

## Observation on Azygos System of Veins in Jharkhand Population

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**Abstract: Background and objectives:** Azygos system of veins with its wide range of communications and tributaries, definitely have an effect on the disease process of congenital and pathological origins. This study has thereafter been taken in population of Jharkhand so as to study the Azygos System of veins and their anatomic variations and its influence on congenital and pathological diseases.

**Methods:** The present study was conducted on 50 cadavers. After complete removal of thoracic viscera, the posterior thoracic wall was carefully dissected out preserving the tributaries of azygos vein. The pattern of azygos vein along with its tributaries were noted. The pattern of ascending lumbar, subcostal, accessory hemiazygos, and hemiazygos were traced and variations noticed. Finally the length & diameter of azygos, hemiazygos and accessory hemiazygos were taken with the help of measuring scale.

**Results:** The average length of azygos vein was 21.5 cm in male and 20.9 cm in female though the average diameter was same in both sexes (1.1 cm).

The percentage of sacculation was 24% in male and 36% in female cadavers. The incidence of sign of phlebitis was 12% in male & 16% in female cadavers. The length and diameter of the main tributaries of the Azygos vein like Hemiazygos, Accessory Hemiazygos and posterior Intercostal were variable among male & female cadavers. Tributaries from oesophageal, pericardial & bronchial were variable in number in both male & female cadavers. Oesophageal numbered between 6-12, pericardial between 2-6 and bronchial between 2-4. Incidence of absence of hemiazygos vein was only 4% and exclusively in male. Whereas incidence of absence of accessory hemiazygos vein was 24% in male & 12% in female. The occurrence of crossing of azygos to left was found in 52% in male & 44% in females.

**Conclusion:** The average length of azygos vein was 21.5 cm in male and 20.9 cm in female. Occurrence of phlebitis is more common than other pathological conditions in azygos (12% in male & 16% in female). Tributaries from oesophageal, pericardial & bronchial were variable in number in both male & female cadavers. Incidence of absence of hemiazygos vein was only 4% and exclusively in male.

**Keywords:** Azygos vein, Hemiazygos vein, Accessory hemiazygos vein

Date of Submission: 17-05-2019

Date of acceptance: 02-06-2019

### I. Introduction

Much work on venous pattern and patterns of Azygos venous system has been done by various workers like Hilton J, William et al [1,2]. These workers were usually European with different topology and socio-economic conditions. Azygos system of veins with its wide range of communications and tributaries, definitely have an effect on the disease process of congenital and pathological origins. This study has thereafter been taken in population of Jharkhand so as to study the Azygos System of veins and their anatomic variations and its influence on congenital and pathological diseases.

Literally “azygos” means unpaired or single. No other vein in the body so categorically named, perhaps due to its embryological background. It is derived from the persistence of right posterior cardinal vein of human embryo while the disappearance and the replacement of left posterior cardinal vein has given rise to accessory hemiazygos and hemiazygos veins. Azygos venous system drains a very wide range of vital organs and viscera of ectodermal, mesodermal and endodermal origins. These consists of some of the organs of pelvis through ascending lumbar veins, calveria through internal and external vertebral plexus of veins along with their intercommunication and communications with dural sinuses, of the posterior wall of the trunk, thyroid, esophagus, diaphragm and pericardium through posterior intercostal and superior intercostal veins and have clinical importance as this may cause haemometastasis of infection and malignant cells.

Its direct and indirect tributaries had been the matter of establishment of concrete anatomical concept applied to the management of disease processes in past (Kendall D, Cross J Net al) [3,4] and still requires new concept if socio-economic pattern of society is related to disease processes (Amias A G) [5]. Azygos vein and its tributaries show wide variations during developmental stage and this touches the re-learning of “Azygos

system of vein” because we are passing through a complete socio-economical upheaval of the society and its pattern which may sensitize the embryological background of Azygos venous system giving rise to further varieties of its patterns. The concept of variation should be kept in mind if we want to see our dream “Health For All” to be a reality.

Starting from the historical and pioneering work of Harvey W, much work on venous patterns and patterns of azygos venous system in particular has been done by workers like Hilton J, Streeter GL, Gladstone RJ, Quiring DP, Anderson RC et al, Batson OV, Wollem DHL et al, Barceti NR and others [1,6,7,8,9,10,11,12]. But majority of workers are from European countries whose field of work have their own topographical and socio-biological anthropology, quite different from those of a tropical country like India. The low socio-economic conditions of majority of our population, the population explosion and environmental pollution add much point towards congenital variation and their effect on disease processes of both congenital and pathological origins. With wide range of communications and tributaries, the Azygos system of veins cannot be kept apart from the effects, specially in case of infections and malignancies.

