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Is 3 Dimensional Echocardiography Superior to 2D Echocardiography in Assessment of Mitral Regurgitation and Anatomic Variables in Patients Undergoing Percutaneous Balloon Mitral Valvuloplasty

Sandarbh Patel[1], Vishal Sharma[2], Zeeshan Mansuri[3], Roopesh Singhal[4], Kamal Sharma[5], Jit Brahmbhatt[6], Dinesh Joshi[7], Sharad Jain[8], Krutika Patel[9], [10]Hemal Thakkar, Amit Soni[11]

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Author's Affiliation: [1]Interventional Cardiologist, Aaradhya Heart Care, Ahmedabad, Gujarat 380007, India, [2,3,4,6,7]Assistant Professor, [5]Associate Professor, [8]Professor, [9]Research fellow, Research Department, [10,11]Resident, Department of Cardiology, U. N. Mehta Institute of Cardiology and Research Centre (UNMICRC), Civil Hospital Campus, Asarwa, Ahmedabad 380016, Gujarat, India.

Corresponding Author: Vishal Sharma, Assistant Professor, Department of Cardiology, U. N. Mehta Institute of Cardiology and Research Centre (UNMICRC), Civil Hospital Campus, Asarwa, Ahmedabad 380016, Gujarat, India.

E-mail: dr.vishal88@gmail.com

Abstract

Context: Percutaneous balloon mitral valvuloplasty (PBMV) is often used to treat suitable Mitral stenosis (MS) of rheumatic etiology. This study evaluated the efficacy of measurement of mitral valve regurgitation by 2D echocardiography (2DE). The study also evaluated 3D echocardiography as compared to 2DE for assessment of Mitral valve anatomy and geometry both pre-PBMV and post-PBMV.

Materials and Methods: This was prospective, observational single Centre study in which 60 patients of severe mitral stenosis suitable for PBMV were enrolled. The data collection of each patient included demographics, pre-PTBMV and post-PTBMV functional class, electrocardiogram (ECG), 2DE & RT3DE both pre and post-PTBMV with special focus on real time 2DE and 3DE assessment of MV anatomy and MV Regurgitation. Post-PBMV, MV Regurgitation and anatomy were assessed in catheterization laboratory using 2DE and RT3DE.

Results: There were 32 (53%) females and 28 (47%) males. The mean Pre-PBMV LA Area by 2D Echo (31.38±7.66) and 3D Echo (29.38±7.93) were concordant (p=0.16). Majority patients 24(40%) had mild mitral regurgitation (MR) and only 2(3.3%) had moderate MR before PTBMV. Values of mobility, calcification and subvalvular pathology detected by 2D and 3D Echocardiography showed statistically significant difference (P=0.04 and <0.0001). No significant difference was found in thickness of valve (P=0.29). Higher grades of MR were picked by RT3DE as compared to 2DE.

Conclusions: Transthoracic and transesophageal real-time 3D echocardiography (RT3DE) were better in assessing subvalvular pathology, mobility calcification of MV and post-PBMV MR. There was no difference between 2DE and RT3DE for assessment of MV thickness.

Key words: Real-time 3D Echocardiography; Rheumatic mitral valve stenosis; Balloon mitral valvuloplasty.

Introduction

The mitral valve is a most common valvular affection by the rheumatic process, for which percutaneous balloon mitral valvuloplasty (PTBMV) was introduced as a treatment of selected patients, safe invasive procedure with equivalent or better results as surgical commissurotomy.[1] The safety and success of PTBMV techniques are generally dependent on the selection of patients. There are various predictors of the outcome, including age, functional class, previous commissurotomy, pre-

procedure mitral valve area, valve anatomy, and balloon size used.[2]

Morphology of the mitral valve is considered as the main predictor of a successful PTBMV and hence mitral valve evaluation by echocardiography is of crucial importance.[3] Precise images are needed for complex dynamic structure in an interventional procedure like balloon valvulotomy and repair to operator for better outcome. 2DE is essential in the selection of patients for percutaneous mitral valvuloplasty; 2DE can calculate MV area by planimetry and pressure half-time (PHA). Planimetry has become the most reliable method for calculating mitral valve area and has been compared to the invasively derived Gorlin's formula, which by some is considered the gold standard for mitral valve area calculation.[3] However, real-time 3D echocardiography (RT3DE) may be a more accurate and feasible method for calculating MVA in patients being evaluated for PTBMV.[4] Recently, the other factors such as commissural fusion and calcification are also strong predictors of outcome after PTBMV.[5]

