

The influence of atherosclerotic abdominal aorta on the shape of duplicated inferior vena cava: its potential clinical implications and vascular complications

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Duplication of the inferior vena cava (IVC) is a congenital condition where there are 2 large vessels: right IVC (RIVC) and left IVC (LIVC) on both sides of the abdominal aorta. Here, we present 2 cases of duplicated inferior cava coexisting with rare morphology of left gonadal (ovarian/testicular) vein. Both were observed during multidetector 64-row computer tomography. In first case atherosclerotic, tortuous abdominal aorta models both inferior venae cavae. The shape of veins were more- (RIVC) and less-arcuate (LIVC). Two years ago, the patient had been diagnosed with pulmonary thromboembolism. In second case abdominal aortic aneurysm models both large veins. The RIVC has a highly right-arcuate shape, while the LIVC has a less left-arcade shape. Our observation would seem to be especially important, because the tortuous abdominal aorta changes the shape of both IVC, and may predispose them for thrombosis formation. The presented report precisely describes the topography and measurements of the vessels in the retroperitoneal area. The literature concerning this anomaly, potential clinical implications and vascular complications are reviewed and the possible practical aspects are discussed. A familiarity with the anatomy of the most common types of venous anomalies is crucial for all surgeons, urologists and oncologists to reduce the risk of severe haemorrhage during all abdominal procedures. (Folia Morphol 2014; 73, 4: 521–526)

Key words: inferior vena cava, duplication, computed tomography angiography, anatomical variations

INTRODUCTION

Duplication of the inferior vena cava (IVC) is a congenital condition where there are 2 large veins on both sides of the abdominal aorta: the right IVC (RIVC) and left IVC (LIVC), which join at the level of the kidney to become 1 vein (IVC) [4, 23]. The frequency of this anomaly estimated 0.45–4.4% of population [4, 8, 18].

Several examples exist of influence of variations in retroperitoneal region posing particular potential hazards for the surgeon during abdominal aortic surgery [6, 10, 13, 22]. An injury to an unrecognised anomalous vein can result in an unexpected severe haemorrhage. It is also clinically important in certain situations in retroperitoneal surgery [15, 21] and

laparoscopic nephrectomy [6], and can be a source of diagnostic uncertainty [20]. Duplication of the IVC can be mistaken as a pathological lesion, such as lymphadenopathy [15] or left pyelo-ureteric dilatation [7]. Knowledge of the IVC anomalies is necessary to reduce surgical risk and determine the strategy for the treatment of aortic abdominal aneurysms. Therefore, careful preoperative evaluation is important for establishing the presence of an associated venous anomaly and is the first step towards avoiding vascular injury during abdominal procedures.

This study reports on the influence of an atherosclerotic abdominal aorta on the shape of the duplicated IVC and presents rare topography of the left gonadal (ovarian/testicular) vein. Such coexistence may complicate surgical treatment and thus predispose the patient to thrombosis. Our observations should increase diagnostic attention in the detection of possible associated vascular variations that might aid the surgeon in avoiding injury and subsequent bleeding from these anomalous structures during operations.

CASE REPORTS

General study

We retrospectively analysed computer tomography (CT) scans of 284 patients obtained using a dual-phase CT of abdomen between January 2011 and December 2013. Multidetector CT (MDCT) imaging was performed with a 64-row MDCT scanner (LightSpeed VCT, GE, Waukesha, Wisconsin, US).

Case 1

A 64-year-old Caucasian female suffering from purulent fistula as a complication of an implantation of a right hip joint endoprosthesis was referred for CT examination of the abdomen. Heavy chronic rheumatic arthritis had been the leading problem in her medical history for about 30 years, resulting in total bilateral knee arthroplasty, 8 and 6 years before. Two years previously, she had been diagnosed with pulmonary thromboembolism. The presence of the fistula at the level of the greater trochanter of the right femur was confirmed.

