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Case Report
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Anatomical Case Report: A Pre-Aortic Circumflex Interazygos Vein

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Abstract

The azygos venous system demonstrates some variability arising from the complex regression and persistence of the supracardinal, subcardinal, and posterior cardinal veins during embryonic development. Among its historically rarer variants, a pre-aortic interazygos vein represents an additional venovenous connection between the left-sided hemiazygos and right-sided azygos systems. This additional connection is seldom documented in the literature and provides valuable insight into the developmental plasticity of the thoracic venous network. During routine mediastinal dissection of an adult female cadaver, an example of this distinct venous channel was identified. In this specimen, the pre-aortic interazygos vein formed the ventral limb of a loop around the thoracic aorta, while the dorsal limb, to which it connected, persisted as the expected anatomical pattern of the hemiazygos system. This inferior, pre-aortic circumflex interazygos vein ascended obliquely at the levels of T7 to T9.

In this paper, we describe the anatomic features, review the developmental basis, and discuss the clinical relevance of this pre-aortic interazygos system variant. We also discuss that the true incidence of an interazygos vein is likely severely underreported, as most documented cases have been identified through whole-body cadaveric dissection. To date, only 24 prior cases of a pre-aortic interazygos tributary have been reported in the past century. Further, this inferior, pre-aortic circumflex interazygos vein is the first case of this anastomotic pattern to be documented. Recognition of this venous variant is essential for accurate radiologic interpretation, avoidance of iatrogenic injury during thoracic and retroperitoneal procedures, and consideration of mediastinal

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Introduction

In what is considered the typical or most common arrangement, the azygos venous system consists of three longitudinal channels: the azygos vein on the right, and the hemiazygos and accessory hemiazygos veins on the left, which together provide a critical collateral network between the superior and inferior venae cava [1].

The azygos vein, situated along the right side of the vertebral column, originates from the right ascending lumbar vein and the right subcostal vein, ascending through the aortic hiatus of the diaphragm. It receives both parietal and visceral tributaries and serves as a return channel for deoxygenated blood from the posterior thorax [2,3]. The parietal branches include the right posterior intercostal veins, typically from the 5th to the 11th spaces, the subcostal vein, and the superior lumbar veins. The visceral tributaries include the bronchial, esophageal, mediastinal, and pericardial veins. At about the level of T4, the azygos vein arches anteriorly over the root of the right lung and empties into the superior vena cava, forming a prominent venous arch visible on radiographs as the “azygos shadow,” [4].

On the left side, the hemiazygos vein typically arises from the left ascending lumbar vein around the level of T12, ascends on the left side of the vertebral bodies, and crosses the midline posterior to the aorta to empty into the azygos vein near T8-T9 [5]. The hemiazygos serves as a return channel for deoxygenated blood from the lower left posterior thorax.

Superior to this, the accessory hemiazygos vein drains the 4th through 7th left posterior intercostal veins, though its origin and termination can vary widely, it may receive tributaries directly from the left brachiocephalic vein, join the hemiazygos below, or communicate directly with the azygos vein itself [6,7].

Both the hemiazygos and accessory hemiazygos veins typically course posterior to the thoracic aorta, thoracic duct, and esophagus, maintaining a symmetrical but independent drainage pattern relative to the azygos on the right.

The azygos and hemiazygos veins contain very few valves, a feature that permits bidirectional flow and enables them to serve as important portocaval and cavo-caval anastomotic pathways. This is supported by anatomical evidence showing that the azygos vein typically possesses only one valve, and rarely two, most often located in the arch, near its entry into the superior vena cava in 70% to 90% of cases [8,9]. The hemiazygos vein infrequently contains valves, with an incidence of about 3%, usually found near its confluence with the azygos vein [10].

