

Original Research Article

Morphometric Analysis of Mitral Valve in Formalin Fixed Human Cadaveric Hearts

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ABSTRACT

Background: Mitral valvular pathology is the most important cause of mortality and morbidity in India. This study gives insight into the dimensions of mitral valve to surgeons who deal with valve replacements.

Materials and method: The present study was undertaken on the morphometry of the mitral orifice and cusps in 60 formalin fixed hearts. Various measurements like length, breadth and height of the cusps including the number of cusps and the circumference of the annulus were measured.

Results: Out of 60 cadaveric hearts studied, 80% of the hearts (48) had 2 cusps, 18.3% of the hearts (11) had 3 cusps, 1.7% of the hearts (1) had 4 cusps. Mean circumference of the annulus was 7.68cm. Mean length of anterior cusp; posterior cusp, accessory cusp-1 and accessory cusp-2 were 2.26cm, 2.16cm, 1.31cm, 1.2cm respectively. Mean breadth of anterior cusp, posterior cusp, accessory cusp-1 and accessory cusp-2 were 2.97cm, 3.02cm, 1.39cm, 1.4cm respectively. Mean height of anterior cusp, posterior cusp, accessory cusp-1 and accessory cusp-2 were 1.72cm, 1.68cm, 1.3cm, 1cm respectively.

Conclusion: Mitral valve is the commonly affected valve of the heart. The morphometric analysis of the mitral annulus with its cusps is important in assessing various pathological conditions like mitral stenosis and regurgitation. In the present study it is evident that the number of cusps varies greatly and this morphometric analysis is useful for determining the size of the prosthetic valve. Hence, it is of immense importance to cardiologists and cardiothoracic surgeons who perform valvotomy, valve repair and prosthetic valve replacements to be aware of these variations as an increase in the number of the cusp and their improper approximation causes various valvular disorders.

Keywords: Cadaveric study, Cusps, Mitral valve, Mitral annulus & Morphometry.

INTRODUCTION

Mitral orifice is an opening between the left atrium and left ventricle guarded by a valve called mitral valve or bicuspid valve or left atrio-ventricular valve to ensure unidirectional flow of blood and prevent regurgitation.

Mitral valve is a complex structure comprising of an annulus and two leaflets, the anterior and the posterior. Mitral annulus is an area where muscular fibers of atrium and ventricle are attached with 2 cusps. The anterior cusps guard one-third of the circumference of the orifice and the

posterior cusp guards guard two-thirds of the circumference. The chordae tendineae from the papillary muscles are attaches to both leaflets of the mitral valve. [1] According to text (Gray's anatomy 39th edition) mitral valve mean circumference is 9cm in males; 7.2cm in females. Orifice is almost vertical in diastole and at 45 degree to the sagittal plane with slight forward tilt. [2]

Developmentally, around the left atrioventricular canal, the mesenchyme proliferates to form collars of the endocardial cushions. The mitral valve develops from cushion tissue and myocardium of the ventricle. Abnormal splitting of the cushion tissue may result in the increased number of cusps. [3] Heart disease is one of the major causes for mortality and morbidity in India. This is due to an increasing incidence of the sedentary life style of Indians. [4]

The mitral orifice is altered in conditions like stenosis, regurgitation, congenital valve disease, valve prolapse and acquired valve diseases like infections, infective endocarditis and rheumatic fever, fibro-calcific degeneration or dilatation of the valve annulus. Cardiac valvular anomalies and abnormalities form an important factor for heart disease. [1,2] Though the normal mitral valve function depends upon the anatomic and mechanical integrity of the chordate tendineae [5] but the advances in echocardiography, invasive cardiology (including balloon mitral valvuloplasty) and surgical reconstruction of mitral valves necessitate an appreciation of many variations in the anatomy of the mitral valve.

Data on the dimensions of the mitral valve may be of interest to anatomists, cardio-thoracic surgeons and researchers to assess the exact mechanical reason for valve insufficiency because of its importance in

mitral valve repairs in severe cardiac malfunctions and in evaluating an operative treatment plan. Hence, Morphometric study will provide a baseline data with reference to the severity of reduction in valvular lumen incase of stenosis. [6]

MATERIALS AND METHODS

The present study was conducted in 60 formalin fixed human cadaveric hearts of both the sexes obtained from the department of anatomy, Rajarajeswari medical college and hospital, Bangalore. Human adult cadaveric hearts (above 65yrs) were collected from individuals whose death was caused by non cardiac diseases. 10% formalin was used to preserve the hearts after embalming. The specimens were in good condition after removal from the cadaver and retained their true features.

After confirming the Position and orientation of the heart and its chambers the dissection was done to expose the mitral orifice and valve by following the guidelines of "Cunningham's Manual of Practical Anatomy-Volume2, Sixteenth Edition".

