



ORIGINAL RESEARCH PAPER

Anatomy

MORPHOMETRIC ANALYSIS OF ATTACHMENT OF LEAFLETS OF NORMAL ADULT HUMAN FORMALIN FIXED MITRAL VALVE

KEY WORDS: Anterior leaflet, Posterior leaflet, Mitral valve, Formalin fixed

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ABSTRACT

Mitral valve lies between the left atrial and left ventricular chambers guarding unidirectional flow to the left ventricle. Human mitral valves have two leaflets namely anterior and posterior which vary from individual to individual. Mitral valve diseases, have now assumed demands in surgery and need consideration of the anatomy in detail. Therefore, a study was conducted to analyze the attachment of the leaflets and to compare the differences in various studies. In the study average length of attachment of anterior leaflet was 3.05 ± 0.59 cm in males and 2.84 ± 0.26 cm in case of females and average length of attachment of posterior leaflet measures 4.82 ± 0.67 cm in male and 3.90 ± 0.65 cm in the female hearts. Throughout life, length of attachment of anterior and posterior leaflet of mitral valve is more in case of males than females.

INTRODUCTION:

The intrinsic anatomy of the mitral valve apparatus suggests that variations in its architecture may have functional significance. The functional anatomy of the mitral valve apparatus has been well documented in recent years and it is at present widely acknowledged pertaining to the fact that disturbances in coordinated interaction of the various anatomical components may underlie valve insufficiency (1). The great practical importance of mitral valve diseases, has now assumed demands in surgery and need consideration of the anatomy and function of the normal valve and the pathological anatomy of the diseased valve. (2).

The AV valve of the left ventricle, the mitral valve, is bicuspid, with an anterior (aortic, or septal) leaflet and a posterior (mural, or ventricular) leaflet. (3).

Harmonious interplay of these, together with the atrial and ventricular myocardial masses, depends on the conduction tissues and the mechanical cohesion provided by the fibro elastic cardiac skeleton. All parts change substantially in position, shape, angulations and dimensions during a single cardiac cycle.

The mitral orifice is a well-defined transitional zone between the atrial wall and the bases of the cusps. It is smaller than the tricuspid orifice (mean circumference is 9.0 cm in males, 7.2 cm in females). The approximately circular orifice is almost vertical in diastole and at 45° to the sagittal plane, but with a slight forward tilt. Its ventricular aspect faces anterolaterally to the left and a little inferiorly towards the left ventricular apex. It is almost co-planar with the tricuspid orifice but poster superior to it, whereas it is poster inferior and slightly to the left of the aortic orifice. The mitral, tricuspid and aortic orifices are intimately connected centrally at the central fibrous body. When the cusps of the mitral valve close, they form a single zone of coaptation, sometimes termed the commissure.

Since the earliest descriptions, the mitral valvular cusps have been described as paired structures. Hence, the name 'bicuspid valve' is more explicit, although erroneous (the cusps are not cuspid, or 'peaked', in form) and surely less picturesque than the clinical term 'mitral'. The official names for these cusps, anterior and posterior, although simple, are somewhat misleading because of the obliquity of the valve.

The mitral valve When laid open, the anterior cusp (aortic, septal, 'greater' or anteromedial) is seen to guard one-third of the circumference of the orifice and to be semicircular or triangular, with few or no marginal indentations. Its fibrous core (lamina fibrosa) is continuous, on the outflow aspect, beyond the margins of the fibrous subaortic curtain, with the right and left fibrous trigones. Between these, it is continuous with the fibrous curtain itself and, beyond the trigones, with the roots of the annular fibrous prongs.

The posterior cusp (mural, ventricular, 'smaller' or posterolateral) usually has two or more minor indentations. Examination of the valve in the closed position, shows that the posterior cusp can conveniently be regarded as all the valvular tissue posterior to the anterolateral and posteromedial ends of the major zone of apposition with the aortic cusp. Thus defined, it has a wider attachment to the annulus than does the anterior cusp, guarding two-thirds of the circumferential attachments. Further indentations usually divide the mural cusp into a relatively large middle scallop and smaller anterolateral and posteromedial commissural scallops. Each scallop has a crescentic, opaque rough zone, receiving on its ventricular aspect the attachments of the chordae that define the area of valvular apposition in full closure. (4)