Azygos vein may arise from posterior aspect of inferior vena cava at or below the level of renal veins as “lumbar azygos” which ascends anterior to the upper lumbar vertebrae. The azygos vein may pass behind the right crus of diaphragm or pierce it. Occasionally it may pass through the aortic opening of the diaphragm on right side of the cisterna chyli. Anterior to the twelfth thoracic vertebral body it is joined by a large vessel formed by the right ascending lumbar and right subcostal veins, which passes forward and right of the twelfth thoracic vertebra behind the right crus. This common trunk may, in the absence of a lumbar azygos, form the azygos itself. Whatever its origin, the azygos vein ascends in the posterior mediastinum to the fourth thoracic vertebra, arching forward above the right pulmonary hilum to end in the superior vena cava, before the latter pierces the pericardium. It is anterior to the lower eight thoracic vertebral bodies, anterior longitudinal ligament and right posterior intercostal arteries. Right lateral are the right greater splanchnic nerve, lung and pleura; left lateral in most of its course are the thoracic duct and aorta and, where it arches forward, the oesophagus, trachea and right vagus. In the lower thorax it is covered anteriorly by a costomediastinal recess of the right pleural sac and oesophagus, emerging from behind the latter to ascend behind the right hilum.

Present study is focused on variation in pattern of Azygos venous system in Jharkhand population. This will help to those in medical line facing daily management of various infective and malignant diseases. In addition it will also help in interpretation of radiographs of azygos and other veins.

## **II. Materials and methods**

### **2.1 Materials**

#### **1) Chemicals**

A solution of Water 10lb, Carbolic acid ½ lb, Glycerine ½ lb, Potassium carbonate 8oz., Linseed oil ½ lb, 40% formaldehyde 2lb and extra amount of carbolic acid.

#### **2) Instrument and appliances**

Fillips forceps, Canula injector, Rubber tube, Embalming machine, B.P. Handle with blades, Retractors, Thread, Artery forceps, Scissors, Bone cutters, Plain and toothed forceps, Gauze, Metal probes, Bone saw, Camera, Measuring scale.

### **2.2 Method**

The present study was conducted on 50 cadavers brought to dissection hall of Anatomy Department and Forensic Medicine Department of Rajendra Institute of Medical Sciences, Ranchi. There was no history attached with any of the cases and they were studied irrespective of cause of death.

The body was painted with carbolic acid after shaving. The femoral vein and artery were dissected out. With a special cannula inserted and well ligated into femoral artery and connected by rubber tube to embalming machine, the solution of 40% formaldehyde 2lb, glycerine ½ lb, carbolic acid ½ lb, Potassium carbonate 8oz, Linseed oil ½lb and Water 10lb was infused into femoral artery.

Anterior wall of thorax and abdomen was removed out with the help of bone saw, B.P. Handle with blades and scissors taking care not to damage the thoracic and abdominal viscera. With the help of retractors and toothed forceps and scalpel, the azygos vein was dissected out above the root of right lung entering into superior vena cava. The gradual removal of thoracic viscera was done while preserving the superior vena cava and azygos vein. Now after complete removal of thoracic viscera, the posterior thoracic wall was carefully dissected out preserving the tributaries of azygos vein. The pattern of azygos vein along with its tributaries were noted.

The pattern of ascending lumbar, subcostal, accessory hemiazygos, and hemiazygos was traced. If any deviation from normal pattern was noticed it was added into variations noticed.

Finally the length & diameter of azygos, hemiazygos and accessory hemiazygos were taken with the help of measuring scale. While taking diameter veins were splitted by scissor and circumference measured. The

diameter was obtained through formula  $Circumference = \pi d$ . Variation in numbers of thoracic tributaries like oesophageal, bronchial and pericardial veins were also noticed.

### 2.3 Statistical analysis

All the statistical analyses were performed using statistical package for social sciences (SPSS Inc., Chicago, Illinois, USA).

### III. Observations

25 male and 25 female cadavers brought to dissection hall of Anatomy Department and Forensic Medicine Department of Rajendra Institute of Medical Sciences, Ranchi were selected for observation on Azygos system of veins. All important observations were tabulated for purpose of better understanding and analysis to achieve proper discussion and conclusion.

Following are abbreviations used during tabulation :

X – Female group of cadavers.

Y – Male group of cadavers.

