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Original Research Article

Morphometric Analysis of Annulo - Papillary Distances in Left Ventricle of Human Hearts

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ABSTRACT

Objective: Heart dimensions play an important role in heart valve replacement surgeries of the modern era. While fixing of valve during replacement even a minimal difference in the measurements will be crucial for effective postsurgical effective functioning of the valve. There is a marginal difference in the measurements between the attachments of the chordae from the papillary muscle to the valve and the measurements between the papillary muscles to the valve. This study aims to highlight the crucial differences between these measurements which will provide a ready reference for the operating surgeon. **Materials & Methods:** The left ventricle was studied in 50 human hearts. The distances between the anterior and posterior papillary muscles to the mitral annulus were measured from four fixed points. **Results:** The mean vertical diameter of the mitral annulus was 16.56mm SD ± 3.27. The mean transverse diameter of the mitral annulus was 18.06 mm SD ± 2.93.Mean measurements from the tip of the anterior papillary muscle to the four fixed points in the annulus were 15.97mm, 17.82 mm, 11.95 mm and16.57 mm. Measurements from the tip of the posterior papillary muscle to the four fixed points in the annulus were 16.20 mm, 13.58 mm, 12.35 mm and 14.97 mm. In cases where the tip of the papillary muscles was bifid, anterior papillary muscle bifidity was 60% and posterior papillary muscle was 30% and 10% in both the papillary muscles. **Conclusion:** These distances are crucial in heart valve replacement surgeries for maintaining the continuity of the annulo papillary apparatus. This continuity is also done using sutures. Hence a ready reckoner for measurements of the annulo papillary distance will give the operating surgeon a fair idea during prosthetic heart valve replacement surgeries.

Key words: Annulus, papillary muscle, mitral valve, left ventricle, leaflet and cusp.

INTRODUCTION

Prosthetic heart valve replacement surgeries are advocated for severe valvular heart disease. In persons who undergo artificial valve replacements, the quality of life improves post surgically. For an error free heart valve replacement, always special emphasis is placed on the continuity of the annulo papillary apparatus. This continuity is the crux for persons undergoing this prosthetic valve replacement and also for the operating surgeon.

Any alteration in the pre existing dimensions of the annulo papillary apparatus

will lead to complications like regurgitation and valvular incompetence. So it is imperative that a surgical procedure to replace the mitral valve has to be done very meticulously. The operating surgeon has to keep in mind about the biodynamic considerations before proceeding with a prosthetic valve replacement.

A prosthetic valve replacement done without taking the above mentioned factors can even result in a redo procedure which results in an increased incidence of morbidity and even a risk of mortality.

The mitral annulus is not a simple fibrous ring. It is made up of fibrocollagenous elements of varying consistencies from where the cusps take origin. These variations are the one which are responsible for changes in shape and size of the mitral annulus during the different phases of the cardiac cycle. [1] The mitral annulus is structurally very strong transversely and is named as the trigones. The chordal struts are attached to the trigones as well as the anterior and posterior parts termed as prongs. The chordae arise from the papillary muscles support the mitral annulus. Frequently the tips of the papillary muscles are bifid. The papillary muscles, the mitral annulus, the chordae, cusps and the leaflets constitute the annulo papillary apparatus which is a very complex arrangement. During diastole ventricular filling occurs and during systole ventricular contraction takes place. Hence the contraction of the papillary muscle is precise which also results in increasing tension in the chordae prevents the valvular eversion and maintains competency of the mitral valve. The mitral valve undergoes changes in shape, position and area due to the complexity in arrangement. During systole the mitral valve is anterior and to the left and during diastole it is posterior and to the right. The surface area of the mitral annulus also reduces by about 40% during systole. [2] Due leverage has to given to these factors during prosthetic valve replacement.

