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**Original Research Article**

# Evaluation of left and right ventricular functions pre and post balloon mitral Valvuloplasty using speckled tracking echocardiography

**Pawan Mehta[1], Vishwa Deepak Tripathi[2]***

[1]Department of Cardiology, Eternal Heart Care Centre, Jaipur, Rajasthan, India
[2]Department of Cardiology, Vindhya Hospital and Research Centre, Rewa, Madhya Pradesh, India

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***Correspondence:**
Dr. Vishwa Deepak Tripathi,
E-mail: drvdtripathi@hotmail.com



## ABSTRACT

**Background:** Rheumatic heart disease remains a considerable cause of cardiovascular morbidity and mortality in developing countries such as India. The aim of the present study was to compare ventricular (LV and RV) function in patients with severe mitral stenosis (MS) undergoing balloon mitral Valvuloplasty (BMV) with those on medical management and also with healthy controls and to assess the burden of ventricular (LV and RV) systolic dysfunction, its determinants, and its reversibility with percutaneous balloon mitral Valvuloplasty using speckle tracking echocardiography in patients with severe MS.
**Methods:** This prospective study was performed in a tertiary care center, Dr. Ram Manohar Lohia Institute of Medical Sciences, Lucknow in patients with severe MS, from September 2014 to September 2015. A total of 60 were divided into three groups. Cases (n=30), patients with severe MS undergoing BMV; case controls (n=20), patients with severe MS who did not give consent for BMV and chose medical management and healthy controls (n=10). Cases who underwent BMV were analyzed pre and post BMV and detailed echocardiographic and speckle-tracking echocardiography (STE) was done at baseline, 24-48 hours after BMV and at post one month after BMV. Appropriate statistical analysis was applied and different parameters were compared.
**Results:** Most of the cases (56.7%) control (65%) and healthy controls (40%) were between 21-30 years of age. Female preponderance was observed in the study. A significant (p=0.01) decrease in the LA size, PASP (p=0.0001), MV PG area (p=0.0001) and significant (p=0.0001) increase in the LVEF, MVA area was observed from baseline to post 24-48 hours and at post one month after BMV among cases. Significant improvement was noticed in longitudinal strain and regional rotation in different LV segments as assessed by STE at post 24-48 hours and post one month after BMV (p value 0.001) among cases. No significant (p>0.05) difference in the 2D echo parameters was seen from baseline to follow-ups among the case controls. No significant improvement was observed in regional rotation, global rotation in different LV and RV segments after one month as assessed by STE among case controls whereas significant improvement was seen in cases.
**Conclusions:** BMV results in marked improvement in LV and RV GLS immediately post BMV with improvement towards normalization at follow up after one month and the same can be easily assessed by Speckle tracking echocardiography.

**Keywords:** Rheumatic heart disease, Mitral stenosis, Speckle tracking echocardiography

## INTRODUCTION

Rheumatic heart disease (RHD) is one of the most common forms of cardiac diseases worldwide, particularly in developing countries, where it remains the second most common cause of cardiovascular morbidity and mortality after atherosclerotic vascular disease. Even in developed nations, where RHD has been almost

eradicated, recent reports have emphasized the disturbing possibility of a resurgence of this disease.[1,2]

Although the exact pathogenesis of RHD remains controversial, it is primarily a disease of the endocardium, causing permanent damage to the cardiac valves.[3,4] Mitral stenosis (MS) is the most common valve lesion seen in chronic RHD and usually manifests with exertional dyspnea and features of right heart failure resulting from pulmonary hypertension. Unlike the other commonly encountered valve lesions (mitral regurgitation, aortic stenosis, and aortic regurgitation), MS does not produce any significant hemodynamic load on the left ventricle, and therefore, left ventricle (LV) systolic dysfunction is pretty uncommon in the setting of MS. However, a few studies have reported that LV systolic dysfunction may not be so uncommon in patients with rheumatic MS.[5,6]

Right ventricular (RV) function plays an important role in development of clinical symptoms and prognosis in patients with MS. This is primarily because of hemodynamic effect on RV due to pulmonary hypertension. Long-term improvement in RV function in patients with MS has been shown in different hemodynamic studies after percutaneous balloon mitral Valvuloplasty (BMV).[7] However, immediate effect of BMV on RV function was examined in only few studies.

Two-dimensional speckle-tracking echocardiography (STE) is being used now days to assess ventricular systolic functions, as it permits more comprehensive evaluation of myocardial contractile function than conventional measures. We planned to assess the burden of ventricular (LV and RV) systolic dysfunction, its determinants, and its reversibility with percutaneous balloon mitral Valvuloplasty using speckle tracking echocardiography in patients with severe MS.

## METHODS

This study is a prospective study performed in a tertiary care center, Dr. Ram Manohar Lohia Institute of Medical Sciences, Lucknow in patients with severe MS, from September 2014 to September 2015. A total of 60 patients were included in the study after receiving informed consents. Patients were analyzed pre and post intervention (Medical/BMV) using speckle tracking echocardiography and baseline LV and RV systolic functions were compared with healthy controls.

Patients with age >10 years of both sexes who are ready to give informed consent and with severe MS suitable for BMV were included in the study. Patients having coexistent significant MR or aortic valve disease, established coronary artery disease or any other structural heart disease, patients associated with diabetes mellitus, COPD, pregnancy, malignancy, CKD and patients who developed more than moderate MR after BMV and any contraindication to BMV were excluded from the study.

Patients visiting cardiology OPD or IPD with the diagnosis of rheumatic MS were thoroughly examined after taking detailed history and were subjected to routine hematological and biochemical investigations.

Transthoracic echocardiographic examination was done by Philips IE 33 (Philips Medical Systems, USA) machine and once BMV was planned on the basis of echo findings, speckle tracking echocardiography was done and recorded by single observer (PM). All examinations were recorded for offline analysis. Ventricular strain and strain rate were derived from apical four chambers, three chamber and short axis views.

Subjects were divided into three groups:

- Cases (n=30): Patients with severe MS undergoing BMV
- Case controls (n=20): Patients with severe MS who did not give consent for BMV and chose medical management
- Healthy controls (n=10).