Incision was made on the left margin of the heart extending from the left auricle to the coronary sinus. After thorough washing with water, the measurements were taken. The mitral leaflets with the annulus were measured using a thread, a measuring scale and a Vernier caliper. The number of cusps was considered separate only when the fissures of the cusps touched the margin of the annulus.

Following were the parameters taken in to account.

1. Number of cusp
2. Cusp length
3. Cusp breadth
4. Cusp height
5. Circumference of the annulus.

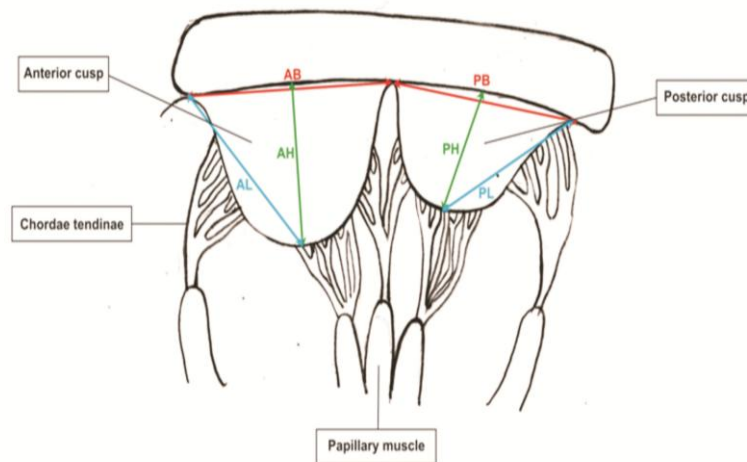


Figure 1: AB-Breadth of anterior cusp, AH-Height of anterior cusp, AL-Length of anterior cusp. PB-Breadth of posterior cusp, PH-Height of posterior cusp, PL-Length of posterior cusp.

For circumference, the thread was placed along the boundary of the annulus conforming to its shape and the meeting ends of the thread were measured with a ruler after it was straightened. The peripheral margin of the mitral annulus was represented by a sulcal margin.

The lengths of the cusps were measured from the attached margin to the free margin of the cusps using a thread which was straightened and measured with a ruler. The breadths of the cusps were measured on the attached margin of the cusps using a thread and a ruler. The heights of the cusps were measured from the attachment of the leaflet to the annulus using a Vernier caliper. All the data were tabulated and statistically analyzed.

Statistical analysis

The measurements obtained were statistically analyzed using SPSS software to calculate the Mean, Standard deviation.

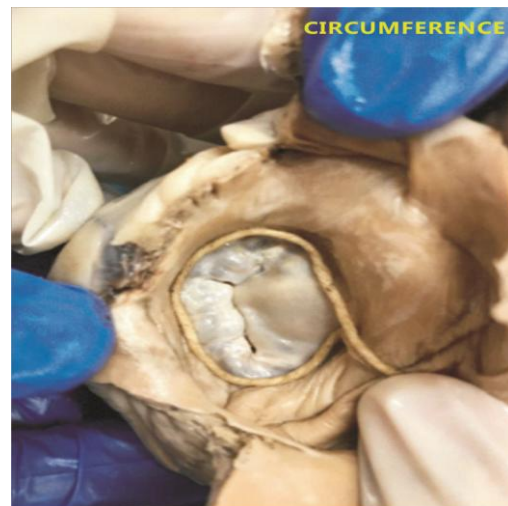


Figure 2: 60 Formalin fixed cadaveric hearts and circumference of mitral valve.

RESULTS

Morphometry of 60 cadaveric hearts were calculated and tabulated. The number of cusp of mitral valve was variable in

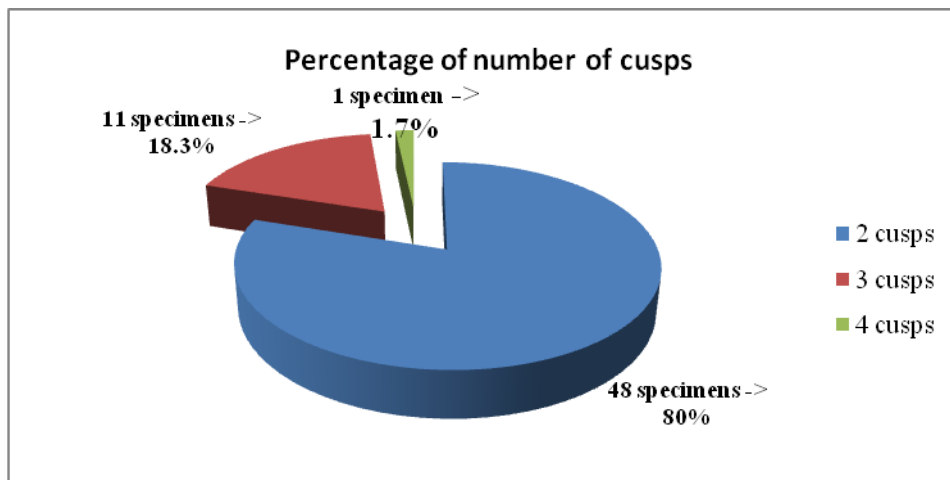
majority of the specimens there were 2 cusps, but hearts with 3 or 4 cusps were also found. Out of the 60 cadaveric hearts studied, 80% of hearts (48) had 2 cusps,

