



A sling of a normal right inferior vena cava around the abdominal aorta

Ali Devrim Karaosmanoglu¹ · Selin Ardali Duzgun¹ · Deniz Akata¹ · Mustafa Nasuh Ozmen¹ · Musturay Karcaaltincaba¹

Received: 19 November 2020 / Accepted: 20 January 2021 / Published online: 6 February 2021
© The Author(s), under exclusive licence to Springer-Verlag France SAS part of Springer Nature 2021

Abstract

Variations in the anatomy of inferior vena cava (IVC) may have important clinical implications. In-depth knowledge of its embryology and variations are of fundamental importance to prevent any potential medical complications related to anatomic variations of the IVC. In this article, we described a previously unreported, to the best of our knowledge, a variation of IVC. In the case we presented, the IVC was seen almost completely encircling the abdominal aorta. We decided to call this anatomic variation as “a sling of a normal right IVC around the abdominal aorta”. Cross-sectional imaging is a prompt and highly reliable method to evaluate IVC anatomy and may have significant clinical importance to prevent any potential complications related to IVC during surgery or interventional radiology procedures.

Keywords Imaging · Inferior vena cava · Anatomic variation

Introduction

Inferior vena cava (IVC) is the fundamental pathway for venous return from the lower extremity, pelvis and kidneys. The complex sequential development during embryogenesis may lead to anatomical variations of the IVC. Among these variants, duplicated IVC, left-sided IVC, azygos continuation of the IVC, retroaortic left renal vein, circumaaortic left renal vein, double IVC with retroaortic right renal vein and hemiazygos continuation of the IVC may be counted [2, 6]. Although the anatomic variations of IVC have an overall

reported prevalence of 0.5% [5], it can be up to 5% in young patients with spontaneous deep venous thrombosis [3].

On cross-sectional imaging studies, the diseases affecting IVC and its anatomic variations may be easily overlooked, especially to inexperienced eyes. Duplicated IVC, left-sided IVC, and circumaaortic left renal vein may be misdiagnosed as pathologically enlarged lymph nodes and retroperitoneal masses [2]. As the anatomic variations of IVC may be easily confused with several disease processes on imaging and its variations may have a significant impact on surgical and minimally invasive interventions, a thorough knowledge of its embryology, anatomy and diseases affecting it should be well-known to imagers to prevent potentially devastating clinical ramifications.

✉ Ali Devrim Karaosmanoglu
alidevrim76@yahoo.com

Selin Ardali Duzgun
selin.ardali@gmail.com

Deniz Akata
dakata@hacettepe.edu.tr

Mustafa Nasuh Ozmen
mozmen@hacettepe.edu.tr

Musturay Karcaaltincaba
musturayk@yahoo.com

Case report

A 29-year old male patient was referred for follow-up liver magnetic resonance imaging (MRI) study for surgically and percutaneously treated hydatid liver cyst from an outside center.

The MRI scan (Table 1) confirmed the absence of left liver lobe due to surgical removal and a ventral abdominal wall hernia related to surgery. There was no evidence of active disease in the abdomen.

¹ Department of Radiology, School of Medicine, Hacettepe University, Hacettepe Universitesi Tıp Fakültesi Hastanesi, Sıhhiye, 06100 Ankara, Turkey

Table 1 MRI scan parameters (Achieva 1,5 T, Philips Healthcare, The Netherlands)

Sequence	TR (msec)	TE (msec)	Slice thickness (mm)
Axial T2W FSE (fast spin echo)	417	80	6
Coronal b-SSFP (balanced steady-state free precession)	2.9	1.5	8
Axial T2W SPAIR (spectral presaturation with inversion recovery)	415	80	6
Dual echo (spoiled gradient echo)	137	in-phase 4.6 out-of-phase 2.3	6
Axial DWI- EPI (diffusion weighted imaging-echo planar imaging) (b = 50 and 600 s/mm ²)	1428	58	8
Dynamic T1 GRE (gradient echo) (0, 30, 60, 150 ms)	4	1.9	4.8

An incidental note is made of the IVC coursing behind the abdominal aorta (AA) and crossing to the left side of the abdomen. After this first curve, the IVC was not seen to ascend to the chest on the right side of the abdomen and rather it was seen to cross back to the right side of the AA to its usual course to the heart through the liver parenchyma. There was no evidence for neither AA compression to IVC nor an endoluminal thrombus. The caudal portion of IVC could not be detected as the study was limited to the liver.

For better outlining this unusual IVC anatomy, a computed tomography (CT) venography was planned. On the CT venography (Table 2), the iliac veins were seen to preserve their usual anatomy with subsequent formation of the IVC on the right side of the AA. Around the level of the renal hila, IVC again was visualized crossing to the left side of the abdomen coursing behind the abdominal aorta, with a subsequent acute bend to the right side of the abdomen to its usual location after almost completely encircling the AA (Fig. 1). The left renal vein was seen to join the IVC at this acute bend, with subsequent joining of the right renal vein

as IVC starts to ascend toward the liver (Fig. 2). Again there was no evidence of an endoluminal thrombus or mass in the retroperitoneum.

