

## Variations in Azygos Venous System in The Eastern Indian Population: A Cadaveric Study

Smruti Rekha Mohanty <sup>\*1</sup>, Mamata Panigrahi <sup>2</sup>, Jagannath Upadhyaya <sup>3</sup>.

<sup>\*1</sup> Professor, Kalinga Institute of Medical Sciences, KIIT University, Bhubaneswar, Odisha, India.

<sup>2</sup> Assistant Professor, Kalinga Institute of Medical Sciences, KIIT University, Bhubaneswar, Odisha, India

<sup>3</sup> Tutor, Kalinga Institute of Medical Sciences, KIIT University, Bhubaneswar, Odisha, India.

### ABSTRACT

**Background:** This study aimed to classify Azygos vein patterns in the Eastern Indian population.

**Methods:** During the routine dissection of MBBS in the 2018–2020 academic year, 20 formalin embalmed cadavers aged 50–70 were used to classify the azygos system. The cadaver's age was verified by its entry into our institute's anatomy register. The register confirmed that all cadavers used for dissection were of Indian origin. Though gender was not compared in this study, it was noted for record purposes by identifying the external genitalia and confirming it to the records. These were the exclusion criteria: 1) No major thoracic surgeries; 2) No major thoracic deformities. Azygos, hemiazygos, and accessory hemiazygos veins were also examined.

**Results:** The Anson & McVay system was used to classify the recruited cadavers' azygos system. The cadavers were classified into Type-1, Type-2, and Type-3. Type 2 was again subdivided into 5 subgroups and Type-3 into 2 sub-groups. In one cadaver, Type-1 was observed, 17 cadavers had Type-2 azygos system and 2 cadavers showed Type-3. Of the 17 cadavers of Type-2, 3 and 7 cadavers had Type-2A and -2B, respectively. Similarly, 4 and 1 cadavers had 2C and 2D patterns, respectively. Also, 2 cadavers showed 2E type. Of the 2 cadavers of Type-3, one was Type -3A and one Type-3B. The termination of the azygos vein vertebral level was between T2 and T4, of the hemiazygos vein was T8 to T11, and accessory hemiazygos veins were between T7 and T10.

**Conclusion:** These variations should be well studied to avoid misinterpretation during radiological investigations and surgical interventions.

**KEY WORDS:** Azygos vein, Hemiazygos vein, Posterior mediastinum, Radiological investigation, Variation.

**Corresponding Author:** Dr. Smruti Rekha Mohanty, Professor, Kalinga Institute of Medical Sciences, KIIT University, Bhubaneswar, Odisha, India. Phone No. 9438330440

**E-Mail:** [smohanty47@gmail.com](mailto:smohanty47@gmail.com)

Access this Article online	Journal Information
<b>Quick Response code</b>  DOI: 10.16965/ijar.2022.248	<b>International Journal of Anatomy and Research</b> ISSN (E) 2321-4287   ISSN (P) 2321-8967 <a href="https://www.ijmhr.org/ijar.htm">https://www.ijmhr.org/ijar.htm</a> DOI-Prefix: <a href="https://dx.doi.org/10.16965/ijar">https://dx.doi.org/10.16965/ijar</a> 
	Article Information
	Received: 30 Aug 2022 Peer Review: 01 Sep 2022 Revised: 10 Sep 2022
	Accepted: 01 Nov 2022 Published (O): 05 Dec 2022 Published (P): 05 Dec 2022

### INTRODUCTION

Venous blood is drained by the azygos system of veins from the upper section of the posterior abdominal wall and thoracic wall. Three connected major veins exist in the azygos system, namely, the hemiazygos vein, accessory hemiazygos vein, and azygos vein

[1,2]. Azygos vein serves as a link joining the inferior vena cava and the superior vena cava and has very few or no valves. Because of this arrangement, this vein can shunt the blood in both ways [3]. Although the formation of this vein is variable, it is mostly formed adjacent to the first lumbar vertebra by the joining of

the right subcostal vein and the right ascending lumbar vein. Along the right side of the vertebral column, it ascends, thereby terminating into the superior vena cava. Azygos vein leaves the abdomen adjacent to 12<sup>th</sup> thoracic vertebra via the aortic opening or may leave by means of puncturing through the diaphragm's right crus [4].

