Chapter 8

Coexistence of the Aortic Aneurysm with the Main Vein Anomalies: Its Potential Clinical Implications and Vascular Complication

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Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/66768

Abstract

Four major variations of the venous system in the retroperitoneal space are the retroaortic left renal vein, left renal vein collar, left-sided inferior vena cava, and caval duplication. During surgery, especially, injury in veins is responsible for the most unexpected intraoperative bleeding. Therefore, above-mentioned anomalies pose potential hazards to surgeons during treatment of abdominal aortic aneurysm. Preoperative diagnosis is highly desirable but is not always available so, during abdominal surgery, familiarity with the anatomy of the most common types of venous variations is the first step toward preventing vascular injury. The chapter includes information describing the demographic, clinical, and morphological characteristics of the presence of the aforementioned main vein anomalies including: gender distribution, frequency in population, the most commonly reported symptoms, and associate complications. Massive intraoperative bleeding may be dangerous during aortic dissection; however, venous bleeding is more complicated than arterial hemorrhage. Significant venous bleeding, in particular, can occur if major retroperitoneal venous anomalies are present. The anomalous veins are typically thin-walled, dilated, and tortuous. As a result, manipulation of these veins during abdominal aortic surgery places the patient at high risk of long-term massive hemorrhage.

Keywords: aortic aneurysm, vascular variations, retroaortic left renal vein, left renal vein collar, left-sided inferior vena cava, caval duplication

1. Introduction

There are four major variations of the venous system in the retroperitoneal space: retroaortic left renal vein, left renal vein collar, left-sided inferior vena cava, and caval duplication [1, 2] (**Figures 1–3**). These anomalies pose potential hazards to surgeons during treatment of

abdominal aortic aneurysm. An injury to an unrecognized anomalous vessels can result in severe hemorrhage [3, 4]. Especially, injury to veins is responsible for the most unexpected intraoperative bleeding [4, 5]. The anomalous veins are typically thin-walled, dilated, and tortuous [6], and manipulation of these veins during abdominal aortic surgery places the patient at high risk of massive hemorrhage [1, 7]. The majority of cases of retroaortic left renal vein, left renal vein collar, left-sided inferior vena cava, and caval duplication are diagnosed incidentally on the base of radiological examinations performed for other reasons, but these variations can have significant clinical implications [1, 5].

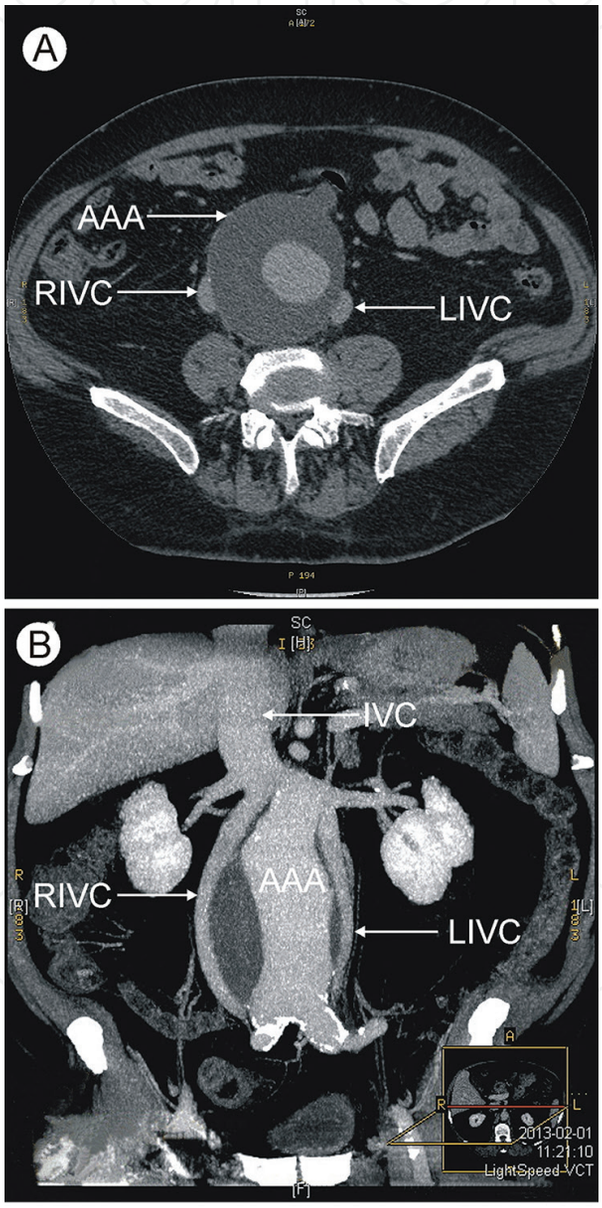

Figure 1. Computed tomography investigation of the abdomen with duplication of the inferior vena cava (CT-64-row MDCT scanner, Light-speed VCT, GE, Waukesha, Wisconsin, USA). (A) Transverse scan on L3 level, (B) three-dimensional computed tomography reconstruction of the vessels (posterior view). Ao: aorta, AAA: abdominal aortic aneurysm, IVC: inferior vena cava, LIVC: left inferior vena cava, RIVC: right inferior vena cava.

