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Case Report

Duplicated Inferior Vena Cava in Human Cadaver: Embryological and Clinical Implications

Kristen Skonieczny[1]*, Nikos Solounias[2] and Gregory Saggio[3]

[1]New York Institute of Technology College of Osteopathic Medicine, Old Westbury, NY, United States

[2]Department of Anatomy, New York Institute of Technology College of Osteopathic Medicine, Old Westbury, NY, United States

[3]Department of Clinical Specialties, Division of Surgery New York Institute of Technology College of Osteopathic Medicine, Old Westbury, NY, United States

***Corresponding Author:** Kristen Skonieczny, New York Institute of Technology College of Osteopathic Medicine, Old Westbury, NY, United States.

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Abstract

The inferior vena cava is the largest vein in the body traveling from the lumbar region to the right atrium of the heart. A duplicated inferior vena cava is a rare anatomic variant and thus this report is valuable in keeping clinicians informed of its existence and clinical implications. The duplicated inferior vena cava was discovered on routine posterior abdominal wall dissection during a first-year medical school gross anatomy lab cadaveric dissection. The duplicated inferior vena cava traveled from the left common iliac vein to the level of the renal veins, where it crossed anterior to the aorta to join the right inferior vena cava which continued in its normal course. Embryologic development of the inferior vena cava is a complicated process with several moving parts, creating opportunities for anatomical variations. Such variations include a left sided inferior vena cava, a duplicated inferior vena cava, and renal vein anomalies. Knowledge of variations in the inferior vena cava is critical to surgeons, radiologists, and other medical professionals to minimize complications and provide the necessary patient care. Here we present a case of a duplicated inferior vena cava and aim to discuss the appropriate anatomy, embryology, classification, and clinical relevance related to such cases.

Keywords: *Inferior Vena Cava; Vein; Vascular; Venous Thromboembolism, Anatomy*

Abbreviations

L: Lumbar; IVC: Inferior Vena Cava

Introduction

The inferior vena cava is the largest vein in the body. Its function is to return deoxygenated blood from the lower half of the body, including the portal venous system via the hepatic veins, to the right atrium. The IVC receives blood from many tributaries, of which the renal veins are of importance [1]. The IVC is formed by the junction of the right and left common iliac veins around the level of L5. The union occurs about 2.5 cm to the right of the median plane and just below the aortic bifurcation [1]. The IVC ascends cranially along L5-L3 vertebrae and along the right psoas major muscle. The IVC exits the abdomen via the caval opening in the diaphragm, at the level of T8 where it then enters to thorax and drains into the right atrium of the heart [1].

An articulate sequence of embryological events is required for inferior vena cava development. The developing embryo possesses three main venous systems that carry out different functions. The vitelline system drains the gastrointestinal tract and its derivatives, the umbilical system transports oxygenated blood from the placenta to the embryo, and the cardinal system drains the head, neck and body wall of the embryo [2]. The cardinal venous system develops and remodels from around 4 weeks of gestation to 8 weeks of gestation. Three sets of paired parallel veins arise, remodel, regress, and contribute to the formation of the inferior vena cava and other venous structures [2]. These three sets of paired parallel veins are the cardinal veins, the subcardinal veins, and the supracardinal veins. The suprahepatic IVC is derived from the cranial segment of the right vitelline vein [3]. The retrohepatic segment of the IVC is derived from the caudal segment of the right vitelline vein and the cranial segment of the right subcardinal vein [3]. The infrahepatic/suprarenal IVC is derived from the right subcardinal vein. The infrarenal IVC is derived from the abdominal portion of the right subcardinal vein and right supracardinal vein [3]. Errors at any of these steps may result in an IVC anomaly. A left IVC results from the regression of the right supracardinal vein and the persistence of the left supracardinal vein. This occurs at an estimated prevalence of 0.2 - 0.5% [4]. A duplicated IVC is due to the persistence of both the left and right supracardinal veins. This occurs at a prevalence of about 0.2 - 3.0% [4].

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A case of duplicated IVC was observed during routine dissection of the posterior abdominal wall in an elderly female cadaver (Figure 1). The age and death of the cadaver are unknown. The right portion of the duplicated IVC was normal in position and size coursing along the lower lumbar vertebrae and the right psoas major muscle. The left portion of the duplicated IVC began around the location of the left common iliac vein and it ascended upwards to the left of the aorta and medial to left psoas major muscle. The left IVC anastomosed with the left renal vein just before crossing anterior to the aorta to join the right IVC. Just distal to the joining of the left renal vein, the left IVC received the left ovarian vein. The right ovarian vein drained into the right IVC, as is the normal course. The right IVC was larger in caliber than the left IVC, with the pre-aortic trunk being larger than either.