This vein vertically ascends upward to the 4<sup>th</sup> thoracic vertebra and thereby comes in front of the vertebral column. It curves onward to the right lung's hilum and opens into the posterior of the superior vena cava at the 4<sup>th</sup> thoracic vertebra. The hemiazygos vein is located on the left side and appears as a reflection of the azygos vein's lowest portion. This vein can be formed either due to the joining of the subcostal vein and left ascending lumbar vein or a continuation of the left lumbar azygos vein, which arises from the posterior surface of the left renal vein. The hemiazygos vein pierces the left crus of the diaphragm and enters the posterior mediastinum. This vein climbs up to the 8<sup>th</sup> thoracic vertebra level and opens into the azygos vein. Hemiazygos vein receives 9<sup>th</sup>, 10<sup>th</sup>, and 11<sup>th</sup> left posterior intercostal veins on its way [3]. Blood is drained by the accessory hemiazygos vein from the 4<sup>th</sup> or 5<sup>th</sup> intercostal spaces to the 8<sup>th</sup> intercostal spaces via posterior intercostal veins and drained into the azygos vein at the level of the 7<sup>th</sup> thoracic vertebra [2].

The somatic venous network of the trunk is made of the azygos system that may function as a collateral pathway in pathological situations [5]. The azygos venous system has many variations in the pattern of its origin, vertical channel number, course, horizontal anastomoses number, and the nature of the termination. Anomalies in the azygos veins are not rare, and various deviations of this venous system have been reported [6-8]. Complex embryological development has been considered the predominant reason for these variations. The knowledge of these variations of azygos veins holds a lot of importance for cardiothoracic surgeons and radiologists for various surgical, echography, and radiological techniques [8]. Moreover, the record of various changes evident in the azygos system

in the context of CT and MRI of the mediastinum is crucial, as a few of the anomalies of this system could be misinterpreted with various other pathological conditions such as aneurysms, enlarged lymph nodes, and tumors [9]. For a long, researchers have been extensively involved in deciphering the different types of classification of the azygos system [2,10], but still, this topic is a matter of debate and further investigation. Keeping this in view, this study aimed to observe the population-specific changes in the azygos system among the Eastern Indian population. We studied the classification of the communication patterns during the course of the azygos venous system in the East Indian population. Secondly, we also attempted to find the variation in the termination of the azygos venous system.

## METHODS

**Study design:** This was an observational study conducted at the Kalinga Institute of Medical Sciences, Bhubaneswar, during the routine dissection for 1<sup>st</sup> year MBBS students. Conventional dissection of azygos venous system was conducted in 20 formalin embalmed cadavers that were aged between 50-70 years. All these cadavers were from the East Indian population after following the proper proceedings for body procurement and voluntary donation process and getting written informed consent from their relatives. The study duration was 2 years, from February 2018 to February 2020.

**Surgical procedure:** The posterior mediastinum was exposed after removing the lungs, heart, thoracic aorta, and esophagus. The diaphragm was depressed, and the accessory hemiazygos vein, hemiazygos vein, and azygos vein were cleaned with water for better visualization.

**Imaging:** Photographs of the dissected portion were taken using Canon digital camera with a power shot S 150 IS. The schematic drawing was made for each specimen for better understanding.

### Classification of the Azygos venous system

Azygos venous system was categorized on account of Anson and Mcvay [11] classification into three types:

- (A) Type 1-primitive-two longitudinal azygos lines without any connection
- (B) Type-2-transitional-which was further divided into five groups viz. 1) 2A-having one retro aortic communication 2) 2B-having 2 communications 3) 2C-3 communications 4) 2D-4 communications 5) 2E-5 or more communications
- (C) Type-3-unicolumnar- single vein in the midline, draining the posterior intercostal veins from both sides, further subdivided into type 3A and type 3B.

**RESULTS**

We observed that out of 20 cadavers studied, Type 1, the primitive type, was observed in one cadaver (Figure 1a). In this, the two longitudinal veins were without any communication. The left vein poured into the left brachiocephalic vein, and the right vein into the superior vena cava. Type 2 was the most

common category of Azygos venous system observed in 17 cadavers (Figure 1b – Figure 2c). These Type 2 cadavers were further divided into the sub-types, and it was found that Type 2A was observed in 3 cadavers (Figure 1c), type 2B in 7 cadavers (Figure 2a), 2C in 4 cadavers, 2D in 1 cadaver and 2E in 2 cadavers (Figure 2c).

