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Unusual Combination of Vascular Variations in the Retroperitoneal Region. A Morphological Study

ORIGINAL

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Abstract

Background: Blood supply of kidney and gonads is characterized by the presence of variations, which are usually silent and unnoticed until they are found by retroperitoneal surgery, radiologic examination or necropsy. Multiple renal vessels are no longer relative contraindication for laparoscopic donor nephrectomy, however of their presence may help avoid possible complication on a patient with these variations. The purpose of this morphological study was to analyze the frequency of supernumerary renal and testicular vessels and describe an unusual combination of vascular variations in the retroperitoneal region.

Methods and Findings: A total of 18 cadavers with different age group and 10 visceral blocks were used for the study in the Morphology Laboratory of the University of Pamplona. Multiple bilateral anatomical variations of testicular and renal vessels were found during routine dissection in a 65-year-old male cadaver. The variations found were: bilateral presence of three renal arteries and three renal veins. The three left renal arteries are divided and gave rise to seven branches: the left main renal artery originates two branches; the upper branch originates four branches and the lower branch originates one branch. Retro-aortic left renal vein. Three left testicular artery and double right testicular artery all originating from accessory renal arteries.

Conclusions: Awareness of renal and testicular vessels anomalies is essential for decreasing the rate of accidental injuries in surgical procedures in the retroperitoneal region as well as aid in diagnosis of diseases associated with vascular variation in the posterior abdomen. An understanding of the morphology of renal and testicular vessels is necessary in uroradiology, doppler imaging and computed tomography studies.

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Anatomical Variation, Inferior Vena Cava, Renal Vein, Retro-Aortic Left Renal Vein, Testicular Vein, Renal Artery, Testicular Artery, Abdominal Aorta.

Introduction

A single renal artery to each kidney is present in approximately 70% of individuals. Renal arteries take origin from the aorta bilaterally just below the superior mesenteric artery. The arteries vary in their level of origin and obliquity. Near the renal hilum each artery divides into an anterior and a posterior division which divide into segmental arteries supplying the renal vascular segments. [1-3]

One or two accessory renal arteries are present in 20-30% individuals [1]. They frequently arise, (especially on the left side) usually from the aorta, above or below the main artery (the former is slightly more often), enter the kidney above or below the renal hilum; if below, the vessel passes anterior to the ureter and may cause hydronephrosis by obstructing the ureter. On the right side, such artery passes usually anterior to the inferior vena cava. These arteries are regarded as the persistent embryonic lateral splanchnic arteries. [1]

Kidneys are drained by left and right renal veins. The left renal vein (LRV) passes the space between the superior mesenteric artery and the abdominal aorta, then it opens into the inferior vena cava (IVC). However, the right renal vein (RRV) directly opens into the IVC with a shorter course. The LRV is approximately three times longer than the RRV. Variations of renal vein are frequent and result from anomalies in vessel embryogenesis [4]. 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, with incidence rates of 1.7% and 1.6% in men and women respectively [5]. 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. 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 [6].

Testicular arteries are originated from the anterolateral aspect of abdominal aorta below the renal artery at the level of the second lumbar vertebra. Although, most commonly a single artery is found on each side, duplications of the testicular arteries have been described. The origins of duplicate testicular arteries are variable, both can originate from the aorta or one arises from aorta and other from different vessels such as renal or suprarenal arteries [7]. The right and left testicular veins which accompany the corresponding testicular artery drain in the inferior vena cava on the right and the left renal vein on the left side [8]. The purpose of this morphological study was to analyze the frequency of supernumerary renal and testicular vessels and describe an unusual combination of vascular variations in the retroperitoneal region. The variations reported here, have already been reported as individual cases, but occurrence of this vascular variations, bilaterally, in the same person, is a rare occurrence. It is the first case reported so far in the available scientific literature.

