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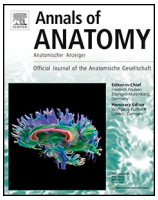
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Bilateral duplicated inferior vena cava associated with aberrant internal iliac and gonadal veins: A case-based narrative review

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ABSTRACT

Background: The left side anterior retroperitoneal approach is preferred for the management of lumbosacral spine disorders as there is reduced risk for vascular injury. The presence of multiple and uncommon venous variations on either side of the spine, like the bilateral duplicated inferior vena cava (DIVC), may complicate surgery in this region. The current study describes two rare cases of bilateral duplicated inferior vena cava associated with internal iliac and gonadal veins.
Methods: The cases were identified during routine human dissections of the posterior abdominal wall of 89 (45 males, 44 females) individuals. The course, relations and morphometry of each duplicated inferior vena cava were examined and recorded.
Results: Two (2.2%) of the 89 (1 male, 1 female) dissected individuals showed the presence of bilateral duplicated infrarenal segments of the inferior vena cava. In both cases, the pre-aortic trunk (vein) was the largest and the left inferior vena cava was the smallest. Both cases of bilateral DIVC presented with anomalous interiliac communicating veins, internal iliac veins, and drainage sites of the left gonadal veins.
Conclusions: The duplicated inferior vena cava may present with associated venous anomalies like those related to the gonadal and internal iliac veins. Knowledge of the duplicated inferior vena cava and its associated venous anomalies may be essential for accurately identifying and diagnosing vascular dysfunction and improving radiological interpretation across multiple surgical specialities.

1. Introduction

The anterior retroperitoneal surgical approach to the lumbosacral spine is widely used to manage abnormalities of the aorta and the spine, particularly spinal deformities, degenerative diseases, and traumatic injuries (Manunga et al., 2020). The advantages of this approach include enhanced alignment of the spine during spinal fusion procedures, better access during device implantation in degenerative disc diseases, and improved performance for discectomy (Brewster et al., 2008; Phan et al., 2017; Zairi et al., 2017). Successful anterior surgical approach to the lumbosacral spine requires adequate knowledge of the vascular, nervous, and overlying abdominal viscera in order to reduce iatrogenic injuries. This approach is associated most commonly with vascular injuries which are potentially life-threatening (Klezl et al., 2014; Manjatika et al., 2023). To reduce such injuries, the left side retroperitoneal approach to the lumbosacral spine is preferred, allowing for the safer and simpler retraction of the abdominal aorta based on its elasticity profile (Klezl et al., 2014). In addition to the abdominal aorta, the left side of the lumbosacral spine primarily contains segmental vessels that can be well managed during exposure of the lumbosacral spine (Yagi et al., 2022). The left side approach is also an ideal choice for some minimally invasive techniques like oblique lumbar retroperitoneal approach to the spine above the fifth lumbar vertebral body (L5) (Berry, 2019). The inferior vena cava (IVC) is the main venous channel of blood

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from the regions of the body below the diaphragm (Mishra et al., 2014; Karaosmanoglu et al., 2021). The IVC is formed by the union of the left and right common iliac veins (CIV) on the anterior surface of the L5 vertebral body and ascends on the right side of the lumbar spine to drain into the right atrium of the heart. However, the presence of unexpected and unfamiliar vascular variations occurring on the left side of the lumbosacral spine may complicate surgical approach in this region. Such variations include the bilateral duplicated inferior vena cava (DIVC), iliolumbar, gonadal, and iliac veins (Regenbogen et al., 2007; Manjatika et al., 2023).