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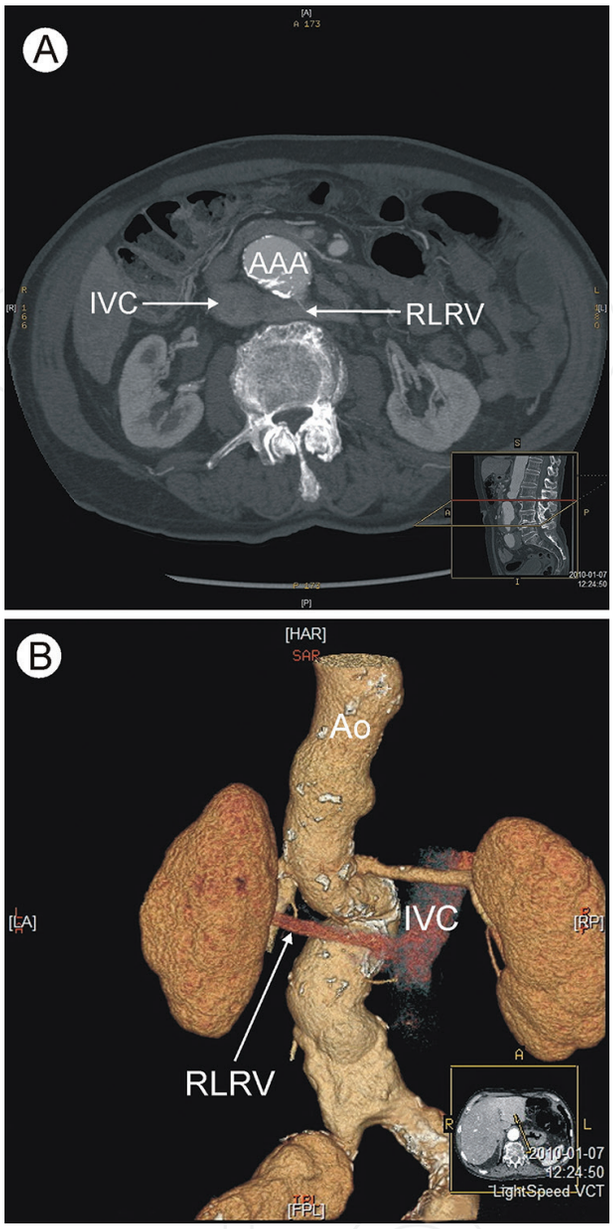

Figure 2. Computed tomography investigation of the abdomen with retroaortic left renal vein (CT-64-row MDCT scanner, Light-speed VCT, GE, Waukesha, Wisconsin, USA). (A) Transverse scan on L2 level, (B) three-dimensional computed tomography reconstruction of the vessels (posterior view). Ao: aorta, AAA: abdominal aortic aneurysm, IVC: inferior vena cava, RLRV: retroaortic left renal vein.

Preoperative diagnosis is highly desirable but not always available and most venous anomalies are diagnosed during operations. Therefore, during abdominal surgery, familiarity with the anatomy of the most common types of venous variations is the first step toward preventing vascular injury [5].

Additionally, compression of surrounding vessels by abdominal aortic aneurysm or atherosclerotic aorta forms a rich collateral circulation that exists in the abdomen and prevents the presence of ischemic symptoms [8, 9]. However, when hemodynamic compensation mechanisms

begin to fail, the effects may be extremely serious. Such coexistence may complicate surgical treatment and thus predispose the patient to thrombosis [10–12].

