An unusual duplication of the inferior vena cava in a patient with endovascular repair for abdominal aortic aneurysm

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Abstract
A 66-year-old Caucasian male, with sensation of abdominal pulsation was admitted to our hospital. In multidetector 64-row computed tomography (CT) angiography, an abdominal aortic aneurysm was observed. Endovascular aortic repair was performed. Control CT confirmed prosperity with stent graft fixation and absence of any vascular complications. Investigation also showed asymmetrical duplication of the inferior vena cava (IVC). Right (RIVC) and left (LIVC) inferior vena cava arose from the confluence of the right and left iliac veins. The LIVC continued as left renal vein.

Keywords: inferior vena cava, duplication, abdominal aortic aneurysm, computed tomography, vascular variations.

Introduction
In the retroperitoneal space, four major anomalies of the venous system are encountered: retroaortic left renal vein, left renal vein collar, left sided inferior vena cava (IVC), and caval duplication [1, 2]. These anomalies are unusual and pose potential hazards to surgeons during abdominal aortic surgery. An injury to an unrecognized anomalous vessels can result in severe hemorrhage [1, 3, 4]. Especially, injury to veins is responsible for most unexpected intraoperative bleeding [5]. 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 towards avoiding vascular injury.

Duplication of the inferior vena cava is a condition where two veins on both sides of the aorta (right and left IVC) usually join at the level of the renal arteries to become one vein (IVC) [1, 2]. The presence of a duplicated IVC is clinically important in retroperitoneal surgery [6], laparoscopic nephrectomy [7], and can be a source of diagnostic uncertainty [8]. It can also be mistaken as a pathological lesion such as left pyelo-ureteric dilatation [9] or lymphadenopathy [6].

The presented case first illustrates the coexistence of duplication of the IVC with an unusual confluence of the left renal vein to the left inferior vena cava in patient with abdominal aortic aneurysm. Such anomaly may complicate open surgical treatment and probably predispose the patient to thrombosis.

Our findings should increase diagnostic attention to detection of possible associated vascular variations and can help in the selection of the safer option of treatment for aortic abdominal aneurysms (open surgical or endovascular – EVAR).

Case report
A 66-year-old Caucasian male with arterial hypertension and coronary disease, reported a sensation of abdominal pulsation to his cardiologist. He did not suffer from any other symptoms, including muscle pain, claudication or scrotal swelling. Thirteen years earlier, he had suffered a heart attack. In 2008, he was treated by coronary artery bypass surgery and had been under regular medical supervision to date. He did not suffer from diabetes or any renal disorders. After physical examination, the cardiologist referred the patient for Doppler-sonography examination, which revealed an aneurysm of the abdominal aorta (AAA). This diagnosis was subsequently confirmed by computed tomography (CT) angiography (64-row MDCT scanner, LightSpeed VCT, GE, Waukesha, Wisconsin, USA). The AAA begun about 40 mm below the renal arteries, and had a maximum transverse diameter of 79 mm. The diameters of the right and left common iliac arteries were 14 mm, and 15 mm respectively. The patient was qualified and gave consent for endovascular treatment. Endovascular aortic repair (EVAR) was performed in February 2012. Standard aseptic approach was used. The device used was Stentgraft Powerlink 28-16-140 BL, 28-28-95 RL (Endologix, Irvine, CA, USA). Recovery was uneventful and the patient was discharged from the hospital.

A control dual-phase helical CT was performed on an MDCT scanner (64-row MDCT scanner, LightSpeed VCT, GE, Waukesha, Wisconsin, USA) after an injection of nonionic iodinate contrast medium (Iomeron 400, Bracco Mediolan, Italy). The contrast material (1.5 mg/kg) was injected into a vessel of 4 mL/s through an intravenous cannula. Scanning was started 25 s (first phase) and 60 s (second phase) after the initiation of contrast bolus. Images were reconstructed at every 0.625 mm interval.
Three-dimensional CT reconstruction and measurement of the diameters of the abdominal vessels were performed using Advantage Workstation software (GE).