**Table 1. Showing congenital anomalies of Azygos vein**

Group	Anomalies	Number	Percentage
X	Sacculated	9	36%
	Left superior vena cava	nil	0
	Congenital absence	nil	0
	Congenital replacement of inferior Vena cava	nil	0
	Non origin from inferior vena cava	17	68%
Y	Sacculated	6	24%
	Left superior vena cava	nil	0
	Congenital absence	nil	0
	Congenital replacement of inferior Vena cava	nil	0
	Non origin from inferior vena cava	18	72%

**Table 2. Showing evidence of disease**

Group	Disease	Number	Percentage
X	Sign of Phlebitis	4	16%
	Thrombosis of inferior vena cava	nil	0
	Thrombosis of superior vena cava	nil	0
	Malignant metastasis	nil	0
Y	Sign of Phlebitis	3	12%
	Thrombosis of inferior vena cava	Nil	0
	Thrombosis of superior vena cava	Nil	0
	Malignant metastasis	Nil	0

**Table 3. Showing the serous investment near termination**

Group	Pleural and Pericardial involvement	Number	Percentage
X	Pleural membrane	7	28%
	Pericardial membrane	nil	0
Y	Pleural membrane	6	24%
	Pericardial membrane	nil	0

**Table 4. Showing relation with Inferior Vena Cava & Mode of entrance to Thoracic cavity**

Group	Relation and Passage	Number	Percentage
X	Retro venacaval	8	32%
	Lateral venacaval	17	68%
	Through Aortic opening	20	80%
	Through other opening of diaphragm	5	20%
Y	Retro venacaval	10	40%
	Lateral venacaval	15	60%
	Through Aortic opening	18	72%
	Through other opening of diaphragm	7	28%

**Table 5.** Showing the diameter of Azygos Vein

Group	Name of diameter	Measurement
X	Range of diameter	0.95 – 1.3 c.m.
	Average diameter	1.1 c.m.
Y	Range of diameter	1.0 – 1.4 c.m.
	Average diameter	1.1 c.m.

**Table 6.** Showing the Length of Azygos Vein

Group	Length	Measurement
X	Range of length	14 – 23 c.m.
	Average length	20.9 c.m.
Y	Range of length	19 -24 c.m.
	Average length	21.5 c.m.

**Table 7.** Showing the length of tributaries

Group	Tributaries	Measurement	
		Range	Average
X	Hemiazygos		
	Length	7 – 9 c.m	8 c.m.
	Diameter	0.16 – 0.56 c.m.	0.3 c.m.
	Accessory Hemiazygos		
	Length	6 -10 c.m.	9 c.m.
	Diameter	0.26 – 0.67 c.m.	0.45 c.m.
	Ascending Lumbar		
	Length	9 – 11 c.m.	10 c.m.
	Diameter	0.26 – 0.66 c.m	0.45 c.m.
	Posterior Intercostal		
	Length	24 -41 c.m.	32.5 c.m
	Diameter	0.06 - 0.26 c.m.	0.15 c.m.
Y	Hemiazygos		
	Length	9 – 11 c.m.	10 c.m.
	Diameter	0.4 – 0.8 c.m	0.6 c.m.
	Accessory Hemiazygos		
	Length	8 – 12 c.m.	11 c.m.
	Diameter	0.5 -0.9 c.m.	0.7 c.m.
	Ascending Lumbar		
	Length	11 – 13 c.m.	12 c.m.
	Diameter	0.3 – 0.9 c.m.	0.7 c.m.
	Posterior Intercostal		
	Length	26 – 43 c.m.	34.5 c.m.
	Diameter	0.3 -0.5 c.m	0.4 c.m

**Table 8.** Showing incidence of absence of Hemiazygos and Accessory Hemiazygos vein

Group	Incidence	Number	Percentage
X	Absence of Accessory Hemiazygos	3	12%
	Absence of Hemiazygos	nil	0
Y	Absence of Accessory Hemiazygos	6	24%
	Absence of Hemiazygos	1	4%

**Table 9.** Showing number of Tributaries from Bronchus, Oesophagus and others

Group	Tributaries	Number
X	Oesophageal	6-12
	Bronchial	2-4
	Pericardial	2-6
Y	Oesophageal	6-12
	Bronchial	2-4
	Pericardial	2-6