Type -3 Azygos venous system was evident in 2 cadavers. To the best of our knowledge, we are the first to classify the type 3 cadavers into two types, viz. Type 3A and Type 3B. Type 3A was the one in which a single vein was formed initially in the center but later joined by the accessory vein. This arrangement was seen in one cadaver (Figure 3a). This single vein initiated at the level of T12 and joined with AHV at the level of T9. Type 3B was also seen in one cadaver. In this arrangement, a single azygos vein was found to be draining the posterior intercostal veins of both sides. This

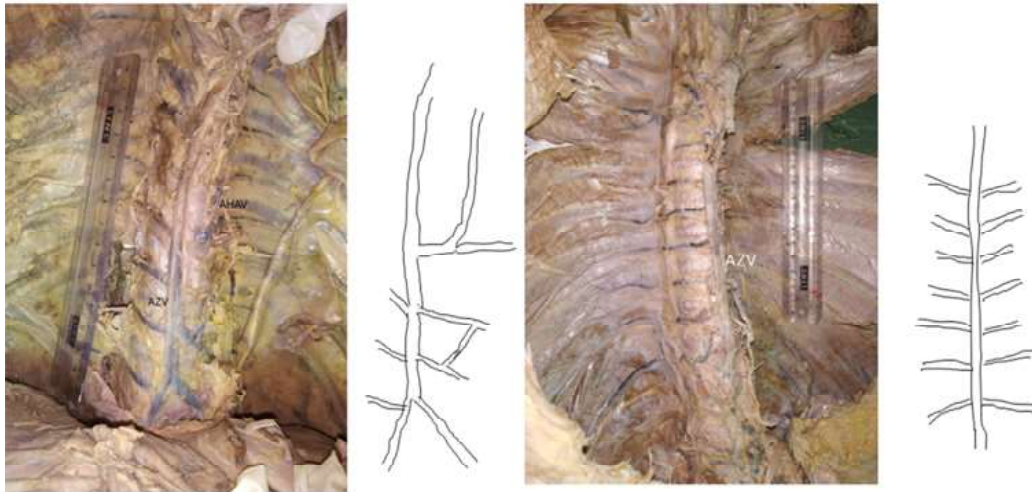


**Fig. 1:** a) Showing 2 completely separate veins, the right azygos and left azygos vein, without any communication between them. It corresponds to type 1. Left azygos drains into the left brachiocephalic vein. b) Showing only one communication, type 2 A. both accessory hemiazygos and hemiazygos veins are draining at T8 level into the azygos vein. c) Showing type 2A, both accessory hemiazygos and hemiazygos joined together and drained into azygos vein at T10 vertebra level.



**Fig. 2:** a) Showing type 2B, Hemiazygos vein draining between T8 and T9 level and azygos vein at T7 level. b) Showing 2C type. Hemiazygos vein drains at T10 and accessory hemiazygos at the level T8 into the azygos vein. 9th posterior intercostals vein drains separately into the azygos vein. There is also communication between the accessory hemiazygos vein and 9th rt posterior intercostals vein. c) Showing 2 venous lines with more than 5 retroaortic communications, type 2 E.





**Fig. 3:** a) Showing type 3 A, single azygos vein formed initially and later joined by accessory hemiazygos vein at T8 level.

b) Showing unicolunar type, type 3 B, one single azygos vein receiving posterior intercostals veins of both the sides.

single vein was initiated at the T11 level (Figure 3b).

We found in the current research that the termination level of the azygos vein was between T2 and T4, with T3 being the most common level (Table 1).

The level of termination of hemiazygos was between T8 to T11, with T11 being the most common level (Table 2). The level of termination of accessory hemiazygos was between T7 and T10, with T9 being the most common level (Table-3).

**Table 1:** Termination level of azygos vein.

Levels	Frequency	Percent
T2	1	5
T2-3	3	15
T3	11	55
T3-4	4	20
T4	1	5
<b>Total</b>	<b>20</b>	<b>100</b>

**Table 2:** Level of termination of hemiazygos vein.

Levels	Frequency	Percent
T6	0	0
T7	0	0
T7-8	0	0
T8	0	0
T8-9	2	10
T9	1	5
T10	5	25
T10-11	3	15
T11	6	30
Can't be determined	3(type 1 and type 3)	15
<b>Total</b>	<b>20</b>	<b>100</b>

**Table 3:** Level of termination of accessory hemiazygos vein.

Levels	Frequency	Percent
T6	0	0
T7	5	25
T7-8	1	5
T8	4	20
T8-9	1	5
T9	6	30
T10	1	5
Can't be determined	2(type 1 and type 3 B)	10
<b>Total</b>	<b>20</b>	<b>100</b>

**Table 4:** Comparison of termination levels of azygos vein, hemiazygos vein, and accessory hemiazygos in different studies.

