

**Original article:**

## **Morphometric study of aortic orifice and valve in cadavers of north Karnataka**

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### **Abstract:**

**Introduction:** Heart is the important organ in the body which is essential for life. Proper functioning of the heart helps to lead normal life. These normal functions of the heart are carried out by the pumping of the blood from the different chambers of the heart to the different systems of the body. The blood which contains the nutrients is carried to the different organs of the body and prevents them from the consequences from its deprivation. Pumping of the blood is carried out by the contraction of the musculature of the heart and along with unidirectional flow of the blood through the valves present in the heart. Circumference and diameter of the orifices and valves vary from person to person. Aim of the present study is to measure the average size of the valve in the cadavers available in the Department of Anatomy by using cardiac sizer which could help the selection of the prosthetic valve in the cardiac surgery.

**Materials and Methods:** The present study was carried out on 40 adult cadaveric hearts (30 males and 10 females). Left ventricle was dissected according to the Cunningham's dissection manual. The aortic orifices and valves were exposed. The circumference of the orifice was measured by the cardiac sizer. The diameter was measured by Vernier caliper.

**Results:** Mean diameter of aortic valve in male was 16mm whereas in female it was 12.9 mm. The mean circumference was 50.2 mm in males, whereas 40.4 mm in females. The standard deviation (SD) for mean diameter was  $\pm 2.81$  and  $\pm 3.44$  mm in male and female respectively. The circumference was  $\pm 7.89$  and  $\pm 10.82$ mm in male and female respectively. (Table nos.5 & 6).

Comparing the diameter in male and females, the diameter of the aortic valve was more in males than in females. ( $t= 3.103$  DF= 38 and  $p$  value=.004). The mean circumference was more in males as compared to females ( $t=3.101$  DF=38 and  $p$  value=.004).

**Conclusion:** The size of the aortic valve in the North Karnataka region was found to be less as compared to other studies. The present study might help cardio-thoracic surgeon as well the prosthetic valve manufacturing companies for the rough estimation of the aortic valve size

**Key words:** Aortic orifice, aortic valve, cardiac sizer and Vernier caliper

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### **Introduction:**

Cardiovascular system is the earliest system to develop in the body. Development begins between 2<sup>nd</sup> to 4<sup>th</sup> weeks of intra-uterine life. Heart develops from splanchnopleuric mesoderm, coelomic epithelium and neural crest cells. Valves of the heart develop from the proliferation of the

endocardium. The valves of the heart maintain the unidirectional blood flow which are four in number viz, aortic, pulmonary, tricuspid and mitral. Tricuspid valve situated between right atrium and right ventricle. Mitral valve is between left atrium and left ventricle. Pulmonary valve regulates blood flow through the pulmonary trunk, whereas aortic valve

regulates through the aorta. These valves regulate the inflow and outflow mechanism. Aortic valve prevents the backflow of the blood into the left ventricle. For the proper functioning of the heart all valves of the heart should be intact. Apart from congenital anomalies, acquired heart diseases can damage the valves of the heart. Syphilis, Marfan's syndrome and rheumatic fever may involve the aortic valve<sup>1</sup>. The sedentary life style also leading the heart diseases, which accounts to rise in mortality and morbidity among humans.<sup>2</sup> In such conditions they are to be replaced completely by surgery. For this purpose accurate measurements of these valves are required. Severe damage to the heart valves can be corrected with prosthetic valves.<sup>3</sup>

Evaluation of the stenosis, dilatation and cardiac enlargement can be done by the measurement of valve circumference. From these guidelines surgeon can aim to insert prosthesis of appropriate size. The detailed knowledge of the normal anatomy of heart valve is necessary for the valve pathologies by imaging modalities, manufacturing prosthetic valves of appropriate size and surgical correction of damaged heart valves. It is essential that knowledge of the anatomy of the valve is fundamental in understanding key principles involved in valvar replacement. This study is done on 40 cadavers of both sexes and different age groups. Among them 30 were males and 10 were females. An attempt is made to compare the measurements of circumference of aortic valve with that of previous studies for standardization which can help in prosthetic valve manufacturing. In this study the measurements were taken by using cardiac sizer, thread and Vernier caliper.