The contrast material (1.5 mg/kg) was injected into a vessel of 4 mL/s through an intravenous cannula. Scanning was started 20 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

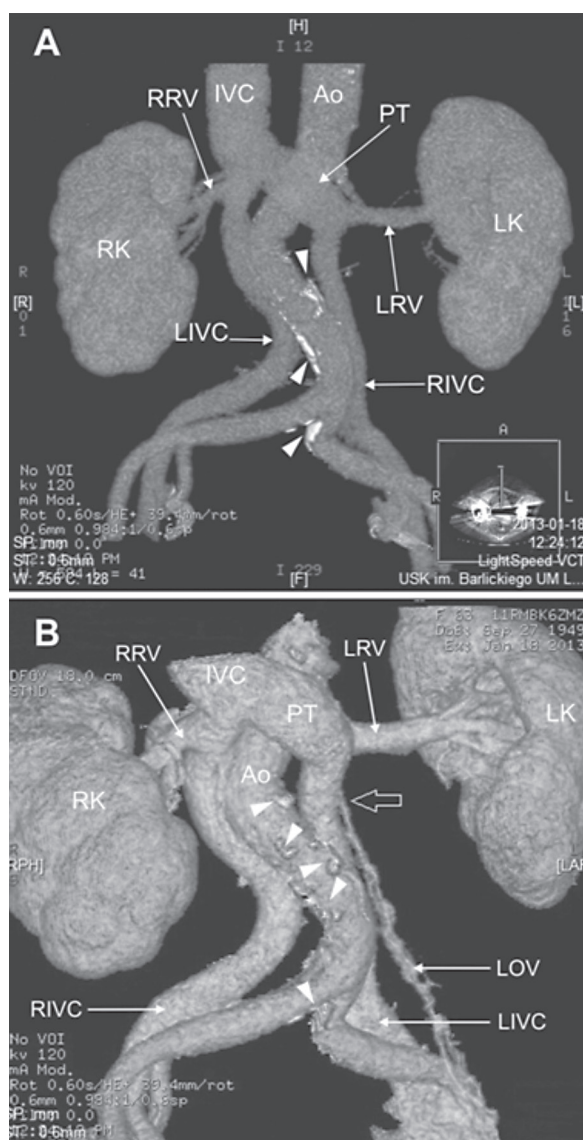


Figure 1. A, B. Three-dimensional computed tomography reconstruction of the structures of the abdomen (Case 1); Ao — abdominal aorta; IVC — inferior vena cava; LIVC — left inferior vena cava; LK — left kidney; LOV — left ovarian vein; LRV — left renal vein; PT — pre-aortic trunk; RIVC — right inferior vena cava; RK — right kidney; RRV — right renal vein; arrowhead — atheromatous plaque; arrow — opening of LOV to the LIVC.

measurement diameters of vessels were performed using Advantage Workstation (GE).

No stenosis of the aorta, renal arteries, mesenteric arteries and either common iliac artery was reported in CT examination. The abdominal aorta was atherosclerotic with tortuous shape below the level of the origin of the renal arteries (Fig. 1). The maximal diameter of the abdominal aorta was 23.0 mm. In CT, a duplication of IVC was also identified (Fig. 1). The LIVC was a continuation of the left common iliac vein

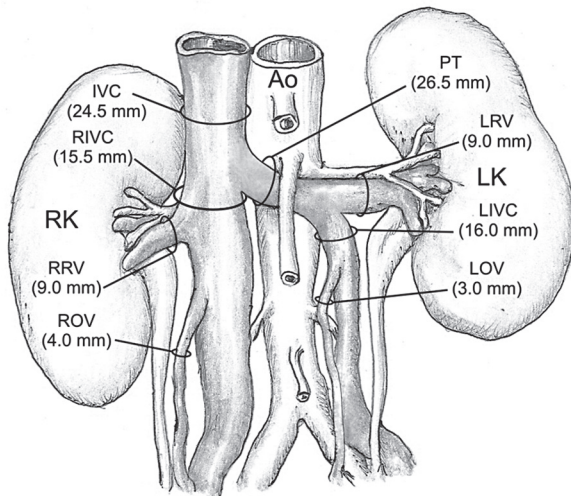


Figure 2. Schematic arrangements of the abdominal vessels with their diameters (Case 1); Ao — abdominal aorta; IVC — inferior vena cava; LIVC — left inferior vena cava; LK — left kidney; LOV — left ovarian vein; LRV — left renal vein; PT — preaortic trunk; RIVC — right inferior vena cava; RK — right kidney; ROV — right ovarian vein; RRV — right renal vein.

