ORIGINAL RESEARCH PAPER
Volume - 9 | Issue - 9 | September - 2020 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

ASSESSMENT OF COMMISSURAL MORPHOLOGY BY 2-DIMENSIONAL AND 3-DIMENSIONAL ECHOCARDIOGRAPHY TO PREDICT THE IMMEDIATE OUTCOME OF PERCUTANEOUS TRANSVENOUS MITRAL COMMISSUROTOMY IN PATIENTS WITH RHEUMATIC MITRAL STENOSIS

Cardiology

Jeet Ram Kashyap*	MD, DM, FACC, FSCAI, Associate Professor, Department of Cardiology, Government Medical College & Hospital, Sector-32B, Chandigarh, India. 160030. *Corresponding Author
Kewal Chand Goswami	MD, DM, Department of Cardiology, Cardiothoracic and Neurosciences Centre, All India Institute of Medical Sciences, New Delhi, India.
Rakesh Yadav	MD, DM, Department of Cardiology, Cardiothoracic and Neurosciences Centre, All India Institute of Medical Sciences, New Delhi, India.
Ganesan Karthikeyan	MD, DM, Department of Cardiology, Cardiothoracic and Neurosciences Centre, All India Institute of Medical Sciences, New Delhi, India.
Neeraj Parakh	MD, DM, Department of Cardiology, Cardiothoracic and Neurosciences Centre, All India Institute of Medical Sciences, New Delhi, India.
Vinay Kumar Bahl	MD, DM, Department of Cardiology, Cardiothoracic and Neurosciences Centre, All India Institute of Medical Sciences, New Delhi, India.
Rashmi Kashyap	MD, Department of Community Medicine, Dr. Y.S. Parmar Government Medical College, Nahan, Himachal Pradesh, India.
Sreenivas Reddy	MD, DM, Department of Cardiology, Government Medical College & Hospital, Sector-32B, Chandigarh, India. 160030.
Suraj Kumar	MD, DM, Department of Cardiology, Government Medical College & Hospital, Sector-32B, Chandigarh, India. 160030.
Raghavendra Rao K.	MD, DM, Department of Cardiology, Government Medical College & Hospital, Sector-32B, Chandigarh, India. 160030.

ABSTRACT

OBJECTIVE: To find various commissural morphologic predictors of immediate outcome of percutaneous transvenous mitral commissurotomy by two and three dimensional echocardiography.

METHODS

Design: Cross sectional study

Setting: Teratiry care hospital

Participants: Symptomatic patients with severe rheumatic mitral stenosis aged more than 12 years without any contraindications for the procedure.

Intervention: 2D and 3D echocardiographic evaluation of commissural morphology was done by measuring commissural thickness score, commissural fusion score, commissural calcification and intercommissural distance.

End point: Predictors of successful procedure.

RESULTS: Sixty-five patients were screened. Ten were excluded because of (commissural calcification 5, > moderate mitral regurgitation 2, thrombus in left atrium 2 and emergency procedure in a pregnant lady 1). Fifty five patients (29 (53%) men and 26 (47%) women), mean age 30.58 ± 9.27 were studied. The procedure was successful in 47 (86%) patients. The following parameters predicted the success; lower commissural fusion score by 3D echo 1.5 (0.5 – 2.0) vs. 2.0 (0.5 -2.0); $p \leq 0.002$, higher intercommissural distance by 2D echo 19.0 (12.5 – 21.5) vs. 16.5 (12.0 – 18.5); $p \leq 0.009$, lesser commissural thickness score 3D echo 5.0 (0.4 – 10.2) vs. 8.8 (3.9 – 10.0); $p \leq 0.028$ as well as by 2D echo 5.1 (1.7 - 9.8) vs 8.5 (4.3 - 9.7); $p < 0.037$. Commissural thickness score by 2D echo was the best predictor of outcome ($r=0.509$, $P<0.0001$).

CONCLUSIONS: Comissural morphology is an important independent predictor of immediate outcome of percutaneous transvenous mitral commissurotomy.

KEYWORDS

Percutaneous Transvenous Mitral Commissurotomy (PTMC), 2 Dimensional Echocardiography, 3 Dimensional Echocardiography, Commissural fusion score, Commissural thickness score, commissural calcification, Intercommissural distance.

INTRODUCTION

Rheumatic Mitral Stenosis (MS) is the commonest cause of valvular heart disease in developing countries.[1,2] The Percutaneous Transvenous Mitral Commissurotomy (PTMC) has become a well established procedure for its treatment.[3-9] Various scores and individual parameters have been used to predict its immediate and long term outcome of PTMC.[4-14] Commissural morphology has gained importance as commissural spliting is the main mechanism behind surgical and baloon mitral commissurotomy.[10] Commissural calcification and commissural fusion have been used as independent predictors of outcome.[11-13] Recently 3 dimensional echocardiography (3D Echo) has evolved as a novel tool for evaluation of mitral valve and commissures. The advantages of 3D is that the image can be adjusted by manipulating various angles and planes and enface view can be seen.[14-17] In this study we evaluated some newer commissural parameters like commissural thickness score and intercommissural distance along with commissural fusion score by 2D and 3D echocardiography.

