CASE REPORT

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Variations of the retroperitoneal venous system: a case report featuring a unique branching pattern of the right testicular vein in combination with a rare circumaortic left renal vein

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SUMMARY

Here we present a rare case featuring two vascular variations discovered during routine dissection of a 71-year-old male formalin-fixed cadaver including; 1) a type III circumaortic left renal vein, and 2) a duplicated right testicular vein with a unique branching pattern. The gross anatomical characteristics, embryological origin, and clinical relevance of these anomalies are described in this report. Awareness of the vascular variations presented in this case may be of great clinical importance, especially in the case of laparoscopic retroperitoneal surgery, diagnostic procedures, and nephrectomy.

Key words: Anatomic variation – Cadaver – Renal veins – Retroperitoneal – Testicular veins

INTRODUCTION

Anatomical variations are quite common and can occur in various body systems. However, as anatomical dissectors it still surprises us how many cases we see. Vascular structures are known to exhibit notable variations that can have significant implications clinically (Anson et al., 1947; Gupta et al., 2015; Haladaj et al., 2019). These variations can influence diagnostic imaging procedures, vascular interventions, and surgical planning. Variations of the retroperitoneal venous system in particular are quite rare, but have the potential to impact both physiological function and clinical presentation (Anson et al., 1947; Gupta et al., 2015; Haladaj et al., 2019).

Standard anatomical descriptions indicate that typically, a single right testicular vein drains directly into the inferior vena cava (IVC) (Favorito et al., 2007) with the left renal vein following the same pattern (Anson et al., 1947; Haladaj et al., 2019). These vessels drain the spermatic cord and kidneys, respectively. Here we present a unique case of renal and testicular vein variations identified during routine dissection. This report aims to highlight the multiple variations present in this individual to enhance awareness of lesser-known

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variants, potentially helping to minimize risks in clinical practice.

CASE REPORT

Ethical approval for this study was granted by the University of Manitoba Health Research Ethics Board.

The formalin-fixed male donor featured in this report passed away from myocardial infarction at the age of 71. During routine dissection, multiple variations of the retroperitoneal venous system were observed, including a type III circumaortic left renal vein (CLRV) and a duplicated right testicular vein with a unique branching pattern. In addition to these rare variations, the donor presented with a small fusiform abdominal aortic aneurysm just superior to the bifurcation of the abdominal aorta into the common iliac arteries.

Circumaortic Left Renal Vein

A circumaortic left renal vein (circumaortic renal collar) was found draining into the inferior vena cava (Fig. 1a). Two renal veins originated separately from tributaries in the renal hilum; one preaortic (anterior, superior) and one retroaortic (posterior, inferior). The preaortic vein crossed the anterior surface of the abdominal aorta just inferior to the superior mesenteric artery, and drained into the IVC at the level of the first lumbar vertebra. It measured 12.5 cm in length and 1 cm in diameter. The retroaortic vein travelled along the posterior aspect of the aorta and drained into the IVC at the level of the second lumbar vertebra. This vein measured 10 cm in length and 2.5 cm in diameter. The distance between the confluence of each vein with the IVC was 7 cm. The preaortic component received the left suprarenal and left inferior phrenic veins, and the retroaortic component received the left gonadal vein. A schematic representation of this variation can be viewed in Fig. 1b. The renal veins formed an anastomosis 4 cm distal to the renal hilum (Fig. 2a). A schematic representation can be viewed in Fig. 2b.