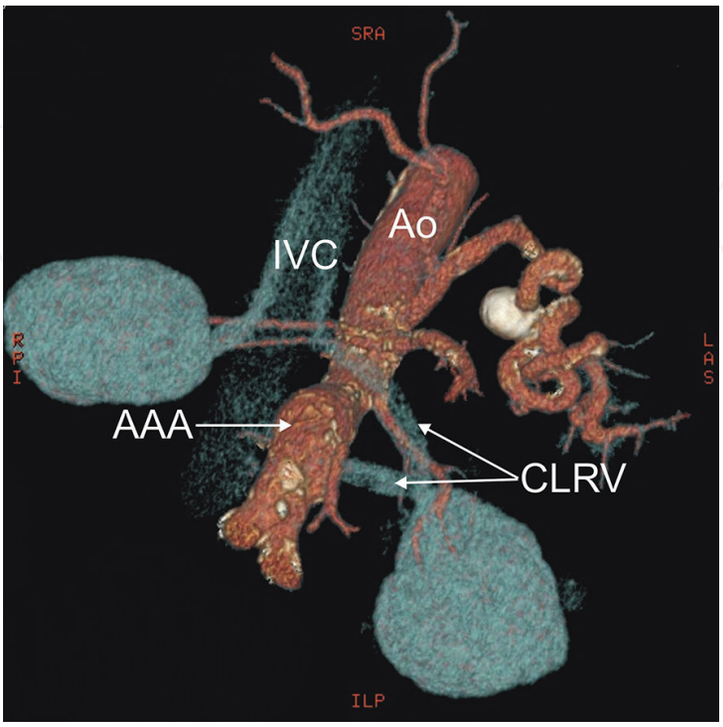

Figure 3. Three-dimensional computed tomography reconstruction of the vessels (CT-64-row MDCT scanner, Lightspeed VCT, GE, Waukesha, Wisconsin, USA). Ao: aorta, AAA: abdominal aortic aneurysm, CLRV: circumaortic left renal vein, IVC: inferior vena cava.

2. Duplication of the inferior vena cava

Duplication of the inferior vena cava is defined as an anomaly with two large veins situated on both sides of the abdominal aorta (**Figure 1**). These veins usually join to form one vein at the level of the origin of the renal arteries [1, 2]. It is a rare developmental variant that has been reported to occur in 0.2–4% of the population [13–16]. However, coexistence of duplication of the inferior vena cava with the abdominal aortic aneurysm is described only in a few studies [5, 17–19], in which it accompanies other vascular variations [18] or developmental anomalies [20]. The duplicated inferior vena cava has a reported incidence of 2–3% in autopsy studies [15, 18]. However, this anomaly diagnosed by CT, was only 0.3–0.6% [13, 16]. This difference in occurrence suggests that the smaller component is not readily apparent on CT. Duplicated veins are typically thin-walled, dilated, and even may be tortuous [8, 17]. Such morphology may complicate surgical treatment and predispose the patient to unexpected bleeding. Embryological explanation of such developmental variation as duplication of the inferior vena cava is complex. During fetal development three segments constitute the inferior vena cava: the upper hepatic segment, the renal (subcardinal) segment, and the supracardinal (sacrocardinal) segment [21–23]. In 1925, McClure and Butler proposed the theory of inferior vena duplication [23]. It was modified by Larsen in 2001 [24]. According to their explanation

such an anomaly occurs due to failure of the caudal left supracardinal vein to regress resulting in an additional vein: the left inferior vena cava [23, 24].

Chen et al. [25] note that inferior vena cava anomalies were significantly more common in men than in women. A radiological study by Morita et al. [16] also found that such anomalies were significantly more common in men (39 of 3821 cases—1%) than in women (12 of 2473 cases—0.5%); men/women ratio is 2:1.

The knowledge of presence of a duplicated inferior vena cava in patient is clinically very important. It increases risk during abdominal aortic surgery [2]. The main reason is that anomalous veins are typically thin-walled, dilated, and therefore manipulation on them is challenging and at high risk of massive hemorrhage [6]. Probably, several small vessels at retroperotineal space may be injured during abdominal surgery. They are formed as rich collateral circulation compression of both the surrounding inferior vena cava by abdominal aortic aneurysm or atherosclerotic aorta [3]. Most commonly the left inferior vena cava ends as a junction with the left renal vein. They form a preaortic trunk, which opens to the right inferior vena cava [1, 10, 23, 25]. It existed in 67.9% of the cases with this variation [25]. In some examples, this junction is situated much lower and termed as the common iliac confluence [26, 27]. Sometimes the preaortic trunk was absent and the duplicated infrarenal left inferior vena ended as a left renal vein and with a reno-hemiazygos-lumbar trunk (RHLT) inserted into their junction [9, 28–30]. Knowledge on the duplication of the inferior vena cava with hemiazygos continuation of the left-sided IVC, preaortic trunk connection, and normal drainage of the right-sided IVC into the right atrium is also important from a hemodynamical point of view. Scrotal edema has already been described in patients with a duplication of the inferior vena cava, raising the question as to whether this anatomical variant is a predisposing factor [31].

