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Original Article

Association of the Left Ventricular Function Before and After Percutaneous Balloon Mitral Valvotomy in Patients with Rheumatic Mitral Stenosis

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Abstract

Aims: This study aims to identify subclinical left ventricle (LV) dysfunction by 2D strain echo before percutaneous balloon mitral valvuloplasty (PBMV) in patients with rheumatic mitral stenosis (MS). Our study also analyze the post-operative evaluation of overall LV systolic function (by conventional and 2D strain echo) and serial follow-up and evaluation of the LV systolic function over a period of 6 months.

Materials and Methods: A cross-sectional, observational study was attending Cardiology Outpatient Department, NRS Hospital. One hundred patients aged between 18 and 45 years who were fulfill inclusion criteria. Pre-PBMV echocardiographic data were taken (both 2D and strain echo) and recorded. After completion of successful PBMV as denoted by mitral valve area >1.5 cm^2 and reduction of pressure gradient across mitral valve >50% with no significant mitral regurgitation, follow-up echocardiographic evaluation was done after 24 h of procedure, at 1 month and 6 months.

Results: In pre-operative, the mean ejection fraction (EF) (mean ± S.D.) of patients was 58.9000 ± 5.6147. In after 24 h, the mean EF (mean ± S.D.) of patients was 59.3600 ± 5.3664. In after 1 month, the mean EF (mean ± S.D.) of patients was 57.3200 ± 6.1314. In after 6 months, the mean EF (mean ± S.D.) of patients was 55.8200 ± 6.4470. Distribution of mean EF versus group was statistically significant ($P = 0.0001$). We found that in pre-operative, the mean mitral annular plane systolic excursion (MAPSE) (mean ± S.D.) of patients was 11.2840 ± 1.0907. In after 24 h, the mean MAPSE (mean ± S.D.) of patients was 11.9470 ± 1.3094. In after 1 month, the mean MAPSE (mean ± S.D.) of patients was 13.2420 ± 1.4659. In after 6 months, the mean MAPSE (mean ± S.D.) of patients was 14.7560 ± 1.5787. Distribution of mean MAPSE versus group was statistically significant ($P < 0.0001$).

Conclusion: Patients with MS and preserved EF% had a lower 2D longitudinal LV systolic S and Sr compared to the control group. 2D longitudinal LV systolic S and Sr imaging appears to be useful in the detection of subclinical LV systolic dysfunction in patients with MS and preserved EF%.

Key words: Echocardiography and left ventricular, Mitral stenosis, Percutaneous balloon mitral valvotomy, Rheumatic mitral stenosis

INTRODUCTION

Measuring left ventricular (LV) function has a critical importance in diagnosis and treatment of patients with cardiac diseases. This is particularly more important in patients with valvular heart disease (VHD). Rheumatic heart disease (RHD) remains one of the most important causes of VHD in India. In RHD, mitral valve involves commonly either alone or in combination with other valve. RHD is the result of autoimmune response triggered by Group A beta-hemolytic streptococcal pharyngitis leading to immune inflammatory injury of the cardiac valves. Mitral valve stenosis (MS) remains the most common manifestation of chronic rheumatic valvulitis. MS affects the LV functions at various levels due to inflammatory and hemodynamic factors. In general, gross LV systolic function in isolated MS is well preserved.[1] The LV chamber typically is normal or small. However, coexisting mitral regurgitation (MR), aortic valve disease, ischemic heart disease, systemic

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Table 1: Distribution of mean LV EDD, EF, and MAPSE group