Clinically, this capacity becomes significant in conditions such as superior vena cava (SVC) obstruction, where blood is rerouted through the azygos system to the inferior vena cava, or in portal hypertension, where esophageal veins draining via the hemiazygos system can become engorged, producing esophageal varices. Enlargement of the azygos vein on imaging is a key radiographic sign of SVC syndrome, reflecting its compensatory role in maintaining venous return in the setting of caval obstruction [11].

Given a typical posterior venous plane relationship, a transverse anastomosis that crosses anterior to the aorta, as in this case report, represents an unusual and striking deviation from the norm, highlighting the embryonic variability and the capacity for persistent venous communications.

Historically, this transverse anastomosis has been referred to as an "interazygos vein." A recent, preceding review and case report by Sahai et al. found there to be only 24 reported instances of this variation in the past century. Further, only 3 prior cases of the variation forming a venous loop have been reported.

Case Presentation

During a routine gross anatomy dissection in the medical curriculum at Noorda College of Osteopathic Medicine, a rare anatomic variation was identified in the posterior mediastinum, anterior to the aorta. The body donor was a 60-year-old female whose death was caused by complications of metastatic lung adenocarcinoma. Donor specimens utilized in this educational program are provided by The Body Donor Program administered by the University of Utah Department of Neurobiology, which follows all ethical guidelines established under the Uniform Anatomical Gift Act, with informed consent obtained prior to donation.

In this case, the pre-aortic interazygos vein formed the ventral limb of a loop around the thoracic aorta, while the dorsal limb, to which it connected, persisted as the expected anatomical pattern of the hemiazygos system.

The interazygos vein originated from the left hemiazygos vein at the T9 vertebral level and ascended obliquely, passing anterior to the aorta and thoracic lymphatic duct, before draining into the right azygos vein at the T7 vertebral level (Figure 1). Its connection with the retro-aortic hemiazygos vein formed a venous loop that enclosed both the aorta and thoracic lymphatic duct (Figures 1, 2.2, and 2.3). A smaller, inferior tributary to this interazygos vein was also identified (Figure 2.1). This branch further divided into multiple smaller vessels that appeared to drain the esophagus, diaphragm, and pericardium.

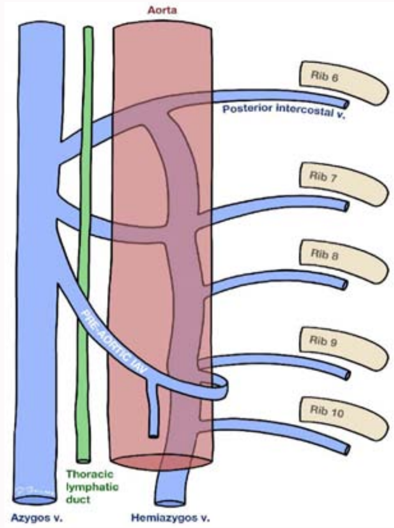

Figure 1: Schematic diagram depicting the variant described in this case report. The typical venous configuration of the azygos venous system is included while highlighting the observed pre-aortic interazygos vein (PACIAV) with a ventral course. As shown, the PACIAV ascends obliquely at the levels of T9 to T7.

Figure 2.1: Anatomical dissection image of the pre-aortic interazygos vein (PACIAV) identified in this present study. This is a centered, anterior view of the thoracic cavity with the venous variant positioned ventral to the thoracic aorta. TLD: Thoracic Lymphatic Duct. AHA: Accessory Hemiazygos Vein. HA: Hemiazygos Vein.

The length and diameter of the pre-aortic interazygos vein were measured using digital calipers and a flexible, medical tape measure. All measurements were obtained by three independent observers. Each observer measured the interazygos vein length and diameter three times. All measurements were pooled, and a single average value was calculated across all observers (Table 1).

The vein length was measured using a Medline medical tape measure, which was sufficiently flexible to follow the curved surface of the vein from its junction with the azygos vein, over the aorta, to its junction with the hemiazygos vein. The tape measure had an uncertainty of ± 0.5 mm.