Study	Most common level of termination of azygos vein	Most common level of termination of hemiazygos vein	Most common level of termination of accessory hemiazygos vein
Kutoglu et al 2012 [12]	T3	T8	T8
Daharan et al 2016 [7]	T3-T4	T8	T5
Tartar I et al 2008 [15]	T5		
Vijaya Nirmala et al. 2015	T3-4	T8	T7
<b>This study 2020</b>	<b>T3</b>	<b>T11</b>	<b>T9</b>

## DISCUSSION

This study was designed to decipher the classification of the azygos venous system and its variations in the East Indian population. The azygos vein is developed from the right azygos venous line, along with the cephalic section of the right posterior cardinal vein persisting as an extension of the azygos vein. The left azygos venous line makes the superior and inferior Hemi-azygos veins. In the present study, we found that the accessory hemiazygos veins were the most variable veins, in contrast to the previous studies which reported azygos veins as the most variable veins [9,10] and these accessory hemiazygos veins might pour into the left brachiocephalic, hemiazygos, or azygos vein.

Mostly, the conspicuous 'right-sided azygos vein with few representatives of the hemiazygos veins are present. The presence of hemiazygos veins shows variation and can be absent or underdeveloped. Sometimes, only one azygos vein may appear in a midline location and lack hemiazygos tributaries or separate right and left azygos veins (the early embryonic form) are present. Lots of variations are seen in the retro-aortic transvertebral connections from accessory hemiazygos and hemiazygos veins to azygos veins, and there could be up to 5 connections. In the absence of hemiazygos veins, the necessary intercostal veins cross the vertebral bodies and culminate in the azygos vein [8].

The azygos venous system has been classified into 11 subtypes and three main types based on the number of retro aortic transverse anastomoses by Anson BJ in his study of 100 dissected cadavers [12].

As per his findings, the Type I-primitive type included two different veins without anastomoses located parallel to one another in the posterior mediastinum and was seen in 1% of cases. The right vein opened in the SVC, and the left vein poured into the left brachiocephalic vein. Type II was the most familiar type seen in 98% of the cases and consisted of groups 2 to 10, which depended on the number of connections.

Type III included only one azygos vein lying at the midline anterior of the vertebral column, and it was seen in 1% of cases. In his study, two cases did not correspond to any type and were classified as atypic.

Seib [13] categorized the azygos venous system into 21 subtypes and three main types in his 200 cadaver dissections, to which he referred as transition, double-column, and single-column types. The embryological type was defined with respect to the non-connection of azygos and hemiazygos veins and was observed in 1-2% and single-column type in 5% cases.

Dahran and Sames [7], in their study of 30 cadavers, included atypic cases in type 2D (7). In the study by Kadir S [14] and Seib [13], single-column azygos veins were reported in 1–2% of cases, and the azygos vein was midline in 41 cases. It usually arches and opens at the fifth thoracic vertebra. Sometimes, the level of opening matched the carina. In this research of 20 cadavers, we classified the azygos venous system utilizing Anson and McVay's classification into three types: primitive (type 1), transitional (type 2), and unicolumnar (type 3).

According to the number of retro aortic anastomoses between the right and left azygos lines, type 2 was divided again into five groups.

Furthermore, we classified type 3 into two subtypes: type 3A, wherein one single azygos vein was formed at the center, draining the posterior intercostal veins of both sides but later joined by an accessory hemiazygos vein, and type 3B, where a single azygos vein was draining all the posterior intercostal veins of both the sides.

We found, based on this classification, one cadaver of type 1 and 17 cadavers of type 2, which were further sub-divided, and we found 3 type 2A cadavers, 7 type 2B cadavers, four type 2C cadavers, 1 type 2D and two cadavers were of type 2E. 2 cadavers studied were of type 3, of which one was type 3A and other type 3B. We did not find any effect of age and gender on the results. We further looked into the vertebral termination level of the azygos

vein. Kutoglu et al. [8] have reported the level of termination of the azygos vein at T3 in most of the cases. Between T7 and T10, the termination levels of the hemiazygos vein were ascertained. Lastly, T6-9 and T3-4 were the termination levels for the accessory hemiazygos and right superior intercostal veins, respectively. According to the study of Tatar et al. [15], the azygos vein terminated at the T5 level near to the carina.

As per Dahran and Soames [7], the most common termination level of the accessory hemiazygos vein was at T5, and the hemiazygos vein was at T8.

In our study, Table 1 shows the termination level of the azygos vein varied from T2 vertebra level to T4, with T3 being the most common level of termination. The termination level of the hemiazygos vein varied from T8 to T11, with T11 being the most common level (Table 2), and this observation was very different from other studies. The extent of termination of accessory hemiazygos vein varied from T7 to T 10, with T9 being the most common level (Table 3).