**Table 10.** Showing difference of dimension

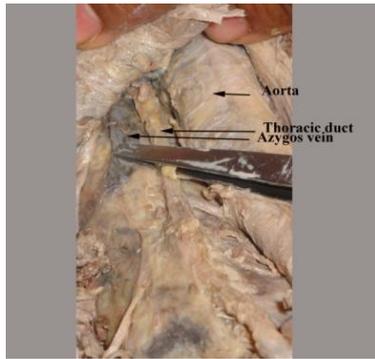
Group	Name	Dimension
X	Azygos vein	
	Length	20.9 c.m
	Diameter	1.1 c.m.
	Hemiazygos	
	Length	8 c.m.
	Diameter	0.3 c.m.
	Accessory Hemiazygos	
	Length	9 c.m.
	Diameter	0.45 c.m.
	Ascending Lumbar	
Length	10 c.m.	
Diameter	0.45 c.m.	
Y	Azygos vein	
	Length	21.5 c.m.
	Diameter	1.1 c.m.
	Hemiazygos	
	Length	10 c.m.
	Diameter	0.6 c.m.
	Accessory Hemiazygos	
	Length	11 c.m.
	Diameter	0.7 c.m.
	Ascending Lumbar	
Length	12 c.m.	
Diameter	0.7 c.m.	

**Table 11.** Showing course of Azygos Vein in relation to midline of Vertebral column

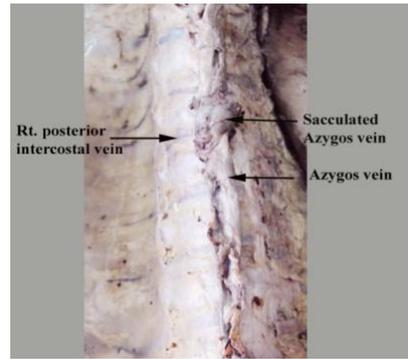
Group	Course	Number	Percentage
X	Rt. of midline of vertebral column.	13	52%
	Midline of vertebral column.	1	4%
	Crossing to left side of midline & then again back to rt. side to terminate in superior vena cava.	11	44%
Y	Rt. of midline of vertebral column.	12	48%
	Midline of vertebral column.	Nil	0
	Crossing to left side of midline & then again back to rt. side to terminate in superior vena cava.	13	52%

**Table 12.** Showing presence of valve in Azygos vein at termination into Superior vena cava

Group	Valve	Number	Percentage
X	Valve present	12	48%
Y	Valve present	11	44%



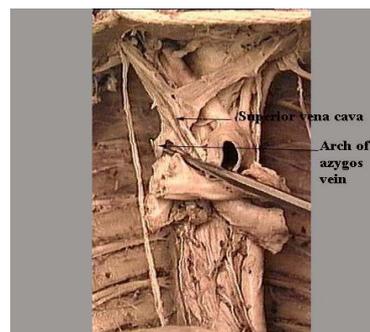
**Fig.1** Sacculated azygos vein



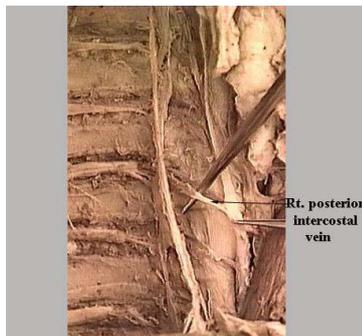
**Fig. 2** Aortic opening showing Azygos vein, Thoracic duct and Aorta



**Fig. 3** Azygos vein



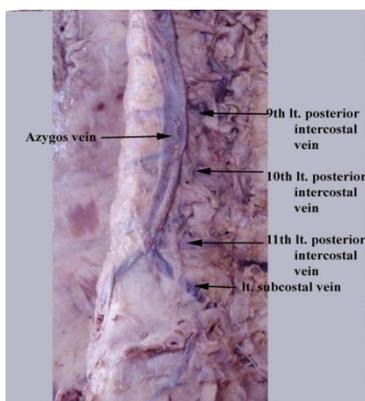
**Fig. 4** Arch of Azygos vein



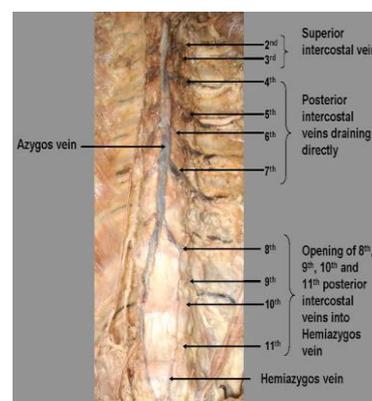
**Fig. 5** Posterior intercostal veins draining into Azygos Vein



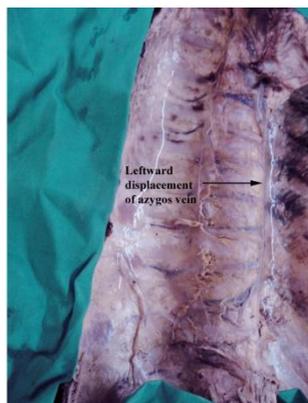
**Fig. 6** Hemiazygos and Accessory Hemiazygos veins draining into Azygos vein.