Methods

This work was previously approved by the Ethics Committee in Research and Environmental Impact of the University of Pamplona, conformed by resolution 030 of January 16 of 2014 and Resolution No. 008430 of 1993 of October 4 of the Ministry of Health of Republic of Colombia by which regulates the scientific, technical and administrative norms for health research. This descriptive cross-over study was designed to determine the morphologic features, prevalence and anatomical variations of the renal and testicular vessels. A total of 18 cadavers with different age group and 10 visceral blocks 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. Anterior abdominal wall was opened by giving the following incisions and both the kidneys were exposed.

Renal vessels were studied arising from the abdominal aorta and pre-hilar branches of the main artery, directed to the kidneys. The aortic branch of larger caliber was called renal artery and its pre-hilar branches were those arising at the hilum. The hilum limits were set by a line drawn between the two most medial points in the frontal plane of each kidney.

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

Out of 18 cadavers and 10 visceral blocks of the present study a standard text book pattern of renal and testicular vessels was observed in 27 cases (96.4%). Single renal and testicular vessels were observes on the left and right side.

The length and diameter of the left renal vein were 6.0±1.5 cm and 1.24±0.2 cm respectively

The length and diameter of the right renal vein were 2.5±0.7 cm and 1.23±0.2 cm, respectively

The length and diameter of the right renal artery found was 4.72±1.19 cm and 6.8±0.16 mm respectively.

The length and diameter of the left renal artery found was was 3.7±1.08 cm and 6.9±0.2 mm respectively.

The testicular artery originates directly from the abdominal aorta at L2-L3, just below the origin of the renal arteries descending in a straight course to its termination in 23/27 cases (85%). In 4/27 cases (15%), it showed a slight or marked convoluted course. The right testicular artery after crossing the inferior vena cava was observed posterior to the horizontal part of the duodenum, right colic and ileocolic arteries, root of the mesentery and terminal ileum. The left testicular artery was observed posterior to the inferior mesenteric vein, left colic artery and descending colon. Testicular arteries on both sides descended superficial to the psoas major muscles, and genitofemoral nerve, crossed the ureters (supplies its middle portion) and runs along the pelvic brim above the external iliac artery and then pass to the deep inguinal ring to enter the spermatic cord.

In 1 case (3.6%), arterial and venous anatomic variations were found on the right and left side of a male cadaver of 65 years of age:

On the left side

The size of the left kidney was 13x6x5cms. It received three renal arteries with separate origins of the abdominal aorta. The left main renal artery (length

of 4 cm and diameter of 5.5 mm) took their origin from the anterior aspect of the abdominal aorta at the level of L1 vertebra; the upper branch (length of 3.7 cm and diameter of 6.5 mm) took origin from the lateral aspect of the abdominal aorta at level of L1 vertebra just superior to left main renal artery. The lower branch (length of 4.82 cm and diameter of 6.0 mm) took their origin from the anterior aspect of the abdominal aorta at the level of L2 vertebra. Among all the renal arteries, the upper branch was the thickest and even the two branches (upper and lower) were of greater caliber than the left main renal artery. Prehiliar level three renal arteries are divided and gave rise to seven branches: the left main renal artery originates two branches; the upper branch originates four branches and the lower branch originates one branch. **Figure 1**.

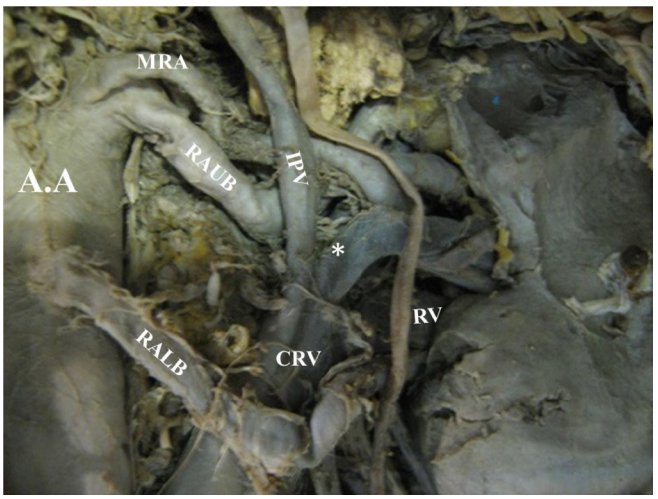
Three left testicular artery was observed, originating from accessory renal artery (renal artery-lower branch). **Figure 2**.