We owe the variations observed in our study to the ethnic differences and consider it for further evaluation on a larger number of specimens (as our study was limited to 20 specimens).

## CONCLUSION

Identifying azygos venous variations are critical in mediastinum computed tomography and magnetic resonance imaging. Aneurysm, lymphadenopathy, and tumors are all examples of anomalous azygos venous systems. When performing mediastinal or large vessel surgery, it is critical to consider all these variations.

There are some limitations of our study as there is very little study of azygos venous systems among the Indian population, so our data could not be compared with other Indian studies.

**Source(s) of support** in the form of grants, equipment, drugs: Non

**Conflicts of Interests:** None

## ACKNOWLEDGEMENTS

Thanks to Dr. BikashSathpathy and Staffs of Anatomy for helping in taking the photographs and for proper positioning of cadavers for taking photographs.

**Statement:** The manuscript has been read and approved by all the authors, and each author believes that the manuscript represents honest work.

## REFERENCES

- [1]. Drake R, Vogl AW, Mitchell AW. Gray's anatomy for students E-book. Elsevier Health Sciences; 2009. <https://www.elsevier.com/books/grays-anatomy-for-students/drake/978-0-323-39304-1>
- [2]. Badagabettu SN, Shetty P, D'Souza MR. A unique variation of azygos system of veins. *J CardiovascEchogr.* 2016;26(2):61-64.
- [3]. Alves EC, Porciúncula Junior WR, Monte Bispo RF, Sousa-Rodrigues CF, Rocha AC. Formation of the azygos vein. *Int J Morphol.* 2011;29(1):140-143.
- [4]. Loukas M, Tubbs RS. Adrenal, renal, gonadal, azygos, hemiazygos, lumbar, and ascending lumbar veins. *Bergman's Comprehensive Encyclopedia of Human Anatomic Variation.* 2016:890-893.
- [5]. Dudiak CM, Olson MC, Posniak HV. CT evaluation of congenital and acquired abnormalities of the azygos system. *Radiographics.* 1991;11(2):233-246.
- [6]. Brener BJ, Darling RC, Frederick PL, Linton RR. Major venous anomalies complicating abdominal aortic surgery. *Arch Surg.* 1974;108(2):159-165.
- [7]. Dahran N, Soames R. Anatomical variations of the azygos venous system: classification and clinical relevance. *Int J Morphol.* 2016;34(3):1128-1136.
- [8]. Kutoglu TU, Turut M, Kocabiyik NE, Ozan HA, Yildirim ME. Anatomical analysis of azygos vein system in human cadavers. *Rom J MorpholEmbryol.* 2012;53(4):1051-1056.
- [9]. Prasad M, K. Jeyanthi. Variations in Formation And Termination Of Azygos Vein In South Indian Population. *Int J Anat Res.* 2018,6:5384-5389.
- [10]. Quadros LS, Potu BK, Guru A, Pulakunta T, Ray B, D'Silva SS, et al. Anomalous azygos venous system in a south Indian cadaver: a case report. *Cases J.* 2009;2:6746.
- [11]. Anson BJ, McVay CB. *Surgical anatomy, 60th edition,* W.B. Saunders Co., Igaku-Shoin Saunders, Tokyo: 1984:464-465.
- [12]. Cunningham FG, Leveno KJ, Bloom SL, Spong CY, Dashe JS. *Williams Obstetrics.* 23rd Ed. New York: Williams Obstetrics Co; 2001.
- [13]. Seib GA. The azygos system of veins in American whites and American negroes, including observations on the inferior caval venous system. *Am J PhysAnthropol.* 1934;19:39-163.
- [14]. Kadir S, Brothers MF. *Atlas of normal and variant angiographic anatomy.* WB Saunders Company; 1991.

- [15]. Tatar I, Denk CC, Celik HH, Oto A, Karaosmanoglu DA, Ozdemir BM, et al. Anatomy of the azygos vein examined by computerized tomography imaging. Saudi Med J. 2008;29(11):1585-1588.
- [16]. Vijaya Nirmala, Teresa Rani S. Study of Azygos System and its Variations. Journal of Evolution of Medical and Dental Sciences 2015;4(33):5652-5657

**How to cite this article:**

Smruti Rekha Mohanty, Mamata Panigrahi, Jagannath Upadhyaya. Variations in Azygos Venous System in The Eastern Indian Population: A Cadaveric Study. Int J Anat Res 2022;10(4):8505-8511. **DOI:** 10.16965/ijar.2022.248