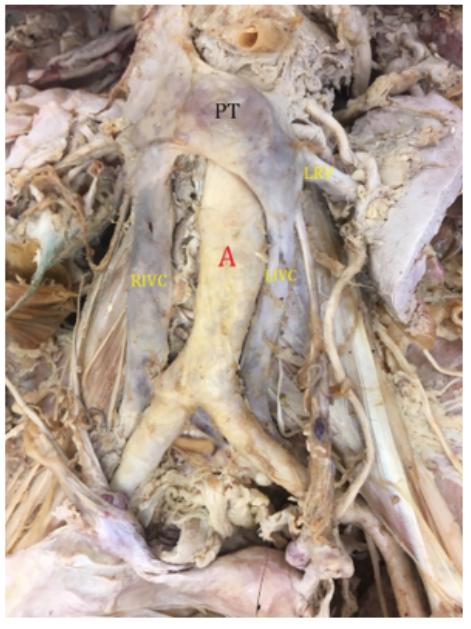

Figure 1: *Photographic image of a duplicated inferior vena cava in an elderly female cadaver. A: Aorta, RIVC: Right Inferior Vena Cava; LIVC: Left Inferior Vena Cava; PT: Pre-Aortic Trunk; LRV: Left Renal Vein.*

Discussion

Several classification systems have been proposed regarding duplication of the inferior vena cava. One such proposal suggests the relative sizes of the right IVC, left IVC, and pre-aortic trunk be used to organize the different variations [5] (Figure 2). This classification system is divided into three types, each of which describe the different variants of duplicated IVC in relation to size. Type I, also called major duplication, is when the two inferior vena cavae and the pre-aortic trunk are all of similar size and caliber [5]. Type II, or minor type, refers to two inferior vena cavae that are of similar size and caliber, but the pre-aortic trunk is much larger [5]. Here, the prominent venous structure is the pre-aortic trunk. In Type III, or asymmetric type, there are a couple of combinations that may be found. There could be a small left IVC, a larger right IVC, and an even larger pre-aortic trunk. There could also be a small left IVC, a larger pre-aortic trunk, and an even larger right IVC. In type III duplicated IVC, the prominent venous structure is either the pre-aortic trunk or the right IVC [5]. Our cadaver would be classified as Type III, since the left IVC appears smaller, the right IVC larger, and pre-aortic trunk as the prominent venous structure.

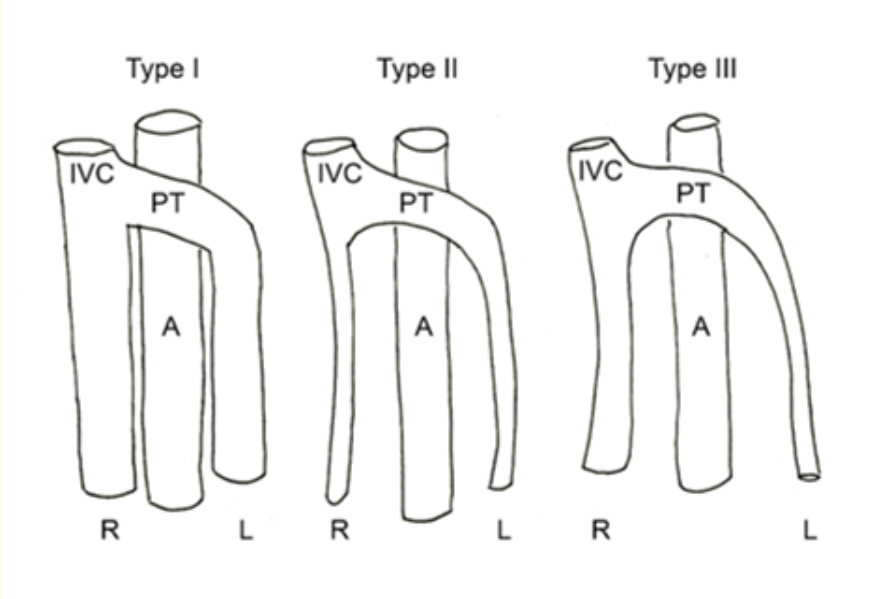

Figure 2: *Schematic illustration of the three types of IVC duplication regarding the relative sizes of the right IVC, left IVC, and pre-aortic trunk. IVC: Inferior Vena Cava; PT: Pre-Aortic Trunk; A: Aorta; R: Right; L: Left. After Natsis., et al. "Duplication of the Inferior Vena Cava: Anatomy, Embryology and Classification Proposal" 2009.*