Variables	Number	Mean	SD	Minimum	Maximum	Median	*P*-value
LV EDD							
Pre-operative	100	43.6280	4.5521	34.9000	52.3000	43.7000	<0.0001
After 24 h	100	44.0400	4.3186	34.9000	51.9000	44.6000	
After 1 month	100	45.0800	3.8851	35.5000	51.9000	46.0000	
After 6 months	100	46.2920	3.8046	37.0000	53.4000	46.1500	
EF							
Pre-operative	100	58.9000	5.6147	50.0000	69.0000	59.5000	0.0001
After 24 h	100	59.3600	5.3664	51.0000	69.0000	60.0000	
After 1 month	100	57.3200	6.1314	46.0000	69.0000	57.0000	
After 6 months	100	55.8200	6.4470	44.0000	69.0000	54.5000	
MAPSE							
Pre-operative	100	11.2840	1.0907	9.4000	14.0000	11.3000	<0.0001
After 24 h	100	11.9470	1.3094	9.5000	15.0000	12.0000	
After 1 month	100	13.2420	1.4659	10.5000	18.0000	13.1000	
After 6 months	100	14.7560	1.5787	11.0000	18.0000	14.9500	

LV EDD: Left ventricle end-diastolic dysfunction, EF: Ejection fraction, MAPSEL: Mitral annular plane systolic excursion

hypertension, and cardiomyopathy, all may be responsible for the elevation of the LV end-diastolic pressure.[2] The LV dysfunction has been described in pure mitral stenosis (MS), which may be a due to change in interaction between the right and LVs, myocardial fibrosis, or a chronic decrease in preload. In patients with rheumatic MS, there is alteration in the LV compliance, diastolic dysfunction, abnormal interaction with the right ventricle, pulmonary hypertension, thickening of subvalvular apparatus, and chronic myocardial inflammation and all these factors lead to subclinical LV dysfunction. In a few patients with MS, ultrastructural, pathological alterations might occur in the muscle cells of the LV. In proportion with these alterations, contractile functions of the LV also decrease. In the assessment of the LV systolic function, a number of imaging techniques – such as echocardiography, magnetic resonance imaging, scintigraphy, and computed tomography scan have been used. In echocardiography, traditionally, ejection fraction (EF), tissue Doppler imaging (TDI), strain echo, and strain rate imaging were extensively used for the assessment of the LV function (a).[2] Subclinical systolic dysfunction has been shown through TDI in patients with MS.[3] In TDI velocity analysis used for the evaluation of regional myocardial functions, some problems, such as continuing elongation of myocardium-like structures and transmission of active and passive deformation in adjacent segments, have been encountered.

Although there is a downward trend in the prevalence of rheumatic fever and rheumatic MS in developed countries, it stands out as a huge public health problem in the developing countries. It particularly affects young people aged between 5 and 15 years. Although in India, rheumatic fever can occur even in 3 years of age. Major determinants of this persistent high burden of RHD are low socioeconomic status, overcrowding, lack of proper surveillance, and lack of effective implementation of primary and secondary preventive strategies. Acute rheumatic fever (ARF) leads to pancarditis (inflammation of the all three layers of heart). Pericarditis and myocarditis generally resolve, but endocarditis along with valvulitis became chronic. In chronic rheumatic valvulitis, there are chronic inflammation and scarring thickening of the subvalvular apparatus along with calcification. In patients with ARF, valvular regurgitations are common, whereas stenosis is the rule for chronic rheumatic valvulitis. The most common form of chronic rheumatic valvulitis is MS. Concomitant aortic valve or tricuspid valve involvement may present. Pulmonary valve involvement is rare in rheumatic fever. MS is a slowly progressive disease with long latency period. The LV function generally well preserved in the initial period unless there is concomitant regurgitation. Traditional echocardiographic parameters failed to show any abnormality in gross LV systolic function. Even with normal EF (indicating preserved global LV function), there can be impairment in long-axis function (measured by tissue Doppler echocardiography).[4] Altered LV long-axis movement has been shown to be a sensitive indicator of early myocardial dysfunction. Atrial fibrillation has shown to cause impairment of the LV function. Pulsed-wave Doppler tissue velocities have been proven to be a good tool for the assessment of long-axis ventricular shortening and lengthening. In the echocardiographical assessment of the LV function, the EF, TDI, Doppler strain, and 2D strain have been widely used. EF is the most widely used index of contractile function, but has high interobserver variability.[5] TDI and Doppler strain are characterized by limitations of angle dependence, limited spatial resolution, and deformation analysis in one dimension. 2D strain is a novel technique which evaluates LV systolic functions more objectively and quantitatively, and does not have the limitations seen in EF, TDI, and Doppler strain; thus, it has become more commonly used in recent years. Strain echocardiography is particularly important to assess subclinical LV systolic dysfunction.[6] In the diagnosis of the LV dysfunction due to MS, some studies have shown EF, TDI, and Doppler strain to be useful, however, there is a paucity of data.