which joined the left renal vein to form a preaortic trunk (PT). The PT was seen to unite with the RIVC and form a single IVC 24.5 mm width above the junction. Tortuous, atherosclerotic abdominal aorta modelled both IVC to change their shape on more- (RIVC) and less-arcuate (LIVC) (Fig. 1). The right renal vein opened to the RIVC, and both ovary veins could be seen to have an almost straight shape, opening into ipsilateral corresponding IVCs beneath the level of the renal veins (Fig. 1B). The distribution of vessel diameters is presented in schematic arrangements on Figure 2.

Case 2

A 79-year-old Caucasian male reported the sensation of an abdominal pulsation to his general practitioner. The general practitioner referred the patient for Doppler-sonography examination, which revealed abdominal aortic aneurysm (AAA). This diagnosis was subsequently confirmed by CT. The AAA begun about 30 mm below the renal arteries, and had a maximum transverse diameter of 59 mm (Fig. 3A), which contained a circular thrombus with a maximum size of 34 mm. The diameters of the aorta before bifurcation, and of the right and left common iliac arteries, were 59 mm, 17 mm, and 26 mm, respectively. The patient was qualified and consented for endovascular treatment. Endovascular aortic repair was performed. Recovery was uneventful and patient was discharged from hospital.

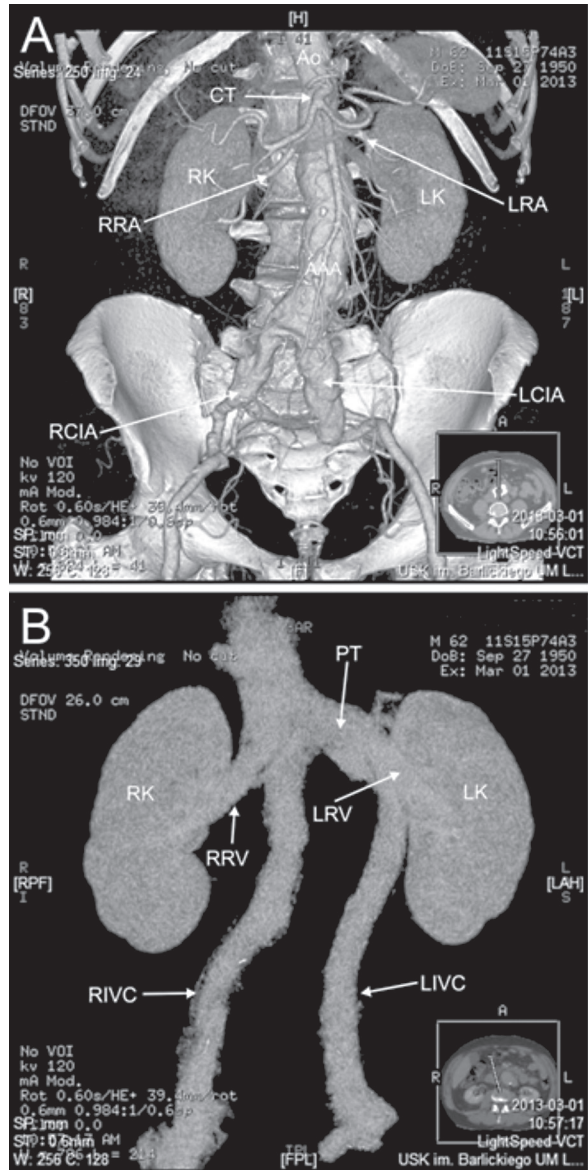


Figure 3. Three-dimensional computed tomography reconstruction of the vessels of the abdomen (Case 2); **A.** Arterial phase; **B.** Venous phase; AAA — abdominal aortic aneurysm; Ao — abdominal aorta; CT — celiac trunk; LCIA — left common iliac artery; LIVC — left inferior vena cava; LK — left kidney; LRA — left renal artery; LRV — left renal vein; PT — preaortic trunk; RCIA — right common iliac artery; RIVC — right inferior vena cava; RRA — right renal artery; RRV — right renal vein; RK — right kidney.