#### **Materials and methods:**

Forty human hearts were dissected from the cadavers available in the KLE University's J.N. Medical

College Department of Anatomy. Among 40 cadavers, 30 were males and 10 were females. Cadavers received were from the North Karnataka Region. Dissection was done according to the Cunningham's Manual of dissection. Following incisions were taken. Parasternal incisions were taken from first to sixth intercostals spaces. Ribs and cartilages were cut open. Sternum was cut at the sterno-clavicular joint and the clavicles were separated. Sternum was pulled downwards the thoracic cavity was opened. Pericardium was cut and the great vessels were separated. The heart was taken out from the thoracic cavity. Transverse incision was taken through the half of superior vena cava and aorta at the junction of ascending aorta with the arch of aorta. Then the knife was turned inferiorly and another cut was taken longitudinally in between superior vena cava and aorta. The incision was extended inferiorly up to the apex of the heart. The slice was turned forwards; this exposes the cavity of ventricle and aortic vestibule.

The aortic root is the direct continuation of the left ventricular outflow tract. The orifice lies in the right posterosuperior part of the ventricle i.e. relative to the sub pulmonary infundibulum. Aortic root extends from the basal attachment of the aortic valvar leaflets within the left ventricle to their peripheral attachment at the level of the sinutubular junction.<sup>4</sup> the aortic valve components are the sinuses of Valsalva, the fibrous interleaflet triangles, and the valvar leaflets themselves. This valve is the same as the pulmonary valve except that the valves are thicker and differently placed (named two anterior and one posterior) and the aortic sinuses are larger. Normal hearts were chosen for the study. Abnormal diseased, pathological and calcified valves were excluded. The materials used were digital Vernier caliper, foot ruler, thread and cardiac sizer.

**Objectives/aims:**

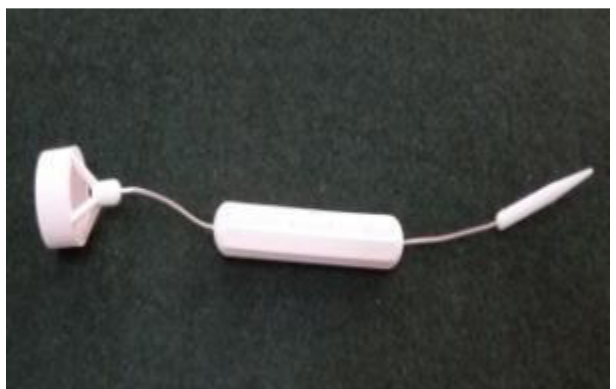
Following observations were noted. (Both in males and females).

1. Annular diameter of the aortic valve.
2. Calculated circumferences from the diameter using the formula  $C=\pi \times D$

**Materials used in the procedure.**



**Fig.1. Digital Vernier caliper. Fig.2. Measurement of Diameter of the aortic valve by Vernier caliper.**



**Fig.3. Cardiac Sizer. Fig.4. Measurement of diameter by Cardiac Sizer.**

**Table No: 1. Annular diameter and circumference of aortic valve. (In Male).**

Sr. Nos.	Diameter of aortic valve. (In mm). (D).	Calculated circumference $\pi \times D$ (mm).	No of specimen.	Percentage.
1.	11.47	36.01	2	7.0
2.	13.22	41.51	3	10.0
3.	14.79	46.44	4	13.0
4.	15.19	47.69	2	7.0
5.	16.54	51.93	7	23.0
6.	17.40	54.63	5	17.0
7.	18.20	57.14	2	7.0
8.	19.52	61.29	3	10.0
9.	20.21	63.45	1	3.0
10.	10.06	31.58	1	3.0
			30	100%

**Table No: 2. Annular diameter and circumference of aortic valve. (In Female).**

Sr. Nos.	Diameter of aortic valve. (In mm). (D).	Calculated Circumference $\pi \times D$ (mm).	No of specimen.	Percentage.
1.	7.43	23.35	1	10
2.	9.20	28.8	1	10
3.	10.94	34.35	2	20
4.	11.50	36.11	1	10
5.	12.93	40.61	1	10
6.	15.88	49.9	2	20
7.	16.16	50.74	1	10
8.	17.90	56.20	1	10
			10	100%

**Table No: 3. Frequency distribution table of diameter and circumference of aortic valve. (In Male).**

Sr.Nos	Diameter (D).	Circumference.	Frequency	Percentage.
1.	10.06-13.22	31.58-41.51	6	20
2.	14.79-16.54	46.44-51.93	13	43
3.	17.40-20.21	54.63-63.45	11	37
			30	100%