1. To identify subclinical LV dysfunction by 2D strain echo before percutaneous balloon mitral valvuloplasty (PBMV) in patients with rheumatic MS
2. Post-operative evaluation of overall LV systolic function (by conventional and 2D strain echo)
3. Serial follow-up and evaluation of the LV systolic function over a period of 6 months.

MATERIALS AND METHODS

Study Population

Patients aged between 18 years and 45 years with severe rheumatic MS who were attended Cardiology Outpatient Department, NRS Hospital, and eligible for PBMV were included in this study. Written informed consent was taken from patient or their relatives in their own language before enrollment in the study.

Study Period

The study period was from July 2019 to December 2020 (18 academic months).

Inclusion Criteria

Severity of MS was determined by:

1. Mitral valve area <1.5 cm^2 calculated by planimetric method in parasternal short axis view of conventional 2D echocardiography
2. Mean pressure gradient across mitral valve >10 mm of Hg
3. Peak pulmonary systolic pressure >50 mm of Hg – Pulmonary artery pressure (PAP) was measured from the apical 4-chamber view and was derived from the tricuspid regurgitant jet velocity using the simplified Bernoulli equation assuming a right atrial pressure of 10 mmHg.

Selection of patient for PBMV eligibility was done by Wilkins score.[7]

Exclusion Criteria

Patients with severe MS who have any one of the following criteria were excluded from the study.

1. Hypertension or diabetes mellitus
2. Patient with atrial fibrillation
3. Significant other VHD (i.e., coexisting MR or aortic valve disease)
4. Coronary artery disease (significant in coronary angiography)
5. Presence of the left atrial thrombus, clot, or spontaneous echo contrast.

Statistical Analysis

For statistical analysis, data were entered into a Microsoft Excel spreadsheet and then analyzed by SPSS 24.0. and GraphPad Prism version 5. A Chi-squared test (χ^2 test) was any statistical hypothesis test wherein the sampling distribution of the test statistic is a Chi-squared distribution when the null hypothesis is true. Without other qualification, "Chi-squared test" often is used as short for Pearson's Chi-squared test. Unpaired proportions were compared by Chi-square test or Fisher's exact test, as appropriate. $P \leq 0.05$ was considered for statistically significant.

RESULTS AND DISCUSSION

We found that the mean age (mean ± S.D.) of patients was 35.2400 ± 9.3885 years. Fifty-eight (58.0%) patients had female and 42 (42.0%) patients had male. The mean body mass index (mean ± S.D.) of patients was 23.8360 ± 2.3035 kg/m^2.

Bilen *et al*.[7] found that the study population consisted of 103 patients (age 40.9 ± 8.3 years, 75.7% female). There were no significant differences between MS patients and control subjects regarding age and gender. There were no significant differences in the LV-EF and LV systolic/diastolic dimensions between the groups. Systolic PAP increased significantly from Group 1 through to Group 4.