The vein diameter was measured using digital calipers positioned perpendicular to the vein axis, at the midpoint of the vein which was

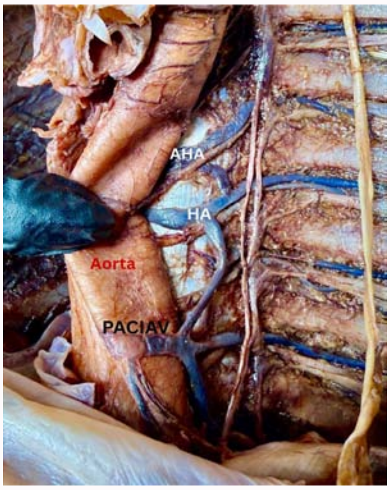

Figure 2.2: Anatomical dissection image providing a left, anterior view of the pre-aortic interazygos vein (PACIAV) identified in this present study. This angle allows for visualization of the variant's anastomosis with the hemiazygos vein (HA), forming the dorsal limb of the venous loop. AHA: Accessory Hemiazygos Vein.

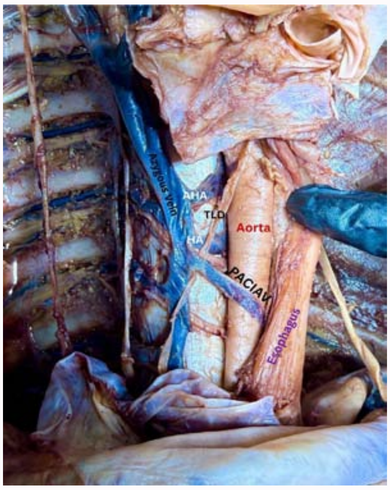

Figure 2.3: Anatomical dissection image providing a right, anterior view of the pre-aortic interazygos vein (PACIAV) identified in this present study. This angle allows for visualization of the venous loop enclosing the thoracic lymphatic duct (TLD). AHA: Accessory Hemiazygos Vein. HA: Hemiazygos Vein.

determined by the average length measurement. The digital calipers had an uncertainty of ± 0.02 mm.

Photographs were taken to document these findings using a 48-megapixel wide-angle camera system with high-resolution digital imaging capabilities. Images were captured from multiple angles to ensure clear visualization of the vein morphology and measurement landmarks.

Historical Representation and Embryonic Origin

The azygos venous system has been recognized since antiquity, with Galen and other early physicians documenting longitudinal veins along the posterior thoracic wall [1]. The major unpaired right-sided vein gave rise to the term "azygos," from the Greek equivalent meaning "unpaired." However, contemporary understanding is

Table 1: Morphometric characteristics of the pre-aortic circumflex interazygos vein. Measurements were independently obtained by three observers, each performing three repeated measurements of both length and diameter. A single mean value was calculated and included in this table.

Parameter	Measurement	Reference Notes
Length	56.67 ± 0.5 mm	Distance between azygos and hemiazygos junctions.
Diameter	5.02 ± 0.02 mm	Measured at length midpoint of vessel.
Vertebral Levels	T7 to T9	Determined by anatomic landmarks.

that the system includes multiple left-sided components, such as the hemiazygos and accessory hemiazygos veins, which perhaps complicates the historical notion of a truly unpaired vessel. Though, its unilateral contribution to the SVC is indisputable.

In terms of embryonic origin, the azygos system develops from the supracardinal veins during the sixth to eighth weeks of gestation [12]. The right supracardinal vein forms the azygos vein, while the left supracardinal vein contributes to the hemiazygos and accessory hemiazygos veins [13]. This variant likely arises from the persistence of a transverse anastomosis between the right and left supracardinal veins, which normally regress or remodel during the sixth to eighth weeks of gestation [14,15]. While most such communications remain posterior, the present case illustrates that ventral persistence is possible, emphasizing the plasticity of thoracic venous development.

Further, it is important to highlight that the etiology of pre-aortic azygos vein tributaries remains unclear. Preceding studies have hypothesized a rare genotypic variation, although no definitive genetic mechanism has been identified [16,17].

