

VALIDATION OF MITRAL VALVE ANNULUS DIMENSIONS MEASURED BY 2D TRANS-THORACIC ECHOCARDIOGRAPHY WITH GOLD STANDARD DIRECT INTRA-OPERATIVE MEASUREMENT

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ABSTRACT: CONTEXT: Precise estimation of Mitral valve annulus dimensions preoperatively through Echocardiography is of paramount importance in replacement/repair surgeries. However a frequent disagreement was experienced between anticipated size of prosthetic valve based on echocardiography and actual valve size. This fact encouraged the authors to validate the measurements through echocardiography with gold-standard direct intra operative measurement. **AIM:** To compare the mitral valve anterior-posterior (short axis) and commissure -commissural (long axis) annulus dimensions estimated through 2D Trans-thoracic Echocardiography with Gold Standard direct Intra-operative Measurement. **SETTING AND DESIGN:** Hospital based prospective longitudinal study. **MATERIALS AND METHODS:** 67 participants suffering from Rheumatic Heart Disease (RHD) patients with severe mitral valve disease were underwent 2-dimensional trans-thoracic echocardiography preoperatively to determine mitral valve short and long axis. Direct measurements for the same were made intra-operatively at the diastolic arrested heart through left atriotomy. **STATISTICAL ANALYSIS:** Univariate analysis (t-test) for difference of mean, confidence interval with standard error estimation. **RESULTS AND CONCLUSION:** Mitral valve annulus axis measurements with or without consideration of Body Surface Area (BSA) were significantly overestimated by 2-D echocardiography judged against direct measurement. A mathematical model or correction index is proposed further to estimate the prosthesis size from these overvalued measurements.

KEYWORDS: Mitral valve prosthesis, Echocardiography, Intra-operative, Heart valve prosthesis, dimension.

INTRODUCTION: It is indeed very difficult to imagine and visualize mitral valve as an anatomical discrete structure; rather it can be considered as the complex of several structures functioning in synchronization. The mitral valvular complex is constituted with annulus, the leaflet, tendinous cords and papillary muscles. The valve is obliquely located in the heart and immediately adjacent to aortic valve. (Works in unison known as aortic-mitral curtain).¹⁻²

The word 'annulus' sounds like a solid ring of fibrous tissue to which the leaflets (of mitral valve) are attached but anatomical reality is far away from the definition. The annulus marking of Anterior Mitral leaflet (AML) is ill-defined; as here AML is in fibrous continuity with neighboring aortic area. Aortic root, inter-valvular septum, left atrium and anterior mitral annulus are anatomically separate structures but during Echocardiography it is very difficult to distinct them as they lie in close approximation with physiologic perfect unison.³⁻⁴

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Plane formation in 2-dimensional trans-thoracic Echocardiography is rather tricky and subjective exercise which may indeed mislead the calculations of the dimensions (short and long axis) of the mitral annulus.⁵

This study attempts to throw light on this issue by categorically measure anterior-posterior (short) axis and commissuro-commissural (long) axis dimensions obtained through 2-D trans thoracic Echocardiography with the gold standard direct intra -operative measurement.

MATERIALS AND METHODS: This hospital based prospective longitudinal study was conducted in department of Cardiothoracic and vascular surgery of a tertiary care center Gandhi medical college and Hamidia Hospital Bhopal, M.P., from July 2011 to December 2012. The inclusion criteria for the study was determined as all Rheumatic Heart Disease (RHD) patients with severe mitral valve disease i.e. valvular area $<1 \text{ cm}^2$ (severe Mitral stenosis), regurgitant valve with jet reaching up to pulmonary vein(severe Mitral Regurgitation), combined stenotic and regurgitant lesion. The patient presented with simultaneous significant aortic valve disease and/or coronary artery disease patients with mitral valve involvement were excluded from the study because of the potential of these two ailments to alter left ventricular geometry independently. All the patients fit into criteria between the duration were recruited in the study after obtaining the written consent.

A total of 67 subjects were recruited for the study. Written Informed consent was obtained from each participant before enrolment.

The 2-dimensional trans-thoracic echocardiography was performed on all these patients preoperatively to determine mitral valve annular dimensions by traditional method. Anterior-posterior (short axis) of mitral valve annulus was obtained by parasternal long axis view. The posterior annulus was located at the junction of leaflet and the left atrium, and the anterior annulus was located at the junction of left atrium and the aortic root. Transverse that is commissuro-commusural axis (long axis) measurement of mitral annulus made in the apical four chamber view at the junction of leaflet and the left atrium.

Direct measurement was made intra-operatively with the black braided silk thread, Vernier calipers and sub-millimeter demarcated metric steal scale. All the calculations were done at the diastolic arrested heart (non-physiologic state) through left atriotomy at Waterson groove. All the measurements were done from hinge line of anterior mitral leaflet to left atrium at mid-point of A_2 segment for anterior-posterior (short) axis. Commissuro-commissural (long) axis was measured from anterior-lateral commissure to posterior-medial commissure at hinge point of annulus to left atrium.