Real-time three-dimensional echocardiography (RT3DE) and advances in analysis software has improved MV orientation and evaluation.[6]

RT3DE allows a unique view and morphologic analysis of the entire MV apparatus including the MV annulus and subvalvular apparatus, also in relation to other nearby structures.[6]

This study is conducted for the study role of 2D echocardiography versus 3D echocardiography in patients suffering from Rheumatic mitral stenosis with advantage of various parameters of 3D echocardiography like accurate MV area calculation by planimetry and accurate demonstration of mitral valve leaflet morphology, commissural calcification and post-procedure analysis of mitral regurgitation as an aid in performance of balloon mitral valvotomy with more success.

Materials and Methods

Design and Data Collection

This is prospective observational single centre study carried out in the Department of cardiology at U.N. Mehta Institute of Cardiology and Research Centre was approved and cleared by institutional ethics committee. Total of 60 patients of mitral stenosis of rheumatic etiology were enrolled in the study.

All the enrolled patients underwent detailed history, physical examination, non-invasive and invasive testing. This article must comply with the guidelines for human studies and should include evidence that the research was conducted ethically in accordance with the World Medical Association Declaration of Helsinki. Data were obtained from patients after obtained assigned consent form every participating patient's, using a predetermineddata collection form. Information collected included patients' demographics, catheterization laboratory data, pre-BMV and post-BMV functional status, 12-leads electrocardiogram (ECG), two dimensional and three-dimensional transthoracic echocardiogram.

An inclusion criterion of the study is patients who underwent Balloon Mitral Valvuloplasty with the diagnosis of severe rheumatic mitral stenosis, with trivial, mild and moderate mitral regurgitation and rheumatic mitral stenosis. Written consent is must for including patients' in study. Exclusion criteria of the study is patient of severe rheumatic mitral stenosis with associated diseases Persistent left atrial or left atrial appendage thrombus, Severe mitral regurgitation, Massive or bicommisural calcification, Severe concomitant Aortic valve disease or severe tricuspid regurgitation or stenosis, Severe concomitant coronary artery disease requiring bypass surgery.

Equipment

2D & 3D TTE probe (X5 probe-1) with echocardiography machine Philip vivid-i 33 echocardiography machine was used for imaging in the study.

Method

To acquire 3D images, standard 2D images were first acquired to locate the best plane or imaging the mitral valve. Planimetry was performed in parasternal short-axis view, adjusting the probe for an optimal mitral valve orifice in early diastole. MV Wilkins score was estimated, that depended on assessment of four parameters (MV leaflets' mobility, thickness and calcification, and subvalvular involvement). [8]Subsequently, 3D zoom mode, with the biplane image feature was used to focus on the mitral valve and acquire images. Color, full-volume acquisition were performed. Once the 3D data sets were acquired, they were cropped to optimally visualize the cardiac structures.

Statistical Methods

All statistical analyses were performed with commercially available software (IBM SPSS version 20.0). Quantitative variables were expressed as

mean ± standard deviation. Independent t-test was used to find any significant difference in various subgroups after confirming normal distribution. Chi-square test used for categorical variables.P value < 0.05 was considered to indicate significant difference between two groups.

Results

A total of 60 patients 32 (53%) females and 28 (47%) males with a diagnosis of rheumatic mitral stenosis were analyzed in the study. According to the analysis maximum number of patients 31 (51.7 %) in NYHA class II, 18(30%) in class I and 11(18.3%) were class III level of dyspnea. Maximum male and female subjects were having NYHA class II dyspnoea (53.1% and 50% respectively). In present study 13 (21.7%) patients having atrial fibrillation while 47(78.3%) patients having sinus rhythm. Highest prevalence was seen in the age group 51 to 60 years.

