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MORPHOMETRIC STUDY OF HUMAN AORTIC VALVE IN ADULTS OF WESTERN MAHARASHTRA: A CADAVERIC STUDY

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Abstract

Objective: To estimate the mean of morphometric values of human aortic valve in the population of western Maharashtra. The morphometric variables include mean area and the circumference of the human aortic valve of both genders.

Materials and Methods: The present study was carried out on 30 adult cadaveric hearts in the department of Anatomy at a tertiary care hospital in western Maharashtra. Heart and aortic arch were dissected according to standard dissection techniques. The aortic orifice and valves were exposed; pictures were taken keeping a plastic ruler alongside the periphery of the valve. The pictures were analyzed using Image J software (64 Bit Java 1.8.0V) to calculate circumference and area of the aortic valve. Results were analyzed using unpaired t test.

Results: The mean circumference of aortic valve was 8.827 cm in males and 8.179 cm in females. The mean area of male aortic valve was 5.365cm² and female aortic valve is 4.641cm². The circumference results were found to be significant whereas the area results were not significant.

Conclusion: The size of the aortic valve in the western Maharashtra region was found to be more as compared to other studies. The present study might help the cardiothoracic surgeons as well as the prosthetic valve manufacturing companies for the rough estimation of the aortic valve size.

Keywords: Aortic valve, valve area, valve circumference

Introduction

Cardiovascular system is one of the earliest system to develop in human body. It begins to develop in the middle of the third week when placenta alone cannot suffice for the nutritional requirements of the developing embryo (1). It develops from primary and secondary heart fields with primary heart field forming the atria, the left ventricle, part of right ventricle and secondary heart field forming outflow tracts and rest of the right ventricle (1).

There are four valves namely two atrioventricular valves (tricuspid and bicuspid valves) and two semilunar valves (aortic and pulmonary valves). Tricuspid valve is situated between right atrium and right ventricle. Mitral valve is in between the left atrium and left ventricle. Pulmonary valve regulates blood flow through the pulmonary trunk, whereas aortic valve regulates the blood flow through the aorta. The aortic and pulmonary valves are semilunar valves with each having three leaflets. The valves are responsible for unidirectional blood flow and their structural integrity is essential for the proper functioning of the heart.

These valves keep the blood flowing in the correct direction through the heart. The aortic valve separates the heart's main pumping chamber (left ventricle) and the main artery (aorta) that supplies oxygen-rich blood to the body. With each contraction of the ventricle, the aortic valve opens and allows blood to flow from the left ventricle into the aorta. When the ventricle relaxes, the aortic valve closes to forestall blood from flowing backward into the ventricle (2).

The aortic and pulmonary valves are formed from endocardial cushions and become populated by neural crest cells, in addition to endocardial and pharyngeal derived mesenchyme(1).They consist of a core of connective tissue with the overlying endocardium(3). They are attached to a framework of dense irregular connective tissue which forms the fibrous rings and surrounds the orifices containing the valves (2).

When the aortic valve isn't working properly, it can interfere with blood flow as well as, force the heart to work harder to supply the necessary blood to the rest of the body. In some people, aortic valve disease may not cause any signs or symptoms for many years. Others may experience shortness of breath, fatigue, chest pain, loss of consciousness, irregular heartbeat (arrhythmia), heart failure and sudden cardiac death (4). Aortic root which is the anatomical bridge between the left ventricle and the ascending aorta, can be best visualized as a three-pronged coronet. It consists of aortic valve leaflets and the inter

leaflet triangles interposed between their basal attachments. The hinge line of the leaflets crosses the ventriculo-arterial junction which is making a transition between the myocardium and the fibroelastic tissue of the valve sinuses (2).

Aortic valve can be damaged due to numerous causes. The causes can be congenital or acquired. The most common congenital cause is Bicuspid aortic valve which may ultimately leads to aortic stenosis or aortic regurgitation. Acquired causes include Syphilis, Marfan's syndrome, Seronegative spondylarthritis, SLE and Rheumatic fever (4), (5), (6). In such conditions, the valve gets structurally damaged and one of the modalities of treatment offered is replacement of the valve by surgery. Aortic valve repair or aortic valve replacement can treat aortic valve disease and help restore normal blood flow, reduce symptoms, prolong life and help preserve the function of the heart muscle. Replacement is done by mechanical and bio-prosthetic valves each having its pros and cons (7). Mechanical valves have a longer life but require lifelong anti-coagulation treatment to prevent thrombosis. Biological valves have a comparatively shorter life but do not require any anti-coagulation (7).