RESULT: The finding of the study is summarized in table-1 and table-2 which shows the short and long axis dimensions of mitral valve taken from 2-D trans-thoracic echocardiography and direct intra-operative measurement.

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Table 1: Difference in short and long axis dimensions of mitral valve taken from 2-D trans-thoracic Echocardiography and direct intra-operative measurement.

Axis of Mitral valve measured	Measurement modality	Mean Value (95%LCL-95%UCL) (mm)	Mean difference in the measurement (standard error)(mm)	t-value	Probability level
Transverse axis	Direct Intraoperative	34.139 (33.366-34.912)	-2.895(0.45) (-3.785 to -2.005)	-6.434	0.000
	2-D Echo Cardiography	37.035 (36.577-37.492)			
Long axis	Direct Intraoperative	38.691 (37.821-39.561)	-3.776(0.558) (-4.880 to -2.672)	-6.764	0.000
	2-D Echo Cardiography	42.467 (41.771-43.163)			

Table 1

The measurement for both short and long axis were estimated more by 2-D Echo compared to direct intra-operative measure; this difference was detected highly significant at 99%Confidence level. (p=0.00)

The next table demonstrates the standardized short and long axis dimensions of mitral valve in reference with body surface area.

Table 2: Difference in short and long axis dimensions of mitral valve in reference with Body surface area (BSA) taken from 2-D trans-thoracic echocardiography and direct intra-operative measurement.

Mitral valve axis measurement (in reference with BSA)	Measurement modality	Mean Value (95%LCL-95%UCL) (mm)	Mean difference in the measurement (standard error)(mm)	t-value	Probability level
Transverse axis/Body surface area	Direct Intra-operative	25.670 (24.963-26.377)	-2.231(0.503) (-3.227 to -1.236)	-	4.433
	2-D Echo Cardiography	27.902 (27.188-28.616)			
Long axis /Body surface area	Direct Intra-operative	29.096 (28.291-29.902)	-2.888(0.591) (-4.059 to -1.717)	-	4.879
	2-D Echo Cardiography	31.984 (31.120-32.848)			

Table 2

The measurement for both standardized (axis/Body Surface Area) short and long axis were more for 2-D ECHO compared to direct intra-operative measure; this difference was detected highly significant at 99%Confidence level.. (p=0.00).

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DISCUSSION: The shape of mitral valve annulus varies in various phases of cardiac cycle. It takes the elliptical shape in diastole while it becomes kidney (bean) shaped during systole. As also reported by Ormiston et al in their study, the corrected mitral orifice area (in reference with Body Surface Area) due to systole was $3.8 \pm 0.7 \text{ cm}^2/\text{m}^2$ compared to $2.9 \pm 0.6 \text{ cm}^2/\text{m}^2$ in diastole. They further reported of reduction of $26\% \pm 3\%$ in mitral valve orifice area during systole due to contraction of base of heart and displacement of aortic- mitral curtain toward center of mitral orifice.⁶⁻⁸

Echocardiographic measurements in the present study were taken during peak systole and direct measurements were calculated on diastolic arrested heart. As mentioned above; despite the tendency of reduction of the mitral valve dimensions during systole, in this study, the systolic measurements through Echocardiography were significantly higher than the diastolic direct measurements. The reasons for this discrepancy lie in ill-defilement of mitral valve anterior annulus.⁹

Although direct measurement seems to be more precise but it is on diastolic arrested heart (non-physiological state). Direct measurement also do not offer the other advantage of 2D transthoracic echocardiography such as repeatability, measurement in physiological state, non-invasiveness, less time consuming, non-hazardous and less costlier. On the other side, Trans-thoracic 2 D echocardiography do have the limitations like requirements of optimal plane formation, more observer dependent, less appropriate anterior mitral leaflet (AML) length determination, less precise sub-valvular deformity analysis. The pathological conditions affecting the heart like abnormal rhythm, pulmonary artery hypertension, associated valvular diseases and coronary artery diseases also affect the precise echocardiographic measurements as they change the dimensions of otherwise physiological heart.¹⁰⁻¹¹

Translating these theoretical postulations into application, available literature does not comments much on the precise difference in numerical dimensions of direct and indirect methods. This study from this perspective stands among the pioneer studies.

Optimal effective valve area with ventricular geometric restoration is paramount aim of mitral valve surgery. 2-D echo cardiography, although a cost effective modality in resource limiting setting, may not grant a very precise measurement as shown by the present study. To overcome this limitation, authors propose a further research in order to construct a mathematical model taking account of this overestimation or to compute a conversion factor for the precise estimation of prosthetic valve dimensions from echocardiographic measurements

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