Discussion

The pre-aortic interazygos vein described in this report represents an exceedingly rare anatomic variant of the thoracic venous system. The typical azygos system is composed of the right-sided azygos vein and the left-sided hemiazygos and accessory hemiazygos veins, which generally course posterior to the thoracic aorta. While transverse communications between the two sides have been described, most of these connections are retro-aortic or posterior in orientation. The presence of a vein crossing ventral to the descending thoracic aorta, as observed in this cadaver, is unusual and has been documented only rarely in the literature, with this case likely representing the 25th reported instance [17] in the last century. The preceding 24 cases presented with various anastomotic patterns, making the present case the first of its pattern to ever be documented.

The true incidence of such variants is difficult to ascertain and is likely underreported. Many cases have historically been identified through whole-body cadaveric dissection. Modern imaging studies of the thorax, such as CT or MRI, also have limitations, as thin-walled venous structures may collapse or be overlooked.

Additionally, rare variations are not routinely sought out in standard imaging or anatomical evaluations. As a result, although these variants are described as rare, their actual prevalence may be somewhat higher than reported, though they remain exceptional findings. This under-reporting complicates both anatomical and clinical understanding, as surgeons and radiologists may encounter unexpected structures that are poorly represented in reference texts.

Hemodynamic Considerations

This pre-aortic circumflex interazygos vein also raises important considerations regarding hemodynamics and potential vulnerability.

In this position, the vein itself is subjected to compressive forces from anterior thoracic organs that would normally act only on the aorta, particularly when the body is supine. Unlike arteries, veins have thinner walls with less smooth muscle and elastic tissue, making them less capable of withstanding external pressure [18]. This structural difference renders the vein more susceptible to compression, which could theoretically impede venous return from the left side of the thorax or necessitate diversion of blood through collateral pathways. Additionally, the compression or engorgement of an anteriorly coursing interazygos vein may mimic other mediastinal pathologies on imaging, such as lymphadenopathy or masses, potentially complicating radiologic interpretation [19,20]. Such mechanical challenges may help explain the rarity of this variant, as sustained compressive forces could limit the long-term prominence or functional persistence of an anteriorly coursing interazygos vein.

Lymphatic Drainage Implications

The venous loop encircling the thoracic duct could have significant implications for lymphatic drainage. By partially surrounding the duct, the loop may create areas of mild compression or altered flow dynamics, potentially slowing the transport of lymph from the lower body and left thoracic structures. Such anatomic variations could predispose the thoracic duct to temporary stasis, increasing the risk of lymphatic congestion or dilatation upstream [21,22]. In procedures involving the posterior mediastinum, the presence of this loop could pose a higher risk of inadvertent injury to the thoracic duct [23]. Additionally, the loop might influence collateral lymphatic pathways, as lymph may be redirected to smaller tributaries if ductal flow is partially impeded [21,22].

On the other hand, it is possible that the presence of the aorta within the loop helped protect the thoracic duct from significant compression. The rigid structure of the aorta may have acted as a barrier, maintaining a stable space for the duct and preventing it from being fully constricted by the surrounding veins. This arrangement could allow lymphatic flow to remain largely unimpeded despite the unusual venous configuration.

Conclusion

The present case documents a unique pre-aortic interazygos vein, representing the first venous variant of this pattern and the 25th interazygos vein to be documented. Its anterior course across the descending thoracic aorta highlights the variability of azygos-hemiazygos connections and underscores the importance of careful observation during cadaveric dissection.

While the true incidence is likely underreported due to limitations in both dissection and imaging, this finding remains a noteworthy contribution to anatomical knowledge. Recognition of this and similar venous variants is important for anatomical education and clinical practice, as they may be encountered during thoracic surgery, retroperitoneal procedures, or mediastinal imaging. Awareness of such anomalies may also help prevent inadvertent venous injury and related complications.

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Conflicts of Interest

The authors declare no conflicts of interest.

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