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, it receives as tributaries, the adrenal vein, the inferior phrenic vein, fine parietal branches of the left lumbar region. A single left testicular vein (diameter of 5.4 mm) was observed which was tributary of the retro-aortic left renal vein. Figure 2. Further, at the hilum was found three renal veins embraced the main renal artery and the upper arterial branch. **Figure 1** & **2**. 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), which has a diameter of 24 mm and a length of 8.5 cms. Instead of passing horizontally, it coursed obliquely downwards and joined inferior vena cava at the level of of the fourth vertebra lumbar. **Figure 2**.

On the right side

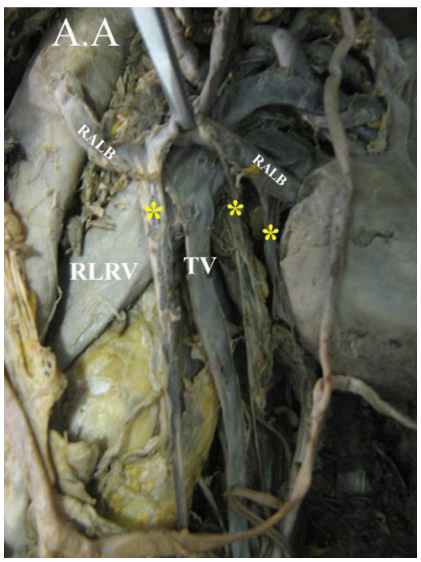
The size of the right kidney was 13x6x4cms. It received three renal arteries. The right main renal artery

Figure 1: Anterior view of retroperitoneal left region.



A.A: Abdominal aorta; MRA: Main renal artery; RAUB: Renal artery-upper branch; RALB: Renal artery-lower branch; RV: Renal vein; White asterisk: double renal veins embraced the main renal artery and the upper arterial branch; IPV: Inferior phrenic vein; CRV: common renal vein.

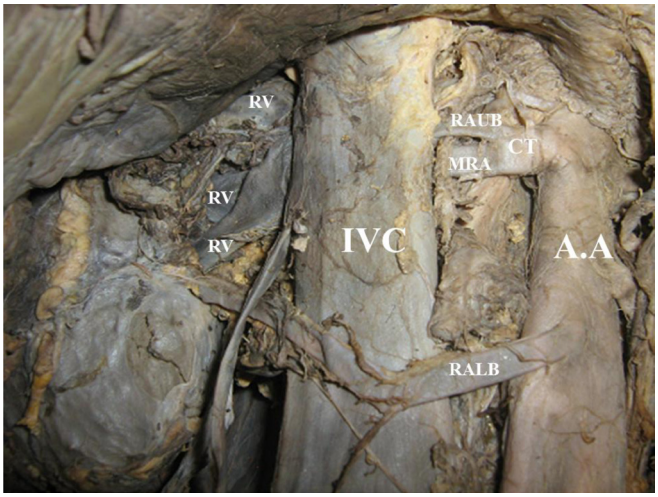
Figure 2: Anterior view of left retroperitoneal region.



A.A: Abdominal aorta; RLRV: Retro-aortic left renal vein; RALB: Renal artery-lower branch; Yellow asterisk: Testicular arteries; TV: testicular vein.