Duplicated Testicular Vein

A duplicated testicular vein does not fully describe the variation that was observed on the right side. In addition to two testicular veins coming from the inguinal canal, there were multiple branches draining into the inferior vena cava and right renal vein (Fig. 3a). For ease of explanation, we will term the duplicated veins the medial and lateral testicular veins. Both the medial and lateral testicular veins bifurcate proximally, splitting into a total of three terminal branches. Stemming from the 18 cm in length medial testicular vein, there was a branch approximately 5 cm in length draining directly into the IVC (A), and a branch that merged with the lateral testicular vein before draining into the confluence of the renal vein and IVC (B). This branch measured approximately 5

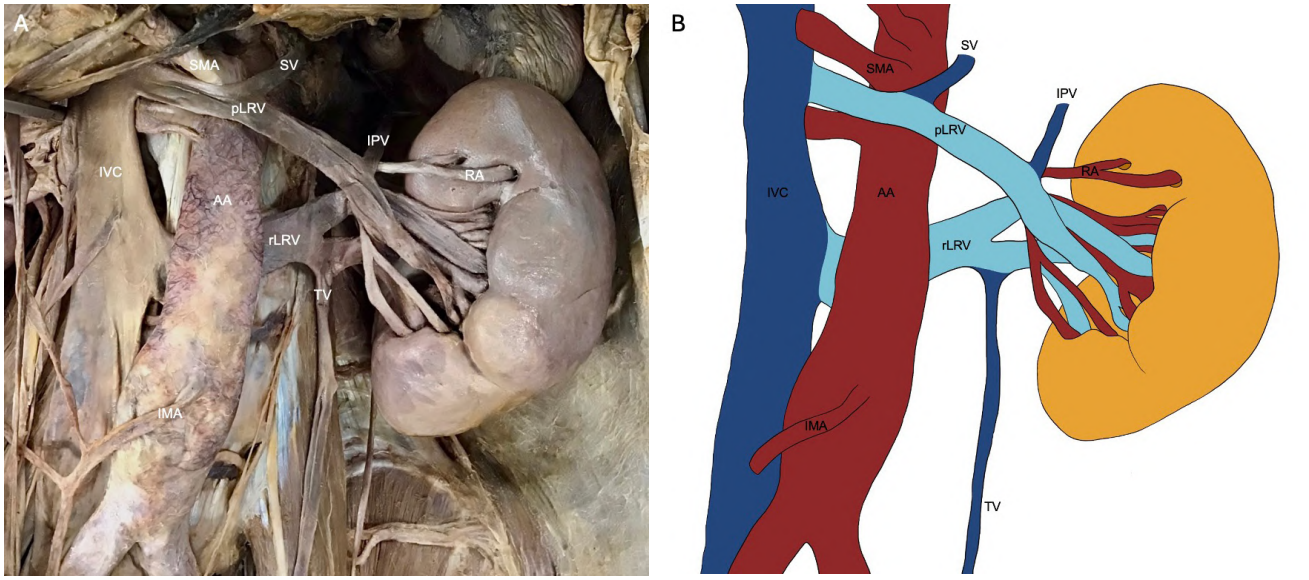

Fig. 1.- a: Anterior view of the circumaortic left renal vein and relational anatomy. b: Schematic representation of the circumaortic left renal vein and its tributaries (AA: abdominal aorta, RA: left renal artery, SMA: superior mesenteric artery, IMA: inferior mesenteric artery, IVC: inferior vena cava, pLRV: preaortic left renal vein, rLRV: retroaortic left renal vein, SV: left suprarenal vein, IPV: left inferior phrenic vein, TV: left testicular vein).