18.3% of hearts (11) had 3 cusps and 1.7% of hearts (1) had 4 cusps. The number of specimens having variable cusps were tabulated and represented in pie chart below. Accessory cusps were smaller than the anterior and posterior cusps.

Most common and widely accepted configuration for leaflet anatomy was the description provide by Carpentier (1976) described 3 posterior leaflet scallops with 2 clefts separating them, 2 commissures

separating the anterior and posterior leaflet, and 1 anterior scallop.

Any clefts that were found in regions described as being scalloped regions by the current nomenclature were termed deviated clefts. Our findings were based on the above description we have found 3-4 prominent indentations considering it as commissure as they were deep, having attached chordate from separate papillary muscles.



Graph 1: Number of specimens and their percentages with respect to the number of cusps present.



Figure 3: Hearts with 3 and 4 cusps in mitral valve

The mean circumference and standard deviation of the mitral valve were 7.98cm and ± 1.83 cm respectively. The mean and standard deviation for the length, breadth and height of the cusps were calculated and tabulated in table 1, 2 & 3:

Table-1: Length of the cusps

	Anterior	Posterior	Accessory1	Accessory2
Mean	2.26	2.16	1.31	1.2
Standard Deviation	± 0.59	± 0.59	± 0.72	-----

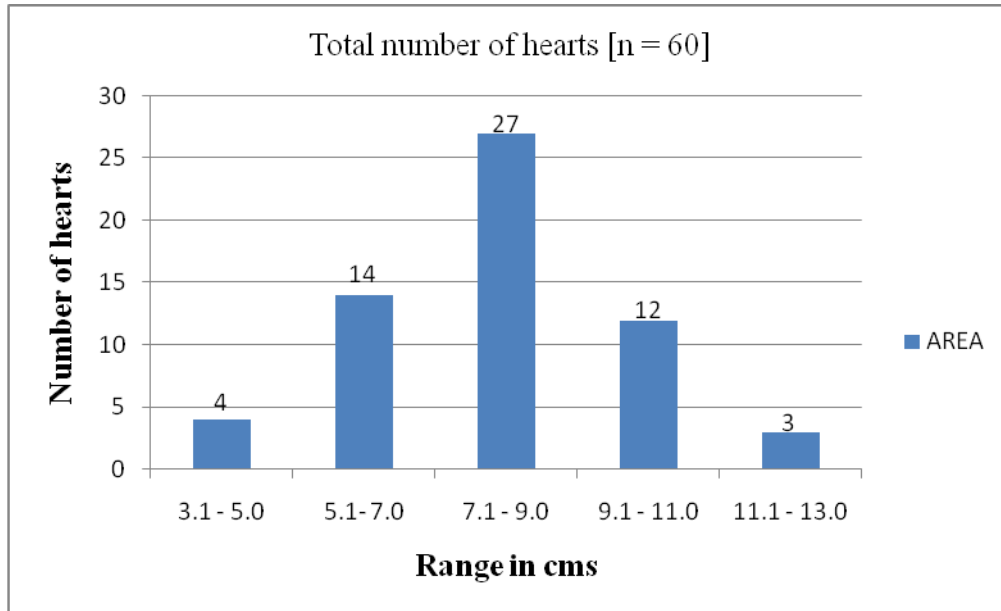
Table-2: Breadth of the cusps

	Anterior	Posterior	Accessory1	Accessory2
Mean	2.97	3.02	1.39	1.4
Standard Deviation	± 0.70	± 0.77	± 0.73	-----

Table-3: Height of the cusps

	Anterior	Posterior	Accessory1	Accessory2
Mean	1.72	1.68	1.3	1
Standard Deviation	±0.54	±0.51	±0.55	-----

The mean annular circumference of mitral orifice was 7.98cm. The number of hearts with certain range of circumference was represented in column chart. (Graph - 2)



Graph 2: Circumference of mitral orifice

DISCUSSION

Mitral valve is the commonly affected valve among four cardiac valves. Important aspect of management of valvular heart disease is replacement of diseased valve by a prosthetic valve surgically. This needs accurate assessment of valvular area, circumference and various other measurements. [7]