**Table No: 4. Frequency distribution table of diameter and circumference of aortic valve. (In Female).**

Sr. Nos.	Diameter(D).	Circumference.	Frequency	Percentage.
1.	7.43-10.49	23.35-34.35	4	40
2.	11.50-15.88	36.11-49.9	4	40
3.	16.16-17.90	50.74-56.20	2	20
			10	100%

**Table No: 5. Mean diameter and circumference of aortic valve (Male).**

Sr.Nos.	Parameters.	Mean +SD (mm)	Range Value (mm).
1.	Diameter of aortic valve	16 ±2.81 SD(mm)	10.06-20.21.
2.	Circumference of aortic valve	50.2 ± 7.89 SD (mm)	31.58-63.45

**Table No: 6. Mean diameter and circumference of aortic valve (Female).**

Sr. No.	Parameters.	Mean ±SD (mm)	Range value (mm).
1.	Diameter of aortic valve	12.9 ±3.44 SD (mm)	7.43-17.90
2.	Circumference of aortic valve	40.4 ± 10.82 SD (mm)	23.35-56.20

**Results and observations:**

In the present study, annular circumference of aortic valve was found to be in the range of 31.58 to 63.45mm in males. In females the range was from 23.35 to 56.2mm. (Table No 1).

**In males:** Out of 30 cadaveric hearts, only 1(3%) heart had maximum annular circumference of

63.45mm. whereas 1(3%) of them had minimum circumference of 31.58mm.

Maximum 7(23%) hearts had the aortic valve circumference of 51.93mm followed by 5(17%) 54.63mm, then 4(13%) 46.44mm, then 3(10%) 41.51mm and then 3(10%) 61.29mm.

Majority (73%) of hearts had aortic valve circumference ranging from 41.51 to 57.14mm.

**In females:**The results are as follows.(Table No 2).

Out of 10 cadaveric hearts only 1(10%) heart had maximum annular circumference of 56.2mm whereas 1(10%) of them had minimum circumference of 23.35mm.

Maximum 2(20%) and 2 (20%) hearts had the aortic valve circumference of 34.35 and 49.9mm respectively followed by 1(10%) 23.35 and then 1(10%) 56.2mm.

Majority (80%) of hearts had aortic valve circumference ranging from 23.35 to 49.9mm. The frequency of distribution of valve in male and female is shown in table no 1 and 2.

Similarly,**in males** the diameter of aortic valve ranged from 10.06 to 20.21mm. 23% of hearts had aortic valve diameter of 16.54mm followed by 11.47mm, in 71% hearts only 1(3%) of heart had maximum diameter of 20.21mm and 1(3%) of heart had minimum diameter of 10.06mm.

Majority of hearts (80%) had aortic valve diameter ranging from 14.79 to 19.52mm.

**In females:**The diameter of aortic valve ranged from 7.43 to 17.9mm. 40% of hearts had aortic valve diameter of 10.94 and 15.88 mm followed by 9.20mm in 40% hearts only 1(10%) hearts had minimum diameter of 7.43mm and 1(10%) heart had maximum diameter of 17.9mm.

Majority of hearts (80%) had the aortic valve diameter ranging from 9.2 to 16.16 mm. (Table no.3&4).

Mean diameter of aortic valve in male was 16mm whereas in female it was 12.9 mm. The mean circumference was 50.2 mm in male, whereas 40.4 mm in female, while the standard deviation (SD) was  $\pm 2.81$  and  $\pm 3.44$  mm in male and female respectively. The mean circumference was  $\pm 7.89$  and

$\pm 10.82$ mm in male and female respectively. (Table no.5 & 6).

Comparing the diameter in male and females the diameter of the aortic valve was more in males than in females. ( $t=3.103$  DF=38 and  $p$  value=.004).

The mean circumference was more in males as compared to females ( $t=3.101$  DF=38 and the  $p$  value=.004).

Here,  $t$  – student's test

DF – Degree of Freedom.