CT confirmed prosperity with stent graft fixation and absence of any vascular complications, especially endoleaks (Figure 1). CT also showed also a variation of abdominal veins – an unusual duplication of the inferior vena cava (Figures 1 and 2). Both IVC appeared to originate from the confluence of the right and left common iliac veins (Figure 1). Next, they ran cranially on the contra-lateral postero-lateral wall of the abdominal aorta (Figure 2). The right inferior vena cava (RIVC) was significantly larger in diameter than the left inferior vena cava (LIVC) (19.5 mm vs. 11.5 mm) (Figures 1 and 3). RIVC and LIVC passed through diaphragm by openings for inferior caval vein and between lateral and medial arcuate ligaments, respectively. Based on the topography and diameter of the vessel, we suppose that LIVC continued in the thorax as the hemiazygos vein. At the level of hilum of the left kidney, left renal vein joint with LIVC (Figure 1). Right testicular vein opened into RIVC. Left testicular vein opened into left renal vein near its termination (Figure 1). Measurements of the vessels of the abdomen (including level of measurements) are presented in Figure 3.

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**Figure 1** – Three-dimensional CT reconstruction of the vessels of the abdomen. Ao: Abdominal aorta, CCIV: Confluence of common iliac veins, LIVC: Left inferior vena cava, LK: Left kidney, LRA: Left renal artery, LRV: Left renal vein, LTV: Left testicular vein, RIVC: Right inferior vena cava, RK: Right kidney.

**Figure 2** – Helical computer tomography, transverse scan at the L3 level: (A) First phase; (B) Second phase. Ao: Abdominal aorta, LIVC: Left inferior vena cava, RIVC: Right inferior vena cava.
Figure 3 – Schematic arrangements of the vessels of the abdomen. LCIv: Left common iliac vein, LIvC: Left inferior vena cava, LK: Left kidney, LRv: Left renal vein, LTV: Left testicular vein, RCIV: Right common iliac vein, RIVC: Right inferior vena cava, RK: Right kidney, RRv: Right renal vein, RTv: Right testicular vein.

Discussion

Duplication of the IVC is a rare but well-recognized developmental variation. Three segments constitute the IVC in the embryonic period: the upper hepatic segment, the renal (subcardinal) segment and the supracardinal (sacrocardinal) segment [10–12]. According to the key theory of IVC duplication, offered by McClure & Butler [12] modified by Larsen [13], such anomaly is due to failure of the caudal left supracardinal vein to regress, resulting in an additional vein: the left IVC. However, explanation of the development of the presented case is more difficult. The renal veins develop from vessels, which are an anastomosis between the left and right subcardinal and supracardinal veins (subsupracardinal anastomoses). During embryogenesis, each kidney is drained initially by an anterior and posterior limb, after which the posterior limb regresses [14]. In our case, also proximal part of the anterior limb regressed. Due to the absence of proximal part of the left renal vein, only persistent caudal left supracardinal vein (left inferior vena cava) enabled the blood outflow from the kidney. In our opinion, similar diameter and actuate shape of the opening of the left renal vein into the duplicated left inferior vena cava confirmed such explanation.

Duplication of the IVC is estimated to occur in 0.3–4% of cases [15–18]. However, its coexistence with the AAA is described only in a few studies [6, 16, 19], in which it accompanies other vascular variations [16] or developmental anomalies [19, 20]. The duplicated IVC has a reported incidence of 2 to 3% in autopsy series [15, 16]. However, this anomaly diagnosed by CT, was only 0.3–0.6% [17, 18]. This difference in occurrence suggests that the smaller component is not readily apparent on CT.