Microscopically, the valves of the heart are composed of a core of collagenous fibrous tissue covered on each surface by vascular endothelium. [8]

Circumference of mitral orifice (mean =7.98cm) in the present study corresponds with the values in the study by Senthil Kumar et al.(mean =7.92cm). [4]

Badal Singh et al in his study on 52 formalin fixed human hearts found that the average annular circumference was 8.136cm. The average length and height of anterior cusp were found to be 2.98cm and 2.034cm respectively. The posterior cusp has average length and height of 1.21cm and 1.01cm respectively. The average length and height of accessory cusp were found to

be 1.04cm and 0.871cm respectively. They were of the opinion that the average annular circumference is less in north Indian population compared to other population and average height of anterior and posterior cusps is almost matching with other populations. [9]

According to a study by Sulochana Sakthivel et.al which was done on 50 formalin fixed hearts, the average annular circumference was 8.29cm. The length and width of the anterior cusps was 3.23cm and 2.42cm respectively. The average length and width of posterior cusp was 4.82cm and 1.28cm respectively. [1]

According to Parmatma P. Mishra et.al 55.83% of mitral valves had a circumference between 7.5cm – 10cm, while 1.67% had less than 5cm. Length of anterior cusp was 0.73cm – 5.71cm (82.5% = 2.5cm-5cm). Height of anterior cusp was 1.11cm – 3.74cm (79.11%=0-2.5 cm and 20.83% =2.5cm -5cm). Length of posterior cusp was 2.15cm-9.31cm(54.7%=5.1cm-7.5cm).

Height of posterior cusp was 0.61cm-2.55cm.(99.17%=0.61cm-2.5cm). Length of

accessory cusp was 2cm. Height of accessory cusp was 0.76cm-1.02cm. [6]

In a study by Abhijeet Yadav et al on 50 formalin fixed hearts on the heights of commissure of mitral valve, have found that the average height of anterolateral and posteromedial commissure was 0.65cm & 0.72 in males, in females it was 0.60cm & 0.70 respectively. [10]

Deopujar R and et.al have studied on mitral valve & leaflets in 34 adult embalmed hearts and have found out that 15% of hearts studied had extra leaflets and also has confirmed that an increase in annular circumference if not compensated by appropriate increase in anterior leaflet tends to result in formation of an extra leaflet. [11]

The mean length of attachment of anterior leaflet was 3.05±0.59cm in males and 2.84±0.06cm in female. Attachment of anterior leaflet maximum in range 2.6-5cm in a study by Amar Jyothi Borah and Satyajit mitra on 50 cadaveric hearts. [12]

Mitral valve repair is considered as the gold standard to treat mitral regurgitation. The re-emergence of the edge to edge approximation of the leaflets is commonly called the Alfieri technique. [13]

According to Lai DT & et al., the technique of cusp commisuroplasty can be used to reconstruct atrioventricular valves that have been damaged by endocarditis of the commissure and adjacent cusps. [14]

Francesco Faletra et.al has compared the mitral valve areas of patients with rheumatic mitral valve stenosis as determined by means of 4ECG and Doppler methods with those obtained by direct anatomic measurements. They have found a strong correlation between the anatomical measurements of mitral valve with that of 2D planimetry. [15]

Morphometric analysis of mitral valve showed variable findings depending upon the method used. The various studies were analysed with fresh hearts and cadaveric hearts and also 2D echocardiography performed during the cardiac cycle.

From the above discussion we found that our measurements are slightly less compared to the study by Dr. B. Senthil Kumar et. al and Sakai et.al the reason could be that after 60 yrs, attachment of anterior leaflet decreases in both females and males significantly. [16]

The present study was done with the cadaveric hearts by conventional dissection method can be applied to improve several surgical valvular repair techniques and its replacements the effect of formalin might cause shrinkage to valvular components.

CONCLUSION

The present study gives a morphometrical analysis of the mitral valve annulus and the mitral cusps. One should keep in mind that the mitral valve is not always a bicuspid valve and its morphometric analysis is useful in valve replacement procedures like valvotomy, valve repair and prosthetic valve replacements like commisurotomy and commisuroplasty. These data aids the surgeon in understanding valve anatomy to correlate with its pathophysiology and in designing reconstructive procedures. An increase in annular circumference, if not compensated by appropriate increase in leaflets may result in the formation of extra leaflets. The data available in textbooks is inadequate for the need of cardiac surgeons hence the present study will be useful as it gives insight into the variability in the number of cusps and measurements of both anterior and posterior cusps along with the measurements of mitral orifice. Knowledge acquired through this study will be of much help to surgeons during reconstructive procedures of mitral valve.

Conflict of interest: None.

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