MATERIAL AND METHODS

This study was carried out at All India Institute of Medical Sciences, New Delhi, India by a single team after obtaining an informed written consent from the patients or their legal heirs. The study was approved by the institutional ethics committee.

Inclusion Criteria: Symptomatic patients with severe rheumatic MS aged more than 12 years undergoing PTMC.

Exclusion Criteria: Patients having calcific MS, thrombus in left atrium or appendage, mitral or aortic regurgitation > grade 2, acute rheumatic fever within past 3 months, infective endocarditis, emergency PTMC, pregnant females and not consenting for the study.

Echocardiographic Evaluation: A day before the procedure an ECG gated 2D and 3D echo was done in all standard views on Philips iE-33 machine, Phillips Medical System, Hamburg, Germany. Three dimensional echocardiography was done using full volume and live mode and stored on a compatible DICOM system for offline analysis. The commissural morphology was assessed in parasternal short axis end diastolic frames. Commissural thickness of each commissures was measured at the margin of mitral orifice and summed to obtain commissural thickness score. The commissural fusion score was calculated as score 0 = unfused/minimally fused commissures, 0.5 as partially fused and 1.0 as fully fused for each commissures and then added to obtain commissural fusion score. The intercommissural distance (ICD) was measured as the distance between two commissures. **(Figure 1)** Presence of commissural calcification was an exclusion criteria. The mitral valve area (MVA) was measured by 2D and 3D planimetry at the tip of mitral leaflets as well as by pressure half time (PHT) method. Post PTMC echo was done to look for commissural splitting, MVA by 2D and 3D planimetry and for development of mitral regurgitation or pericardial effusion.

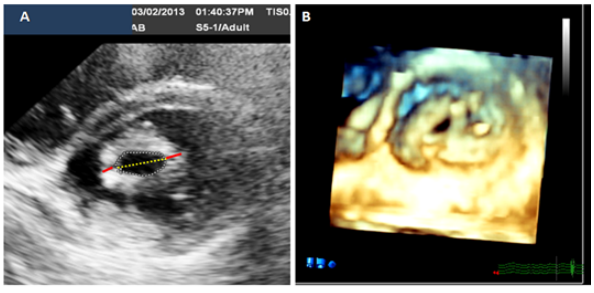

Figure 1: Parasternal Short axis view **(A)** 2D echo Red lines showing measurement of commissural thickness at the margins of mitral orifice **Commissural thickness score** was obtained by adding the thickness of medial and lateral commissures **(ICD):** Yellow dotted line ; Intercommissural distance measured from inner edge of Medial to inner edged of lateral commissures **(B)** Enface view of the mitral orifice

Figure 1: (A) Parasternal short axis view 2D echo showing commissural morphology and (B) Enface view of mitral valve

PTMC Procedure: All patients underwent PTMC by antegrade transseptal approach using Inoue balloon. Procedural success was defined as a final MVA of >1.5 cm^2, 50% increase in MVA from baseline and > 50% decrease in mean left atrial pressure with mean transmitral gradient of less than 10 mm of Hg in the absence of major complications like mitral regurgitation > Seller's grade 2, systemic embolism, cardiac tamponade or death.

Statistical Analysis: Statistical analysis was done using SPSS-version 21. The various 2D and 3D echocardiographic variable were compared by using paired t-test and represented as mean ± SD and a p value of < 0.05 was considered significant. The comparison between 2 groups successful versus unsuccessful was done by Wilcoxon Rank-Sum (Mann-Whitney) test. Univariate and multivariate regression analysis was done to find the best predictors of successful PTMC.

RESULTS

Sixty-five patients were screened by 2D echocardiography. Ten patients were excluded because of commissural calcification in 5, more than moderate mitral regurgitation in 2, left atrium thrombus in 2 and emergency PTMC in a pregnant lady 1. Fifty five patients, 29 (53%) males and 26 (47%) females were evaluated. The mean age was 30.58 ± 9.27 (range 13 - 50) years. The average height was 160.12 ± 9.04 cm, mean weight 49.47 ± 10.58 kg and the mean body surface area 1.49 ± 0.19 $(m)^2$. The other clinical characteristics are shown in **Table 1**.

