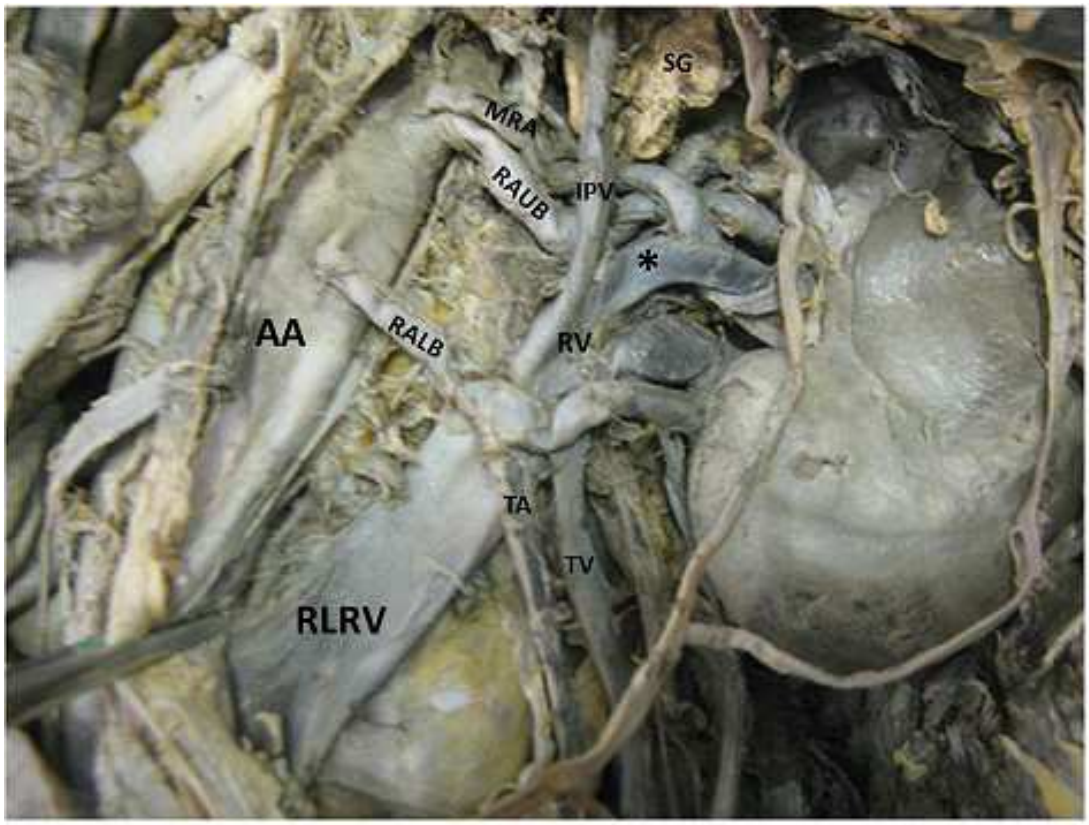

Figure 1. Case 1. Anterior View of Retroperitoneal Upper Left Region Showing Details of Hiliar Renal Region. A.A: Abdominal aorta; MRA: Main renal artery; RAUB: Renal artery-upper branch; RALB: Renal artery-lower branch; RV: Renal vein; TV: Testicular vein; TA: Testicular artery; SG: Suprarrenal gland; RLRV: Retro-aortic left renal vein; IPV: Inferior phrenic vein; Asterisk: double renal veins embraced the main renal artery and the upper arterial branch

The size of the left kidneys was 13x6x5cms. The venous drainage of the left kidneys was through three renal veins that bind and form a common venous trunk which corresponds to the left renal vein (In both cases the left renal vein has a diameter of 24 mm), which receives as tributaries, the adrenal vein, the inferior phrenic vein, fine parietal branches of the left lumbar region and under the testicular vein, further, at the hilum was found that the renal veins embraced the main renal artery and the upper arterial branch. Figures 1 and 2.