Cases who underwent BMV were analyzed pre and post BMV and detailed echocardiographic and STE was done at baseline, 24-48 hours after BMV and at post one month after BMV. During BMV different cardiac catheterization parameters were examined and recorded (a wave, v wave, LA mean pressure, EDG and LVEDP). Appropriate statistical analysis was applied and different parameters were compared pre and post BMV (24-48 hours and post one month).

Case controls (patients with severe MS on medical management) were analyzed at baseline and at one month follow up. Detailed 2D echocardiographic and STE was done and recorded. Appropriate statistical analysis was applied and different parameters were compared from baseline with one month.

Detailed 2D echocardiographic and STE was done and recorded at baseline of healthy controls and compared them with cases and cases controls.

### *Statistical analysis*

The results are presented in mean±SD and percentages. The Chi-square test was used to compare the categorical variables at the baseline between cases and controls.

The Unpaired t-test was used to compare discrete variables at the baseline between cases and controls. The paired t-test was used to compare the change in discrete variables from baseline to post and one month. The McNemar's and Kendal's tests were used to compare the changes in the dichotomous and categorical variables from baseline to post and one month respectively. The p-value<0.05 was considered significant. All the analysis was carried out by using SPSS 16.0 version (Chicago, Inc., USA).

## RESULTS

A total of 60 patients were involved in the study after meeting inclusion criteria.

Most of the cases (56.7%) controls (65%) and healthy controls (40%) were between 21-30 years of age with no significant (p=0.79) difference in the age between the groups as given in Table 1.

**Table 1: Age distribution of cases and controls.**

| Age in years | Cases (n=30) | | Controls (severe MS) (n=20) | | Healthy controls (n=10) | |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % |
| <20 | 4 | 13.3 | 1 | 5.0 | 1 | 10.0 |
| 21-30 | 17 | 56.7 | 13 | 65.0 | 4 | 40.0 |
| 31-40 | 4 | 13.3 | 3 | 15.0 | 3 | 30.0 |
| >40 | 5 | 16.7 | 3 | 15.0 | 2 | 20.0 |
| Mean±SD | 28.77±11.02 | | 30.00±10.01 | | 27.8±10.02 | |

**Table 2: Gender distribution of cases and controls.**

| Gender | Cases (n=30) | | Controls (severe MS) (n=20) | | Healthy controls (n=10) | |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % |
| Male | 7 | 23.3 | 5 | 25.0 | 3 | 30.0 |
| Female | 23 | 76.7 | 15 | 75.0 | 7 | 70.0 |

**Table 3: Baseline MV scores between cases and controls.**

| MV score parameters | Cases (n=30) | Controls (severe MS) (n=20) | p-value[1] |
|---|---|---|---|
| Calcification | 1.10±0.30 | 1.15±0.36 | 0.60 |
| Thickening | 1.97±0.18 | 1.90±0.30 | 0.34 |
| Subvalvular apparatus | 1.97±0.18 | 1.95±0.22 | 0.77 |
| Mobility | 1.93±0.25 | 1.80±0.41 | 0.16 |
| Total | 6.96±0.55 | 6.80±0.76 | 0.37 |

**Table 4: Baseline other echocardiographic measurements between cases and case controls (severe MS).**

| Other echocardiographic measurements | Cases (n=30) | Controls (severe MS) (n=20) | p-value |
|---|---|---|---|
| LA size ($mm^2$), mean±SD | 3713.00±847.15 | 3647.00±859.92 | 0.79[a] |
| LVEF (%), mean±SD | 54.37±2.41 | 53.80±2.68 | 0.44[a] |
| **MR, no. (%)** | | | |
| Mild | 28 (93.3) | 18 (90.0) | 0.67[b] |
| Moderate | 2 (6.7) | 2 (10.0) | |
| **AR, no. (%)** | | | |
| Mild | 29 (96.7) | 20 (100.0) | 0.40[b] |
| Moderate | 1 (3.3) | 0 (0.0) | |
| **TR, no. (%)** | | | |
| Mild | 4 (13.3) | 3 (15.0) | 0.58[b] |
| Moderate | 10 (33.3) | 4 (20.0) | |
| Severe | 16 (53.3) | 13 (65.0) | |
| **PAH, no. (%)** | | | |
| Mild | 2 (6.7) | 4 (20.0) | 0.42[b] |
| Moderate | 6 (20.0) | 5 (25.0) | |
| Severe | 21 (70.0) | 10 (50.0) | |
| No PAH | 1 (3.3) | 1 (5.0) | |
| PASP, mean±SD (mmHg) | 96.43±27.01 | 97.05±23.80 | 0.93[a] |
| MV area, mean±SD $cm^2$ | 0.75±0.10 | 0.73±0.11 | 0.70[a] |
| MV PG, mean±SD (mmHg) | 35.00±10.91 | 33.95±10.90 | 0.74[a] |
| MV MG, mean±SD(mmHg) | 17.73±4.23 | 17.45±4.43 | 0.82[a] |

[a]Unpaired t-test, [b]Chi-square test; MR- Mitral regurgitation; AR- aortic regurgitation; TR- tricuspid regurgitation; PAH- Pulmonary hypertension.

Table 2 shows the gender distribution of cases and controls. Majority of the cases (76.7%), controls (75%) and healthy controls (70%) were females with no significant (p=0.89) difference in the gender difference between the groups. Table 3 presents the baseline MV score between cases and controls. No significant (p>0.05) difference was observed in MV score parameters between cases and controls at baseline.

No significant (p>0.05) difference in the echocardiographic measurements between cases and controls at baseline was noted as given in Table 4.

Table 5 presents the changes noted in various determinants associated with MV at base line, pre and post BMV among cases. A significant (p=0.01) decrease in the LA size, PASP (p=0.0001), MV PG area (p=0.0001) and significant (p=0.0001) increase in the LVEF, MA area was observed from baseline to post 24-48 hours and at post one month. A significant (p <0.01) change in LV speckled tracking GC strain, GL strain and RV speckled tracking (GL strain) was observed from baseline to post 24-48 hours and post one month.