The prevalence of bilateral DIVC globally ranges from 0.2% to 3%, as observed incidentally from intraoperative, radiologic, dissection, and electrophysiology studies (Adachi, 1940; Reis and Esenther, 1959; Sarma, 1966; Chuang et al., 1974; Mj et al., 1979; Cohen et al., 1982; Doyle et al., 1992; Soltes et al., 1992; Shingleton et al., 1994; Nagashima et al., 2006; Grubb et al., 2007; Milani et al., 2008; Bergman et al., 2009; Ng and Ng, 2009; Sahin et al., 2017; Cheung and Wong, 2020). Multiple classification systems for bilateral DIVC exist within prior literature and have vastly improved general understanding (Huntington and McClure, 1920; Edwards, 1951; Sarma, 1966; Chuang et al., 1974; Meyer et al., 1998; Morita et al., 2007; Natsis et al., 2010). A recent classification by Natsis et al. (2010) categorizes the bilateral DIVC into three types based on vessel caliber (diameter). The right and left IVC, and pre-aortic trunk have similar calibers in type one classification. In type two classification, the right and left IVC have similar caliber but are both smaller than the pre-aortic trunk. In type three classification, the pre-aortic trunk is the largest, and the left IVC is the smallest (Adachi, 1940; Natsis et al., 2010; Pineda et al., 2013; Cheung and Wong, 2020). In most cases of bilateral DIVC, the right IVC is larger in diameter than the left (Morita et al., 2007; Natsis et al., 2010). While the implications for the presence of bilateral DIVC during reconstructive surgery of the abdominal aorta are widely described in the literature (Shindo et al., 2000; Aljabri et al., 2001; Karkos et al., 2001; Dimic et al., 2017), there is limited knowledge for the implications of its presence during the exposure phase of the anterior lumbosacral spine. More detailed anatomical knowledge of the bilateral DIVC may be crucial to spine and vascular (access) surgeons as well as general and visceral surgeons for a multitude of reasons (Sahin et al., 2017). The anterior approach to the retroperitoneal space is also the preferred route for oncological resections in cases of retroperitoneal sarcomas, pancreatic tumors with multivisceral infiltration, liver tumors with retroperitoneal extension, or adrenal tumors (Watson and Harper, 2015; Yamaguchi et al., 2021). The purpose of the current study is to present two rare cases of bilateral DIVC with anomalies relating to the interiliac communicating vein, bilateral internal iliac vein, and gonadal vein. In addition, a narrative literature review regarding various forms of DIVCs and its classification systems, embryology, and surgical implications is included to aid surgical knowledge in vascular preoperative assessment and planning in order to improve surgical success.

2. Material and methods

Two cases of bilateral DIVC were discovered incidentally during a separate study investigating the anatomical variations and topography of the iliolumbar veins in the retroperitoneal space of the posterior abdominal wall (Manjatika et al., 2023). The study was in accordance with the Human Tissue Act 65 of 1983 and holds the ethics clearance number: W-CBP-210401–01, obtained from the School of Anatomical Sciences at the University of the Witwatersrand. Two (2.2%) of the 89 (45 males, 44 females) dissected individuals had bilateral duplicated IVCs.

To study the DIVCs, the individuals were dissected in the supine position. To open the anterior abdominal wall, a midline incision was made from the xiphoid process to the pubic symphysis. The peritoneum and its contents were removed to access the retroperitoneum. The presence of the bilateral duplicated inferior vena cava, the pre-aortic trunk and the interiliac communicating vein, and their relations to the lumbar spine were observed and recorded. To determine the vessel caliber, diameters of the inferior vena cava, pre-aortic trunk and the interiliac communicating veins were taken at the widest point using a Vernier caliper (accuracy ±0.02 mm, resolution ±0.01 mm, repeatability ±0.01 mm). The common iliac, external, and internal iliac veins were also fully exposed and examined for any variations in their course and drainage patterns. The drainage patterns of the renal, suprarenal, and gonadal veins were also examined.

Using the available literature, from the early 19th century (AD 1800) till present, studies (case reports, original articles, monographs, and review articles) that reported the duplicated inferior vena cava with or without the coexistence of other venous anomalies were reviewed with no language restrictions.

3. Results

3.1. Case 1

A male individual aged 77 years, 1.70 m in height and 91 kg in weight, who died of natural causes presented with bilateral duplicated infrarenal segments of the IVC (Fig. 1A-C). The right IVC had a diameter of 15.4 mm, while the left was 11.6 mm (measured at the widest part). The left and right testicular veins drained into the left and right IVC, respectively. The left IVC and left renal vein joined to form a pre-aortic renal trunk which had a diameter of 16 mm. This trunk coursed transversely anterior to the aorta to join the right IVC at the level of second and third lumbar (L2/L3) intervertebral disc space inferior to the superior mesenteric artery. The left suprarenal vein drained into the pre-aortic renal trunk. At the second lumbar (L2) vertebral body level, the right renal vein drained into the right IVC. An interiliac communicating vein, 14 mm in diameter, connected the left and right common iliac veins. The communicating venous channel ran obliquely upwards and anteriorly from the level of the fifth lumbar and first sacral (L5/S1) intervertebral disc space on the left side to the level of the fourth and fifth lumbar (L4/L5) intervertebral disc space on the right side. The left common iliac vein was normally formed by joining the internal and external iliac veins. The right common iliac vein was formed by the union of the two internal iliac veins and the external iliac vein (Fig. 1A-C).