Rajesh *et al*.[8] found that there were 43 patients (25 in sinus rhythm) in the study group and 20 subjects in the control group. Majority were female with no significant gender difference in either group (79.1% vs. 75%, $P = 0.718$). Heart rates were also similar ($P = 0.084$). Intraclass coefficient was analyzed for assessing inter- and intra-observer variability. For intra-observer variability, intraclass coefficients were mitral annular systolic velocity (MASV) – 0.95, myocardial performance index (MPI) – 0.86, E0 – 0.91, and mitral annular plane systolic excursion (MAPSE) – 0.97. For interobserver variability, intraclass coefficients were MASV – 0.92, MPI – 0.84, E0 – 0.89, and MAPSE – 0.96. All the parameters had intraclass coefficient more than 0.7 (acceptable range 0.7–1). Maximum intra- and inter-observer variabilities were for MPI.

We found that in pre-operative, the mean LV end-diastolic dysfunction (EDD) (mean ± S.D.) of patients was 43.6280 ± 4.5521. In after 24 h, the mean LV EDD (mean ± S.D.) of patients was 44.0400 ± 4.3186. In after 1 month, the mean LV EDD (mean ± S.D.) of patients was 45.0800 ± 3.8851. In after 6 months, the mean LV EDD (mean ± S.D.) of patients was 46.2920 ± 3.8046. Distribution of mean LV EDD versus group was statistically significant ($P < 0.0001$) [Table 1].

We found that in pre-operative, the mean LVESD (mean ± S.D.) of patients was 27.8200 ± 4.4725. In after 24 h, the mean LVESD (mean ± S.D.) of patients was 28.0880 ± 4.3234. In after 1 month, the mean LVESD (mean ± S.D.) of patients was 28.4480 ± 4.1846. In after 6 months, the mean LVESD (mean ± S.D.) of patients was 28.8060 ± 4.2468. Distribution of mean LVESD versus group was not statistically significant ($P = 0.3960$).

In pre-operative, the mean EF (mean ± S.D.) of patients was 58.9000 ± 5.6147. In after 24 h, the mean EF (mean ± S.D.) of patients was 59.3600 ± 5.3664. In after 1 month, the mean EF (mean ± S.D.) of patients was 57.3200 ± 6.1314. In after 6 months, the mean EF (mean ± S.D.) of patients was 55.8200 ± 6.4470. Distribution of mean EF versus group was statistically significant ($P = 0.0001$).

In patients with MS, varying degrees of deterioration in the LV function have been reported. The data on the prevalence of longitudinal LV dysfunction in rheumatic MS are not enough. Rajesh *et al*.[8] showed that lower MAPSE, MASV, and E0, with higher MPI in MS patients, compared to controls. Rajesh *et al*.[8] showed that 77% of the study group had evidence of LV longitudinal dysfunction. The higher prevalence of longitudinal LV dysfunction in our group may be due to the fact that they have taken only patients with severe MS. Other factors that may have contributed to this are the delay to medical care from onset of symptoms, as well as earlier onset of valvular disease in Indian population.

The study by Ozdemir *et al*.[4] showed that MS affects long-axis left ventricular performance. The myocardial velocities of the LV indicating left ventricular function were found to be significantly lower in patients with pure MS. Ozer *et al*.[3] examined LV long-axis function of patients with pure MS. There was no significant difference in global systolic function, but tissue Doppler systolic velocities were significantly lower in patients with MS than in controls. Our study showed lower indices of the LV function (MPI) in AF subset, though EF difference was non-significant between the groups. In patients with MS and AF, the causative mechanisms of the LV dysfunction are not well known.

We found that in pre-operative, the mean fractional shortening (mean ± S.D.) of patients was 30.0000 ± 3.2660. In after 24 h, the mean fractional shortening (mean ± S.D.) of patients was 29.6400 ± 2.7980. In after 1 month, the mean fractional shortening (mean ± S.D.) of patients was 29.3000 ± 2.8302. In after 6 months, the mean fractional shortening (mean ± S.D.) of patients was 28.6600 ± 4.1420. Distribution of mean fractional shortening versus group was statistically significant ($P = 0.0314$).