Echocardiography and Cardiac Catheterization Data

In this study echocardiographic data was collected by 2D echocardiography and 3D echocardiography method. Various parameters like left atrial diameter and volume, Wilkin's score were measured pre and post BMV and were compared with each other.

Table 1: Comparison of findings of Pre and post BMV 2D and 3D Echocardiography.

	Pre BMV- 2D Echo N=60	Pre BMV- 3D Echo N=60	P value	Post BMV-2D Echo N=60	Post BMV-3D Echo N=60	P Value
LA Area (cm^2)	31.38±7.66	29.38±7.93	0.16	28.93±7.66	31.00±9.00	0.18
LA Volume (cm^3)	64.51±8.99	63.66±9.64	0.62	56.56±11.54	55.06±11.50	0.66
Wilkin score	7.58±0.94	7.52±1.21	0.76	6.25±0.77	6.97±0.97	0.001
			MR Grade			
Trivial	24(40)	21(35)	0.71	19(31.6)	24(40)	0.45
Mild	34(56.7)	37(61.7)	0.71	34(56.7)	31(51.7)	0.71
Moderate	2(3.3)	2(3.3)	0.61	7(11.7)	5(8.3)	0.76
Severe	0(0)	0(0)	0.93	0(0)	0(0)	0.93

BMV: Balloon mitral valvuloplasty; LA: Left atrium; MR: Mitral regurgitation.

Comparative findings of 2D and 3D Echocardiography are mentioned in table 1. The mean LA Area measured by 2D Echocardiography and 3D Echocardiography before and after PTBMV procedure (31.38±7.66 vs. 29.38±7.93 and 28.93±7.63 vs. 31.00±9.00); there were no significant difference found between them (p=0.16 and p=0.18).

Table 2: Mitral Valve Apparatus Characteristics by 2D and 3D echocardiography.

Mitral Valve Apparatus Characteristics	2D Echo-cardiography N=60	3D Echo-cardiography N=60	P Value
Mobility	2.4±0.49	2.2±0.57	0.0415*
Calcification	1.4±0.49	2.2±0.53	< 0.0001*
Sub-valvular Pathology	1.6±0.47	2.2±0.46	< 0.0001*
Thickness	1.8±0.42	2.0±1.38	0.2850
Wilkin's Score	7.58±0.94	7.52±1.21	0.51

*P value=<0.05 significant

Similarly the mean LA Volume measured by 2D Echocardiography and 3D Echocardiography (64.51±8.99 vs. 63.66±9.64 and 56.56±11.54 vs. 55.06±11.50) were not having significant difference between them (p=0.62 and p=0.48). Wilkins score showed only significant difference for post BMV procedure (6.25±0.77 vs. 6.97±0.97; p=0.001) and didn't showed significant difference before BMV 7.58±0.94 vs. 7.52±1.21; p=0.76 after procedure.

2D pre and post PTBMV echocardiography 40.0% and 31.67% had trivial MR, maximum (56.67%) subjects were having mild MR, only 3.33% and 11.67% subjects were suffering from moderate degree of MR. 3D pre and post PTBMV echocardiography 35% and 40% had trivial MR, maximum (61.67% and 51.7%) subjects were having mild MR, only 3.33% and 8.33% subjects were suffering from moderate degree of MR. There was no subject with severe MR in both groups.

Values of mobility, calcification and subvalvular pathology detected by 2D and 3D Echocardiography 2.4±0.49 vs 2.2±0.57; p=0.04, 1.4±0.49 vs 2.2±0.53; p= <0.0001 and 1.6±0.47 vs 2.2±0.46; p=<0.0001 consecutively showed statistically significant difference showed in table 2. No significant

difference was found in thickness of valve (1.8±0.42 vs 2.0±1.38; P=0.29). Post PTBMV MR grade was in proportion to commissural calcium grade assessed pre-BMV by 3D echocardiography. Occurrence of moderate MR was seen more in patient with commissural calcium grade 2 (33.3%). Post-PTBMV MR severity correlated with mitral leaflet mobility assessed by 3D echocardiography as shown in table 3.

Table 3: Relation of commissural calcium distribution with occurrence of post BMV mitral regurgitation as shown by RT3D.

