Bifurcation of the Azygos Vein and Its Clinical Consequences a Comprehensive Review

Eulalia Fitzgerald*

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ABSTRACT

The azygos vein is a key component of the venous system in the thorax, draining blood from the posterior chest and abdominal walls into the superior vena cava. Anatomical variations in the azygos vein, particularly its bifurcation, have been noted in numerous cadaveric studies and imaging reports. While typically a singular structure, the azygos vein can occasionally bifurcate into two separate trunks, each draining into different segments of the superior vena cava or even the right atrium. This article explores the clinical consequences of azygos vein bifurcation, including implications for thoracic surgeries, radiological interventions, and potential diagnostic challenges. Understanding the anatomical variations and their impact on clinical procedures is crucial for preventing complications and ensuring optimal patient outcomes.

Keywords: Azygos vein; Bifurcation; Venous anomalies; Thoracic surgery; Vascular anatomy; Radiology; Clinical implications; Diagnostic imaging

INTRODUCTION

he azygos vein is an important vessel in the systemic venous circulation, The azygos vein is an important vesser in the specific located along the right side of the vertebral column. It primarily serves as a channel for draining the posterior thoracic and abdominal walls, as well as parts of the mediastinum, into the superior vena cava. Anatomically, the azygos vein is typically a single structure, originating from the right lumbar veins and ascending along the right side of the vertebral column to enter the superior vena cava. However, various anatomical anomalies, including bifurcation of the azygos vein, have been documented in medical literature. The bifurcation of the azygos vein, where the vein divides into two branches that may either drain into different segments of the superior vena cava or directly into the right atrium, can have significant implications for both surgical and diagnostic procedures. This anatomical variation can complicate the management of thoracic surgeries, interfere with interventional radiological techniques, and present challenges in interpreting diagnostic imaging. This article reviews the occurrence of azygos vein bifurcation, its clinical consequences, and the importance of recognizing this variation in medical practice [1].

ANATOMY OF THE AZYGOS VEIN

The azygos vein is typically formed by the confluence of the right lumbar veins and the right subcostal vein, emerging at the level of the T12 vertebra. It ascends along the right side of the vertebral column, crossing over the midline at the level of the T5 to T7 vertebrae to drain into the superior vena cava at the T3 or T4 vertebral level. The azygos vein collects blood from the posterior walls of the thorax and abdomen, including the intercostal veins, the bronchial veins, and the mediastinal veins [2].

In the majority of individuals, the azygos vein follows a standard course, entering the superior vena cava at the point where the right pulmonary artery crosses. However, variations in the course and structure of the azygos vein are relatively common, with bifurcation being one of the more significant anomalies. The bifurcation may occur at various levels and can result in the formation of two distinct venous trunks. These branches may drain into different parts of the superior vena cava or even into the right atrium, complicating the typical venous drainage of the thoracic and abdominal regions [3].

MECHANISMS OF AZYGOS VEIN BIFURCATION

The bifurcation of the azygos vein can be attributed to embryological variations

during the development of the venous system. During fetal development, the venous system undergoes significant remodeling, with many vessels forming and regressing based on genetic and environmental factors. The azygos vein and its tributaries are formed from a network of subcardinal and supracardinal veins, which can develop in an aberrant pattern, resulting in bifurcation or other variations in venous drainage.

Bifurcation into Two Trunks: The most common form of bifurcation, where the azygos vein splits into two branches, both of which ascend along different courses toward the superior vena cava or right atrium.

Bifurcation with Separate Drainage: In this variant, one branch drains into the superior vena cava, while the other may drain directly into the right atrium. This can be seen in some cases where the bifurcation occurs at a higher or lower level than usual [4].

Partial Bifurcation: A less common anomaly where the azygos vein may appear to bifurcate partially but maintains continuity through a larger central trunk.

The frequency of bifurcation varies among individuals, with some studies suggesting a prevalence rate of 10-15%. However, in clinical practice, this variation may be underreported or misidentified, particularly in patients with other thoracic anomalies.