We found that in pre-operative, the mean LV Tei Index (mean ± S.D.) of patients was 0.3442 ± 0.0351. In after 24 h, the mean LV Tei Index (mean ± S.D.) of patients was 0.3512 ± 0.0336. In after 1 month, the mean LV Tei Index (mean ± S.D.) of patients was 0.3546 ± 0.0327. In after 6 months, the mean LV Tei Index (mean ± S.D.) of patients was 0.3294 ± 0.0320. Distribution of mean LV Tei Index versus group was statistically significant ($P < 0.0001$).

We found that in pre-operative, the mean MAPSE (mean ± S.D.) of patients was 11.2840 ± 1.0907. In after 24 h, the mean MAPSE (mean ± S.D.) of patients was 11.9470 ± 1.3094. In after 1 month, the mean MAPSE (mean ± S.D.) of patients was 13.2420 ± 1.4659. In after 6 months, the mean MAPSE (mean ± S.D.) of patients was 14.7560 ± 1.5787. Distribution of mean MAPSE versus group was statistically significant ($P < 0.0001$).

Rajesh *et al*.[8] showed that EF and MAPSE did not show significant change with BMV. MASV and E0 showed improvement immediate post-BMV, while MPI showed a decrease only at 3-month follow-up. The immediate improvement of the LV long-axis parameters may be due to mechanical effect of BMV, while the improvement of MPI (indicating global LV function) took longer time. Another possible explanation for lack of MPI change immediate post-BMV could be due to the fact that MPI, though averaged for 5 cycles in AF patients, could produce significant intraobserver variability. In a study by Lee *et al*.,[9] most patients with impaired LV EF showed improvement after mitral valvuloplasty. A study by Nurcan *et al*.[10] which included 76 consecutive patients, who underwent BMV for isolated rheumatic MS, showed improvement in MASV and E0 post-BMV. The LV global function by MPI did not improve significantly 48 h and 3 months after BMV. This is in contrast to the results of our study, which showed a decrease in MPI at 3 months following BMV. Thus, serial evaluation of changes in mitral annular velocities by Doppler tissue imaging aids clinical assessment of immediate improvement in the LV function after BMV.

Subclinical LV dysfunction related to MS has been evaluated through several different methods. Dogan *et al*.[11] used Doppler strain, and Ozdemir *et al*.[12] used 2D strain imaging (for the 1st time) in the assessment of subclinical LV dysfunction in patients with MS. In almost all of these studies, mild and moderate MS patients were included in the studies, while the number of severe MS patients was either very small or excluded.

Rajesh *et al*.[8] found that magnitude of change in MPI post-BMV had inverse correlation to baseline MPI. The improvement of global LV function after BMV is thus inversely correlated to baseline global LV function. Hence, it may be assumed that the performance of early BMV, before significant worsening of global LV function may yield better long-term outcomes and needs to be assessed by future studies with larger sample size.

We found that in pre-operative, the mean GLS (mean ± S.D.) of patients was −16.4240 ± 1.6995. In after 24 h, the mean GLS (mean ± S.D.) of patients was −17.4860 ± 1.6318. In after 1 month, the mean GLS (mean ± S.D.) of patients was −17.9720 ± 1.7786. In after 6 months, the mean GLS (mean ± S.D.) of patients was −19.3640 ± 1.3759. Distribution of mean GLS versus group was statistically significant ($P < 0.0001$).

CONCLUSION

There was a significant reduction in the LV function parameters in severe rheumatic MS. Impaired LV long-axis function was present in 77% of the study group. Immediately after BMV, there was an improvement in the LV long-axis function. There was a gradual improvement in global LV function post-BMV.

Patients with MS and preserved EF% had a lower 2D longitudinal LV systolic S and Sr compared to the control group. 2D longitudinal LV systolic S and Sr imaging appears to be useful in the detection of subclinical LV systolic dysfunction in patients with MS and preserved EF%.

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