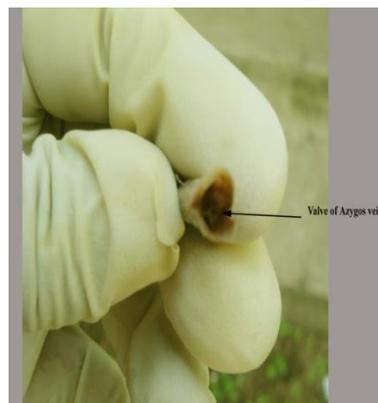
**Fig. 7** Absent hemiazygos vein



**Fig. 8** Absent accessory hemiazygos Vein



**Fig. 9** Leftward displacement of Azygos vein



**Fig. 10** Showing valve in azygos vein at termination

#### IV. Discussion

The observation about anomalies of Azygos vein made by Gladstone RJ [8] paved way for further observation and discussion on azygos vein. Sacculation was observed in total 6 male cadavers and 9 female cadavers. Gladstone RJ, Anderson RC et al, Woollen et al, Longinova and Grzybiak et al [7,9,11,13] had their extensive work on the pattern of Azygos vein but none had categorically mentioned about this anomaly. Our observation stands unparalleled on this aspect

(Table 1). Although Langman's review of literature describes that sometimes Hemiazygos vein, Accessory Hemiazygos vein and Left superior Intercostal vein formed a long continuous channel, not communicated to Azygos vein but always had communication with coronary sinus. In that case that longitudinal column was called as left superior venacava. None such condition was observed in the present work (Table 1). Since it belongs to rare anomalies of azygos vein so we don't find any such case in our work

Although Arslan G et al has reported about absence of azygos vein and also suggested about its confirmation by chest PA view by absence of AV shadow on normal position and presence of aortic nipple [14]. In other literatures too it is mentioned among rare congenital anomalies. None such condition was observed in the present work (Table 1) may be because it belongs to rare anomalies. Gladstone and Franklin were the main workers to observe this phenomena in which they described that all the inferior vena caval blood were carried to superior Vena cava directly. In those cases the hepatic veins opened onto the right atrium by a channel which represented the upper end of inferior Vena cava [7]. None such condition was observed in the present work. There were 18 male cases and 17 female cases in which Azygos vein was formed by the union of right subcostal and ascending lumbar vein. Gladstone's observation suggests the origin of vena azygos by union of subcostal and ascending lumbar stands by accordance with our observations (Table 1).

Out of 25 male group 3 cases of phlebitis were observed. The observation was based upon the thickness of the wall of the azygos vein. In female group total of 4 cases were observed with evidence of Phlebitis. Krayenbuhl, Huggenberg & Kesselring, Martin J.P. and Stevins H, Goldmen, Eckerling and Gans Carrol et al and others had their extensive observations on the mode of spread of infection via azygos system of veins and its tributaries to other regions of body [15,16]. Our findings are in accordance with their observations. (Table 2). 6 cases in male group and 7 cases in female group were found of pleural investment. Pericardial investment was observed in none (Table-3). William and Warwick in their review of literature had mentioned the occurrence of pleural investment of azygos vein [2].

10 cases among male group and 8 cases among female group of Retro venacaval azygos vein were observed. Lateral vena caval azygos were observed in 15 cases of male and 17 cases of female groups. The unusual entrance through an additional opening in diaphragm was observed in 7 cases of male and 5 cases of female. The remaining cases of female and male groups pass through normal aortic opening with normal relation.

Gladstone observed variable relations of Azygos vein while passing through diaphragm [7]. William and Warwick had reviewed the other workers and found generally passing through aortic opening [2]. Our findings of some case with separate entrance to thoracic cavity was not in accordance with the above workers (Table 4).