A second method of classifying duplicated IVC cases involves the presence and characteristics of the interiliac vein [6] (Figure 3). This system aims to characterize variations in the IVC, ranging from normal (Type 1) to complete left sided IVC with normal iliac vein connections (Type 3). Type 2, or duplicated IVC, is further sub-classified based on the variants in the interiliac vein. An interiliac vein is described as a vein that drains blood from the common iliac veins to the contralateral IVC [6]. Type 2a is a double IVC that has no interiliac vein present [6]. Each IVC receives contributions from its respective common iliac vein which further receives contributions from its own internal and external iliac veins. Type 2b describes a double IVC with an interiliac vein that courses superiorly from the left common iliac to right IVC [6]. Type 2c is a duplicated IVC with an interiliac vein that courses superiorly from the right common iliac to the left IVC [6]. Type 2d is a double IVC with a completely transverse interiliac vein connecting both the left and right vena cavae [6]. Type 3 is simply a left inferior

vena cava up to the level of the renal veins, without a ride sided portion [6]. Our cadaver would fall under Type 2b, since it appears to have a vein connecting the left common iliac to the right IVC.

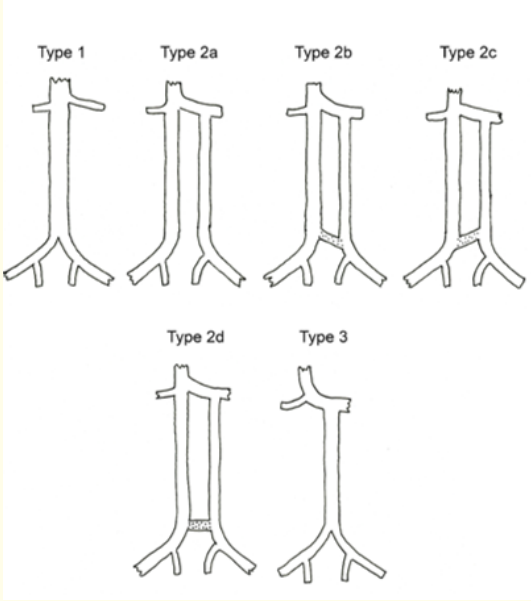

Figure 3: *Schematic illustration of the normal and anomalous inferior vena cava regarding the presence and characteristics of the interiliac vein (dotted line). Type 1, normal IVC; Type 2a, duplicated IVC with no interiliac vein; Type 2b, duplicated IVC with interiliac vein from left common iliac to right IVC; Type 2c, duplicated IVC with interiliac vein from right common iliac vein to left IVC; Type 2d, duplicated IVC with interiliac vein coursing transversely; Type 3, left IVC with normal iliac connection. After Chen., et al. "Double Inferior Vena Cava with Interiliac Vein: A Case Report and Literature Review" 2012.*

Being aware of anatomic variations of the inferior vena cava is extremely important for a vast array of health care professionals, including but not limited to, surgeons, radiologists, and urologists [7,8]. CT, MRI, and ultrasound are all useful tools to help interpret a given patient's anatomy. However, anomalies of the IVC can be mistaken radiologically as aorto-lumbar lymphadenopathy, pyeloureteric dilation, saccular aortic aneurysms, retroperitoneal cysts, or loops of small bowel [7,8]. A cavogram best outlines the course of the inferior vena cava. Instances where knowledge of a duplicated inferior vena cava is crucial include the settings of lower extremity deep vein thrombosis, aortic surgery, and renal organ procurement. A duplicated IVC should be considered in patients who have had an IVC filter placed for venous thromboembolism protection and have recurrent pulmonary emboli [9]. In such cases dual filter placement may be needed for full protection due to the presence of an alternative pathway for embolism [3]. Variations in the anatomy of the IVC may complicate dissection and exposure during aortic surgery and increase the risk of bleeding due to the natural proximity of the vessels [7]. Variations may also pose a challenge in renal organ procurement and transplantation since the left renal vein is often shorter in patients with double IVC [10]. These are just some of the many clinical instances where knowledge of such variation is vital for patient care and outcomes.

Conclusion

This case report identifies a rare variation of the inferior vena cava and central venous system. Surgeons and interventional radiologists frequently depend upon reports of anatomical variations during surgical procedures. Thorough and deep understanding of these

rare but easily encounterable variations can help the clinician plan as well as execute the proper procedures to allow for safe and favorable outcomes for patients.

Conflict of Interest

The authors declare that they have no conflict of interest.

Author Contribution

Kristen Skonieczny has prepared the manuscript for publication. Dr. Nikos Solounias has performed anatomical dissection. All authors edited the manuscript and prepared the final version for submission. All authors read and approved the final manuscript.

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