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Original article

# Assessment of Left Ventricular Deformation in Rheumatic Mitral Stenosis Patients: Speckle Tracking Study

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## Abstract

**Objectives:** to utilize speckle tracking echocardiography to assess the left ventricular (LV) systolic function in rheumatic mitral stenosis (MS) patients. **Methods:** 100 patients were evaluated with pure rheumatic MS who were contrasted with 50 healthy individuals of matched age, gender, and risk factors. We assessed the mitral valve area (MVA) utilizing planimetry and the mean transmitral pressure gradient; then based on MVA, the patients were split into two groups. MS patients in the first group were classified as having severe symptoms, while patients in the second group had moderate symptoms. Speckle tracking echocardiography was employed to determine LV subclinical systolic dysfunction. **Results:** Regarding clinical data and LVEF, no statistically significant distinctions were seen between the groups. Global LV longitudinal strain was significantly diminished in MS patients. Both global basal and mid segments strain were significantly diminished in MS patients (P <0.001). On the contrary, with relation to the global apical strain, no statistically significant distinction existed between the groups under investigation (P=0.96). The global basal, mid, and apical longitudinal strain exhibited a significant negative relationship with the mean transmitral pressure gradient. **Conclusions:** MS patients had subclinical LV dysfunction when assessed by strain analysis, and this was unrelated to how severe the hemodynamic blockage was.

**Keywords:** Rheumatic mitral stenosis; Speckle tracking echocardiography; Global longitudinal strain; Left ventricle.

## Introduction

Rheumatic mitral stenosis (MS) continues to be the most prevailing valvular heart condition in poorer nations [(1)]. Nearly, twenty five percent of pure MS patients had impaired left ventricular (LV) performance detected by conventional echocardiography [(2)].

Conventional echocardiography is the principal imaging method employed to determine MS patients regarding the severity and hemodynamic consequences [(3)]. However, it couldn't detect subclinical LV systolic dysfunction in this group of patients.

Speckle-tracking echocardiography is a sophisticated echocardiographic modality that enabled us to evaluate myocardial segmental deformation along the axes that are radial, circumferential, and longitudinal [(4)]. Strain and strain rate can be measured offline after tracking displacement of speckles throughout the cardiac cycle. Myocardial strain is an objective technique for global and regional LV function evaluation [(5)].

Therefore, the objective of our research aimed to determine the LV systolic function in patients with rheumatic MS utilizing speckle tracking echocardiography.

## Methods

***Study population:***

This cross sectional, single center research was performed at Benha University Hospital's cardiac department. It included pure rheumatic MS patients and preserved LF systolic function (LV ejection fraction "LVEF" more than 50%) assessed at our echocardiography unit from July 2021 to July 2023. While conducting the research, 203 MS patients were assessed. 103 patients were excluded due to the existence of associated other valve disorder (n= 34), associated mitral regurge (n= 27), atrial fibrillation (n= 42). The final study population included 100 patients who were separated into two groups: 50 patients with moderate MS comprised the first group, while 50 patients with severe MS comprised the second. They were compared with 50 healthy individuals of matched age, gender, and risk factors as a control group.

We excluded patients with associated mitral regurge and/or other valvular disorder, ischemic heart disease, reduced LV systolic function (LVEF less than 50%), rhythm other than sinus rhythm, rheumatological, liver, and kidney disease.

All patients agreed to participate in our research by delivering an informed consent form. Local ethics committees granted approval for the research.

***Echocardiography:***

Transthoracic echocardiography was completed in the left lateral position with simultaneous ECG recording using EPIQ equipment (Philips, Erlangen, Germany). Digital copies of the images were retained for the purpose of offline analysis. The assessment of echocardiographic measurements was conducted in adherence

to the guidelines set forth by the American Society of Echocardiography [6]. LV volumes and LVEF were measured utilizing modified Simpson's technique. MVA was assessed utilizing mitral valve planimetry with a short axis parasternal view. The mean transmitral pressure gradient was evaluated. All patients had controlled heart rates to avoid inaccurate assessment of transmitral gradient. Severity of MS was estimated according to MVA and transmitral mean pressure gradient; mild MS (MVA >1.5 $cm^2$ and the mean gradient < 5 mmHg), moderate MS (MVA 1-1.5 $cm^2$ and the mean gradient 5- 10 mmHg), and severe MS (MVA <1$cm^2$ and the mean gradient > 10 mmHg) [7].