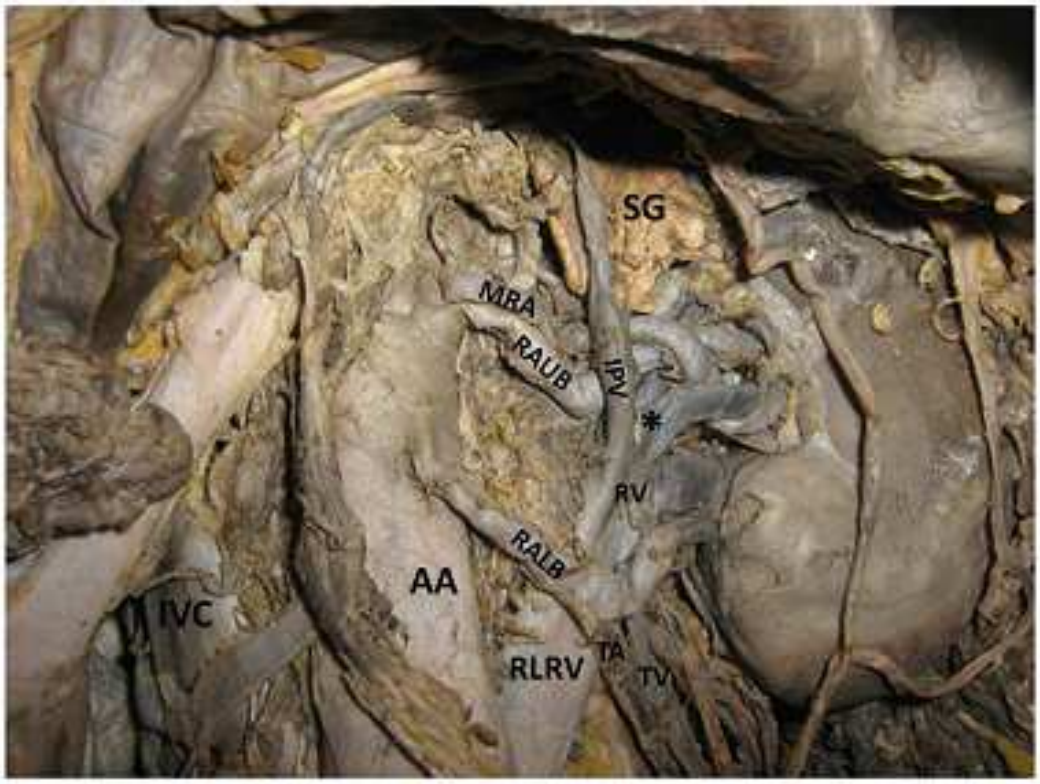

Figure 2. Case 2. Anterior View of Retroperitoneal Upper Left Region Showing Details of Hiliar Renal Region. Anterior View of Retroperitoneal Upper Left Region Showing Details of Hiliar Renal Region. A.A: Abdominal aorta; MRA: Main renal artery; RAUB: Renal artery-upper branch; RALB: Renal artery-lower branch; RV: Renal vein; IVC: inferior vena cava;TV: Testicular vein; TA: Testicular artery; RLRV: Retro-aortic left renal vein; IPV: Inferior phrenic vein; SG: Suprarrenal gland; Asterisk: double renal veins embraced the main renal artery and the upper arterial branch

The retro-aortic left renal vein has been studied by many authors and its prevalence is presented in Table 1. This is true for a single left renal vein passing retro-aortically. However, the incidence of 2 left renal veins, one passing anterior and other posterior to aorta i.e. renal collar or circum-aortic venous ring varies from 0.3% to 16.83%.

The left and right renal veins are of large size placed in front of the renal arteries and open into the inferior vena cava almost at right angles (at the level of L2 vertebra). The left renal vein is thrice the length of the right (2.5 cm to 7.5 cm) and has a much thicker muscular layer than the right. The left renal vein crosses the posterior abdominal wall lying behind the splenic vein and the body of the pancreas, and, near its termination, the left renal vein passes in front of the aorta just below the origin of the superior mesenteric artery. The two important non-renal branches that empty into the left renal vein are inferiorly the gonadal vein and superiorly the left adrenal vein. Occasionally the left renal vein may be duplicated, and in these cases one vein passes behind the aorta to join the inferior vena cava [24,25]. Variations of renal veins are usually clinically silent and remain unnoticed until discover during venography, operation or autopsy. To transplant surgeon, morphology acquires special significance, since variations influence technical feasibility of operation. Variations restrict availability of vein for mobilization procedures [26].