The measurement of annulo papillary distance in cadaveric hearts holds relevance because it is observed that left ventricular end diastolic volume generally increases after valvuloplasty of mitral valve. [3] Conventional mitral valve replacement without preservation of the annulo papillary apparatus continues to be associated with high prevalence of left ventricular functional disturbances postoperatively which results in an increased incidence of mortality. [4] Preservation of the annulo papillary apparatus in valve replacement procedures leads to improvement of ventricular remodeling post surgically. [5] Valve replacement surgeries resulted in increased long term survival after posterior leaflet preservation. [6] Some authors have observed that even adequate Posterior leaflet preservation does not change hemodynamic valvular characteristics even after long term follow up. [7]

MATERIALS AND METHODS

Fifty fresh cadaveric human hearts were made available for the study from the Departments of Anatomy and Forensic medicine of Vinayaka Missions Kirupananda Variyar Medical College, Salem. The following equipments were utilized for the study included dissecting instruments, digital vernier calipers, hand lens, measuring scale and digital camera.

The left atrium was incised both anteriorly as well as posteriorly to expose the mitral annulus. Four distinctive points were marked on each of the specimens which were equidistant (Fig-1). The first point was marked as A1 on right edge of the annulus. The second point was marked as A2 on the left edge of the annulus. The third point was marked as B1 on the anterior margin of the annulus equidistant between A1 and A2. The fourth point was marked as

B2 on the posterior margin of the annulus equidistant between A1 and A2. Measurements were taken from A1 to A2 which was the transverse diameter (Fig-2). Measurements were taken from B1 to B2 which was the vertical diameter. The left ventricle was incised alongside the margins to expose the papillary muscles (Fig-3). Distances were also measured from the tip of both papillary muscles to the set points on the annulus. In specimens where the tip of the papillary muscles was bifid, distances from the highest point of the tip of the papillary muscle was measured from the annulus (Fig-4).

Fig : 1 Set points of Annulus margin

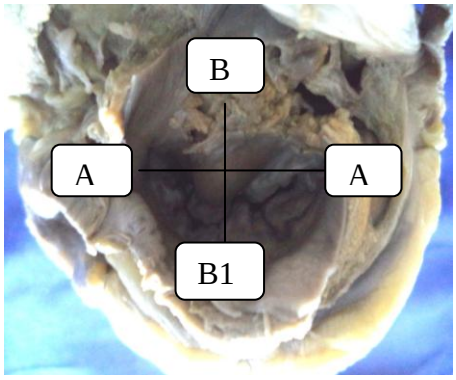


Fig:2 Measurements

Fig:3 Anterior and Posterior Papillary muscles

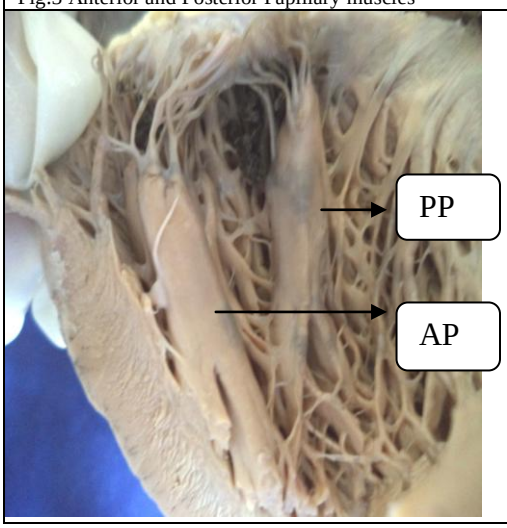
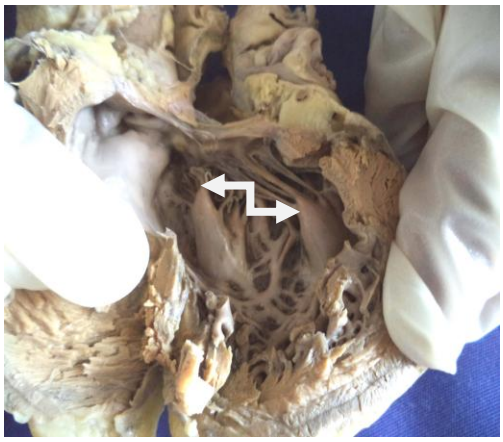


Fig:4 Bifidity of papillary muscles



Statistical Analysis

The measurements thus obtained were subjected to statistical analysis using SPSS software version 16. The range, standard deviation and mean were calculated. Paired "t" test (Table – 3) and chi square test (Table -2) was done to compare the variables.