**Table 5: Changes observed in various determinants after intervention (BMV) among cases.**

| | | Mean change from baseline to follow-ups | P value[1] | Mean change from post 24-48 hours to one month | P value[1] |
|---|---|---|---|---|---|
| **LA size ($mm^2$)** | | | | | |
| Baseline | 3713.00±847.15 | - | - | - | |
| Post 24-48 hours | 3232.83±806.72 | -480.16±836.83 | 0.004* | - | |
| One month | 2955.03±550.55 | -757.96±754.98 | 0.0001* | 277.80±668.83 | 0.03 |
| **LVEF %** | | | | | |
| Baseline | 54.37±2.41 | - | - | - | |
| Post 24-48 hours | 59.87±1.47 | 5.50±2.20 | 0.0001* | - | |
| One month | 62.67±1.34 | 8.30±2.48 | 0.0001* | 2.80±1.60 | 0.0001* |
| **PASP** | | | | | |
| Baseline | 96.43±27.01 | - | - | - | - |
| Post 24-48 hours | 72.76±24.65 | 23.66±19.04 | 0.0001* | - | - |
| One month | 56.24±19.77 | 40.19±21.76 | 0.0001* | 16.52±13.42 | 0.0001* |
| **MV area $cm^2$** | | | | | |
| Baseline | 0.75±0.10 | - | - | - | - |
| Post 24-48 hours | 1.37±0.12 | 0.63±0.13 | 0.0001* | - | - |
| One month | 1.42±0.11 | 0.67±0.13 | 0.0001* | 0.04±0.13 | 0.09 |
| **MV PG (mmHg)** | | | | | |
| Baseline | 35.00±10.91 | - | - | - | - |
| Post 24-48 hrs | 16.63±7.22 | 18.36±11.59 | 0.0001* | - | - |
| One month | 12.70±4.75 | 22.30±10.82 | 0.0001* | 3.93±4.50 | 0.0001* |
| **MV MG (mmHg)** | | | | | |
| Baseline | 17.73±4.23 | - | - | - | - |
| Post 24-48 hours | 7.30±5.55 | 10.43±6.08 | 0.0001* | - | - |
| One month | 5.87±4.44 | 11.86±4.44 | 0.0001* | 1.43±3.10 | 0.01* |
| **LV speckled tracking GL strain %** | | | | | |
| Baseline | -13.10±3.67 | - | - | - | - |
| Post 24-48 hours | -14.77±3.98 | 1.66±3.86 | 0.02* | - | - |
| One month | -17.20±3.44 | 4.10±2.73 | 0.0001* | 2.43±2.51 | 0.0001* |
| **LV speckled tracking GC strain%** | | | | | |
| Baseline | -19.18±7.58 | - | - | - | - |
| Post 24-48 hours | -24.86±8.23 | 5.67±8.26 | 0.001* | - | - |
| One month | -28.18±7.10 | 9.00±5.31 | 0.0001* | 3.32±3.02 | 0.002* |
| **RV speckled tracking GL strain %** | | | | | |
| Baseline | -9.43±5.75 | - | - | - | - |
| Post 24-48 hours | -13.87±8.93 | 4.43±7.52 | 0.003* | - | - |
| One month | -17.37±5.72 | 7.93±6.93 | 0.0001* | 3.50±6.24 | 0.005* |

[1]Paired t-test, *Significant; LVEF- LV ejection fraction, PASP- Pulmonary artery systolic pressure,

Figure 1 shows the comparison of MR from baseline to follow-ups among the cases. No significant (p>0.05) change was observed in MR from baseline to post and one month.

A significant change (p<0.05) was observed in TR and PAH from baseline to post 24-48 hrs and post one month as depicted in Figure 2 and 3.

**Table 6: Comparison of catheterization study parameters from baseline to follow-ups among the cases.**

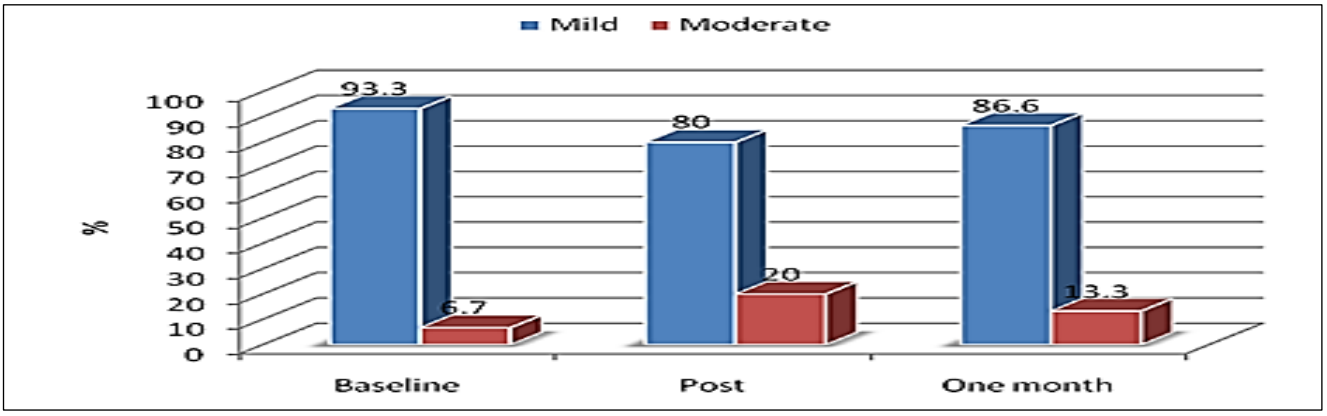
| Catheterization study parameters | Pre BMV (mmHg) | Post BMV (mmHg) | Mean change | |
|---|---|---|---|---|
| | | | Baseline to post BMV | P value[1] |
| A wave | 31.87±6.68 | 22.03±5.43 | 9.83±5.86 | 0.0001* |
| V wave | 34.27±11.36 | 25.77±10.65 | 8.50±13.56 | 0.002* |
| End diastolic gradient | 20.83±7.42 | 5.10±4.38 | 15.73±7.57 | 0.0001* |
| LA mean pressure | 25.50±6.87 | 18.03±6.43 | 7.46±6.97 | 0.0001* |
| LVEDP | 16.87±3.36 | 12.60±4.68 | 4.26±4.46 | 0.0001* |