CLINICAL IMPLICATIONS OF AZYGOS VEIN BIFURCATION

The bifurcation of the azygos vein can have multiple clinical consequences, especially in the context of surgical and diagnostic interventions. The primary implications include complications during thoracic surgery, challenges in radiological procedures, and the risk of misdiagnosis. Azygos vein bifurcation can complicate thoracic surgery, particularly when procedures involve the superior vena cava, right atrium, or adjacent structures. Common procedures that may be affected include

Cardiothoracic Surgery: Surgeries such as coronary artery bypass grafting (CABG) or heart valve replacement often require access to the right atrium and superior vena cava. Anomalous drainage patterns caused by azygos vein bifurcation can lead to difficulties in identifying and managing the venous structures. Surgeons may inadvertently injure or ligate the vein, leading to postoperative bleeding or venous congestion [5].

Lung Resection and Lobectomy: In surgeries involving lung tissue, such as lobectomy or pneumonectomy, the azygos vein may be encountered and need

Department of Anatomy, The University of Melbourne, Australia

Correspondence: Eulalia Fitzgerald, Department of Anatomy, The University of Melbourne, Australia; E-mail: fit_lali44@hotmail.com

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to be resected or preserved. A bifurcated azygos vein could alter the approach to these procedures, requiring extra caution to prevent inadvertent damage to either venous trunk.

Esophageal Resection: The azygos vein often runs near the esophagus, and its bifurcation can pose a challenge during esophageal surgeries. The variability in venous drainage could result in unexpected bleeding or venous congestion in the thoracic cavity during resections. Interventional radiology techniques that involve catheter placement, angioplasty, or venography often require precise knowledge of vascular anatomy. Azygos vein bifurcation can lead to misinterpretation of venous anatomy, especially during procedures such as

Central Venous Access: In patients with bifurcated azygos veins, central venous catheterization or the placement of a port for chemotherapy or dialysis may be challenging. The bifurcation may obscure the usual path of venous drainage, leading to difficulties in catheter insertion or increased risk of complications such as thrombosis [6].

Venous Embolization: In certain cases, interventional radiologists perform venous embolization to control bleeding in the thoracic or abdominal region. The atypical drainage patterns in cases of azygos vein bifurcation can increase the risk of embolization failure or cause unintended embolization in healthy tissues [7].

DIAGNOSTIC CHALLENGES

Imaging techniques such as chest X-rays, CT scans, and MRI scans are often used to visualize the azygos vein. In patients with a bifurcated azygos vein, these imaging studies may reveal a more complex venous anatomy than expected. This can lead to diagnostic confusion, especially if the bifurcation is not readily apparent. Misinterpretation of these variations may delay diagnosis or result in an incomplete surgical or interventional plan.

In some cases, the bifurcation could also be mistaken for other thoracic anomalies, such as venous malformations or lymphatic congestion, leading to incorrect diagnoses and treatment delays [8].

MANAGEMENT AND PREOPERATIVE PLANNING

Given the clinical consequences of azygos vein bifurcation, it is important for clinicians, especially those involved in thoracic surgery or interventional radiology, to recognize these variations. Preoperative imaging plays a crucial role in identifying the anatomical structure of the azygos vein and its tributaries. High-resolution CT angiography, MRI, and 3D reconstruction techniques are invaluable in detecting and mapping these variations before proceeding with surgery or other interventions [9].

Surgeons should ensure that they are familiar with the patient's vascular anatomy prior to performing thoracic procedures. In cases where bifurcation is noted, additional care should be taken to preserve venous drainage during surgery, and special attention should be paid to the potential for unexpected bleeding or venous congestion. For interventional radiologists, knowledge of these variations can help guide catheter placement and embolization procedures, improving the success rates of interventions [10].

CONCLUSION

Bifurcation of the azygos vein is a relatively uncommon anatomical variation that can have important clinical consequences. Its presence may complicate thoracic surgeries, interfere with diagnostic imaging, and pose challenges in interventional procedures. A thorough understanding of the anatomical variations of the azygos vein is essential for minimizing complications and improving patient outcomes. Preoperative imaging and careful surgical planning are crucial for addressing the challenges posed by azygos vein bifurcation, ensuring optimal care for patients undergoing thoracic and abdominal interventions.

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