Discussion

Due to its long course through the several parts of the abdomen, IVC has a complex embryological anatomy with multiple steps in a set order [10]. The abnormal anatomic variants of IVC is well-known for a long time. Abernethy first described a congenital mesocaval shunt and azygos continuation of the IVC in a 10-month-old infant with polysplenia and dextrocardia in 1793 [1].

As of its complex formation, several clinically silent or significant abnormalities may happen in utero. The formation of IVC happens during the 4th–8th weeks of gestation. Three sets of paired veins; the posterior cardinal veins, the subcardinal veins, and the supracardinal veins are present at this stage and they regress as the final IVC forms [8].

Table 2 CT scan parameters (16- channel MDCT, Optima CT540, GE Healthcare, USA)

Tube voltage (kVp)	120
Tube current (reference mAs)	120
Gantry rotation time (s)	0.75
Collimation	16 × 1.25
Pitch	1.375
Matrix	512 × 512
FOV (cm)	50
Scan slice thickness (mm)	5
Reconstruction slice thickness (mm)	2.5
Reconstruction interval (mm)	1.25
Contrast material injection parameters	
Contrast phase	Portal venous phase (70.s)
Volume (ml)	100 (Ultravist 300/100 mg/mL, Bayer Schering Pharma, Berlin, Germany)
Flow rate (ml/s)	4

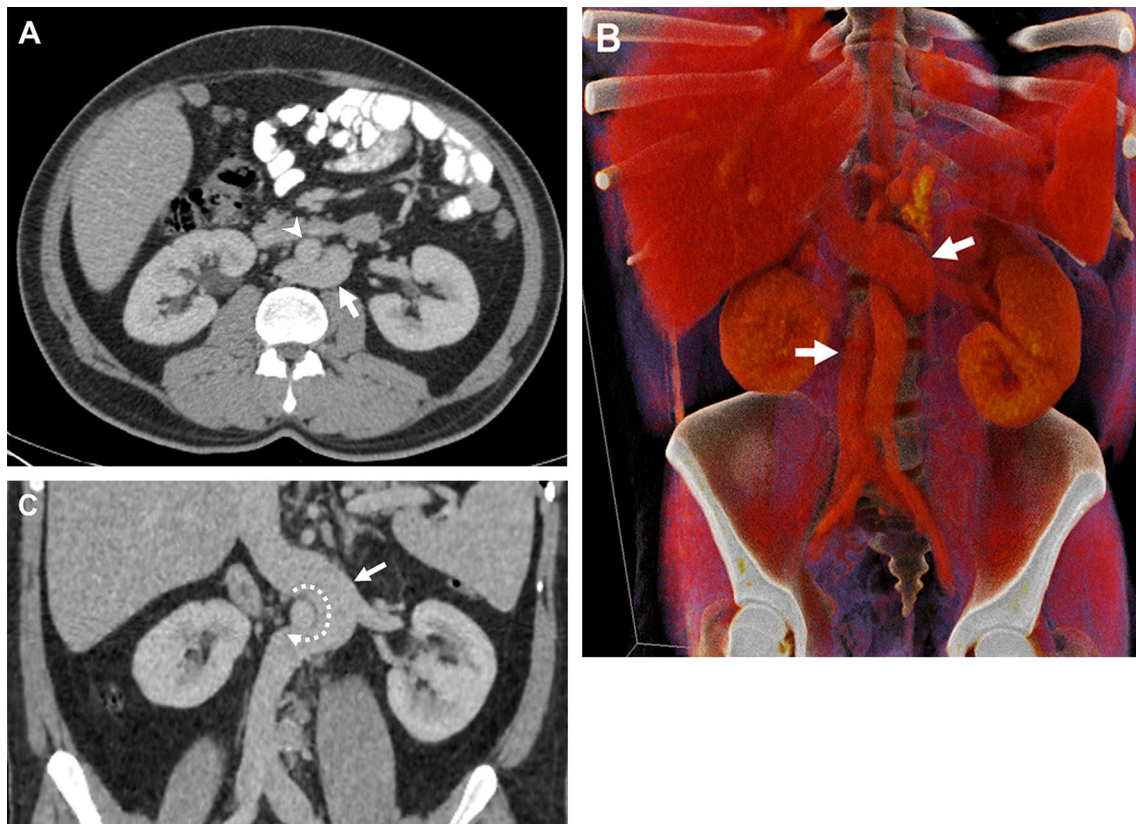


Fig.1 **a** Axial venous phase contrast enhanced CT image demonstrates the IVC (arrow) crossing to the left side of the abdomen by coursing behind the abdominal aorta (arrowhead). **b** 3D cinematic rendering VRT (volume rendering technique) image shows the

route of the IVC, passing behind and encircling the abdominal aorta (arrows). **c** Curved MPR image demonstrates the IVC (arrow) almost completely encircling the abdominal aorta (dashed arrow)



Fig.2 Curved MPR image shows both renal veins (asterisks) joining the IVC. Also note that the left renal vein is draining into the IVC at the level of its acute angulation (arrow)

Initially, a pair of posterior cardinal veins appear during the early stages of the embryologic development and subsequently subcardinal veins start to develop. As the posterior cardinal veins start to gradually regress, supracardinal veins

become the dominant venous structures. In the meantime, the left subcardinal and supracardinal veins also undergo involution. Suprarenal portion of the IVC is derived from the right subcardinal vein, whereas the infrarenal portion develops from the right supracardinal vein. The renal segment of IVC is formed as the anastomoses between the right and left subcardinal veins coalesce [7–9]. Variant IVC anatomy is a result of abnormal persistence or regression of these fetal vessels.