[1]Paired t-test, *Significant; LVEDP- Left ventricular end diastolic pressure

**Table 7: Comparison of speckled tracking parameters in different LV segments from baseline to follow-ups among the cases-longitudinal strain and regional rotation.**

| Longitudinal strain | | | | P value[1] | |
|---|---|---|---|---|---|
| | Baseline | Post 24-48 hours | Post one month | Baseline to post 24-48 hours | Baseline to one month |
| BAL | -10.23±2.24 | -18.34±4.56 | -21.37±4.13 | 0.0001* | 0.0001* |
| MAL | -18.45±5.35 | -21.34±6.34 | -24.14±6.25 | 0.002* | 0.0001* |
| ApL | -19.21±7.45 | -23.47±7.21 | -26.45±7.81 | 0.0001* | 0.0001* |
| Apex | -15.21±6.36 | -19.35±6.29 | -23.46±6.39 | 0.0001* | 0.0001* |
| ApS | -26.57±9.81 | -16.45±7.68 | -14.56±6.24 | 0.0001* | 0.0001* |
| MIS | -9.14±3.23 | -21.37±5.34 | -26.25±6.34 | 0.0001* | 0.0001* |
| BIS | -8.99±4.35 | -17.56±4.78 | -23.12±5.67 | 0.0001* | 0.0001* |
| **Regional rotation** | | | | | |
| BAL | -2.23±1.10 | -3.27±1.15 | -3.79±1.19 | 0.10 | 0.09 |
| MAL | -3.56±1.13 | -4.36±1.17 | -4.99±1.25 | 0.11 | 0.10 |
| ApL | -4.23±1.78 | -5.46±1.89 | -6.01±1.56 | 0.17 | 0.14 |
| Apex | -1.13±0.11 | -1.34±0.15 | -1.57±0.18 | 0.12 | 0.11 |
| ApS | -1.54±0.13 | -1.43±0.16 | -1.34±0.17 | 0.15 | 0.14 |
| MIS | -1.32±0.10 | -1.47±0.15 | -1.67±0.22 | 0.12 | 0.11 |
| BIS | -2.35±1.20 | -2.46±1.23 | -2.56±1.11 | 0.14 | 0.13 |

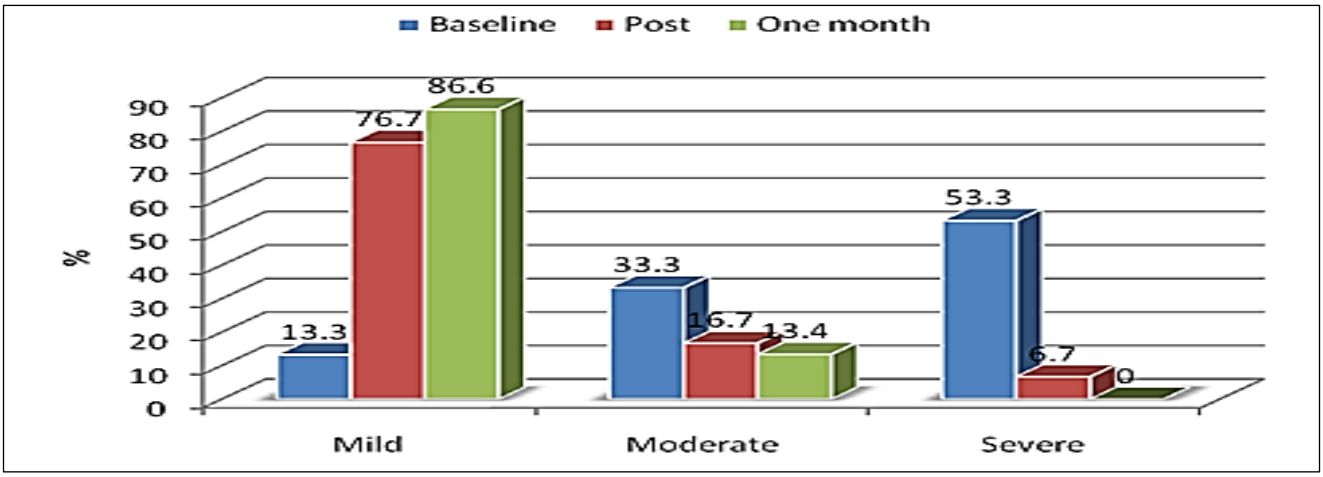
[1]Paired t-test, *Significant; BAL-Basal Anterolateral; MAL- Mid Anterolateral; ApL-Apicolateral; ApS-Apicoseptal; MIS-Midseptal; BIS-Basalseptal




Significance was calculated by McNemar's Test. P=0.11 from base line to post 24-48 hours; p= 0.10 from baseline to one month; p=0.15 from post 24-48 hours to one month.

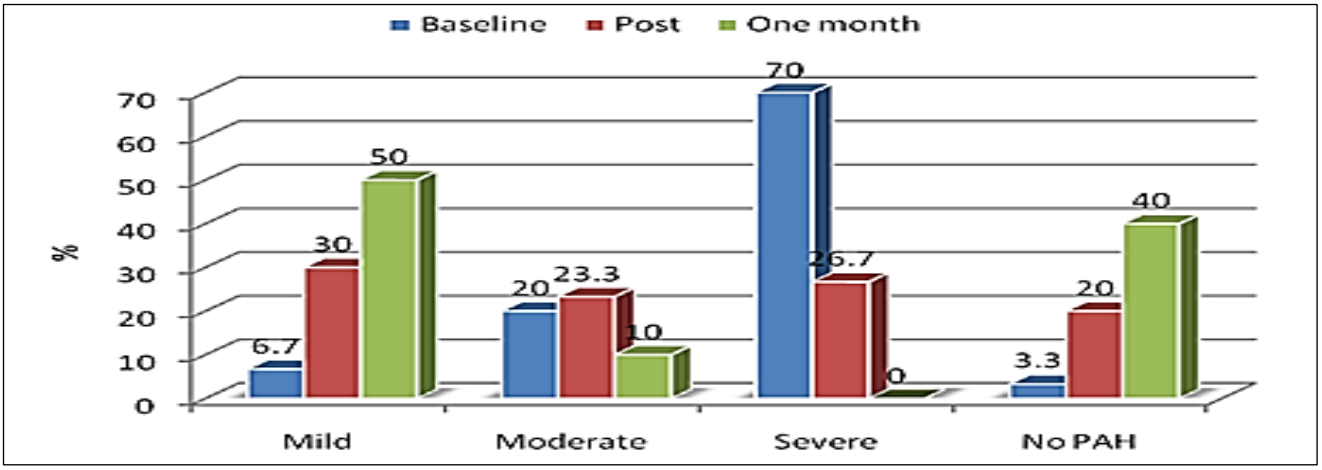
**Figure 1: Comparison of MR from baseline to follow-ups among the cases.**