	Commissural Calcium			
3D Post MR	**Grade 0 N=14(%)**	**Grade 1 N=34(%)**	**Grade 2 N=12(%)**	**P value**
Trivial	13 (92.86)	9(26.47)	2(16.67)	<0.0001*
Mild	1(7.14)	24(70.59)	6(50)	0.0003*
Moderate	0(0.00)	1(2.94)	4(33.33)	0.002*

*P value=<0.05 significant, MR: Mitral regurgitation

Incidence of moderate MR was found to be associated with severely restricted leaflet mobility accurately assessed by 3D echocardiography.

Discussion

In the Asian country like India, mean age of presentation of cases of severe Rheumatic mitral stenosis is lower compared to western countries which get reflected in current comparison.[6] Real time 3D echocardiography offers superiority over 2D echocardiography in qualitative description of morphology of mitral valvular apparatus.[9-11] Specially describing calcification, commissure and detail sub valvular involvement. Anwar et al. proposed a RT3DE score for the assessment MV and prediction of prognosis in rheumatic MS.[6] new

Pre-procedure assessment of mitral regurgitation showed by 2DE that 34 (56.7%) patients had mild mitral regurgitation while only 2 (3.3%) patients had moderate mitral regurgitation that underwent PTBMV. Post PTBMV 37(61.7%) patients found to possess mild mitral regurgitation and 7 (11.7 %) patients had moderate MR. In one amongsimilar study conducted by Julien Dreyfus et al. (70%) patients had mild MR, while 18 (23%) patients had moderate degree of MR.[12] In similar study by David Messika-Zeitoun et al post-PTBMV moderate to severe MR was found in 4 (7%) patients, while none of patients in current study developed severe MR.[13]

Post procedure mitral regurgitation seen in 31(51.7%) patients and moderate MR noticed in 5(8.3%) patients by 3D echocardiography which was more in patients with pre-procedure significant commissural calcification and also more in patient with annular calcium extension. Similar correlation between commissural calcification on 3D echocardiography and post-PTBMV mitral regurgitation severity was studied by Nina C. Wunderlich, et al., Babu et al.and Schlosshan et al. have shown that 3DTEE assessment of commissural morphology has important additional predictive value.[14-16] In our study, the commissure score was a more accurate predictor of outcome than the Wilkins score. All evaluations for commuters were depending on morphology analysis by the investigators. So, in our study commissures were evaluated as no fusion, complete fusion and partial fusion.

The study as compared showed RT-TT3DE is better ready to detect calcification and commissural splitting. Predictors of optimal PMBV results by the 3D scoring system are leaflet mobility and therefore involvement of the subvalvular apparatus.

Conclusions

Transthoracic RT3D is a feasible and accurate technique for measuring MV apparatus in patients with MS. Compared to the PHT method and 2D echo planimetry, RT3DE were better in assessing subvalvular pathology, mobility calcification of MV and post-PBMV MR. There was no difference between 2DE and RT3DE for assessment of MV thickness.

Limitations

Although 3D echo provides a more accurate evaluation of the anatomy of the mitral valve, as with 2D echo, it is importantly influenced by the quality of the acoustic window. Needless to say that although the new equipment provides better resolution and image quality, a bad acoustic window will lead to a poor analysis of the patient.

References

1. Palacios IF. Percutaneous Mitral Balloon Valvuloplasty: Worldwide Trends. J Am Heart Assoc. 2019 Jul 2;8(13):e012898. doi: 10.1161/JAHA.119.012898. Epub 2019 Jun 29. PMID: 31256697; PMCID: PMC6662352.
2. Soliman OI, Anwar AM, Metawei AK, McGhie JS, Geleijnse ML, Ten Cate FJ. New Scores for the Assessment of Mitral Stenosis Using Real-Time Three-Dimensional Echocardiography. CurrCardiovasc Imaging Rep. 2011 Oct;4(5):370-377. doi: 10.1007/s12410-011-9099-z. Epub 2011 Jul 9. PMID: 21949566; PMCID: PMC3165135.
3. Baumgartner H, Hung J, Bermejo J, Chambers JB,

Evangelista A, Griffin BP, Iung B, Otto CM, Pellikka PA, Quiñones M. Echocardiographic assessment of valve stenosis: EAE/ASE recommendations for clinical practice. Journal of the American Society of Echocardiography. 2009 Jan 1;22(1):1-23.