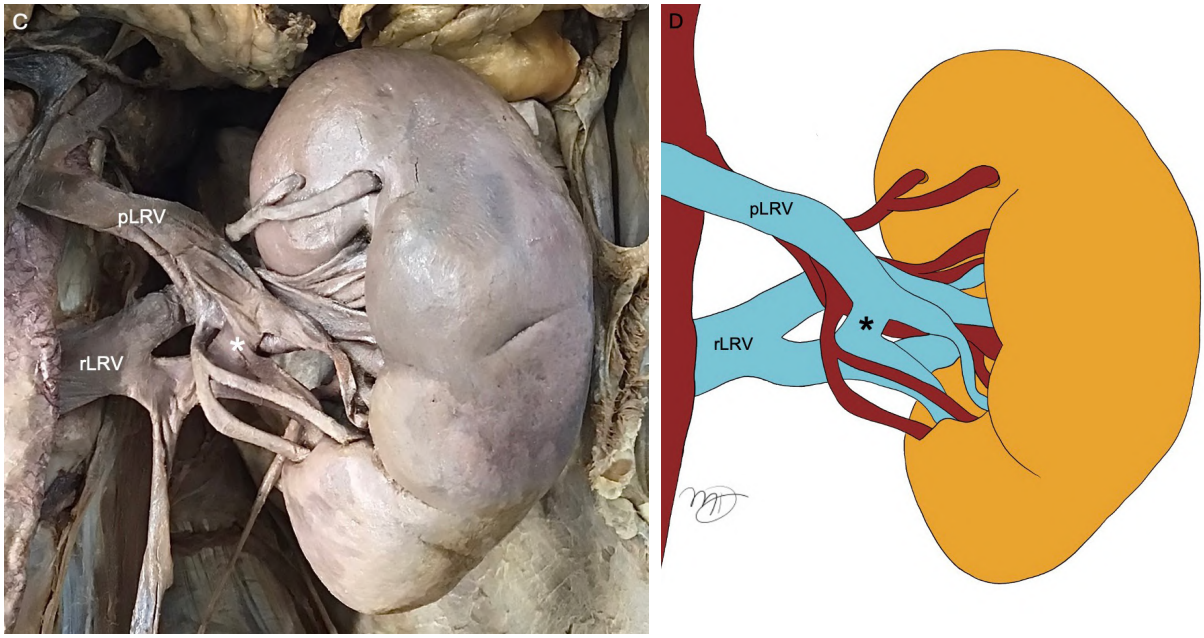

Fig. 2.- a: Anterior view of the anastomosis between the preaortic and retroaortic renal veins. b: Schematic representation of the anastomosis between the preaortic and retroaortic renal veins (pLRV: preaortic left renal vein, rLRV: retroaortic left renal vein, *: anastomosis between the preaortic and retroaortic renal veins).

½ cm in length. The lateral testicular vein measured 21 cm in length, with one branch attaching to division B of the medial testicular vein, and another branch that crossed the anterior surface of the right renal vein (C) and drained directly into the posterior surface of the IVC (+). A communicating vein was also observed between the medial and lateral testicular veins just proximal to the inguinal canal. A schematic representation can be viewed in Fig. 3b.

DISCUSSION

Circumaortic Left Renal Vein

Renal vein anomalies are believed to occur due to abnormal persistence or regression of embry-