As mentioned above, due to its complex and multisegmental embryogenesis, IVC is subject to several developmental abnormalities [4]. The readers may refer to several excellent papers regarding these variants for further information [2, 9, 10].

To the best of our knowledge, the variant anatomy that we observed in this patient has not been reported elsewhere before. We are not sure about the exact embryological pathogenesis of this anatomy but we think that this interesting anatomy may be related to abnormal embryogenesis of the formation of the renal segment of IVC. Although it is speculative, we tend to consider the abnormal union of the right and left subcardinal veins as the main culprit.

Knowing anatomic variations of IVC as these abnormalities may have important clinical consequences. Despite the fact that most of these variations are clinically silent, as in the presented case, these abnormalities have a significant potential to impact patient care. Abnormally located IVC may be misdiagnosed as a retroperitoneal mass or lymphadenopathy or an abnormal course with an acute bend, as in our patient, may give rise to even a caval rupture, a potentially fatal process, during endocaval interventions. Endocaval interventions are very common in modern medical practice, such as IVC filter replacement or thrombolysis with pharmacologic, mechanical or pharmacomechanical means. Correct knowledge of the IVC anatomy before these procedures is crucially important for proper procedural planning to avoid potential complications. Knowledge of renal vein anastomoses may also be important for kidney surgeries.

Cross-sectional imaging, especially CT venography, is extremely helpful for evaluating IVC anatomy. With the advent of state-of-art CT technology, IVC can now be imaged in a very rapid fashion with minimal radiation burden to the patient, owing to the recent developments in dose reduction technology.

As our last words, we tend to name this previously unreported, to the best of our knowledge, abnormality of IVC as “a sling of a normal right IVC around the abdominal aorta”.

Author contributions ADK: manuscript writing, data collection, and image collection. SAD: manuscript editing, image collection, and preparation. DA: manuscript editing, data collection, and image collection. MNO: manuscript editing, data collection, and image collection. MK: manuscript editing, data collection, and image collection.

Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

References

1. Abernethy J (1793) Account of two instances of uncommon formation in the viscera of the human body. *Philos Trans R Soc* 83:59–66. <https://doi.org/10.1098/rstl.1793.0010>

2. Bass JE, Redwine MD, Kramer LA, Huynh PT, Harris JH Jr (2000) Spectrum of congenital anomalies of the inferior vena cava: cross-sectional imaging findings. *Radiographics* 20(3):639–652. <https://doi.org/10.1148/radiographics.20.3.g00ma09639> (PMID: 10835118)
3. Chee YL, Culligan DJ, Watson HG (2001) Inferior vena cava malformation as a risk factor for deep venous thrombosis in the young. *Br J Haematol* 114(4):878–880. <https://doi.org/10.1046/j.1365-2141.2001.03025.x> (PMID: 11564079)
4. Edwards EA (1951) Clinical anatomy of lesser variations of the inferior vena cava; and a proposal for classifying the anomalies of this vessel. *Angiology* 2(2):85–99. <https://doi.org/10.1177/00031975100200201> (PMID: 14819704)
5. Koc Z, Ulsan S, Oguzkurt L, Tokmak N (2007) Venous variants and anomalies on routine abdominal multi-detector row CT. *Eur J Radiol* 61(2):267–278. <https://doi.org/10.1016/j.ejrad.2006.09.008> (PMID: 17049792)
6. Malaki M, Willis AP, Jones RG (2012) Congenital anomalies of the inferior vena cava. *ClinRadiol* 67(2):165–171. <https://doi.org/10.1016/j.crad.2011.08.006> (PMID: 22070941)
7. Maxwell EV, Erwin GS (1928) Four cases of anomalous inferior vena cava with an explanation of their developmental origin. *J Anat* 62:184–197 (PMID: 17104183)
8. McClure CFW, Butler EG (1925) The development of the vena cava inferior in man. *Am J Anat* 35(3):331–383. <https://doi.org/10.1002/aja.1000350302>
9. Shin DS, Sandstrom CK, Ingraham CR, Monroe EJ, Johnson GE (2019) The inferior vena cava: a pictorial review of embryology, anatomy, pathology, and interventions. *AbdomRadiol (NY)* 44(7):2511–2527. <https://doi.org/10.1007/s00261-019-01988-3> (PMID: 30937506)
10. Spentzouris G, Zandian A, Cesmebasi A, Kinsella CR, Muhleman M, Mirzayan N et al (2014) The clinical anatomy of the inferior vena cava: a review of common congenital anomalies and considerations for clinicians. *ClinAnat* 27(8):1234–1243. <https://doi.org/10.1002/ca.22445> (PMID: 25042045)

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.