In this study, a significant (p<0.01) change was observed in the catheterization study parameters from baseline to post BMV among cases as given in Table 6. As shown in Table 7, there was significant improvement in longitudinal strain and insignificant progress in regional rotation in different LV segments as assessed by STE at post 24-48 hours and post one month after BMV (p value 0.001) among cases.




Significance was calculated by Kendal's tau test. P=0.02 from base line to post 24-48 hours; p= 0.03 from baseline to one month; p=0.04 from post 24-48 hours to one month.

**Figure 2: Comparison of TR from baseline to follow-ups among the cases.**




Significance was calculated by Kendal's tau test. P=0.002 from base line to post 24-48 hours; p= 0.001 from baseline to one month; p=0.02 from post 24-48 hours to one month.

**Figure 3: Comparison of PAH from baseline to follow-ups among the cases.**

**Table 8: Comparison of speckled tracking parameters in different LV segments from baseline to follow-ups among the cases-circumferential strain and global rotation.**

| Circumferential strain | | | | P value[1] | |
|---|---|---|---|---|---|
| | **Baseline** | **Post 24-48 hours** | **Post one month** | **Baseline to post 24-48 hours** | **Baseline to one month** |
| BAS | -28.34±11.14 | -43.25±12.34 | -56.13±12.45 | 0.0001* | 0.0001* |
| BA | -38.56±12.24 | -31.34±12.56 | -38.52±12.34 | 0.0001* | 0.0001* |
| BAL | -40.12±13.24 | -32.23±13.25 | -39.34±13.12 | 0.0001* | 0.0001* |
| BIL | -23.12±11.21 | -31.23±11.23 | -37.35±11.56 | 0.0001* | 0.0001* |
| BI | -25.45±13.24 | -38.56±13.67 | -45.65±13.23 | 0.0001* | 0.0001* |
| BIS | -32.78±14.23 | -43.56±14.29 | -49.45±14.12 | 0.0001* | 0.0001* |
| **Global rotation** | | | | | |
| BAS | -9.21±2.26 | -4.47±2.11 | -3.27±2.10 | 0.0001* | 0.0001* |
| BA | -2.90±1.11 | -4.87±2.11 | -6.56±2.16 | 0.02* | 0.0001* |
| BAL | -7.01±2.33 | -5.13±2.12 | -4.15±2.10 | 0.03* | 0.0001* |
| BIL | -9.12±3.12 | -6.10±2.14 | -4.12±2.13 | 0.002* | 0.0001* |
| BI | - | - | - | | |
| BIS | - | - | - | | |

[1]Paired t-test, *Significant; BAL-Basal Anterolateral; MAL- Mid Anterolateral; ApL-Apicolateral; ApS-Apicoseptal; MIS-Midseptal; BIS-Basalseptal

**Table 9: Comparison of speckled tracking parameters in different LV segments from baseline to follow-ups among the cases-longitudinal and circumferential strain rate.**

| Longitudinal strain rat | | | | P value[1] | |
|---|---|---|---|---|---|
| | Baseline | Post 24-48 hours | Post One month | Baseline to post 24-48 hours | Baseline to one month |
| BAL | -1.11±0.23 | -1.23±0.11 | -2.14±0.25 | 0.13 | 0.10 |
| MAL | -1.51±0.12 | -1.12±0.22 | -1.00±0.10 | 0.10 | 0.18 |
| ApL | -1.44±0.17 | -1.66±0.12 | -1.99±0.13 | 0.15 | 0.19 |
| Apex | -2.11±0.18 | -1.13±0.11 | -1.10±0.16 | 0.09 | 0.23 |
| ApS | -1.21±0.13 | -2.14±0.17 | -2.78±0.14 | 0.07 | 0.06 |
| MIS | -1.13±0.14 | -2.14±1.10 | -2.78±0.16 | 0.08 | 0.06 |
| BIS | -1.16±0.16 | -1.25±0.19 | -1.47±0.13 | 0.16 | 0.13 |
| **Circumferential strain rate** | | | | | |
| BAS | -1.32±0.11 | -1.43±0.10 | -1.49±0.13 | 0.15 | 0.14 |
| BA | -1.12±0.17 | -1.32±0.14 | -1.39±0.13 | 0.16 | 0.15 |
| BAL | -1.42±0.10 | -1.21±0.18 | -1.10±0.15 | 0.13 | 0.12 |
| BIL | -1.32±0.16 | -1.52±0.17 | -1.58±0.22 | 0.12 | 0.11 |
| BI | -1.11±0.22 | -1.54±0.14 | -1.57±0.12 | 0.18 | 0.16 |
| BIS | -1.43±0.19 | -1.65±0.13 | -1.72±0.15 | 0.11 | 0.09 |

[1]Paired t-test, *Significant; BAL-Basal Anterolateral; MAL- Mid Anterolateral; ApL-Apicolateral; ApS-Apicoseptal; MIS-Midseptal; BIS-Basalseptal