RESULTS

The mean distance between the tips of the anterior papillary muscle to the right edge of the annulus was 15.97 mm SD ± 2.86 (Table - 1). The mean distance from the tip of the posterior papillary muscle to the right edge of the annulus was 16.20 mm SD ± 3.50 (Table -1). The mean distance from the anterior papillary muscle to the left edge

of the annulus was 17.82 mm SD ± 3.57 (Table -1). The mean distance from the posterior papillary muscle to the left edge of the annulus was 13.58 mm SD ± 4.54 (Table -1). The mean distance between the tips of the anterior papillary muscle to the equidistant of anterior margin of the annulus was 11.95 mm SD ± 3.96 (Table -1). The mean distance between the tips of the posterior papillary muscle to the equidistant of anterior margin of the annulus was 12.35 mm SD ± 5.02 (Table -1). The mean distance between the tips of the anterior papillary muscle to the equidistant of posterior margin of the annulus was 16.57 mm SD ± 3.97 (Table -1). The mean distance between the tips of the posterior papillary muscle to the equidistant of posterior margin of the annulus was 14.97 mm SD ± 3.05 (Table -1). The mean vertical diameter was 16.56 mm SD ± 3.29 (Table – 1). The mean transverse diameter was 18.06 mm SD ± 2.93 (Table – 1).

In specimens with bifid papillary muscles, the incidence of bifidity of the anterior papillary muscle was 60% and in posterior papillary muscle was 30%. The bifidity in both anterior and posterior papillary muscle was 10% (Table – 4).

Table: 1 Mitral valve annulo - papillary distances.

Parameters	Vertical	Transverse	Ant. A1	Ant .A2	Ant.B1	Ant.B2	Post.A1	Post.A2	Post.B1	Post.B2
Mean	16.56	18.06	15.97	17.82	11.95	16.57	16.20	13.58	12.35	14.97
Maximum	10.97	11.60	9.04	7.60	6.20	10.45	8.62	6.80	5.71	9.14
Minimum	24.56	26.85	22.64	25.09	21.70	25.05	24.70	23.99	24.46	23.50
Range	13.59	15.25	13.60	17.49	15.50	14.60	16.08	17.19	18.75	14.36
S.D	3.29	2.93	2.86	3.57	3.96	3.97	3.50	4.54	5.04	3.05
Variance	10.80	8.60	8.18	12.72	15.70	15.74	12.25	20.66	25.43	9.32

Table: 2 Mitral annulo - papillary distance: Chi-square - Test

Parameters	Vertical	Transverse	Ant A1	Ant A2	Ant B1	Ant B2	Post A1	Post A2	Post B1	Post B2
Chi-Square	3.760[a]	1.840[a]	3.760[a]	2.640[b]	1.840[a]	.000[c]	.960[d]	.960[d]	3.360[e]	.000[c]
Df	47	47	47	46	47	49	48	48	45	49
Asymp. Sig.	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

a.48 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 1.0.
b. 47 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 1.1.
c. 50 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 1.0.
d. 49 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 1.0.
e. 46 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 1.1.

Table: 3 Mitral annulo - papillary distances. Paired Samples 't' Test.

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
Pair				Lower	Upper			
Ant A1 – Post A1	-.22500	4.12235	.58299	-1.39656	.94656	-.386	49	.701
Ant A2 - POA2	4.24060	3.60918	.51042	3.21488	5.26632	8.308	49	.000
Ant B1- Post B1	-.39820	3.05907	.43262	-1.26758	.47118	-.920	49	.362
Ant B2- Post B2	1.60060	3.62304	.51238	.57094	2.63026	3.124	49	.003

Table: 4 Bifidity of tip of papillary muscles of left ventricle.