Author	Prevalence of retro-aortic left renal vein
Pick and Anson (10)	16,8% Retro aortic 3,4% Circum aortic
Chuang et al. (11)	2-3% Retro aortic 6- 17% Circum aortic
Reed et al. (12)	1,8% Retro aortic 4.4% Circum aortic
Martinez-Almagro et al. (13)	1,72- 2,35%
Trigaux et al. (14)	3.7% Retro aortic 6,8% Circum aortic
Turgut et al. (15)	1 case
Kalsey et al. (16)	1 case
Bregman. (17)	1,5- 8,7% Retro aortic 2% Circum aortic
Andrade et al. (18)	1 case
Jafarpour & Mofidpour (19)	6,25 6,5% Circum aortic
Dhar and Ajmani (20)	7,8% Retro aortic 4,5% Circum aortic
Mendizabal (21)	22.5%
Karazincir (22)	2.2- 9.3%
Tatar et al. (23)	0,5- 6,8% Retro aortic 0,3- 3,7% Circum aortic
Hemalatha et al. (24)	0,3% Circum aortic 0,5%
Gupta et al. (25)	6.6% Circum aortic 6.6% Retro aortic
Satyapal et al. (26)	0,3%- Circum aortic 0,5%- Retro aortic
Kakros et al. (27)	0,3- 1,9%- Retro aortic 1,5-8,7% - Circum aortic
Yesildag et al. (28)	0,5- 6.8 %- Retro aortic 0,3- 3,7% - Circum aortic
Karaman et al. (29)	3.6% - Retro aortic - tipo I 1.2 %- Circum aortic. 1.4%- Retro aortic – tipo II
Aljabri et al. (30)	0,3- 0,9% Retro aortic - tipo I 0,5%- 1,4- Circum aortic. 0,4- 0,9% - Retro aortic – tipo II
Namburu et al. (31)	6,6% Retro aortic - tipo I 3,3% Circum aortic 1,6% Retro aortic – tipo II
Ferreira H. (present study)	8,7%- Retroaortic-tipoII

Table 1. Incidence of Retro–Aortic Left Renal Vein

Ontogeny:

According to Singh and Pal [32], veins of abdomen are derived from a series of longitudinal venous channels (Figure 3) viz right and left posterior cardinal veins (1); right and left subcardinal veins (2); right and left supracardinal veins (3); intersubcardinal anastomosis which may be anterior/posterior or both to aorta (4); supracardinal-subcardinal anastomosis (5); and anastomosis between subcardinal and right hepatocardiac channel (HCC) (6).

The left renal vein is derived from (Figure 4):

a) Mesonephric vein that originally drains into left subcardinal vein (1 in Figure 4).
b) A small part of left subcardinal vein (2 in Figure 4).
c) Intersubcardinal anastomosis which may be pre-aortic or post-aortic (3 in Figure 4).

As the anastomosis which lies in front of aorta usually persists and the one which lies behind the aorta disappears, left renal vein has similar relationship with aorta. Also the part of right subcardinal vein where intersubcardinal anastomosis joins forms part of inferior vena cava (IVC) so left renal vein drains into IVC.

The left suprarenal vein is remnant of the part of left subcardinal vein above the intersubcardinal anastomosis (4 in Figure 4). Thus it drains into left renal vein.