Chen et al. [21] described that interiliac vein connecting duplicated IVC existed in 67.9% of the cases with this variation. However, confluence of common iliac vein is extremely rare [22, 23]. Pineda et al. [23] presented a case of an unusual duplicated IVC in which a left and right IVC have an equal diameter and arose from an iliac confluence. In the case presented here, both IVC also arose from confluence of common iliac vein but the left had significantly lower diameter than right one. Usually, the left inferior vena cava joined the left renal vein to form a preaortic trunk that opens to the right inferior vena cava [2, 12, 14, 21]. In our case, preaortic trunk was absent and duplicated infrarenal left inferior vena ended as LRv and into their junction was inserted a reno-hemiazygos-lumbar trunk (RHLT). Such variations were previously described by Frantz et al. [24] and Scholbach [25]. Brochert & Reynolds [26] in 2001 reported a unique case of a duplicated IVC with hemiazygos continuation of the left-sided IVC, preaortic trunk connection and normal drainage of the right-sided IVC into the right atrium. Bass et al. [14] described double IVC with a retroaortic right renal vein and hemiazygos continuation of the left IVC. In the recent literature, there are several classifications of the variations of the duplicated inferior vena cava [2, 12, 14, 18, 21].

Christakis et al. [7] present the case of a patient with an infrarenal-duplicated vena cava who had a postoperative course complicated by ipsilateral scrotal swelling after successful laparoscopic left donor nephrectomy. Scrotal edema has already been reported in a few cases of patients with a duplicated inferior vena cava, raising the question as to whether this anatomical variant is a predisposing factor. A study examining the drainage of the left testicular vein in cases of duplicated inferior vena found a great deal of variations attributed to anomalous embryonic development, which may predispose the patient to left varicoceles [27]. In the case presented here, the left testicular vein drained into the left renal vein; however, the patient did not report any prior scrotal swelling.

According to a radiological rapport by Morita et al. [18] the IVC 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 (p=0.02). Also, Chen et al. [21] study confirmed such observation. They analyzed 109 cases of IVC anomalies published in the literature between 1967 and 2011 and found that the ratio of men/women is 72:37.

Undeniably, the presence of a double IVC poses hazards to the surgeon during abdominal aortic surgery [1]. Also, unexpected abnormal venous injuries associated with AAA repair have been reported. Intraoperative bleeding may complicate abdominal aortic aneurysm repair, venous being more troublesome than arterial hemorrhage. Significant venous bleeding, in particular, can occur if major retroperitoneal venous anomalies are present [1, 2]. Downey et al. [9] state that in fact anomalous veins are typically thin walled, dilated and therefore manipulation on them is challenging and at high risk of massive hemorrhage. Also, large lumbar and retroperitoneal veins coalesce to form a complex retroaortic venous system, which is often more vulnerable to injury during dissection than the retroaortic LRv itself [3].

Bass et al. [14] speculate that duplication of the IVC may increase the incidence of thrombosis formation. Their observation is supported by few cases [8, 28, 29]. Leong et al. [29] state that congenital anomalies of the IVC can complicate filter insertion, causing failure of effective...
filtration resulting in recurrent pulmonary embolia. Also, Cheng & Zangan [28] report that anatomic variations of the inferior vena cava and its tributaries are generally asymptomatic but must be recognized during vena cava filter placement because collateral pathways for emboli to bypass the filter may exist.

Although the incidence of duplication of IVC is low, it certainly poses hazards during an abdominal aortic aneurysm repair, and therefore endovascular treatment (EVAR) seems a safer choice than open surgery. Anomalous vein also serves as a decisive factor in determining the strategy for venous interventional radiology, as in IVC filter placement.

Conclusions

Familiarity with the anatomy of the most common types of vascular anomalies is necessary for all surgeons, oncologists and urologists to reduce the risk of severe venous hemorrhage associated with these anomalies. A preoperative CT examination should be performed in patients undergoing a repair of abdominal aortic aneurysm because it can provide details of anomalous venous anatomy to assist safe surgical interventions. On the other hand, as several vascular complications may predispose the patient to unexpected bleeding during surgical treatment. Therefore, endovascular treatment (EVAR) over classical ones in such cases should be considered.

Conflict of interest

The authors declare that they have no conflict of interest.

References

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