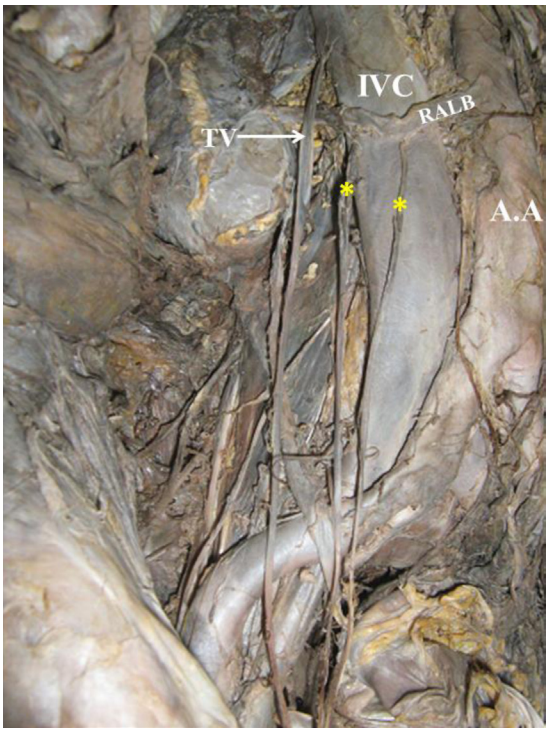
(length of 4.82 cm and diameter of 6 mm) and upper branch (length of 4.87 cm and diameter of 4.87 mm) took their origin from a common trunk (length of 11.8 mm and diameter of 11 mm) coming out of the lateral aspect of the abdominal aorta at the level of L1 vertebra. The other artery, the lower branch (length of 5.82 cm and diame-

Figure 3: Anterior view of right retroperitoneal region.



A: Abdominal aorta; IVC: Inferior vena cava; MRA: Main renal artery; RAUB: Renal artery-upper branch; RALB: Renal artery-lower branch; RV: Renal vein.

Figure 4: Anterior view of right retroperitoneal region.



A.A: Abdominal aorta; RALB: Renal artery-lower branch; IVC: Inferior vena cava; TV: testicular vein; Yellow asterisk: Testicular arteries.

ter of 5.89 mm) took their origin from the anterior aspect of the abdominal aorta at the level of L2 vertebra. The venous drainage of the right kidney is through three renal veins, which formed a common venous trunk draining the blood from the kidney into the inferior vena cava, the length and diameter of the right renal vein were 2.7 cm and 18.3 mm respectively. The arrangement of the structures in the hilium, anterior-posteriorly was right renal artery from lower branch of the abdominal aorta), three veins renal, right main renal artery, renal artery from upper branch both from the common trunk of the abdominal aorta and renal pelvis. **Figure 3**.

Double right testicular artery was observed, both originating from accessory renal artery (renal artery-lower branch). A single right testicular vein was observed which was tributary of the inferior vena cava. **Figure 4**.

Discussion

Arterial variations arising from abdominal aorta are quite common and are frequently reported. Out of all paired and unpaired branches of abdominal aorta the variations are common in renal artery and comparatively less reported in gonadal arteries. In the recent studies, the percentage of single renal artery (RA) was reported to be 70%, for double RA 25% and if third RA persists it was 2.6% [9-10]

Additional renal arteries can be found in up to 33% of patients [11], 8% to 30% of kidneys unilaterally and 10% bilaterally [12]. Adachi studied a total of 338 kidneys. A single renal artery was described in 261 cases (77.2%) and additional renal arteries were described in 77 cases (22.8%). Among kidneys with additional arteries, 2 arteries in 68 cases and 3 arteries in 9 cases were reported. They did not find any kidneys with 4 and more renal arteries [13]. Miclaus and Matusz reported a case of a 58-yr-old male with bilateral quadruple renal arteries. The case emphasized the prevalence of bilateral multiple renal arteries. Bilateral double