Utilizing 2D speckle tracking echocardiography, LV myocardial deformation was evaluated. Harmonic imaging was utilized to capture three consecutive end-expiratory cardiac cycles at a frame rate of 50-70 frames per second in the long axis, two chambers, and apical four chamber views. During end-systole, the endocardial border was manually delineated, while the software autonomously monitored the myocardial region of interest. After optimizing the regions of interest, the software proceeds to produce strain curves for various parts of the myocardium **(Figure 1)** [8].

***Statistical analysis:***

Statistical analysis was conducted utilizing version 22 of the IBM SPSS software package. By employing percentages and numbers, qualitative data were described. After assessing normality with Kolmogorov-Smirnov test, median (minimum and maximum) was employed to represent non-parametric quantitative data, whereas the mean and standard deviation were utilized to analyze parametric quantitative data. The (0.05) level of significance was employed to determine the acquired outcomes.

## Results

The groups were of matched age (P=0.368), gender (P=0.317), and risk factors. Demographic and standard echocardiographic information is provided in **table 1**. Concerning BMI, LVEF, weight, height, and heart rate, no statistically significant variations were noted between the groups. Mean transmitral gradient, left atrial (LA) diameter, and pulmonary artery systolic pressure (PASP) were all significantly heightened in patients with severe MS, but MVA was significantly lower (p< 0.001) **(Table 1)**.

Regarding strain data, global LV longitudinal strain was significantly reduced in MS patients. Both global basal and mid segments strain were significantly reduced in MS patients (-14.81±3.72 vs. -16.80±2.72 vs. -22.83±5.11% and -14.57±4.11 vs. -17.72±3.68 vs. -22.06±3.10% respectively, P <0.001). However, with respect to the global apical strain, no statistically significant variation was noted among the groups under investigation. (P=0.96). Moreover, the segmental strain of the individual basal and mid segments was significantly lower in MS patients (P <0.001) **(Table 2)**.

A significant adverse connection existed between the mean transmitral pressure gradient and global basal longitudinal strain

(r = -0.564, p <0.0 01), global mid longitudinal strain (r = -0.596, p <0.001), and global apical longitudinal strain (r = -0.206, p =0.019) **(Figure 1)**.

**Table 1:** Demographic and conventional echocardiographic data

| | **Severe MS (n= 50)** | **Moderate MS (n= 50)** | **Control group (n= 50)** | **P** |
|---|---|---|---|---|
| **Age (years)** | 43.73± 9.14 | 44.18± 10.23 | 45.63± 8.06 | 0.368 |
| **Gender** | | | | |
| **Male** | 7 (14%) | 4 (8%) | 12 (24%) | 0.317 |
| **Female** | 43 (86%) | 46 (92%) | 38 (76%) | |
| **HTN** | 25 (50%) | 25 (50%) | 27 (54%) | 1.0 |
| **DM** | 8 (16%) | 6 (12%) | 6 (12%) | 0.739 |
| **Smoking** | 5 (10%) | 6 (12%) | 10 (20%) | 0.472 |
| **Weight (Kg)** | 79.53 ± 13.39 | 80.81 ± 11.56 | 83.20 ± 12.46 | 0.353 |
| **Height (cm)** | 161.17 ± 5.23 | 164.82 ± 5.98 | 162.27 ± 4.31 | 0.556 |
| **BMI ($Kg/m^2$)** | 30.8 ± 6.23 | 30.06 ± 4.78 | 31.67 ± 5.01 | 0.533 |
| **Heart rate (bpm)** | 91.28 ± 9.27 | 82.10 ± 11.03 | 77.9 ± 8.54 | 0.063 |
| **SBP (mmHg)** | 127 ± 11.11 | 126.45 ± 10.82 | 127.67 ± 11.04 | 0.812 |
| **DBP (mmHg)** | 80 ± 6.95 | 81.27 ± 7.35 | 82 ± 9.97 | 0.558 |
| **LVEF (%)** | 61.07± 4.15 | 62.17± 4.54 | 64.07± 4.44 | 0.088 |
| **LA diameter (cm)** | 5.09± 0.56 | 4.51± 0.52 | 3.22± 0.59 | <0.001 |
| **MVA ($cm^2$)** | 1.182± 0.062 | 1.521± 0.094 | _ | <0.001 |
| **Mean transmitral gradient (mmHg)** | 12.27± 2.11 | 6.67± 1.76 | _ | <0.001 |
| **PASP (mmHg)** | 64±25 | 45±10 | _ | <0.001 |

HTN: hypertension, DM: diabetes mellitus, BMI: body mass index, SBP: systolic blood pressure, DBP: diastolic blood pressure, LVEF: left ventricular ejection fraction, LA: left atrial, MVA: mitral valve area, PASP: pulmonary artery systolic pressure.