With advanced age, the mitral leaflets thicken somewhat, particularly along their closing edges. (5) Posterior mitral leaflet prolapse usually involves the middle scallop and can be associated with chordal rupture. Both mitral leaflets are normally similar in area. The anterior leaflet is twice the height of the posterior leaflet but has half its annular length. (6) Unlike the tricuspid valve, the normal mitral leaflets have no chordal insertions into the ventricular septum. (7)

The functional orifice of the mitral valve is defined by its narrowest diastolic cross-sectional area. This can be at the annulus when there is extensive annular calcification or close to the papillary muscle tips in patients with rheumatic mitral stenosis. Mitral valve prolapse is characterized by thickened and redundant leaflets, annular dilatation (with or without calcium), and thickened and elongated chordae tendineae (with or without rupture). Prolapse of the posterior leaflet occurs more frequently than that of the anterior leaflet. Rheumatic involvement of the mitral valve causes chordal shortening and thickening without annular dilatation. Rheumatic mitral stenosis is produced by chordal and commissural fusion, often with calcification, whereas rheumatic mitral insufficiency results from scar retraction of leaflets and chords. (5)

MATERIALS AND METHODS:

The present study has been conducted in the Department of Anatomy, Gauhati Medical College, Guwahati. Total number of 50 specimens of heart were collected without any socio-economic status, religion, educational or pathological basis from the following sources:

- i) Unclaimed and donated bodies were officially received by the Head of the department of Anatomy. After that the bodies were embalmed in the department for dissection and later, at a convenient time, the hearts were dissected out.
- ii) After fulfilling of all official formalities specimens were collected from the unclaimed bodies in the department of Forensic Medicine, Gauhati Medical College, Guwahati.

Out of 50 specimens 29 specimens were male and 21 specimens

were female heart. The hearts were studied in three age groups: group "A" (20 to 39 years), group "B" (40 to 59 years) and group "C" (60 to 80 years).

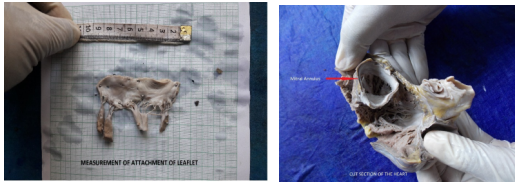


Fig. 1: Figure showing measurement of attachment of leaflet

Fig. 2: Figure showing cut section of the heart

INCLUSION CRITERIA:

Human hearts were collected from cadavers of individuals whose death caused by non cardiac diseases and by accident.

EXCLUSION CRITERIA:

- i) Any gross evidence of congenital heart disease
- ii) Any other pathological condition.

INSTRUMENTS AND MATERIALS:

1. Dissecting Box (with plain forceps, toothed forceps, scalpel, scissors)
2. Trays, surgical gloves
3. "Section" knives
4. Vernier caliper
5. Flexible measuring tape
6. Graph paper
7. 10% formalin
8. Normal saline (0.9% W/V sodium chloride)

Jars, buckets (for storage of specimen)

After collection of heart dissection was performed after twenty four hours, of fixation in the Anatomy department of Gauhati Medical College. Each heart was opened using scissors to make an inverted U-shaped cut through the posterior wall of the left atrium. A cut is given between the openings of the pulmonary vein and a flap is turned inferiorly and the mitral valve was exposed. The left atrioventricular orifice was cleared by removing the clots. Then the shape of the mitral valve orifice was observed and photographed.

An incision was given along the left border of the heart, until its apex, curved along the left of anterior inter ventricular groove until the left coronary sulcus. Flap so obtained was turned to right, and left ventricular chamber was entered. Finally papillary muscles of both ventricles were divided near its wall attachments and the cusps were freed.

The anterior and posterior cusps were identified. The mitral valve along with annulus, chordae tendinae and papillary muscles were removed by dividing its ring at the lateral commissure and by half splitting the medial papillary muscle mass as described by previous authors (3), and pinned in a single plane to a thermocol sheet.

Then it is pinned on a graph paper and measurement is taken with a flexible thread. Then the length of the thread is measured with a measuring tape. Then the measurements of the attached margin of anterior and posterior leaflet were measured separately.

The mean, standard deviation and standard error of mean (S.E.M.) were calculated.

Standard error of mean (S.E.M.) = standard deviation/ square root of number (n).