The detailed knowledge of the aortic valve normal anatomy is necessary for the cardiothoracic surgeons to operate with minimum morbidity and mortality as well as to differentiate between normal and pathological valve. Evaluation of stenosis or dilatation can be done by knowing the measurements of annular circumference. In today's era of heart tissue valve engineering where the valves are produced in laboratories the total area would be useful to calculate the material required to produce the valve (8). This study is done on 30 adult cadavers of both sexes. Among them 15 were males and 15 were females. In this study the circumference and the area is measured using a computerized software (Image J) and compared with the previous studies.

MATERIALS AND METHODS:

The materials used were a standard foot ruler (camlin foot ruler), a mobile camera (Redmi note 5 pro), image J software(https://imagej.nih.gov/ij/download.html), Laptop(hp).

Thirty human hearts were dissected from the cadavers available in the Anatomy department of a tertiary care hospital in western Maharashtra. Among 30 cadavers, 15 were males and 15 were females. Cadavers received were from the western Maharashtra region. Dissection was done according to the Grants Dissector 16thed Manual of dissection (9). Following incisions were taken. Clavicles were cut in the middle by a saw. At the level of xiphi-sternal joint a transverse cut was given by using saw taking care not to damage the deeper structures. The cut was extended laterally so that it is 4 cm superior to the costal margin and then was followed along the costal margin up to midaxillary line. Using saw, the ribs 2-8 are cut from below upwards along with the intercostal muscles, taking care not to damage the deeper structures.

The 1st rib near the costal cartilage is cut with a saw. Then we elevate the inferior end of sternum along with the attached portions of costal cartilage and ribs and reflect the ant thoracic wall superiorly. After identifying the pericardium and great vessels, they were cut, splitting the pericardium, cutting aorta and pulmonary trunk first followed by superior and inferior venacava and finally the pulmonary veins. Any adhesions with the posterior pericardium are detached and the heart are removed from the thoracic cavity.

A transverse incision was given through the junction of ascending aorta and arch of aorta. The knife was turned inferiorly and another cut was taken longitudinally in between superior venacava and aorta. The incision was extended inferiorly up to the apex of the heart. The incision was taken forwards. This exposes the cavity of left ventricle and aortic vestibule. The orifice lies in the posterosuperior part of the lt. After the orifice is exposed and aortic leaflets identified from the superior aspect, a foot ruler calibrated with digital Vernier calliper) is kept alongside the orifice and an image is taken with the mobile phone.

Figure 1: Aortic orifice is exposed and a standard foot ruler is kept beside it.Image is clicked with a mobile camera

Figure 2: Images are analyzed with image J software

STEPS OF ANALYZING THE IMAGES USING IMAGE J SOFTWARE

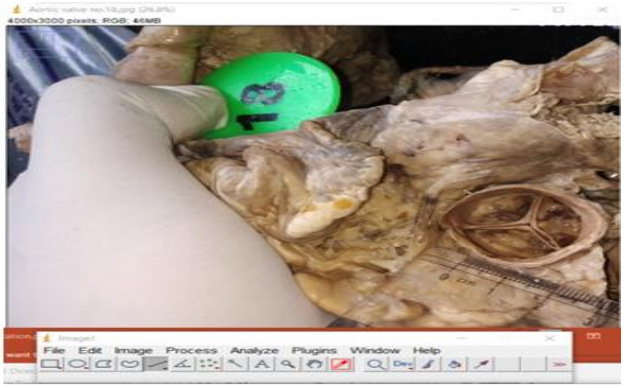


Figure 3: Image is opened in the software

Figure 4: Initial step is setting of scale. We mark the known distance. (Yellow line delineating 1 cm)

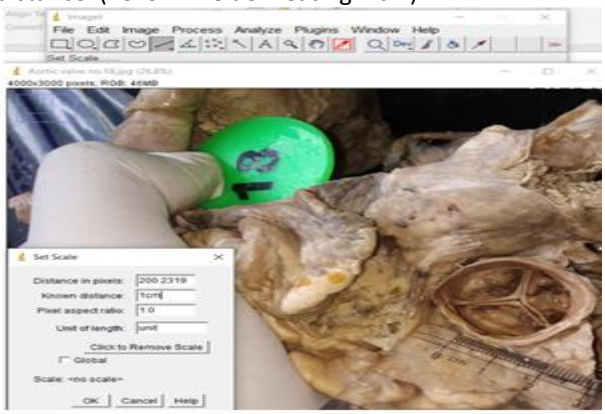


Figure 5: The known distance is analyzed in number of pixels.