Some studies speculate that duplication of the inferior vena cava may increase the incidence of thrombosis formation [7, 10–12]. Although the incidence of duplication of IVC is low, it certainly poses hazards during abdominal aortic aneurysm repair, and therefore endovascular treatment (EVAR) seems a safer choice than open surgery [9].

3. Retroaortic left renal vein

Usually, the human kidney is drained by several veins, which join near the hilum to form a single renal vein (RV). The left renal vein (LRV) passes anterior to the abdominal aorta and opens into the inferior vena cava (IVC) [32]. The morphology of the left renal vein (LRV) is much more complex than that of the right one because of its topography and relationship with the superior mesenteric artery and the abdominal aorta [33]. Also anomalies of the left renal vein are more common as those of the right renal vein because the left one is approximately three times longer and has a more complicated embryogenesis [34–36]. Knowledge about morphology of the left renal vein is especially important in transplantology because left kidney is preferred before donor nephrectomy [14, 37, 38].

One of the most common anomalies of the left renal vein is a retroaortic left renal vein (RLRV; **Figure 2**). It is located between the aorta and the vertebral column and drains into the inferior

vena cava [32, 34]. This congenital anomaly occurs in 0.5–5.9% of the population according to the literature [14, 34, 39–41]. The retroaortic left renal vein was two times more frequent in females than in males [14]. However, according to Arslan et al. [42] and Nam et al. [43], the male to female ratio is similar.

The fourth and eighth gestational weeks are the time for development of the left renal vein. It is formed by the sequential formation, anastomoses, and regression of three paired veins (posterior cardinal, subcardinal, and supracardinal veins) [13, 14, 44]. At this time, there is an anastomotic junction between supracardinal and subcardinal channels, which produced a collar of veins around the aorta. When the ventral portion of the circumaortic collar persists, the normal left renal vein is formed. If the dorsal parts of this collar are persisted, the left renal vein passing posterior to the aorta produced a retroaortic left renal vein [34, 45, 46].

The retroaortic left renal vein is usually asymptomatic. However, its presence is clinically important [43]. Sometimes it may be due to clinical symptoms such as hematuria, abdominal/flank or inguinal pain, and vascular dilatations (varicocele) [34, 43, 47]. According to Karaman et al. [34], studying the frequency of the RLRV was significantly higher in the group with urological symptoms, especially in patients with hematuria, in comparison with the other group without urological symptoms. Heidler et al. [48] described that only 4 of 61 (6.6%) patient with RLRV diagnosed by CT scan were clinical symptomatic (flank pain and microhematuria).

The presence of a retroaortic left renal vein during the renal surgery influences the technical feasibility of the operation. Failure to recognize these anomalies may lead to non-suspected hemorrhage and even renal damage [43, 49]. Therefore, special attention in retroperitoneal space surgery is needed when retroaortic left renal vein is recognized. It seems especially important during an abdominal aortic aneurysm repair. Aortic dissection may be complicated by massive intraoperative bleeding, the most troublesome being venous rather than arterial hemorrhage [3]. Control of this bleeding is very difficult [3, 50]. Brener et al. [50] reported that during abdominal aortic reconstruction, approximately 40% of retroaortic left renal veins were injured. Of these, five were successfully repaired, two needed nephrectomy for control of the hemorrhage, and two patients died as a result of hemorrhage. Also the lumbar and retroperitoneal veins coalesce to form a complex retroaortic venous system whose topography and size depend on aortic aneurysm formation change and may be during dissection than the retroaortic LRV itself [3].

The fistula of the aorto-left renal vein in abdominal aortic aneurysms often co-occurs with the retroaortic left renal vein [51]. Mansour et al. [52] reported that 94% of the patients with aorto-left renal vein fistula also had a retroaortic left renal vein. Such complication is accompanied by hematuria, abdominal pain, left-sided varicocele, and a dysfunction of the left kidney [52–55]. A fistula probably forms due to the combination of the inflammatory process of the expanding abdominal aortic aneurysm and compression of the retroaortic left renal vein between the vertebral bodies and the pulsating aneurysm [53, 54]. Also inflammatory abdominal aortic aneurysm in patients with retroaortic left renal vein independently increases the complication rate during aortic surgery [56, 57].

http://dx.doi.org/10.5772/66768

Familiarity with the morphology of the main venous anomalies (especially including retroaortic and collar left renal vein) is the first step toward avoiding unexpected vascular injury during abdominal aortic procedures [3]. It seems important because coexistence nonruptured abdominal aortic aneurysm, with the prevalence of the retroaortic left renal vein estimated from 0.75 to 1.4% [2, 58].