3.2. Case 2

A female individual aged 105 years, 1.45 m in height and 52 kg in weight who died of natural causes presented with bilateral duplication of the infrarenal part of the IVC (Fig. 2A-B). The right IVC had a diameter of 16.4 mm, while the left was 12.4 mm at its widest part. The drainage of the right and left ovarian veins was into the ipsilateral IVC divisions. The left IVC, left renal vein and left suprarenal veins joined to form a pre-aortic renal trunk which had a diameter of 22.8 mm. The pre-aortic renal trunk coursed transversely at the level of the L2 vertebral body, inferior to the superior mesenteric artery and anterior to the abdominal aorta. The venous drainage of the right renal vein was into the ipsilateral IVC at the level of the L1 and L2 intervertebral disc space. An interiliac communicating vein, 7.6 mm in diameter, connected the left and right common iliac veins. The communicating venous channel ran obliquely upwards and anteriorly from the level of the fifth lumbar and first sacral (L5/S1) intervertebral disc space on the left side to the level of the fourth and fifth lumbar (L4/L5) intervertebral disc space on the right side. The left and right common iliac veins were formed by an external iliac vein and two internal iliac veins. The internal iliac veins bilaterally split into two before joining the external iliac vein, creating an anastomosing venous ring (Fig. 2A-B).

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2014) and retroperitoneal surgical procedures such as retroperitoneal lymph node dissections (Yamaguchi et al., 2021), nephrectomies (Gomez et al., 2010; Eldefrawy et al., 2011; Watson and Harper, 2015), and the management of abdominal aortic aneurysms (Perler, 1989; Sonneveld et al., 1999; Nishimoto et al., 2002; Radermecker et al., 2008; Dimic et al., 2017; Nigro and Ayarragaray, 2022). The presence of bilateral DIVC is considered a risk factor for left lower extremity swelling and pain (Shammas et al., 2017), deep venous thrombosis, and recurrent pulmonary embolism (Kouroukis and Leclerc, 1996; Chee et al., 2001; Mano et al., 2004; Tian et al., 2013).

During surgical interventions, the main precaution when performing the left side anterior retroperitoneal approach, especially for the L4-L5 levels, is the presence of iliolumbar vein variations (Manjatika et al., 2023). The presence of bilateral DIVC may complicate the left side anterior retroperitoneal approach for the L2-L5 levels. This is because of the unusual anatomical course that the left portion of the DIVC takes in relation to the lumbar spine and other midline structures. Vascular surgeons should exercise caution when retracting the left sided or duplicate IVC to avoid rupture/avulsion of the interiliac communicating vein and the pre-aortic trunk in order to minimize hemorrhage. Therefore, preoperative vascular monitoring is highly recommended to detect the presence of any anatomical variations when considering access to single and multiple vertebral level surgery for the L2-L5 vertebral levels (Kim et al., 2013; Berry, 2019; Manjatika et al., 2023). The radiological presentation of the bilateral DIVC may be misinterpreted as pathological lesions such as left pyeloureteric dilatation, aorto-lumbar lymphadenopathy, saccular aortic aneurysms, retroperitoneal cysts, herniated loop of small intestines, metastatic retroperitoneal tumor and enlarged left gonadal veins (Cohen et al., 1982; Klimberg and Wajsman, 1986; Doyle et al., 1992; Soltes et al., 1992; Saito et al., 1995; Milani et al., 2008; Sahin et al., 2017; Cheung and Wong, 2020). Misinterpretation of bilateral DIVC may lead to inadvertent injury causing excessive bleeding. The interiliac communicating vein may be of surgical importance especially when considering anterior exposure of the L4/L5 intervertebral disc, L5 vertebra and L5/S1 intervertebral disc (Kim et al., 2013). Similarly, the left gonadal vein may inadvertently be injured during the retraction of the great vessels to expose the lumbosacral spine due to its anomalous drainage pattern into the DIVC. The internal iliac venous variations may also affect lumbosacral and spinopelvic surgical interventions especially when the spinal area to be exposed is within the venous anastomotic ring (Moshirfar et al., 2005).

5. Conclusions

The current reported cases and related narrative review show that DIVC may present unilaterally/ipsilaterally and/or bilaterally on the sides of the abdominal aorta and lumbosacral spine. The DIVC is an incidental venous anomaly that may coexist with other vascular anomalies like iliac and gonadal veins. Knowledge of DIVC and its associated venous anomalies may be crucial for accurately identifying and diagnosing vascular dysfunctions, correctly interpreting radiological findings, and safe exposure of the lumbosacral spine using the left side anterior retroperitoneal surgical approach.

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Ethical statement

The current study was conducted under the ethical clearance waiver number: W-CBP-210401–01. This study complied with number 65 of the Human's Tissue Act (1983) which allows for the dissection and study of human remains donated to the University of the Witwatersrand for both research and teaching purposes.

CRediT authorship contribution statement

Arthur Tsalani Manjatika: Conceptualization, Methodology, Formal analysis, Writing-Original Draft. **Joshua Gabriel Davimes**: Conceptualization, Writing- Reviewing and Editing. **Pedzisai Mazengenya**: Conceptualization, Writing-Reviewing and Editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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