**Table 2:** Speckle tracking data of the studied groups

| | Severe MS (n=50) | Moderate MS (n=50) | Control group (n=50) | p |
|---|---|---|---|---|
| **GLS** | -16.9 ± 4.01 | -18.87 ± 3.31 | -23.22 ± 3.77 [a,b] | <0.001 |
| **Basal strain** | | | | |
| **Global** | -14.81± 3.72 | -16.80± 2.72 | -22.83± 5.11 [a,b] | <0.001 |
| **Anteroseptal** | -10.13± 2.16 | -12.91± 1.21 | -15.12± 0.57 [a] | <0.001 |
| **Anterior** | -11.67± 1.09 | -14.78± 0.85 | -18.16± 0.56 [a,b] | <0.001 |
| **Anterolateral** | -12.33± 1.90 | -14.99± 1.37 | -17.62± 0.96 [a,b] | <0.001 |
| **inferolateral** | -15.11± 0.78 | -17.39± 0.82 | -20.30± 1.00 [a,b] | <0.001 |
| **Inferior** | -12.87± 0.98 | -17.12± 1.10 | -22.19± 1.26 [a,b] | <0.001 |
| **Inferoseptal** | -16.78± 2.37 | -18.89± 4.31 | -23.23± 3.61 [a,b] | <0.001 |
| **Mid-segment strain** | | | | |
| **Global** | -14.57± 4.11 | -17.72± 3.68 | -22.06± 3.10 [a,b] | <0.001 |
| **Anteroseptal** | -15.27± 1.28 | -16.55± 0.92 | -26.06± 1.75 [a,b] | <0.001 |
| **Anterior** | -14.56± 1.89 | -17.66± 2.08 | -22.66± 3.99 [a,b] | <0.001 |
| **Anterolateral** | -15.22± 0.99 | -18.25± 1.71 | -22.61± 3.36 [a,b] | <0.001 |
| **inferolateral** | -14.23± 1.13 | -18.95± 1.88 | -20.53± 3.25 [a,b] | <0.001 |
| **Inferior** | -13.22± 1.78 | -15.35± 2.55 | -17.34± 2.63 [a] | <0.001 |
| **Inferoseptal** | -12.33± 3.19 | -16.98± 2.05 | -19.28± 3.30 [a,b] | <0.001 |
| **Apical strain** | | | | |
| **Global** | -21.23± 4.21 | -22.10± 3.54 | -24.76± 3.11 | 0.096 |
| **Anterior** | -21±2.03 | -20±1.81 | -23±1.32 | 0.063 |
| **Lateral** | -22±1.8 | -19±2.01 | -24±0.81 | 0.812 |
| **Septal** | -22±1.7 | -22±1.70 | -21±2.09 | 0.558 |
| **Inferior** | -21±2.08 | -21±0.92 | -24±0.91 | 0.561 |

[a]= sig. from severe MS, [b]= sig. from moderate MS. GLS: global longitudinal strain.