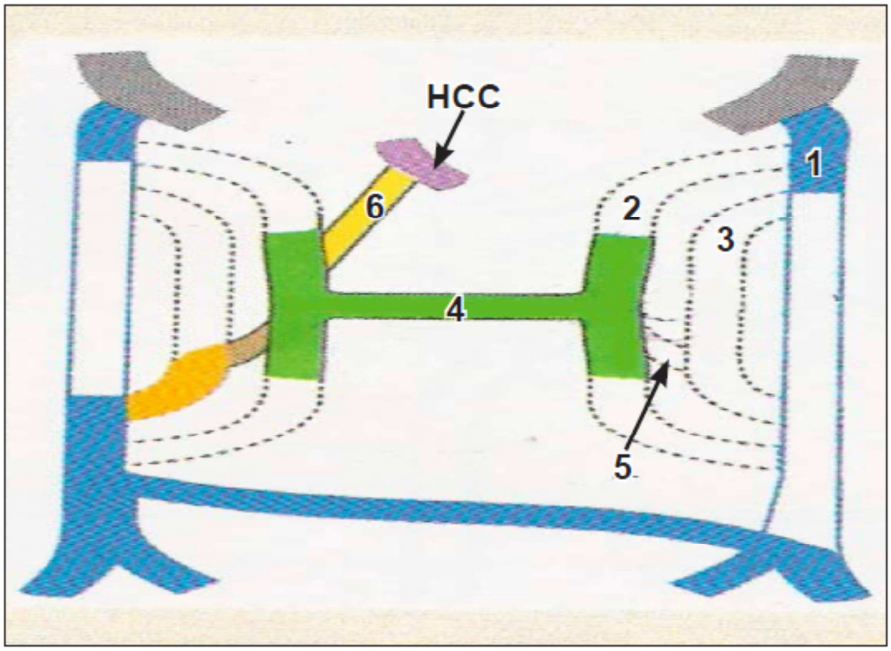

Figure 3. Normal development of abdominal veins. HCC: right hepatocardiac channel; 1: posterior cardinal veins; 2: subcardinal veins; 3: supracardinal veins; 4: intersubcardinal anastomosis; 5: supracardinal–subcardinal anastomosis; 6: anastomosis between subcardinal vein and HCC. (from reference 34)

Arey [33] reasoned out the anomalous blood vessels to be due to any of:
I. Choice of unusual paths in the primitive vascular plexuses
II. Persistence of vessels normally obliterated
III. Disappearance of vessels normally retained
IV. Incomplete development
V. Fusion and absorption of parts usually distinct.

The variant pattern observed in the present cadaver may be explained ontogenically:
1. The retro-aortic left renal vein can be explained by the persistence of posterior limb of renal collar

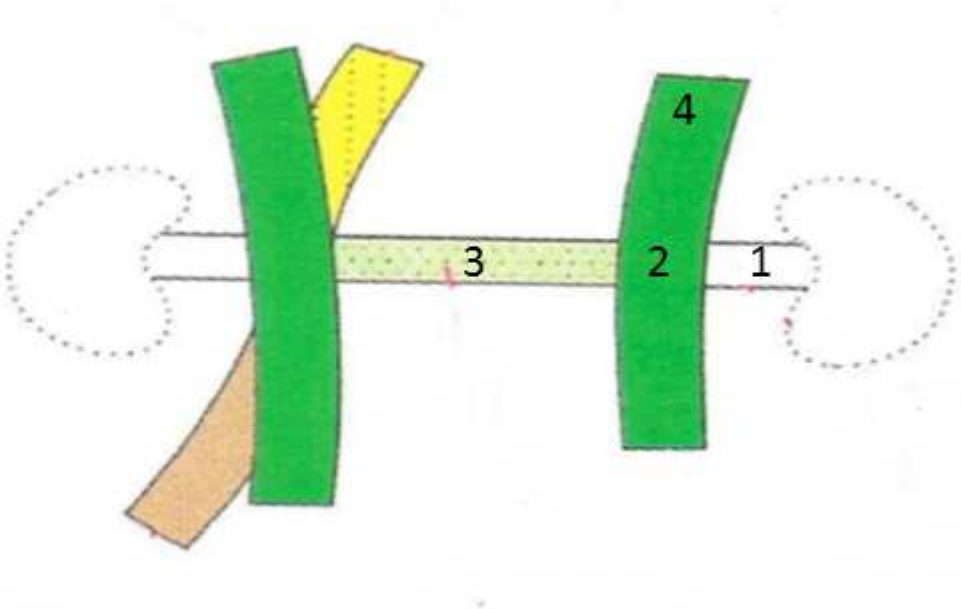

Figure 4. Normal development of left renal vein and left suprarenal vein. 1: left mesonephric vein; 2: part of left subcardinal vein opposite the intersubcardinal anastomosis; 3: intersubcardinal anastomosis; 4: part of left subcardinal vein above the level of intersubcardinal anastomosis. (from reference 34)

Left renal vein anomalies are classified/categorized into four types according to their appearance: I) RLRV joining the inferior vena cava (IVC) in the orthotopic position; II) RLRV joining the IVC at level L4–L5; III) circumaortic or collar left renal vein; IV) RLRV joining the left common iliac vein [35].