**Table 10: Comparison of speckled tracking parameters in different RV segments from baseline to follow-ups among the cases-longitudinal strain and its rate and regional rotation.**

| Longitudinal strain | | | | P value[1] | |
|---|---|---|---|---|---|
| | Baseline | Post 24-48 hours | Post One month | Baseline to post 24-48 hours | Baseline to one month |
| BAL | -6.11±2.21 | -6.10±2.13 | -6.09±2.16 | 0.11 | 0.10 |
| MAL | -8.11±2.30 | -6.15±2.10 | -5.23±2.14 | 0.02* | 0.002* |
| ApL | -6.12±2.12 | -28.14±8.31 | -32.15±8.76 | 0.0001* | 0.0001* |
| Apex | -16.11±4.56 | -20.15±4.23 | -25.27±4.57 | 0.0001* | 0.0001* |
| ApS | -34.23±11.23 | -22.24±10.14 | -16.45±6.78 | 0.0001* | 0.0001* |
| MIS | -10.11±3.21 | -19.45±4.35 | -27.25±5.47 | 0.0001* | 0.0001* |
| BIS | -15.45±5.67 | -8.78±2.30 | -4.56±1.13 | 0.0001* | 0.0001* |
| **Longitudinal strain rate** | | | | | |
| BAL | -1.21±0.11 | -1.80±0.13 | -1.89±0.10 | 0.19 | 0.15 |
| MAL | -1.80±0.16 | -2.32±0.17 | -2.45±0.14 | 0.22 | 0.21 |
| ApL | -8.10±2.13 | -5.11±1.24 | -4.34±1.15 | 0.09 | 0.07 |
| Apex | -10.12±2.17 | -1.18±0.15 | -0.34±0.04 | 0.0001* | 0.0001* |
| ApS | -1.54±0.15 | -2.43±0.17 | -3.10±0.14 | 0.10 | 0.08 |
| MIS | -9.13±2.24 | -1.34±0.16 | -0.36±0.05 | 0.0001* | 0.0001* |
| BIS | -2.32±1.10 | -3.19±1.18 | -4.23±1.21 | 0.19 | 0.15 |
| **Regional rotation** | | | | | |
| BAL | -5.11±1.25 | -6.78±2.13 | -8.56±2.30 | 0.11 | 0.10 |
| MAL | -6.87±2.13 | -8.23±2.25 | -10.67±2.88 | 0.14 | 0.13 |
| ApL | -7.56±3.12 | -6.45±3.16 | -5.45±3.23 | 0.13 | 0.11 |
| Apex | -5.11±2.16 | -7.67±2.89 | -9.34±2.79 | 0.17 | 0.12 |
| ApS | -6.23±2.19 | -7.32±2.45 | -8.79±2.90 | 0.15 | 0.14 |
| MIS | -6.34±2.67 | -7.69±2.16 | -8.67±2.10 | 0.13 | 0.11 |
| BIS | -6.81±3.12 | -5.23±2.19 | -4.56±1.25 | 0.14 | 0.12 |

[1]Paired t-test, *Significant; BAL-Basal Anterolateral; MAL- Mid Anterolateral; ApL-Apicolateral; ApS-Apicoseptal; MIS-Midseptal; BIS-Basalseptal

**Table 11: Comparison of 2D echo parameters from baseline to follow-ups among the case controls (severe MS).**

| | Baseline | One month | Mean change from baseline to one month | P value |
|---|---|---|---|---|
| LA size | 3647.00±859.92mm$^2$ | 3635±768.67mm$^2$ | 12.00±123.45 | 0.11[a] |
| LVEF | 53.80±2.68% | 54.45±3.26% | 0.65±1.56 | 0.10[a] |
| PASP | 97.05±23.80mmHg | 96.12±22.24mmHg | 0.93±2.14 | 0.13[a] |
| MV area | 0.73±0.11cm$^2$ | 0.74±0.22cm$^2$ | 0.01±1.24 | 0.25[a] |
| MV PG | 33.95±10.90 mmHg | 31.56±9.56 mmHg | 2.39±5.68 | 0.18[a] |
| MV MG | 17.45±4.43 mmHg | 16.48±5.34 mmHg | 0.97±2.34 | 0.21[a] |
| **MR, no. (%)** | | | | |
| Mild | 18 (90.0) | 17 (85.0) | - | 0.25[b] |
| Moderate | 2 (10.0) | 3 (15.0) | - | |
| **AR, no. (%)** | | | | |
| Mild | 20 (100.0) | 20 (100.0) | - | 0.34[b] |
| Moderate | 0 (0.0) | 0 (0.0) | - | |
| **TR, no. (%)** | | | | |
| Mild | 3 (15.0) | 4 (20.0) | - | 0.22[b] |
| Moderate | 4 (20.0) | 3 (15.0) | - | |
| Severe | 13 (65.0) | 13 (65.0) | - | |
| **PAH, no. (%)** | | | | |
| Mild | 4 (20.0) | 5 (25.0) | - | 0.21[b] |
| Moderate | 5 (25.0) | 4 (20.0) | - | |
| Severe | 10 (50.0) | 10 (50.0) | - | |
| No PAH | 1 (5.0) | 1 (5.0) | - | |

[a]Paired t-test, [b]McNemar's/Kendal's test; MR- Mitral regurgitation; AR- aortic regurgitation; TR- tricuspid regurgitation; PAH- Pulmonary hypertension.

**Table 12: Comparison of LV and RV speckled tracking parameters from baseline to follow-ups among the case controls.**

| | Baseline | One month | Mean change from baseline to one month | P value[1] |
|---|---|---|---|---|
| **LV speckled tracking parameters** | | | | |
| GL strain | -13.67±4.36% | -14.34±3.26% | 0.67±2.12 | 0.13 |
| GC strain | -18.21±6.57% | -19.23±4.36% | 1.02±2.67 | 0.09 |
| **RV speckled tracking parameters** | | | | |
| GL strain | -9.91±5.36% | -10.11±4.16% | 0.20±3.22 | 0.23 |

[1]Paired t-test

**Table 13: Comparison of speckled tracking parameters in different LV segments from baseline to follow-ups among the case controls (Severe MS)- regional and global rotation.**

| | Baseline | One month | Mean change from baseline to one month | P value[1] |
|---|---|---|---|---|
| **Regional rotation** | | | | |
| BAS | -7.56±2.26 | -7.43±2.15 | 0.13±2.14 | 0.31 |
| BA | -7.67±3.22 | -7.21±2.23 | 0.46±1.34 | 0.12 |
| BAL | -7.89±3.34 | -7.32±1.13 | 0.57±2.15 | 0.47 |
| BIL | -6.16±2.24 | -6.11±2.23 | 0.05±1.13 | 0.13 |
| BI | -6.86±2.47 | -6.52±2.26 | 0.34±2.16 | 0.21 |
| BIS | -8.10±1.11 | -8.01±1.28 | 0.09±1.27 | 0.25 |
| **Global rotation** | | | | |
| BAS | -9.11±2.16 | -8.99±2.23 | 0.12±1.28 | 0.37 |
| BA | -2.78±1.21 | -2.87±1.11 | 0.09±1.29 | 0.56 |
| BAL | -7.11±2.34 | -6.00±2.22 | 1.11±2.35 | 0.23 |
| BIL | -9.11±3.22 | -9.10±2.04 | 0.01±1.12 | 0.66 |
| BI | - | - | | |
| BIS | - | - | | |