In male group the range of length of azygos vein was 19 cm to 24 cm with an average of 21.5 cm. In female the length varied from 14 cm to 23 cm with an average of 20.9 cm. Slight decrease in the average length of female in comparison with that of male group was observed, the cause of which was unexplained. Many workers had done extensive works on Azygos vein but reference of length lacks extremely (Table 6). In male group the range of diameter of azygos vein was 1.0 cm to 1.4 cm with an average of 1.1 cm. In female the diameter varied from 0.95 cm to 1.3 cm with an average of 1.1 cm. Literature regarding the diameter of Azygos

vein had not been traced through numerous literatures. The lack of literature may be due to extreme variations of this vein in many respects. Whatever the cause may be no workers had a claim either to stand by or to contradict our findings (Table 5)

In male group Hemiazygos has the mean length of 10 cm and diameter 0.6 cm ,that of Accessory Hemiazygos 11 cm and 0.7cm respectively, that of ascending lumbar 12 cm and 0.7 cm respectively were observed. In female group Hemiazygos has the mean length of 8 cm and diameter 0.3cm ,that of Accessory Hemiazygos 9 cm and 0.45cm respectively, that of ascending lumbar 10 cm and 0.45 cm respectively were observed (Table 7). These dimensions of tributaries of Azygos vein had not been traced through the literature .The cause may be extreme variability. Our observations had a maiden approach.

In both male & female group the oesophageal tributaries were found to be 6 to 12 in number. The tributaries were found extremely variable with respect to number, course, side and vertebral level .Bronchial were relatively less variable, numbering 2 to 4. Pericardial tributaries were also observed variable in every respect, their number range from 2 to 6. All the above tributaries had more variable number, course, caliber and mode of termination but these tributaries due to its physiological and pathological importance were carefully observed.

William and Warwick had reviewed extensively the works of workers like Jafferson et al ,Glandstone , Michael NA , Tebin CE and concluded the variability of oesophageal, Bronchial and Pericardial tributaries [2,7].Accessory hemiazygos was absent in 3 female and 6 male cases. Rt. Posterior intercostal veins were draining into azygos directly. These were in accordance with Grzybiak et al observations who considered accessory hemiazygos most variable [13].Hemiazygos vein was absent in only 1 male case.

13 cases in male group and 11 cases in female group were found to have azygos vein crossing midline of vertebral column from right to left and then again to right to terminate in superior vena cava.1 case in female group was on midline of vertebral column. Rest of cases were having normal course.Our observation is with the maiden observation of Kagami H. et al in which he observed crossing to left of azygos vein in 22 out of 26 cadavers [17]. These results again confirmed leftward displacement of azygos during aging process.

## **V. Conclusion**

After careful observation made upon 50 cadavers in both male and female sex, the following conclusion were drawn:-

- 1) The percentage of sacculation was 24% in male and 36% in female cadavers. Other congenital anomalies were not found.
- 2) The incidence of sign of phlebitis was 12% in male & 16% in female cadavers. No other pathological conditions were present. Hence it can be concluded that occurrence of phlebitis is more common than other pathological conditions in Jharkhand population.
- 3) The average length of azygos vein was 21.5 cm in male and 20.9 cm in female though the average diameter was same in both sexes. (1.1 cm)
- 4)The length and diameter of the main tributaries of the Azygos vein like Hemiazygos ,AccessoryHemiazygos and posterior Intercostal were variable among male & female cadavers. The average length and diameter of Hemiazygos was 10 cm & 0.6 cm respectively in male, and 8 cm & 0.3 cm in females. The average length and diameter of Accessory Hemiazygos was 11 cm & 0.7 cm respectively in male, and 9 cm & 0.45 cm in females.
- 5) Tributaries from oesophageal , pericardial & bronchial were variable in number. Both male & female showed same variability in numbers. Oesophageal numbered between 6-12, pericardial between 2-6 and bronchial between 2-4.
- 6) Incidence of absence of hemiazygos vein was only 4% and exclusively in male. Whereas incidence of absence of accessory hemiazygos vein was 24% in male & 12% in female.
- 8)The occurrence of crossing of azygos to left was found in 52% in male & 44% in females.

The aim of present study was focused on variation in pattern of azygos venous system in Jharkhand population to help those in medical line facing daily management of various infective and malignant diseases. In addition other objective was also to help in interpretation of radiographs of azygos and other veins. The observations obtained from present study will surely fulfill above objectives.

## **Acknowledgements**

The authors thank all colleagues for their valuable contribution in carrying out the study.

## **Disclosure**

The authors declare no conflict of interest.

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Sachin K Singh. "Observation on Azygos System of Veins in Jharkhand Population." IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), vol. 18, no. 5, 2019, pp 29-37.