4. Left renal vein collar

The circumaortic left renal vein (CLRV) or collar left renal vein is defined as the situation when this vein has an additional component that runs dorsal to the aorta and opens into the inferior vena cava (**Figure 3**) [32, 59]. According to statistics, the incidences of CLRV ranged 0.6–17.0% in cadaver dissection [60, 61], and 0.4–9.3% in clinical studies [47, 62]. In 2008, Natsis et al. [32] described a classification of the different forms of the circumaortic left renal vein based on the findings of 319 patients who underwent a CT angiography scan of the abdomen. The classification distinguished three types: Type I has one left renal vein splitting into two branches, a preaortic and a retroaortic, both of which opened into the inferior vena cava; Type II has two independent left renal veins, one preaortic and another retroaortic, draining into the inferior vena cava; Type III has existing anastomoses between the preaortic and retroaortic vein, being multiple or not, or multiple preaortic or retroaortic renal veins without anastomoses [32].

During the development of the inferior vena cava, there are anastomotic communications between supracardinal and subcardinal channels. The ventral portion of this connection persists as the normal left renal vein. If both the ventral and dorsal portions persist, the circumaortic (collar) left renal vein is formed [45, 46].

The CLRV in most cases is clinically silent and is discovered accidentally usually during Doppler ultrasonography, computed tomography, or magnetic imagining resonance. However, such information of presence of this variation is useful before abdominal surgery especially renal transplantation, caval interruption procedures, nephrectomy, portocaval shunts, and aortic aneurysm connective surgery [39, 63].

Morphology of the circumaortic left renal vein is important in abdominal aortic aneurysms because the retroaortic component of the circumaortic renal collar is usually thinner than the preaortic one and it is always located more caudally [32, 63, 64]. The vein may be damaged when the posterior stitches of the anastomosis are inserted resulting in severe bleeding or the formation of a graft-left renal vein fistula [3]. Abdominal aneurysm surgery poses a particular problem, because the LRV is used as a landmark below which the aorta is clamped [65]. During a retroperitoneal surgery, a preaortic vein is always visualized, but surgeon may be unaware of an additional retroaortic component or a posterior primary tributary and may avulse it while mobilizing the kidney or clamping the aorta [39, 66]. Also the relationship of circumaortic left renal vein to the ureter in the retroperitoneal space may be confusing, especially when aortic aneurysm is present and its topography has been changed [67].

The coexistence of an abdominal aortic aneurysm with RLRV or CLRV may also increase the probability of nutcracker syndrome [68]. The posterior type of nutcracer syndrome results

in the narrowing of the LRV in its retroaortic or circumaortic position: compression between the aorta an`d the vertebral column [69, 70]. Therefore, the presence of an abdominal aortic aneurysm may also increase its symptoms and make treatment more dangerous.

5. Left-sided inferior vena cava

By definition, left-sided inferior vena cava, also known as transposition of the inferior vena cava, occurs when only one inferior vena cava is seen below the diaphragm on the left side of the abdominal aorta [71, 72]. A left IVC is thought to be caused by the regression of the right supracardinal vein with persistence of the left supracardinal vein during embryological development of the venous system [73]. The incidence of left-side inferior vena cava is 0.2–0.5% [74, 75]. According to Nishibe et al. [76], failure to recognize this variation when situated near the neck of the abdominal aortic aneurysm may lead LIVC injury and dangerous for live bleeding. Also proximal control of the neck of the aneurysm through a midline transperitoneal approach can be difficult if an anomalous inferior vena cava passes on the left side of aorta and crosses them during traveling to the right side of the body [2, 71]. Therefore, preoperative x-ray studies would be of value in this case [71, 77].

It is also important to remember that as a result of the transposition, the left adrenal and gonadal veins may empty directly into the left-sided inferior vena cava, while the right adrenal and gonadal veins drain into the right renal vein [78, 79].

6. Conclusion

Familiarity with the morphology of variations of the both left renal vein and inferior vena cava is important for all surgeons, urologists, and oncologists to reduce the risk of unexpected injury to these vessels. Such information is especially important when abdominal aortic aneurysm is present due to changes in the topography of the retroperitoneal space. If it is possible, a preoperative x-ray examination should be always performed in patients undergoing repair of the abdominal aortic aneurysm. All additional information precisely describing number and topography of vessels in retroperitoneal space prevents unexpected bleeding during surgical treatment of abdominal aortic aneurysm. Details of anomalous venous anatomy should be taken into consideration when choosing endovascular (EVAR) over classical treatment as the best and safest procedure.

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http://dx.doi.org/10.5772/66768

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