[1]Paired t-test; BAL-Basal Anterolateral; MAL- Mid Anterolateral; ApL-Apicolateral; ApS-Apicoseptal; MIS-Midseptal; BIS-Basalseptal

**Table 14: Comparison of speckled tracking parameters in different RV segments from baseline to follow-ups among the case controls (severe MS)- regional rotation.**

| | Baseline | One month | Mean change from baseline to one month | P value[1] |
|---|---|---|---|---|
| BAL | -5.08±1.20 | -5.18±2.23 | 0.1±2.14 | 0.17 |
| MAL | -6.47±2.14 | -6.53±2.13 | 0.06±2.11 | 0.34 |
| ApL | -7.36±3.02 | -7.25±3.26 | 0.11±2.17 | 0.13 |
| Apex | -5.02±2.36 | -5.17±2.19 | 0.15±1.25 | 0.12 |
| ApS | -6.13±2.11 | -6.32±2.15 | 0.19±3.26 | 0.11 |
| MIS | -6.12±2.17 | -6.69±2.26 | 0.57±3.25 | 0.09 |
| BIS | -6.71±3.32 | -6.83±2.19 | 0.12±4.21 | 0.12 |

[1]Paired t-test; BAL-Basal Anterolateral; MAL- Mid Anterolateral; ApL-Apicolateral; ApS-Apicoseptal; MIS-Midseptal; BIS-Basalseptal

On comparison of speckled tracking parameters in different RV segments in longitudinal strain and its rate and in regional rotation an improvement was seen from baseline to follow-ups among the cases (Table 10). No significant ($p>0.05$) difference in the 2D echo parameters was seen from baseline to follow-ups among the case controls (Table 11). In this study, no significant improvement was seen in LV GLS, GCS and in RV GLS after one month as assessed by STE among case controls (severe MS).

**Table 15: 2D echo parameters at baseline among healthy controls.**

| Parameters | Baseline (n=10) |
|---|---|
| LA size | 2247.00±359.92 $mm^2$ |
| LVEF | 64.10±2.23 % |
| PASP | 18.15±5.40 mmHg |
| MV area | 3.34±0.67 $cm^2$ |
| MV PG | 10.25±6.80 mmHg |
| MV MG | 6.15±2.13 mmHg |
| **MR, no. (%)** | |
| Mild | 6 (60.0) |
| Moderate | 0 (0.0) |
| No MR | 4 (40.0) |
| **AR, no. (%)** | |
| Mild | 4 (40.0) |
| Moderate | 0 (0.0) |
| No AR | 6 (60.0) |
| **TR, no. (%)** | |
| Mild | 6 (60.0) |
| Moderate | 0 (0.0) |
| No TR | 4 (40.0) |
| **PAH, no. (%)** | |
| Mild | 0 (0.0) |
| Moderate | 0 (0.0) |
| Severe | 0 (00.0) |
| No PAH | 10 (100.0) |

MR- Mitral regurgitation; AR- aortic regurgitation; TR-tricuspid regurgitation; PAH- Pulmonary hypertension

**Table 16: LV speckled tracking parameters at baseline among healthy controls.**

| | Baseline |
|---|---|
| **LV speckled tracking parameters** | |
| GL strain | -22.17±2.30% |
| GC strain | -30.21±4.17% |
| **RV speckled tracking parameters** | |
| GL strain | -21.23±6.16% |

GCS- Global circumferential strain; GLS- Global longitudinal strain

**Table 17: Speckled tracking parameters in different LV and RV segments at baseline among healthy controls- regional rotation and global rotation.**

| | Baseline (%) |
|---|---|
| **Regional rotation in LV segments** | |
| BAL | -8.00±2.12 |
| MAL | -4.78±1.23 |
| ApL | -3.11±1.12 |
| Apex | -7.11±2.11 |
| ApS | -8.44±2.19 |
| MIS | -7.87±1.16 |
| BIS | -4.11±1.00 |
| **Global rotation in LV segments** | |
| BAS | -5.17±2.12 |
| BA | -7.51±2.15 |
| BAL | -6.25±2.13 |
| BIL | -5.22±2.14 |
| BI | - |
| BIS | - |
| **Regional rotation in RV segments** | |
| BAL | -7.24±2.26 |
| MAL | -6.53±2.19 |
| ApL | -34.25±8.16 |
| Apex | -27.17±4.17 |
| ApS | -18.15±6.18 |
| MIS | -29.15±5.27 |
| BIS | -5.16±1.10 |

BAL-Basal Anterolateral; MAL- Mid Anterolateral; ApL-Apicolateral; ApS-Apicoseptal; MIS-Midseptal; BIS-Basalseptal.

Table 13 concludes that no significant improvement was observed in regional rotation, global rotation in different LV segments after one month as assessed by STE among case controls (severe MS). There is no significant improvement in regional rotation in different RV segments after one month as assessed by STE among case controls (severe MS).

Table 15 presents the observation 2D echo parameters of healthy controls at baseline. Out of 10 cases,6 cases showed mild mitral, aortic and tricuspid regurgitation. In 4 cases, no such observations were seen. None of the case had pulmonary hypertension.

Table 16 shows the baseline values of LV and RV speckled tracking parameters among healthy controls. Baseline values of speckled tracking parameters in different LV and RV segments of regional and global rotation among healthy controls was given in Table 17.