The 't' value is calculated as:

$$t = \frac{\text{difference of means}}{\sqrt{\frac{\text{square of S.E.M.1} + \text{square of S.E.M.2}}{2}}}$$

The 'p' value is calculated using Student's t-test Probability chart. Using the 'p' value it can be concluded that whether there is statistically significant difference present in two groups or not.

- lf: p > 0.05 = not significant
- p < 0.05 = significant
- p < 0.01 = highly significant
- p < 0.001 = very highly significant

Fig.3: Figure showing cut sections of mitral valve leaflets



OBSERVATIONS AND RESULT:

The morphology of the heart is studied under three primary groups according to different ages.

Out of 50 specimens, 29 specimens are studied for male heart and 21 specimens are studied for female heart. The hearts are studied in three age groups: group "A" (20 to 39 years), group "B" (40 to 59 years) and group "C" (60 to 80 years).

The group A consists of 6 numbers of male and 10 numbers of female heart from the subjects between 20-39 years of age, group B consists of 17 numbers of male and 7 numbers of female heart from the subjects between 40-59 years of age, group A consists of 6 numbers of male and 4 numbers of female heart from the subjects between 60-80 years of age.

TABLE 1: Table showing number of heart studied for studying the morphology (bicuspid valve)

Morphology of heart		
Groups	Male	Female
Group "A" (20 to 39 years)	6	10
Group "B" (40 to 59 years)	17	7
Group "C" (60 to 80 years)	6	4
Total	29	21

In the present study we measure and calculate mean of each value as follows Length of annular attachment of anterior leaflet 2.91cm, Length of annular attachment of posterior leaflet 4.36cm.

TABLE 2. Showing mean length of attachment of anterior and posterior leaflet of the mitral valve orifice in male and female subgroup of 50 hearts.

Sl no	Parameter(mean)	Measurement	S.D.	S.E.M.
1	Attachment of anterior leaflet circumference	2.91	±0.49	±0.07
2	Attachment of posterior leaflet circumference	4.36	±0.80	±0.11

The mean attachment of anterior leaflet is 2.91 with standard deviation (S.D.) of ±0.49 and standard error of mean (S.E.M.) of ±0.07. The mean attachment of posterior leaflet is 4.36 with standard deviation (S.D.) of ±0.80 and standard error of mean (S.E.M.) of ±0.11.

TABLE 3. Showing mean Length of Attachment of anterior leaflet of mitral valve orifice in male and female in group "A", group "B" and group "C".

Group	A		B		C	
	M	F	M	F	M	F
SEX						
Number of specimen	6	10	17	7	6	4
Mean Length of Attachment of anterior leaflet	2.82	2.75	3.19	3.03	2.88	2.73

S.D.	±0.10	±0.08	±0.75	±0.36	±0.04	±0.15
S.E.M.	±0.04	±0.03	±0.18	±0.14	±0.02	±0.08

The mean Length of Attachment of anterior leaflet of male heart of group A is 2.82 with standard deviation (S.D.) of ±0.10 and standard error of mean (S.E.M.) of ±0.04 and of female heart is 2.75 with standard deviation (S.D.) of ±0.08 and standard error of mean (S.E.M.) of ±0.03. The mean Length of Attachment of anterior leaflet of male heart of group B is 3.19 with standard deviation (S.D.) of ±0.75 and standard error of mean (S.E.M.) of ±0.18 and of female is 3.03 with standard deviation (S.D.) of ±0.36 and standard error of mean (S.E.M.) of ±0.14. The mean Length of Attachment of anterior leaflet of male heart of group C is 2.88 with standard deviation (S.D.) of ±0.04 and standard error of mean (S.E.M.) of ±0.02 and of female is 2.73 with standard deviation (S.D.) of ±0.15 and standard error of mean (S.E.M.) of ±0.08.

TABLE 4. showing mean Length of Attachment of posterior leaflet of mitral valve orifice in male and female in group "A", group "B" and group "C".