CT also showed that the veins were configured in anatomical variant: the common left iliac vein continued into an additional vena cava, the LIVC which joined the left renal vein to form a PT ending in a union with the RIVC at the level of the superior pool of the kidneys (Fig. 3B). Both testicular veins have a straight shape and open into an ipsilateral duplicated IVC. The RIVC has a highly right-arcuate shape,

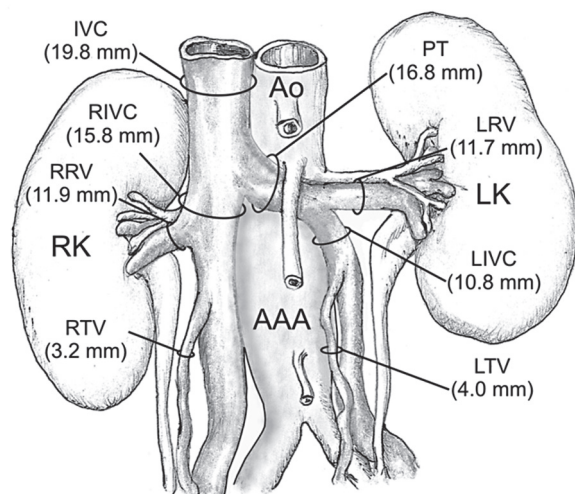


Figure 4. Schematic arrangements of the vessels of the abdomen (Case 2); AAA — abdominal aortic aneurysm; Ao — abdominal aorta; IVC — inferior vena cava; LIVC — left inferior vena cava; LK — left kidney; LRV — left renal vein; LTV — left testicular vein; PT — pre-aortic trunk; RIVC — right inferior vena cava; RK — right kidney; RRV — right renal vein; RTV — right testicular vein.

while the LIVC has a less left-arcade shape (Fig. 3B). Their width at the level of termination was 15.8 mm (RIVC) and 10.8 mm (LIVC). Other important measurements of the vessels of the abdomen were precisely presented on the schematic arrangement (Fig. 4).

DISCUSSION

The embryogenesis of the veins in abdomen is a complicated process involving development, regression, anastomosis and replacement of 3 pairs of vessels: posterior cardinal, supracardinal and subcardinal veins [16, 19]. There are several theories explaining development of this abnormality. One is that persistent left vena cava is due to failure of the anastomosis between the primitive cardinal veins during embryogenesis [2]. The other prominent theory is that duplicated IVC is due to failure of the caudal left supracardinal vein to regress [16].

In 2007, Morita et al. [18] performed the largest study yet to classify pelvic venous variations of congenital IVC anomalies using CT. They found 28 duplications of the IVC within a group of 6,294 examined patients. Morita et al. [18] distinguished 5 types of this anomaly. Of 28 double IVCs examined in their study, 11 (39.3%) displayed no interiliac communication (type a), 5 (17.9%) displayed interiliac communication from the left common iliac vein (type b), 1 (3.6%) had communication from the right common

iliac vein (type c), 6 (21.4%) had communication from the left internal iliac vein (type d), and 5 (17.9%) had communication from the right internal iliac vein (type 2e). According to Morita et al. [18], our cases may be classified as type a.

According to topographical division of anomalies of the IVC proposed by Edwards in 1951 [8], double infra-renal IVC is classified as major anomalies of the cava proper (type 2B). Variations in morphology of the gonadal vein are described independently in group "variations of extra-renal connections" (type 3c).

The newest classification of IVC duplication by Natsis et al. [19] distinguish 3 main types: type I (major duplication) comprises 2 bilaterally symmetrical and approximately of the same calibre veins and a PT of the same calibre, type II (minor type) comprises 2 bilateral veins, but their calibre is smaller in comparison to the PT and type III (asymmetric type) includes a small LIVC, a larger RIVC and an even larger PT. According to Natsis et al. [19] our case may be classified as type II (minor).