## DISCUSSION

Among all the various population groups studied type II In the past, few studies have reported that LV and RV systolic dysfunction may not be uncommon and may indeed contribute to the development of symptoms in patients with MS.[8] Many haemodynamic and myocardial factors have been proposed to contribute to LV dysfunction in MS. In the present study, LA size, transmitral pressure gradient appear to be the primary determinants of LV systolic dysfunction. We performed study on 50 patients with severe MS, and 10 healthy controls; GLS, GCS and global longitudinal strain rate were found to be significantly lower in patients with MS compared with controls.

Present study showed that the RV systolic function is impaired in patients with severe MS as assessed by global and segmental RV strain. It correlates with earlier hemodynamic and clinical studies, which showed impaired RV function in MS patients.[9] The cause of RV dysfunction is attributed to the increased RV afterload in these patients. Left atrial hypertension in these patients leads to chronic pulmonary venous congestion, which ultimately leads to PH. This is thought to be responsible for increased RV after load and subsequent RV dysfunction in these patients.

Present study is the first study to have systematically evaluated the effect of BMV on myocardial deformation (both LV and RV) using STE. BMV resulted in immediate relief of LV inflow obstruction, and the improved hemodynamics were associated with significant increases in both GLS and GCS within 24-48 hours and one-month post BMV. Dray et al reported a case showing improvement in STE-based longitudinal strain in a young girl who underwent BMV.[10]

There was significantly reduced LV GLS in patients with MS compared with healthy controls (-13.10±3.67% versus -22.17±2.30, P=0.0001). This is in agreement with the studies of Bilenet al and Sengupta et al.[6,11] In order to test an underlying myocardial factor responsible for this decrease, in the present study we compared regional LV longitudinal strain in the study group versus healthy control group. The presence of significant decrease in LV basal and mid-segmental strain values compared with healthy control group and less or non-significant decrease in apical segments point out to possible underlying myocardial factor where rheumatic endocarditis and scarring extend from the mitral annulus to the surrounding LV segments. This myocardial factor could be the cause of incomplete improvement of the GLS after BMV and act as a contributing factor to the main effect of preload reduction in patients with MS on GLS.

Immediately and one month after BMV, there was significant improvement of LV GLS compared with the same measurements before BMV (post one month -17.20±3.44 versus post 24-48 hours -14.77±3.98 versus baseline -13.10±3.67; P=0.0001). Sengupta et al, also demonstrated significant improvement in LV GLS after BMV compared with the baseline measurements before BMV.[11] This points out to an underlying hemodynamic factor through the improvement of the LV inflow by relieving the obstruction caused by MS.

This study showed a trend towards normalization of LV GLS compared with the healthy control group after follow-up period of 1 month (-17.20±3.44% versus -22.17±2.30). Whether this trend will continue on long-term follow-up till the complete normalization of these measurements or the suspected underlying myocardial factor will prevent these variables from complete normalization will need longer term follow-up.

There was significant improvement of LV GCS, compared with the same measurements before BMV (post one month -28.18±7.10 versus post 24-48 hours -24.86±8.23 versus baseline -19.18±7.58; P= 0.0001). Similar observation was made by Sengupta et al.[11]

Similarly, there was significant improvement in LV longitudinal strain, longitudinal strain rate, circumferential strain, circumferential strain rate, regional and global rotation in all LV segments as assessed by STE, immediately i.e. 24-48 hours after and one month later.

There was significant immediate reduction in LA anteroposterior dimension and LA area. These findings are in accordance Adavane et al, who showed immediate decrease in LA volume after BMV in patients in sinus rhythm.[12] The most valid explanation of this immediate reduction in LA size is decompression of LA and better emptying by releasing the mitral valve obstruction by the BMV.

We also found that there was minor improvement in LV ejection fraction. Similar observation was made by

Mohan et al[13] The exact reason for this immediate improvement is unclear, but improvement in the atrial contribution to LV filling, and improved myocardial contractility may be the possible explanations.[14,15]

Immediately and one month after BMV, the most important changes were significant improvement in MVA and MG/PG as assessed by 2-D echocardiography as compared to patients on medical follow up. This study also found reduced RV GLS in patients with MS compared with controls (-9.43±5.75 versus -21.23±6.16). Ozdemiret al and Kumar et al also showed decrease in RV GLS in patients with MS compared with control group.[16,17]

There was difference in regional RV longitudinal strain, as seen in significant decrease in the RV strain values of the septal segments, but there was no significant difference between the RV free wall segments, and those in the healthy control group. This is in agreement with the data obtained by Ozdemiret aland Kumar et al.[16,17]

Immediately after BMV, there was significant improvement of the RV GLS compared with the RV GLS before BMV (post one month -17.37±5.72 versus post 24-48 hrs -13.87±8.93 versus baseline -9.43±5.75, P = 0.0001). Similar significant improvement was noticed by Kumar et al.[17] This improvement could be due to the progress in the RV afterload as a result of the relief of the LV inflow obstruction.

This study showed significant improvement of RV GLS compared with the healthy control group immediately after BMV (-13.87±8.93 versus -21.23±6.16) which continued at follow-up after 1 month (-17.37±5.72 versus -21.23±6.16). We believe that this improvement is directly related to the significant reduction in both RV volumes as well as RV systolic pressure post-BMV. Immediately and one month after BMV, there was significant improvement in RV longitudinal strain, longitudinal strain rate and regional rotation in all RV segments as assessed by STE as compared to patients on medical follow up.

Immediately and one month after BMV, there was significant improvement in severity of TR, PASP as assessed by 2-D echocardiography as compared to patients on medical follow up. Immediately after BMV, there was significant improvement in catheterization parameters (a wave, v wave, EDG, LA mean pressure, LVEDP). These findings are in concordance with the findings of Sengupta and Kumar et al.[11, 17]

## CONCLUSION

The findings of the study suggest that reduced LV diastolic filling rather than an irreversible myocardial structural abnormality contributes predominantly to reduced LV mechanical performance in patients with MS.RV systolic function is impaired in patients with severe MS and can be assessed by global and segmental RV strain before the appearance of clinical signs of systemic venous congestion. BMV results in marked improvement in LV and RV GLS immediately post MBV with improving towards normalization at follow up after one month. Speckle tracking echocardiography is a new, simple, easy and inexpensive method with the potential of becoming the reference clinical tool for the evaluation of LV and RV function (shortening, thickening and torsion).

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