### **Discussion:**

The earliest documentation in the Anatomy of the aortic valve complex started from the Renaissance with the drawings and descriptions by Leonardo da Vinci (1513). Many literatures and articles were devoted to this topic.<sup>5-7</sup>

In the recent years, there is an increase in the interest in the study of Anatomy of heart. The important event being the frequent use of conservative surgical techniques for repairing or replacing cardiac valves. Even in mechanical valves prosthesis the thromboembolic complications, ruptures, restenosis and calcifications are the major cause of morbidity and mortality in patient undergoing valvar replacement. So considering these complications an ideal substitute for natural valve, either mechanical or biological providing longevity or low thrombogenicity is yet to be found.<sup>8,9&10</sup>

The interest in the morphology of cardiac valves which during 60's and 70's was limited to the pathological features due to the large number of valves replacements. Detailed knowledge of the anatomical characteristics of the aortic valve should improve in understanding of the anatomy. This knowledge can help to obtain better results in conservative procedures. This promotes to normal functions of the valve. Some technical difficulties were found during the surgical repair of the aortic

valve due to its anatomical features and conditions of the cusps.<sup>11</sup> Specific studies of the anatomy of the aortic valve were carried out by Silver and Roberts.<sup>12</sup> In present study, annular circumference of the valve was found to range from 31.58 – 63.45mm (in males) whereas 23.35 – 56.20mm (in females). Majority (73%) of hearts had aortic valve circumference ranging from 41.51 to 57.14mm (in males) whereas in females (80%) of hearts had aortic valve circumference ranging from 23.35 to 49.9mm.

Similarly the diameter of valve was found to range from 10.06 – 20.21mm in males whereas 7.43 – 17.90mm in females. Majority of hearts (80%) had aortic valve diameter ranging from 14.79 to 19.52mm.in males, whereas in females (80%) had the aortic valve diameter ranging from 9.2 to 16.16 mm.

The observations regarding the aortic valve show variable findings depending upon the method used in this study. The diameter and circumference obtained in the present study was variable from the

previous studies conducted. (Table no.7).In present study, measurements of aortic valve annular diameter & circumference weremorein male and female as compared to previous observations given by Westaby S. (1984) &Kazman et.al (1988).It is less to study conducted bybyKoujichida et.al (1994), Marcelo B.J (1999) ,Krishnaiah M.(2012) & Dr. S. Ilankathir (2015).After discussing normal anatomy of the aortic valve, mention should be made regarding prosthetic valves. Two most commonly implanted aortic valves are the Edwards SAPIEN prosthesis and Core Valve Re volving.Edwards SAPIEN prosthesis valve consists of a ballon expandable, cylindrical frame composed of stainless steel to which is attached a trifoliate, equine pericardium heart valve.<sup>13 & 14</sup> The second type is of CoreValveReValving System consists of a self-expandable, trilevel frame composed of nitinol to which is attached a trifoliate, porcine pericardium heart valve.<sup>15</sup>

Sr. No	Name of authors	Year	Circumference(mm)		Diameter(mm)		Method of study
			Male	Female	Male	female	
1.	Westaby S.	1984	40.81 ±1.3	-----	12.99 ±2.1	3.4-----	Dissection
2.	Kazman et.al	1988	40.11	40.03	12.77	12.74	2D Echo
3.	Koujichida et.al	1994	70.3 ±0.7	-----	22.38 ±1.3	-----	Dissection
4.	Marcelo B.J.	1999	68.94	-----	21 ±3.6	-----	do
5.	Krishnaiah M.	2012	70.98	60.72	22.60	19.33	do
6.	Dr. S.ilankathir	2015	70.54	-----	22.46	-----	do
7.	Present study	-	50.2 ±7.9	40.4 ±10.8	16 ±2.81	12.9	Cardiac sizer & digital caliper after dissection

**Conclusion:**

We observed that, after the study of the described parameters of the aortic valve annulus showed variations in its measurements. The size of aortic annular diameter and circumference in the North Karnataka region was found to be less as compared to other studies. This study might help cardio – thoracic surgeon as well the prosthetic valve manufacturing

companies for the rough estimation of the aortic valve size. The precise knowledge of aortic valve architecture is necessary for the development and manufacture of the prosthesis. In addition, understanding and knowledge of the structure and function of the normal and pathological cardiac valves are crucial for the selection of the patients for surgery and for planning the best treatment to be

adopted. Despite the above studies, there is need for further investigation of this subject and this study aims to assess the Anatomy of the aortic valve.

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