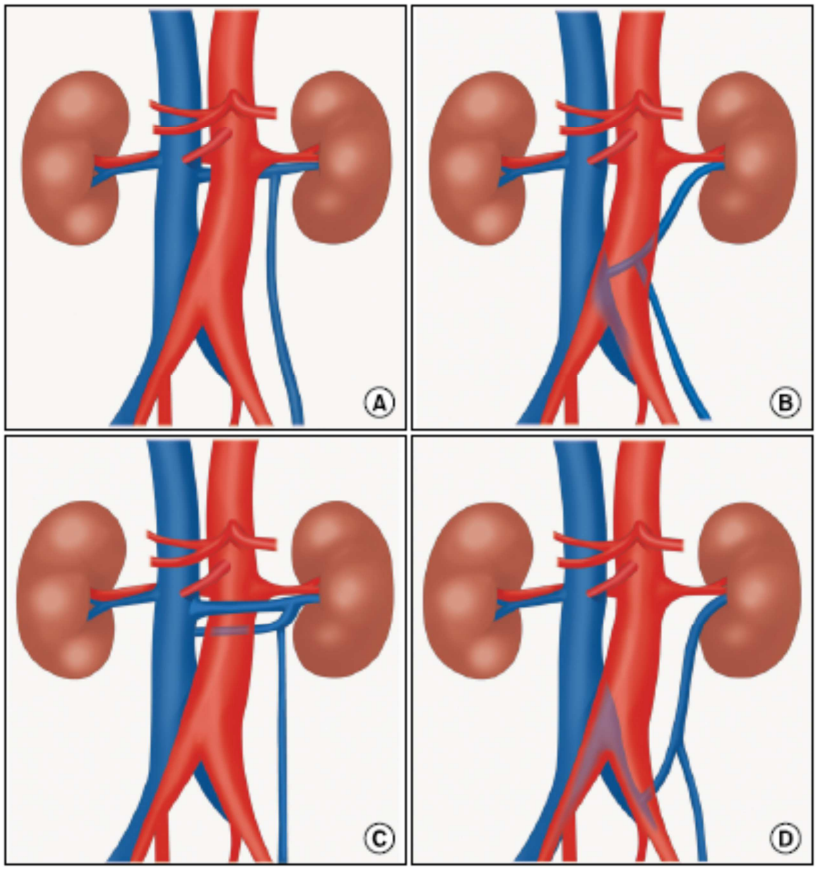

Figure 5. Schematic illustration of the different types of retroaortic left renal vein anomalies. (A) type I, (B) type II, (C) type III, (D) type IV. (from reference 35)

Clinical and Surgical Implications:

Left renal vein hypertension syndrome, also known as Nutcracker Syndrome (NCS), was described by was first described by Deschepper in 1972. It defines the compression of left renal vein with the development of renal venous hypertension that if transmitted backwards to the parenchyma, could result in various symptoms like unilateral haematuria, proteinuria and varicocele left [36]. The compression mechanism or the nutcracker phenomenon is diverse, the most frequent type being trapping in the aortic-mesenteric space which is due to aneurysmal dilatation of aorta (anterior Nutcracker phenomenon). The left renal vein as it lies between the aorta and the superior mesenteric artery (SMA), resembles a nut between the jaws of a nutcracker. There are two forms of NCS including the anterior nutcracker phenomenon and the posterior nutcracker phenomenon. Anterior NCS describes hypertension of LRV due to compression of the vein between the superior mesenteric artery and the abdominal aorta. Posterior NCS refers to hypertension of the LRV due to compression of the vein between the abdominal aorta and the vertebral column. Nutcracker syndrome may present with left flank and/or abdominal pain, hematuria (macroscopic or microscopic), and uretero pelvi junction obstruction (UPJO). The etiology of Nutcracker syndrome has not yet been medically proven. However, several factors may be of cause for the disorder including inadequate stretching of the left renal vein or abnormal branching of the SMA. Normally, the SMA originates from the aorta at a 90 degree angle and travels about 4-5mm before taking a caudal descent, which typically avoids compression of the LRV. However, in the case of NCS the SMA branches from the aorta at an acute angle, immediately descending caudal to the vessel which increases the risk of compression of the LRV [37]. The third part of the duodenum may also add to the pincer effect on the LRV [38]. The key symptom in detecting posterior NCS is hematuria. Hematuria is the most common symptom and is due to rupture of thin-wall varices into the collecting system, secondary to elevated venous pressure**.** It is well known that the gonadal, ascending lumbar, adrenal, ureteral, and capsular veins are potential collateral venous pathways in cases of renal vein compression or obstruction. Pain is the next most common symptom. Congested kidney and renal infarcts secondary to posterior nutcracker phenomenon may lead to

bacterial localization and abscess formation. Aortic thrombosis is a recognized complication of infection and sepsis. Neonatal cases with septicaemia, renal abscess due to nutcracker phenomenon were reported.