Group	A		B		C	
	M	F	M	F	M	F
Sex						
Number of specimen	6	10	17	7	6	4
Mean Length of Attachment of posterior leaflet	4.35	3.61	5.19	4.50	4.25	3.55
S.D.	±0.34	±0.53	±0.61	±0.56	±0.33	±0.25
S.E.M.	±0.14	±0.17	±0.15	±0.21	±0.13	±0.13

The mean Length of Attachment of posterior leaflet of male heart of group A is 4.35 with standard deviation (S.D.) of ±0.34 and standard error of mean (S.E.M.) of ±0.14 and of female heart is 3.61 with standard deviation (S.D.) of ±0.53 and standard error of mean (S.E.M.) of ±0.17. The mean Length of Attachment of posterior leaflet of male heart of group B is 5.19 with standard deviation (S.D.) of ±0.61 and standard error of mean (S.E.M.) of ±0.15 and of female heart is 4.50 with standard deviation (S.D.) of ±0.56 and standard error of mean (S.E.M.) of ±0.21. The mean Length of Attachment of posterior leaflet of male heart of group C is 4.25 with standard deviation (S.D.) of ±0.33 and standard error of mean (S.E.M.) of ±0.13 and of female heart is 3.55 with standard deviation (S.D.) of ±0.25 and standard error of mean (S.E.M.) of ±0.13.

TABLE 5. Showing mean length of attachment of anterior leaflet of the mitral valve orifice in male and female subgroup out of 50 hearts.

sex	M	F
Mean attachment of anterior leaflet	3.05	2.84
S.D.	±0.59	±0.26
S.E.M.	±0.11	±0.06

The mean attachment of anterior leaflet of male heart is 3.05 with standard deviation (S.D.) of ±0.59 and standard error of mean (S.E.M.) of ±0.11 and of female heart is 2.84 with standard deviation (S.D.) of ±0.26 and standard error of mean (S.E.M.) of ±0.06.

TABLE 6. Showing Mean attachment of posterior leaflet of the mitral valve orifice in male and female subgroup out of 50 hearts.

sex	M	F
Mean attachment of posterior leaflet	4.82	3.90
S.D.	±0.67	±0.65
S.E.M.	±0.12	±0.14

The mean length of attachment of posterior leaflet of male heart is 4.82 with standard deviation (S.D.) of ±0.67 and standard error of mean (S.E.M.) of ±0.12 and of female heart is 3.90 with standard deviation (S.D.) of ±0.65 and standard error of mean (S.E.M.) of ±0.14.

TABLE 7. Showing range of attachment of anterior leaflet and their respective number valves and percentage.

SI No	Range of attachment of anterior leaflet	No of valve	Percentage
1	0.1-2.5	2	4
2	2.6-5	47	94
3	5.1-7.5	1	2
Total	2.1-7.5	50	100

Out of 50 hearts annular attachment of anterior leaflet is maximum in range of 2.6-5cm 47 valves (94%) followed by 0.1-2.5cm 2 valves (4%) and lowest in range of 5.1-7.5cm 1 valves (2%).

TABLE 8. Showing range of attachment of posterior leaflet and their respective number of valves and percentage.

SI No	Range of attachment of posterior leaflet	No of valve	Percentage
1	2.5-5	34	68
2	5.1-7.5	16	32
Total	3.2-7.5	50	100

Out of 50 hearts annular attachment of posterior leaflet is maximum in range of 2.5-5cm 34 valves (68%) and lowest in range of 5.1-7.5cm 16 valves (32%).

DISCUSSION:

There are many studies which found different values on the average diameter of mitral valve orifice, circumference of mitral valve annulus, annular attachment of anterior and posterior leaflet and height (length according to some author) of anterior and posterior leaflet. In the present study we found different parameters and compared with established findings of other workers.

TABLE NO 9. Showing different studies on Attachment of anterior and posterior leaflet of mitral valve annulus and present study

Studies	Attachment of anterior and leaflet of mitral valve annulus(cm)	Attachment of and posterior leaflet of mitral valve annulus
A Du Plesis(1964)	3.5	6.7
Dr. B. Senthil Kumar et. al.(2013)	2.85	3.26
Sakai et al.(1999)	3.20	4.7
D. Patil et al (2008)	3.32	-----
Parmatma P. Mishra et. al. (2014)	3.4 ±0.87	-----
Present study (2016)	2.91±0.49	4.36±0.80

According to Luis A Du Plesis (3)the length of the annular attachment of anterior leaflet is 3.5cm, the length of the annular attachment of posterior leaflet is 6.7cm, According to Duplessis and Marchand and Walmsley (3) the anterior cusp is large and its annular attachment that is, the length is smaller than that of the posterior cusp.