Table 1: Demographic profile and clinical characteristics of patients undergoing PTMC

Characteristics	Mean ± SD
Number of patients screened	65
Patients Excluded	10
Number of patients for final analysis	55
Age	30.58 ± 9.27
Height in (cm)	160.12 ± 9.04
Weight in (kg)	49.47 ± 10.58
Body Surface Area $(m)^2$	1.49 ± 0.19
Characteristics	**No (Percent %)**
Male	29 (53%)
Females	26 (47%)
Patients with atrial fibrillation	7 (13%)
Patients undergoing redo PTMC	4 (8%)
NYHA Class – I	0 (0%)
NYHA Class – II	24 (44%)
NYHA Class – III	30 (54%)
NYHA Class – IV	01 (2%)

Echocardiographic Data: The mean MVA was 0.79 ± 0.14 cm^2 by 2D planimetry, 0.75 ± 0.12 cm^2 by 3D planimetry, 0.81 ± 0.13 cm^2 by PHT as compared to 0.73 ± 0.16 cm^2 by Gorlin's formula. The MVA obtained by 3D planimetry had the best agreement with MVA derived by Gorlin's formula (r = 0.525, P < 0.0001) suggesting that 3D echo can obtain more accurate MVA exactly at the tips of mitral leaflets. **(Figure 2)** Overall we did not find any difference between 2D and 3D echo parameters of commissural morphology. **(Table 2)**

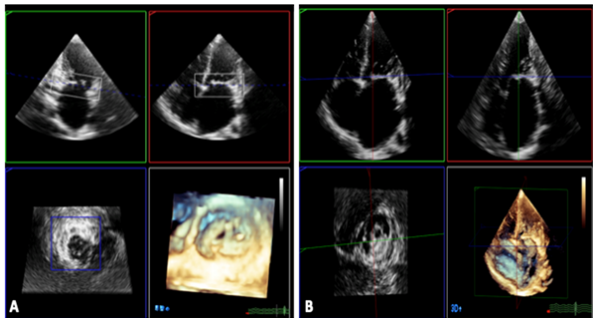

Figure 2: (A) 3-Dimentional echocardiography showing enface view of the mitral valve and MVA after i-croping and (B) showing MVA exactly at the tips of mitral leaflets by adjusting the image.

Table 2: Comparison of 2D and 3D Echocardiographic parameters among all patients

Parameters of Commissural Morphology	2D Echo (n=55)	3D Echo (n=55)	P – Value
Commissural thickness Lateral (mm)	2.65 ± 1.02	2.66 ± 1.30	0.98
Commissural thickness Medial (mm)	2.75 ± 1.08	2.73 ± 1.28	0.61
Commissural thickness score (Lat + Med) mm	5.41 ± 1.99	5.42 ± 2.40	0.92
Commissural Fusion (Lateral)	0.71± 0.28	0.72 ± 0.26	1.00
Commissural Fusion (Medial)	0.74 ± 0.25	0.73 ± 0.25	1.00
Commissural fusion score (Lat +Med)	1.45 ± 0.39	1.45 ± 0.40	1.00
Inter commissural distance (ICD) (mm)	18.02 ± 2.78	18.01± 2.83	0.916
MVA by Planimetry $(cm)^2$	0.79 ± 0.14	0.75 ± 0.12	0.025

Outcome of PTMC: The procedure was successful in 47 (86%) patients. There were 8 (14%) failures; out of which 4 had suboptimal result, 3 developed > grade 2 mitral regurgitation (MR) and one patient had a stroke in catheterization laboratory. One patient with MR required surgery rest 2 were managed medically. The patient who had stroke was managed by percutaneous retrieval of mitral tissue from middle cerebral artery. The mean Gorlin's derived MVA increased from 0.73 ± 0.16 cm^2 to 1.69 ± 0.30 ($p \leq 0.00001$). The mean LA pressure decreased from 28.6 ± 6.29 to 15.86 ± 6.79; $p \leq 0.00001$ and mean cardiac index increased from 2.39 ± 0.36 to 2.81 ± 0.33; $P \leq 0.00001$.

Echocardiographic parameters of successful PTMC: The following echocardiographic parameters of commissural morphology were associated with the successfulness of the procedure; the lower commissural fusion score by 3D echo 1.5 (0.5 – 2.0) vs. 2.0 (0.5 -2.0); $p \leq 0.002$, higher intercommissural distance by 2D echo 19.0 (12.5 – 21.5) vs. 16.5 (12.0 – 18.5); $p \leq 0.009$, lesser commissural thickness score 3D echo 5.0 (0.4 – 10.2) vs. 8.8 (3.9 – 10.0); $p \leq 0.028$ as well as by 2D echo 5.1 (1.7 - 9.8) vs. 8.5 (4.3 - 9.7); $p < 0.037$. The lesser thickness of individual commissures was also significantly related to the success of the procedure. **(Table-3)**

Table 3: 2D and 3D echocardiographic parameters among patients with successful and unsuccessful groups