4. Zamorano J, Perez de Isla L, Sugeng L, Cordeiro P, Rodrigo JL, Almeria C, Weinert L, Feldman T, Macaya C, Lang RM, Antolin RH. Non-invasive assessment of mitral valve area during percutaneous balloon mitral valvuloplasty: role of real-time 3D echocardiography. European heart journal. 2004 Dec 1;25(23):2086-91.
5. SarathBabu D, Ranganayakulu KP, Rajasekhar D, Vanajakshamma V, Pramod Kumar T. Assessment of mitral valve commissural morphology by transoesophageal echocardiography predicts outcome after balloon mitral valvotomy. Indian Heart J. 2013 May-Jun;65(3):269-75. doi: 10.1016/j.ihj.2013.04.022. Epub 2013 Apr 9. PMID: 23809380; PMCID: PMC3861152.
6. Anwar AM, Attia WM, Nosir YF, Soliman OI, Mosad MA, Othman M, Geleijnse ML, El-Amin AM, Ten Cate FJ. Validation of a new score for the assessment of mitral stenosis using real-time three-dimensional echocardiography. Journal of the American Society of Echocardiography. 2010 Jan 1;23(1):13-22.
7. Farrag HMA, SetouhiAM, El-Mokadem MO, El-Swasany MA, Mahmoud KS, Mahmoud HB, Ibrahim AM. Additive value of 3D-echo in prediction of immediate outcome after percutaneous balloon mitral valvuloplasty. Egypt Heart J. 2019 Sep 18;71(1):19. doi: 10.1186/s43044-019-0019-x. PMID: 31659518; PMCID: PMC6821434.
8. Wilkins GT, Gillam LD, Weyman AE, et al Percutaneous balloon dilatation of the mitral valve: an analysis of echocardiographic variables related to outcome and the mechanism of dilatation. Br Heart J 1988; 60: 299e308.
9. Mannaerts HF, Kamp O, Visser CA. Should mitral valve area assessment inpatients with mitral stenosis be based on anatomical or on functional evaluation? A plea for 3D echocardiography as the new clinical standard. EurHeart J 2004;25:2073-4.
10. Binder TM, Rosenhek R, Porenta G, Maurer G, Baumgartner H. Improved assessment of mitral valve stenosis by volumetric real-time three-dimensional echocardiography. J Am CollCardiol 2000;36:1355-61.
11. Langerveld J, Valocik G, Plokker HW, Ernst SMPG, Mannaerts HFJ, Kelder JC, Kamp O, Jaarsma W. Additional value of three dimensional transesophageal echocardiography for patients with mitral valve stenosis undergoing balloon valvuloplasty. J Am SocEchocardiogr 2003;16:84–9.
12. Dreyfus J, Brochet E, Lepage L, Attias D, Cueff C, Detaint D, et al. Real-time 3D transoesophageal measurement of the mitral valve area in patients with mitral stenosis. European journal of echocardiography. 2011;12(10):750-5.56.
13. Messika-Zeitoun D, Brochet E, Holmin C, Rosenbaum D, Cormier B, Serfaty J-M, et al. Three-dimensional evaluation of the mitral valve area and commissural opening before and after percutaneous mitral commissurotomy in patients with mitral stenosis. European heart journal. 2006;28(1):72-9.
14. Wunderlich NC, Beigel R, Siegel RJ. Management of mitral stenosis using 2D and 3D echo-Doppler imaging. JACC: Cardiovascular Imaging. 2013;6(11):1191-205.
15. Babu DS, Ranganayakulu KP, Rajasekhar D, Vanajakshamma V, Kumar TP. Assessment of mitral valve commissural morphology by transoesophageal echocardiography predicts outcome after balloon mitral valvotomy. Indian heart journal. 2013 May 1;65(3):269-75.
16. Schlosshan D, Aggarwal G, Mathur G, Allan R, Cranney G Real-time 3D transesophageal echocardiography for the evaluation of rheumatic mitral stenosis JACC Cardiovasc Imaging. 2011 Jun;4(6):580-8.