Dr. B. Senthil Kumar et. al. (8) studied in 60(cadaveric + autopsied) hearts and found that In cadaveric hearts aortic leaflet was 2.85 with S.D. of ±0.07 cm, mural 3.26 with S.D. of ±0.03 cm.

According to Sakai et.al. (9)the length of the annular attachment of anterior leaflet is 3.20cm, the length of the annular attachment of posterior leaflet is 4.7cm.

According to D. Patil et al (10) the length of the annular attachment of anterior leaflet is 3.32cm.

According to Parmatma P. Mishra et. al. (11) the length of the annular attachment of anterior leaflet is 3.4cm. The anterior cusp showed a wide range in length from a minimum of 0.73 cm to a maximum of 5.71 cm. In 82.5% of cases the length of anterior cusp was in the range of 2.5-5 cm. The posterior cusp showed a wide range in length from a minimum of 2.15 cm to the maximum of 9.31 cm. In 54.17% of cases the length of posterior cusp was in the range of 5.1-7.5 cm.

In present study mean length of attachment of anterior leaflet is 2.91 ± 0.49 cm, posterior leaflet is 4.36 ± 0.80 cm.

In present study mean length of attachment of anterior leaflet is 3.05 ± 0.59 in males and 2.84 ± 0.06 in female.

The attachment of anterior leaflet of both male and female mitral valve annulus starts increasing from 20 years of age up to end of 5th decade significantly ($P < 0.05$) in both males and females.

After 60 years attachment of anterior leaflet decreases in both females and males but it is significant in males ($P < 0.05$), remains higher in males than females which is significant ($P < 0.05$).

In present study mean length of attachment of posterior leaflet is 4.82 ± 0.67 in males and 3.90 ± 0.65 in female.

The attachment of posterior leaflet of both male and female mitral valve annulus starts increasing from 20 years of age up to end of 5th decade significantly ($P < 0.05$) in both males and females and this increase is more in case of males than in females which is significant ($P < 0.05$).

After 60 years attachment of posterior leaflet decreases in both females and males significantly ($P < 0.05$) but remains high in male than female which is significant ($P < 0.05$).

From the above discussion we found that our results correspond with study of Dr. B. Senthil Kumar et. al. (8) anterior leaflet attachment 2.85cm and posterior leaflet attachment 3.26, Sakai et. al. (9) anterior leaflet attachment 3.20cm and posterior leaflet attachment 4.7.

Our measurements on Attachment of anterior leaflet (2.91 ± 0.49 cm) and Attachment of posterior leaflet (4.36 ± 0.80 cm) did not correspond with the values of A Du Plessis (3) (3.5 and 6.7cm), D. Patil et al (10) (3.32cm) (anterior), and Parmatma P. Mishra et. al. (11) (3.4cm) (anterior)

CONCLUSION:

In present study mean length of attachment of anterior leaflet is 3.05 ± 0.59 in males and 2.84 ± 0.06 in female. Attachment of anterior leaflet maximum in the range 2.6-5cm (94%) (TABLE. 7)

The length of attachment of anterior leaflet of both male and female mitral valve annulus starts increasing from 20 years of age up to end of 5th decade. After 60 years of age size of mitral valve annulus starts decreasing till the 80 years of life.

Throughout the life length of attachment of anterior leaflet of mitral valve is more in case of males than the females.

Annular attachment of anterior leaflet is maximum in range of 2.6-5cm 47 valves (94%) followed by 2.1-2.5cm 2 valves (4%) and lowest in range of 5.1-7.5cm 1 valves (2%).

Mean length of attachment of posterior leaflet is 4.82 ± 0.67 in males and 3.90 ± 0.65 in female. Attachment of posterior leaflet maximum in the range 3.2-5cm (68%) (TABLE. 8).

The length of attachment of posterior leaflet of both male and female mitral valve annulus starts increasing from 20 years of age up to end of 5th decade. After 60 years of age size of mitral valve annulus starts decreasing till the 80 years of life.

Throughout the life length of attachment of posterior leaflet of mitral valve is more in case of males than the females.

It is relevant to mention here that the measurements carried out in the study are on formalin fixed static hearts and they are manually taken. However in real-time studies, the valves, annulus, cusps are in a dynamic state in a cardiac cycle. Hence, the measurements two-dimensional, three-dimensional echo findings may differ from the static valve studies. Subtle differences are bound to be there.

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