Parameters	Anterolateral	Posteromedial	Both
Total no. 50	30	15	5
Percentage	60%	30%	10%

DISCUSSION

The importance of preserving the annulo papillary apparatus in mitral valve replacement procedures is repeatedly stressed upon due to post surgical complications. Due to erroneous measurements if a smaller valve is inserted, the annulus may become deformed and can result in perivascular leakage. [8] Preservation of the annulo papillary

apparatus caused significant reduction in diameters of the left ventricle, left atrium and the right ventricle. [9] This outlook will definitely lead to a reduction of the end diastolic left ventricular length in long axis. The distance between the fibrous trigones will expand during regurgitation of the mitral valve. This results in an increase in the distance between the anterior and posterior annulus. Hence the measurements of the annulo papillary distances are bound to give a fair idea in selection of a ring that reduces the septolateral diameter and reduces the intertrigonal distance of the mitral valve. [10] Preoperative or intraoperative determination of distance between the tip of the papillary muscle and the mitral annulus is very important in each case of mitral valve replacement surgeries because of the anatomical variations of the papillary muscles. [3]

Surgical sutures may be prone to disruption in patients with increased left ventricular pressure and in hypertension. So preservation of the annulo papillary apparatus enhances the area for attachment in case of mitral valve replacement procedures. [11] In persons with dilatation of the left ventricle the chorda has to be longer for proper closure of the mitral annulus. In such cases when mitral valve replacement is performed, the attachments are so placed that, it does not affect the mitral valve closure however measurements may prove difficult during surgery. [12] Hence approximate distances have to be measured prior to procedure. In the present study there is only a marginal difference in the distances measured from the tips of the papillary muscles to the annulus. In the distances measured from the tips of the papillary muscles to the left edge of the annulus did not show any significant difference. In the distances between the tips of the papillary muscles and the posterior margin also did not show any significant difference (Table - 3). When these differences were statistically analyzed, the corresponding "p" value was less than 0.03 which is considered statistically significant.

CONCLUSION

The preservation of the annulo papillary apparatus is a must for good prognosis in case of mitral valve replacement. It is stressed through this study that, Measurements of the distances between the papillary muscles and the mitral annulus should be taken into account for replacement of mitral valve. The parameters and the approximate distances obtained from the present study may be taken as a guideline for surgical replacement of mitral valve by surgeons.

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REFERENCES

1. Susan Standring. Gray's Anatomy, 40th Edition. Anatomical basis of clinical practice, Churchill Livingstone, London. 2008; 40:970.

2. Susan Standring. Gray's Anatomy, 40th Edition. Anatomical basis of clinical practice, Churchill Livingstone, London. 2008; 40:972.
3. Tetsuro Sakai, Yutaka Okita, Yuichi Ueda, et al., Distance between mitral annulus and papillary muscles: Anatomic study in normal human hearts in J Thorac Cardiovasc Surg 1999; 118:636 – 641.
4. Ahmed A. Alsaddique., Mitral valve replacement with the preservation of the entire valve apparatus in Braz J Cardiovasc Surg 2007; 22(2): 218 – 223.
5. Gomes OM, Gomes ES, Santana Filho GP. New technical approach for crossed papilloplexy in mitral valve replacement surgery: short term results. Braz J Cardiovasc Surg 2005; 20(3): 340-5.
6. Lee EM, Shapiro LM, Wells FC. Importance of sub valvular preservation and early operation in mitral valve surgery in Circulation 1996; 94:2117 - 2123.
7. Djukic PL, B.B Obrenovic – Kircanski, M.R. Vranes, et al., Posterior leaflet preservation during mitral valve replacement for rheumatic mitral stenosis in Acta chirurgica jugoslavica 2006; 53 (1):13 - 17 .
8. Hideki Sasaki, Kenji Ihashi. Chordal-sparing mitral valve replacement: pitfalls and techniques to prevent complications in European Journal of Cardio-thoracic Surgery 2003; 24: 650-652.
9. U.Straub, P.Feindt, H.Huwer, et al., Postoperative assessment of chordal preservation and changes in cardiac geometry following mitral valve replacement in European Journal of Cardio-thoracic Surgery 1996 ;10: 734-740.
10. Kazuo Tanemoto. Surgical Treatment of Ischemic Mitral Valve Regurgitation in Ann Thorac Cardiovasc Surg 2005; 2 (4): 228-231.
11. Denton A. Cooley, Michael T. Ingram. Intravalvular Implantation of Mitral Valve Prostheses in Texas Heart Institute Journal 1987(June); 34 (2) 188-193.
12. Charles A. Sanders, J.Gordon Scannell, J.Warren Harthorne, et al., Severe Mitral Regurgitation Secondary to Ruptured Chordae Tendineae in Circulation 1965 April;(31)506-516.

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