The majority of cases of IVC duplication are diagnosed incidentally on the base of radiological examinations performed for other reasons, but these variations can have significant clinical implications [3]. The presence of a double IVC poses hazards to the surgeon during retroperitoneal surgery [6, 10, 22]. Unexpected abnormal venous injuries associated with an AAA repair have been reported [6, 13, 21]. With IVC duplication, the aneurysmal neck is usually crossed anteriorly by the junction of the left renal vein and LIVC. These vessels or local lumbar veins may need to be divided to gain control of the neck [13]. Massive intraoperative bleeding may complicate aortic dissection, however more complicated is rather venous than arterial haemorrhage. Significant venous bleeding, in particular, can occur if major retroperitoneal venous anomalies are present [10]. According to Downey et al. [7], anomalous veins are in fact typically thin walled, dilated and tortuous, and therefore manipulation in this area is challenging and at high risk of massive haemorrhage.

Double IVC complicating para-aortic lymphadenectomy has been reported in patients suffering from gynaecological malignancy [1]. Another surgical implication was observed during organ transplantation or nephrectomy [6, 15]. It was especially important with associated with duplicated IVC anomalies such as right retrocaval ureter [12], transcaval ureter [9], renal ectopia [21] or horseshoe kidney [13].

Christakis et al. [6] report the case of a patient with an infrarenal duplication of an IVC who after successful laparoscopic left donor nephrectomy, had a postoperative course complicated by ipsilateral scrotal swelling. Although ipsilateral scrotal oedema has been reported in a few cases, it is usually, but a transient complication [6, 11]. Milloy and Anson [17] stated that knowledge of variations in morphology of the gonadal and renal veins coexisting with duplicated IVC is especially important due to presented several persistent from foetal live thin anastomotic vessels. Such observations are also supported by Edward's study [8]. Therefore localisation of opening of gonadal vein is so important, especially when IVC is doubled [10]. According to Bergman et al. [4], when there is duplicated IVC, the left gonadal vein may be represented for several vessels or may form plexus. In presented cases left ovarian (Case 1) and testicular (Case 2) veins were single and open into LIVC on the level of inferior boundary of renal hilum.

There are several case reports of thromboembolic events occurring in patients with double IVC [3, 5, 14, 20]. Bass et al. [3] and Nirupama et al. [20] speculate that duplication of IVC may increase incidence of thrombosis formation. Also Leong et al. [14] state that double IVC may complicate filter insertion, causing a failure of effective filtration, resulting in recurrent pulmonary emboli. In Cheng and Zangan [5] opinion that anatomical variations of the IVC must be recognised during vena cava filter placement because collateral pathways may exist allowing the emboli to bypass the filter. This would seem to be especially important in the presented report (Case 1), as the tortuous abdominal aorta changes the shape of both IVC, and may predispose them for thrombosis formation. Two years ago, this patient had been diagnosed with pulmonary thromboembolism.

Morita et al. [18] note that IVC anomalies are significantly more common in men than in women: 39 (1.0%) of 3,821 men vs. 12 (0.5%) of 2,473 women; with a female/male ratio of 2:1 ($p = 0.02$).

The most important clinical consequences of the duplication of the vena cava may be observed in retroperitoneal surgery [15, 21]. Although the incidence of IVC anomalies is low, gaining control of the aorta during an AAA repair is often difficult and may be complicated by unexpected venous bleeding. For this reason, it is imperative to be cognizant of venous anomalies when undertaking procedures such as aortic repairs, nephrectomy, sympathectomy, and other dissections of the retroperitoneum.

CONCLUSIONS

The duplication of IVC along with other vessel anomalies in the retroperitoneal space can lead both to misdiagnosis and to surgical complications. CT examination allows pre-operative diagnoses to be made to assist safe surgical interventions, and hence reduce the risk of severe venous haemorrhage associated with these anomalies. Therefore, it is very important to have a comprehensive knowledge of the variations of IVC.

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