Commissural Morphology Parameters	Successful (n=47)	Unsuccessful (n=8)	P-Value
Commissural thickness (Lateral) 2D mm	2.3 (0.9 - 5.1)	4.2 (2.2 - 4.90)	0.049
Commissural thickness (Medial) 2D mm	2.4 (0.8 - 4.9)	4.25 (2.1 - 5.3)	0.049
Commissural thickness Score (Lat + Med) 2D mm	5.1 (1.7 - 9.8)	8.5 (4.3 - 9.7)	0.037
Commissural fusion score (Lateral) 2D	0.5 (0.5-1.0)	1.0 (0.5 - 1.0)	0.188
Commissural fusion score (Medial) 2D	0.5 (0.0-1.0)	1.0 (0.5 - 1.0)	0.188
Commissural fusion score (Lat + Med) 2D	1.5 (0.5 - 2.0)	1.75 (1.5 -2.0)	0.147
Commissural thickness (Lateral) 3D mm	2.2 (0.2 -5.1)	4.2 (2.1 - 5.7)	0.049
Commissural thickness (Medial) 3D mm	2.2 (0.2 -5.4)	4.25 (1.8 - 5.3)	0.049
Commissural thickness Score (Lat + Med) 3D mm	5.0 (0.4 - 10.2)	8.8 (3.9 - 10.0)	0.028
Commissural fusion score (Lateral) 3D	0.5 (0.5 - 1.0)	1.0 (0.5 - 1.0)	0.037
Commissural fusion score (Medial) 3D	0.5 (0.0- 1.0)	1.0 (0.5 - 1.0)	0.028
Commissural fusion score (Lat + Med) (3D)	1.5 (0.5 - 2.0)	2.0 (0.5 – 2.0)	0.002
ICD by 2D (mm)	19.0 (12.5 - 21.5)	16.5 (12.0 - 18.5)	0.009
ICD by 3D (mm)	19.0 (12.5–21.5)	16.2 (12.4 – 18.8)	0.08
MVA (2D) cm^2	0.81 (0.53- 1.02)	0.81 (0.57 – 0.9)	0.75
MVA (3D) cm^2	0.74 (0.55- 0.99)	0.69 (0.55 – 0.77)	0.125
MVA (PHT) cm^2	0.8 (0.53- 1.06)	0.84 (0.57 – 0.98)	0.68

Predictors of Outcome: On multivariate regression analysis the commissural thickness score by 2D echo was found to be the best predictor of successful PTMC ($r = 0.509$; $P < 0.001$).

DISCUSSION

The pathologic process of MS consists of thickening and calcification of mitral leaflets, fusion of commissures and fusion and shortening of chordae tendineae.[1-2] The various characteristics of mitral valve and its supporting structures influence the outcome of balloon valvuloplasty.[3-9] Earlier studies showed that a higher echo score is associated with a poor outcome.[7-10] Commissural calcification and fusion are well recognized factors influencing the outcome of PTMC.[11-13] In our study the lower commissural fusion score, lesser commissural thickness score and higher intercommissural distance favoured the success of the procedure implying that the less deformed commissures are easier to open. Sutaria et. al. in their study used a combined commissural score including commissural fibrosis, fusion and calcification in reverse to ours and found a lower score associated with poor outcome.[12] Similarly Sarath Babu et. al. also found lower commissural score significantly related to outcome of PTMC.[13] Recent studies using 3D echo have shown that the presence of commissural dark zones is associated with better outcome.[14,15] Intercommissural distance and commissural thickness are relatively less studied parameters. We postulate that lesser thickened and lesser fused commissures will have greater ICD hence more chances of successful procedure.

In our study, the MVA by 2D, 3D planimetry and PHT correlated well with each other as well to MVA obtained by Gorlin's formula, however, the MVA by 3D planimetry was in best agreement with Gorlin's derived MVA. Similar observations were made by Zomarano et al. in their study of 80 patients.[16] The reason for this is the ability of 3D echo to adjust the image in a desirable plane regardless of the orientations of acoustic windows.

The overall success rate of the procedure was 86% which is comparable to other studies but slightly lower than our previous study (98.4%).[5] Bahl et.al also reported a success rate of 93% in their study.[18] The reason for slightly lower success may be the change in the team with younger operators performing the procedure.

STUDY LIMITATIONS

The smaller sample size may have limitation in interpreting the results between the groups. Three dimensional echocardiography at the time of this study was a little complex and time consuming but as the technology and operator experience evolves it will be much easier.

CONCLUSIONS:

Assessment of commissural morphology using commissural thickness and fusion score, and intercommissural distance appears useful in predicting the immediate outcome of PTMC. The lesser deformed commissures are easier to open than badly deformed commissures. Further larger studies can enlighten more on these scores.

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