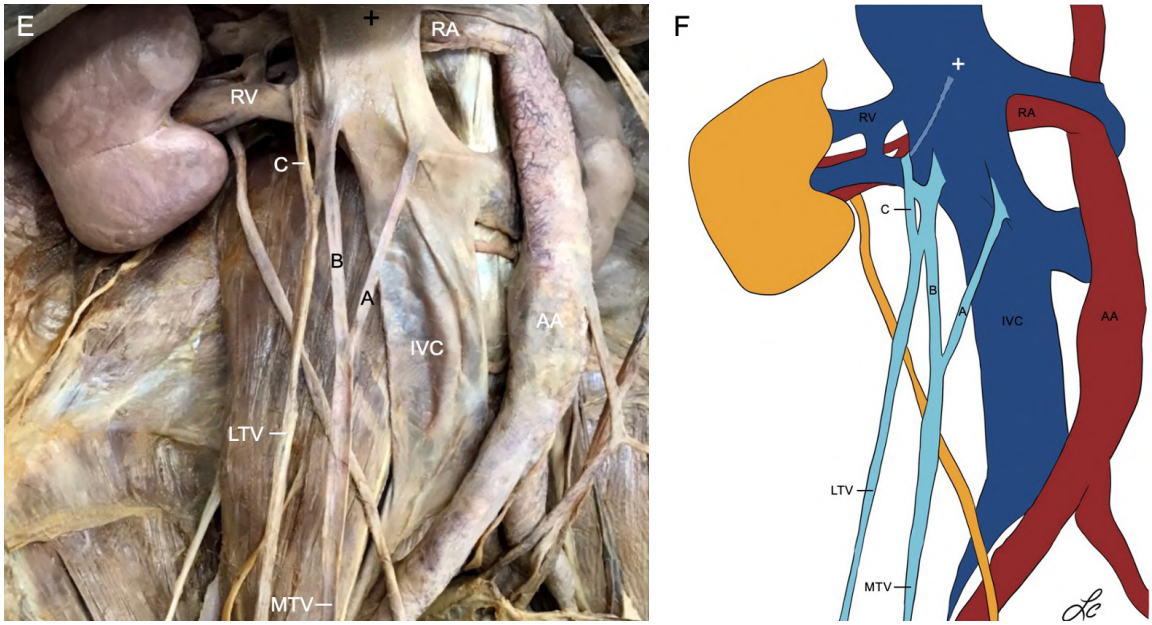

Fig. 3.- a: Anterior view of the testicular vein variation. b: Schematic representation of the duplicated testicular vein and its branches (AA: abdominal aorta, RA: right renal artery, IVC: inferior vena cava, RV: right renal vein, MTV: medial testicular vein, LTV: lateral testicular vein, A: branch of the medial testicular vein draining directly into the IVC, B: branch of the medial testicular vein draining into the confluence of the right renal vein and IVC, C: branch of the lateral testicular vein draining into the posterior surface of the IVC, +: drainage point of branch C on the posterior surface of the inferior vena cava).

onic veins during the early stages of gestation. A CLRV is derived from abnormal persistence of the renal collar, which is formed by an anastomosis between the supracardinal and subcardinal veins (Mathews et al., 1999). During typical development, the dorsal (retroaortic) limb of the renal collar regresses, and the ventral (preaortic) limb becomes the left renal vein (Mathews et al., 1999). When both pre- and retroaortic anastomotic channels persist, a CLRV is formed (Beckman et al., 1980; Haladaj et al., 2019; Nam et al., 2010; Shreevastava et al., 2024). In a study by Natsis et al., CLRV was classified into three morphological subtypes based on findings of CT angiography scans (Natsis et al., 2008). In this case, the CLRV is classified as Type III, as an anastomosis exists between the preaortic and retroaortic renal veins.

Although renal vein anomalies are typically identified by chance through imaging or autopsy, CLRV can present with significant complications in the surgical setting (Haladaj et al., 2019; Mathews et al., 1999). As such, identification of left renal vein variations is important for preoperative planning and to reduce the risk of intra- and postoperative complications, especially in the case of abdominal aortic surgery and nephrectomy (Haladaj et al., 2019; Hashizume et al., 2013; Shreevastava et al., 2024). A significant concern for CLRV in surgery is unexpected venous injury, as identification of the preaortic component may suggest typical left renal vein development, leaving the retroaortic vein at risk for injury during dissection or clamping of the infrarenal abdominal aorta (Brener et al., 1974; Hashizume et al., 2013; Shreevastava et al., 2024). In a surgical case series on left renal vein developmental anomalies by Brener et al., intraoperative venous injury occurred in 50% of reported cases (Brener et al., 1974). Despite advances in imaging technology allowing for the diagnosis of renal vein anomalies prior to surgery, the detection rate of CLRV is still low, and in the case of emergency surgery preoperative identification may not be possible (Dilli et al., 2012; Hashizume et al., 2013).

Multiple renal veins are also associated with greater risk of injury during donor nephrectomy, often resulting in the need for repair during bench surgery and prolonged ischemia time (Shreevastava et al., 2024). This emphasizes the importance of intraoperative identification, as failure to recognize anomalies such as a CLRV may lead to hemorrhage and subsequent renal damage (Dilli et al., 2012; Hashizume et al., 2013; Nam et al., 2010).