Retro-aortic left renal vein has been also associated with Pelvic Congestion Syndrome in females which is characterized by lower abdominal pain, dysmenorrhoea, dyspareunia, vulval, gluteal or thigh varices and emotional disturbances. It may be obstructed by pressure from retroperitoneal growths leading to congestion of kidney. If prolonged, it may give rise to a form of Chronic Interstitial Nephritis [34].

Compression of retro-aortic left renal vein can cause left renal to gonadal vein reflux resulting in lower limb varices and varicocele which may produce difficulties in spermatogenesis and may lead to infertility. Varicocele occurs in the left hemiscrotum in most of the cases. The reason for the left side predominance may be explained anatomically. The left spermatic vein is one of the longest veins in the body, entering the left renal vein at a perpendicular angle. The intravascular pressure in the left renal vein is higher than that on the right, as it is compressed between the aorta and the superior mesenteric artery. This phenomenon causes increased pressure in the left gonadal vein, which can dilate and cause incompetence of the valve leaflets, leading to retrograde flow of blood toward the testis in the erect position. Among all these, the most commonly accepted mechanism is the elevated hydrostatic pressure of the left renal and spermatic veins. RLRV probably causes a higher pressure in the spermatic vein and dilated pampiniform plexus [38].

Diagnosis of renal vein anomalies is important information in retroperitoneal surgery. Unawareness of this situation during retroperitoneal surgery can result in bleeding, nephrectomy, and even death. Surgeons prefer the left renal vein in renal transplantation because of its longer length. Because of this, it is important to know the course of the left renal vein and whether it is pre-aortic or not. It is also important to be aware of anomalies of the renal vein for distinctive diagnosis of retroperitoneal tumors, retroperitoneal lymph node pathologies, and aortic dissection. Before the renal surgery, careful reading of the preoperative RLRV imaging study helps to avoid fatal complications during the operation 35). The risk of venous injury is higher in patients with a circumaortic renal collar than in those with an IVC anomaly. The large anterior component of a renal collar can easily mislead the surgeon to think during operation that the development of a left renal vein is normal and that there is no retroaortic component. The posterior component usually runs obliquely, dorsal to the aorta, entering the IVC caudal to the entry of the anterior component. When proximal aortic isolation is performed blindly, injury to the posterior component of the circumaortic renal collar likely occurs. Circumferential aortic isolation is not recommended when this anomaly is suspected [23].

Abdominal Aortic Aneurysm (AAA) when ruptured into a Retro aortic left renal vein unique syndrome characterized by the: continuous Abdominal bruit, abdominal and left flank pain with an associated pulsatile mass. Accurate preoperative diagnosis is an important aspect of preventing fatal bleeding from an RLRV. In patients with a ruptured AAA, the abdominal aorta should be reconstructed as soon as possible, because the conditions of such patients are often unstable. If an RLRV is not recognized, it can easily be injured when encircling the aorta or dissecting the posterior aortic wall. Careful evaluation of the preoperative computerized tomography study can therefore decrease fatal complications. The risk of venous injury is particularly high in cases of ruptured AAA because the border between the dorsal side of the abdominal aorta and the RLRV may be obscured by retroperitoneal hematoma. Techniques to reduce the risk of venous injury were previously reported. Encircling of the aorta with a tape is not usually necessary. Clamping of the proximal side of the AAA in a vertical direction is recommended, so that only the anterior and lateral sides of the neck of the AAA need to be dissected [39]. Hashizume et al. recommended intraluminal anastomosis of the graft without dissecting the posterior wall. In our case, the proximal aorta was transected and the graft was carefully anastomosed to the posterior aortic wall with direct vision of the RLRV [40].

CONCLUSION

Retro- aortic left renal vein is an important vascular variation and the detection of which is crucial to avoid the complication of catastrophic hemorrhage. Widespread use of diagnostic multidetector computed tomography in retroperitoneal diseases, particularly kidney tumors, can identify changes in the renal vascularization more easily, and thus allows urologists to plan a safe and less complicated aortic, renal, and retroperitoneal surgery. For patients with gross hematuria or flank and inguinal pain, individualized treatment such as conservative care, pyeloplasty, varicocelectomy, and nephrectomy should be selected. Knowledge of anomalies of left renal vein is essential for radiologists, endocrinologists, fertility specialists, urologists and surgeons, in determining the feasibility of complication-free surgical interventions in this region as well as the post-operative management and also for anatomists.

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