and triple renal arteries have been reported in the past, but this case was the first to report bilateral quadruple renal arteries [14]. Rossi et al. reported a case of a 23-yr-old living donor candidate with 4 left renal arteries and 3 right renal arteries [11]. Satyapal et al. state that as blood supply establishes according to the location of kidneys, aberrant positioning of the kidneys predisposes them to abnormal vascular supply [15]. Abnormal inferior position of the harvested kidney can be an indirect indicator of multiple renal arteries in the graft [16]. Orlando et al. reported a rare case of a renal graft with 6 arteries and a double pelvis. This is the greatest number of accessory renal arteries reported in the literature as well as the first case of a kidney with more than 4 arteries to be successfully transplanted [17]. Bachul et al. reported a second kidney graft with more than 4 renal arteries. The results of the transplantation were successful with an uneventful postoperative course [16]. In the present study, left kidney received three renal arteries with separate origins of the abdominal aorta. At prehiliar level, the three renal arteries are divided and gave rise to seven branches: the left main renal artery originates two branches; the upper branch originates four branches and the lower branch originates one branch. The right kidney was received three renal arteries. The right main renal artery and upper branch took their origin from a common trunk coming out of the lateral aspect of the abdominal aorta at the level of L1 vertebra. The other artery (lower branch) took their origin from the anterior aspect of the abdominal aorta at the level of L2 vertebra.

Fernandes et al. reported a case with three renal veins draining the right kidney [18]. Satayapal reported incidence of additional right renal vein was 26% as compared to 2.6% on the left side. Second additional renal vein occurred infrequently on the right side (5%) [19]. Dnyanesh et al reported double renal vein on right side (1%) [20]. Mukundan also reported a case where the right kidney drained into the inferior vena cava through two veins and the left kidney drained into the inferior vena cava through two veins which united to form a single large left renal vein and drained into the inferior vena cava [21]. Panchal et al. reported three kidneys (two left kidney and one right kidney) showed two emerging veins at the hilum which joined to form the main renal vein outside the hilum, while one left kidney showed three emerging vein from the hilum which joined to form the main renal vein outside the hilum [22]. In the present study, left and right kidneys showed three veins emerging from the hilum which joined to form the main renal vein outside the hilum. The left renal vein it receives as tributaries, the adrenal vein, the inferior phrenic vein, fine parietal branches of the left lumbar region. 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. A single left testicular vein was observed which was tributary of the retro-aortic left renal vein. Variations of renal veins are usually asymptomatic and are discovered only during surgical procedures. Morphology of renal vein is significantly important for surgeons during transplantation, since variations restrict the availability of renal vein for mobilization procedures [23].

The variation in testicular arteries (TA) may be with respect to their origin, number or course. They may originate from the abdominal aorta itself at an abnormal level. If not arising from abdominal aorta the TA variants may arise from renal artery, suprarenal artery or any one of the lumbar arteries. Rarely can it arise from common or internal iliac artery, or from the superior epigastric artery. The most common variation with respect to origin of TA was found in association with renal vessels. In regard to numbers, double TA was most common and with respect to course most common varia-

tion was arched TA over ipsilateral renal vein. The arched TA at times on right side had a retrocaval course [10].

Among the variations less frequent of the testicular artery (TA) include double testicular arteries. Cicekcibasi et al. described the variations of the gonadal arteries in 90 fetuses and classified the variations into four alternative types on the basis of their origin and number:

- Type I. TA arising from the suprarenal artery;
- Type II. TA originating from the renal artery;
- Type III. TA of high positional origin from the abdominal aorta, close to the renal artery lineage;
- Type IV. TA duplication originating from the aorta or from various vessels.
- Type IV. Included duplications of the gonadal arteries, in three cases found two right testicular arteries.

The duplications were subdivided into two subtypes:

- Type IV. A, in which both testicular arteries originated from aorta.
- Type IV. B, with different origin, one of them originated from aorta, the other from the suprarenal artery [24].