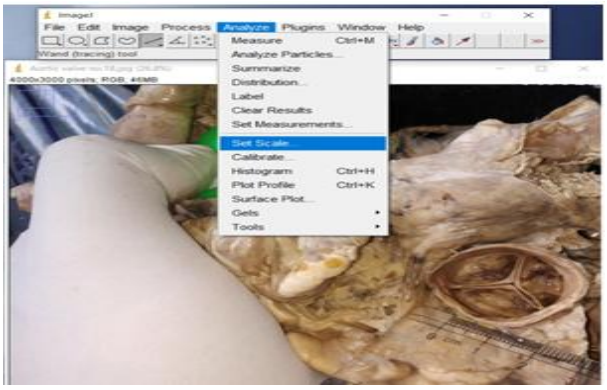


Figure 6: With the pixels standardized to known distance, a scale is set.

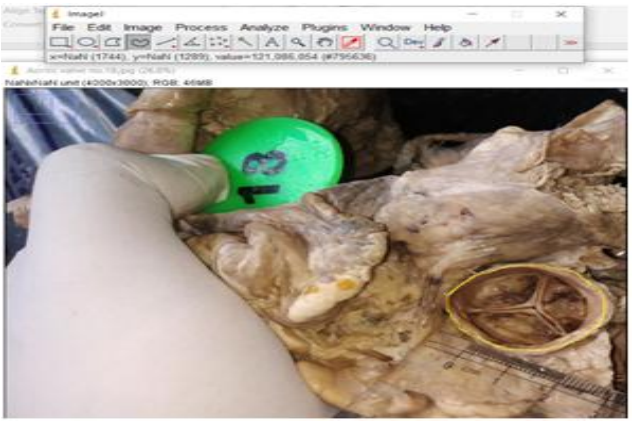


Figure 7: With scale set, draw the circumference of the valve.

The images were analyzed by image J software to yield the result. A fresh scale was set each time while analyzing the image since the distance of taking images was not fixed and standardized. On each occasion the scale was calibrated so that there is no discrepancy in the measurements as the exposure of light and the distance may have differed.

Inclusion criteria included the cadavers of adults above 18yrs of age of both sexes and of western Maharashtra region. Most of the cadavers which were dissected were in the age group of 50-80yrs. Hearts with gross structural abnormalities were excluded from the study.

Results and observations:

In the present study, the mean annular circumference of the aortic valve in males came out to be 8.827cm with a standard deviation of 0.2973cm. In comparison, female hearts had a mean circumference of 8.179cm with a standard deviation of 0.1586cm.

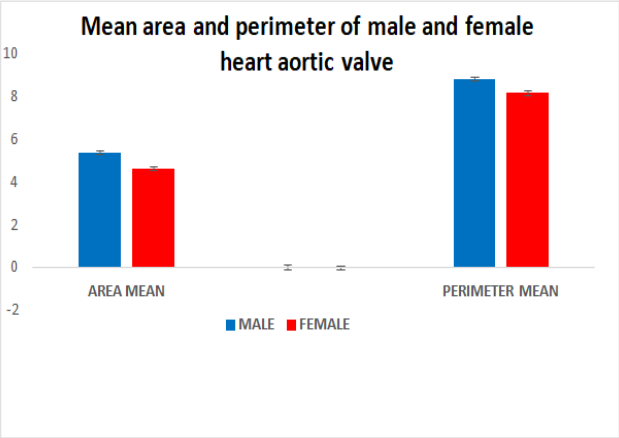
The annular circumference of aortic valve was in the range of 7.251cm to 11.376cm in males. In females the range of the annular circumference varied from 7.179cm to 9.333cm.

The mean area of the aortic valve in males came out to be 5.365cm² with a standard deviation of 0.3698cm². In females the mean area came out to be 4.641cm² with a standard deviation of 0.2123cm².