CLRV is most commonly asymptomatic, but clinical symptoms have been reported in rare cases. Urological problems such as ureteropelvic junction obstruction and hematuria (Dilli et al., 2012) can occur due to the posterior "nutcracker phenomenon", which refers to a decreased space between the abdominal aorta and vertebral column that causes compression of the retroaortic renal vein (Nam et al., 2010; Shreevastava et al., 2024). This can lead to venous hypertension and retrograde flow, which results in renal congestion and rupture of the thin-walled septum separating the veins from the urinary collecting system (Shreevastava et al., 2024). Additionally, increased drainage pressure may cause vascular dilation of the left gonadal vein, leading to varicocele and pelvic congestion syndrome (Nam et al., 2010; Shreevastava et al., 2024).

Duplicated Testicular Vein

Testicular vein variations are typically found on the left side and most commonly drain into the left renal vein (Nallikuzhy et al., 2018), unlike the case reported here, in which the right testicular vein has multiple divisions and a branch that drains posteriorly into the IVC. Similar to renal vein anomalies, the occurrence of variants in testicular veins is believed to be due to abnormal embryological development of the subcardinal venous system (Gupta et al., 2015).

The formation of the gonadal veins (testicular and ovarian) is interconnected with the development of the renal veins and the IVC (Gasser, 1975; Gupta et al., 2015). Both the left and right gonadal veins develop from the caudal part of the subcardinal vein. The primitive left gonadal vein drains into the connection between the sub- and supracardinal veins (Gasser, 1975). This connection becomes part of the left renal vein, and hence the left gonadal vein will drain into it. On the right side, the supra-subcardinal anastomosis and a small portion of the subcardinal vein contribute to the

formation of the IVC. This connection allows the right gonadal vein to drain directly into the IVC (Gasser, 1975; Sharma et al., 2011).

In most cases, individuals can go a lifetime without knowing they possess a unique variation. However, in rare cases testicular vein variations can present with significant clinical implications. Surgical procedures navigating the intricate anatomy of neurovascular structures in the retroperitoneal space, such as laparoscopic retroperitoneal lymph node dissection for testicular cancer (Kenney et al., 2008), gonadal vein transposition to reduce venous pressure in cases of nutcracker syndrome (Gilmore et al., 2021) and nephrectomy (Sharma et al., 2011) require intraoperative vigilance for variant anatomy, especially for cases in which anomalies cannot be identified though preoperative imaging. Additionally, in living donor transplants, the gonadal vein is often used for vascular reconstruction and extension of the renal vein (Gupta et al., 2015). Unfamiliarity with testicular vein variations can cause unintended injury, leading to significant bleeding or scrotal congestion. Furthermore, these variations play an important role in complex pelvic or abdominal surgeries in close proximity to the deep inguinal ring or routine laparoscopic hernia repairs, as any alteration of standard surgical landmarks that surgeons rely on changes the predictability of the surgery and possibly its outcome (Padur et al., 2019).

Testicular vein variations are also clinically significant in radiology, as they have the potential to impact diagnosis, interventional planning, and procedures across various specialties. Variations can cause atypical varicocele presentation and may mimic retroperitoneal masses, dilated ureters, or lymphadenopathy, leading to potential diagnostic confusion on computed tomography or magnetic resonance angiography (Gupta et al., 2015).

CONCLUSION

This report documents a rare case of a duplicated right testicular vein with a unique branching pattern and a type III circumaortic left renal vein. While the variations described in this report are rare, their potential to cause pelvic and renal compromise upon vascular injury highlights the need for increased surgical awareness, and the importance of documentation in both anatomical and clinical contexts.

AUTHOR CONTRIBUTIONS

LG Clayton: manuscript writing/editing, illustration

MM Damjanovic: manuscript writing/editing, illustration, dissection

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