In a study of 34 cadavers, Pai et al. described one case of two right testicular arteries, one lateral arose from artery renal and the other medial emerged from aorta as a common trunk along with the inferior suprarenal and renal capsular arteries [25]. Jyothsna et al. reported one case of left double testicular arteries with a common trunk originating from aorta immediately debranching in testicular and inferior suprarenal arteries; the other testicular artery arose from aorta [26]. Filipovic et al. found one case with two left testicular arteries: One was medial, originating from an accessory renal artery; the other was lateral, branching from the common trunk together with the left inferior suprarenal artery [27]. Paraskevas et al. described a high origin (above the expected level of branching) of the left testicular artery in a common trunk with the inferior phrenic artery [28]. In the present study, on the same cadaver, three left testicular artery was observed, originating from accessory renal artery (renal artery-lower branch) and double right testicular artery was observed, originating from accessory renal artery (renal artery-lower branch), which are considered as a rare entity.

Clinical and surgical implications

Multiple renal arteries are a common finding in renal angiograms and are more common in the aorta and renal vessels in the donor population subjected to angiography, but do not pose any serious risk or contraindication to renal donation [29]. Multiple renal arteries occurred bilaterally in 10.2% of donors and unilaterally in 20.8%, a total incidence of 31%. There was a higher incidence of vascular-related complications following transplantation of kidneys with multiple renal arteries. Attention is drawn to the need for careful technique in identification of multiple renal vessels, especially aberrant vessels, at the time of donor nephrectomy and also to the different techniques available for anastomosis of multiple renal arteries in kidney transplant recipients [29,30]. Besides, the failure to properly anastomose all arteries can lead to graft necrosis, graft rupture, segmental renal infarction, and postoperative hypertension and calyceal fistula formation [1, 29, 31].

Nutcracker syndrome (NCS) is a rare entity caused by the left renal vein (LRV) entrapment,[32] most usually between the aorta and the superior mesenteric artery (SMA), known as anterior NCS. Sometimes a retroaortic position of the LRV also promotes an entrapment, this time between the aorta and the vertebral column, which is named posterior NCS. [33] This is a relatively common anatomical variance, in which the patient stays asymptomatic and it is often diagnosed in an occasional imaging exam. This syndrome can manifest by the left flank and abdominal pain, with or without macroscopic

or microscopic haematuria. When the venous reflux caused by the LRV entrapment leads to the formation of collaterals this syndrome may be a cause of pelvic congestion syndrome characterized by an array of signs and symptoms such as lower abdominal pain and pelvic, perineal and lower limb varices [6, 34, 35].

The clinical implications of anomalies of TAs regarding origin, number and course are varicocele, hydronephrosis, nephroptosis or malrotation of kidney, renal arterial hypertension, and infarction of kidney, testicular atrophy, arched TA or risk of haemorrhage during surgical procedures, segmental ischaemia of kidney, undescended testis. Varicocele is a secondary condition caused due to compression of renal vein by variant TA. Hydronephrosis occurs due to occlusion or compression of ureter during anomalous course of TA. Nephroptosis is malrotation of kidney which can result in anomalous origin and course of TA. Renal arterial hypertension was due to constriction of renal artery to result in renal ischaemia. If there were any arterial variations the risk of infarction in kidney increases during surgical interventions inadvertently done during renal and para-aortic surgeries. Before going for renal surgical procedure clinicians should plan for renal and associated vascular anomaly to prevent any unforeseen complications [10].

Anatomical knowledge of testicular artery is very essential for performing operative techniques of treating varicocele and undescended testes within abdominal cavity. During varicocelectomy, testicular artery must be preserved in order to prevent testicular atrophy. In microvascular autotransplantation of intraabdominal testis, origin and course of testicular artery must be carefully identified. Therefore, awareness of the possible existence of such variations of testicular arteries is of great importance during surgical procedures in this region [26]. Anomalous TA origin may affect the testicular perfusion and testicular function. Since age-related disturbances in spermiogenesis are well described in the literature, it would be wise for the clinician to differentially diagnose age-related impaired spermiogenesis from perfusion induced spermiogenesis [28].

Conclusion

Understanding the anatomical variations of renal, testicular and inferior phrenic vessels is important for anatomists, radiologists, urologist, vascular surgeons, surgeons and oncologist during diagnostic procedures and surgery in the retroperitoneal region.

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Conflict of interest

The author declare no conflicts of interest.

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