The area of the aortic valves varied from 3.508cm² to 8.315cm² in male hearts whereas in females it varied from 3.609cm² to 6.021cm².

In Males:

Out of 15 male cadaveric hearts, the maximum annular circumference found was 11.376cm. whereas one of them had minimum circumference of 7.251cm. Maximum hearts had the aortic valve circumference between 7.6cm to 9.5cm.



The maximum aortic valve area in male hearts was 8.315cm² and the minimum area was 3.508cm². The maximum number of values fell between 3.5-5 cm².

In Females:

Out of 15 female cadaveric hearts, the maximum aortic valve annular circumference found was 9.333cm whereas 1 of them had minimum circumference of 7.179cm. Maximum hearts had the aortic valve circumference between 7.1 to 8.8 cm.

The maximum area of the aortic valve in the female hearts was found out to be 6.021cm² and the minimum area was of 3.609cm².

Statistically, unpaired t test was applied to the results. According to the test the aortic valve annular circumference was found to be significant *(p value=.0387)* whereas the aortic valve area was not significant *(p value=.0659).*

Comparing the annular circumference of aortic valves in males and females the circumference of the aortic valve was more in males than in females. *(p value=.0387).*

The mean area of the aortic valve was also found to be more in males than in females. *(p value=.0659).*

Discussion:

Valvular Heart disease is a disease of elderly (>65 years old) specially in western countries. But the scenario is different in developing countries (10). Valvular heart diseases are common in young and middle aged (<30 years old) of the developing countries due to high incidence of rheumatic heart disease and short life expectancy.

Once the native valve is structurally damaged, it is difficult to treat or revert the pathological changes with medications. One of the modality of treatment which can be offered is valve replacement.

Among the valvular heart diseases, Aortic Valve Disease (AVD) is the most common (44.3% VHD are AVD)(11).The overall prevalence of degenerative aortic valve disease has risen due to an increase in life expectancy(12),(13),(14). Aortic valve disease generally manifests in the form of aortic stenosis or aortic regurgitation. Untreated, calcific aortic stenosis has a fatal outcome within 2–5 years once the patient presents with angina, syncope, or heart failure due to the valve lesion (15).

The normal aortic valve area (AVA) at maximum opening of the valve is 3 to 4 cm^2 (16). The observations regarding the aortic valve in this study differ from the previous studies. In present study, measurements of aortic valve annular circumference were more in males and females as compared to previous observations given by Westaby S. (1984) (17), Kouji chida et.al (1994) (18), Marcelo B.J (1999) (19), Krishnaiah M.(2012) (20) & Dr. S. Ilankathir (2015) (21), Dr.Virupaxi et al(2016) (22).

Study	Year	Aortic circumference (cm)	Method of study
Westaby S et al	1984	4.08±0.13	Dissection
Koujichida et al	1994	7.03±0.07	Dissection
Marcelo B J et al	1999	6.89	Dissection
Krishnaiah M et al	2012	7.098(M) 6.023(F)	Dissection
S.Ilankathir et al	2015	7.054	Dissection
Virupaxi et al	2016	5.02±.079(M) 4.04±1.08(F)	Cardiac sizer & digital caliper after Dissection
Present study	2019	8.84±1.29(M) 8.27±0.832(F)	Image J software after dissection

It is imperative to mention that the measurements have been carried out on formalin fixed hearts. In real time studies such as 2D Echo,3D Echo, the valves are in a dynamic state. Hence the values may differ from dynamic valve studies.

The morphometric measurements in this study along with the previous studies could potentially help the prosthetic valve manufacturing companies to make the valves of the exact size.

It has been inferred that the meticulous knowledge about the anatomical and functional features are required to make a new valve (23).

Conclusion:

The values of aortic valve circumference and the aortic valve area differed in different individuals. The values which were obtained in cadavers of western Maharashtra region were found to be more than the previous studies. This study would be useful to the prosthetic valve companies to design and manufacture appropriate sized valves for the Indian population. In today's era of tissue engineering wherein tissues are made in laboratories, this data would come in handy for manufacturing bio-prosthetic valves according to Indian population. It will also

help the cardio-thoracic surgeons to differentiate between normal and abnormal valves.

Despite the previous studies and the current study, more studies are needed on a larger sample size and different regions of the country to come out on final range of aortic valve size in India.

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