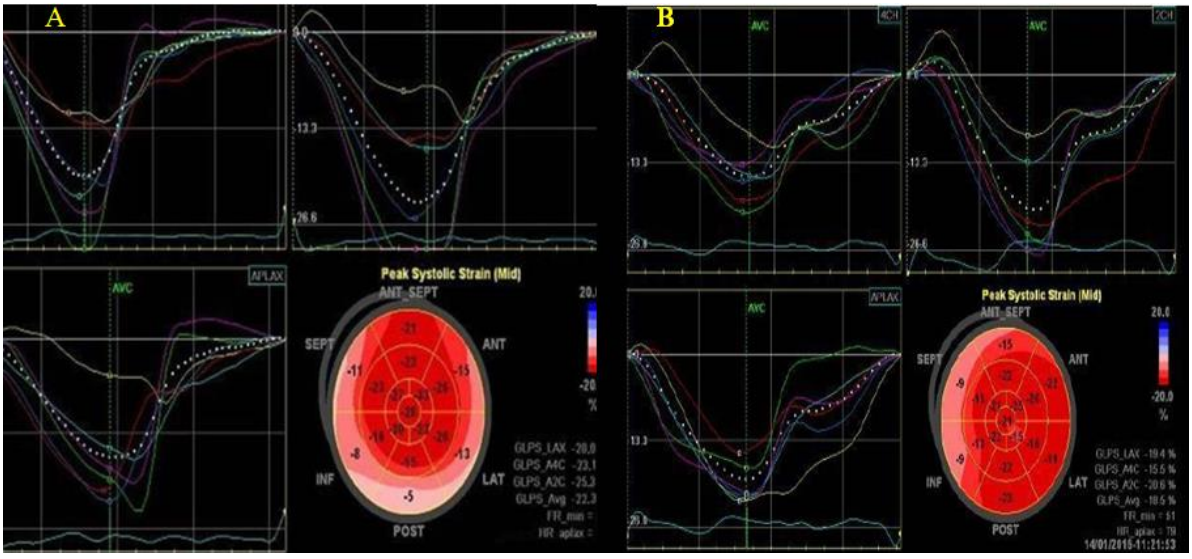


**Figure 1:** Speckle tracking echocardiography strain curves and Bull's eye of LV GLS of (A) a severe MS case; average GLS = -22.3% and (B) moderate MS case showing average GLS = -18.5%. LV: left ventricular; GLS: global longitudinal strain; MS: mitral stenosis.

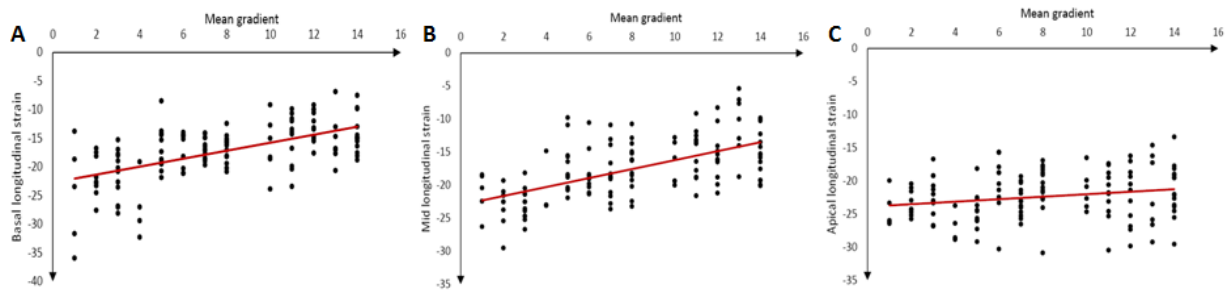


**Figure 2:** Scatter plot correlation between the mean transmitral gradient and global basal (A), mid-segment (B), and apical (C) longitudinal strain.

## Discussion

Rheumatic cardiac disorder is the most prevalent etiology of MS. Despite the decline in its prevalence, it continues to pose a significant health concern [(9)]. MS is purported to have no hemodynamic effect on the LV. However, 25–30% of MS patients exhibit LV dysfunction, according to some studies. In addition, most of these studies were conducted using conventional echocardiography or left ventriculography on patients with severe MS. In our study, all the patients had normal LV systolic function with no significant statistical variation between the studied groups. However, strain measurements revealed that global longitudinal, global basal, and global mid-segment strain were significantly reduced in MS patients. Moreover, the segmental strain of each basal and mid segments was significantly reduced in MS patients. However, the apical strain did not show significant statistical variation between MS patients and controls which may be due to the compensatory mechanisms in response to MS, as changes in LV remodeling or regional contractility may have a different effect on apical segment than basal and mid segments.

Subclinical LV dysfunction in patients with severe MS may be associated with faster disease progression [(10)]. Therefore, patients with severe MS and lower strain values need closer follow up.

Our results were supported by other study [(11)] where it was reported that LV GLS, RV free wall LS (longitudinal strain), IVS (İnterventricular septum) LS, and LV torsion were significantly varied among groups. MS patients exhibit significantly diminished absolute strain values as opposed to their elevated LV torsion.

It was documented that [(12)] the MS group exhibited a significantly reduced global longitudinal, circumferential (GCS), and radial strain ($p < 0.001$ for GLS, $p = 0.02$ for GCS and $p < 0.001$ for GRS). Although the mean twist angle was greater in the MS group ($p = 0.11$), this difference failed to attain statistical significance.

Conversely, LV torsion was significantly greater in MS patients than in control subjects ($p = 0.03$).

Our outcomes showed that a significant negative connection existed between mean transmitral pressure gradient and basal longitudinal strain, mid longitudinal strain, and apical longitudinal strain. A finding like that done by others[12] who established a substantial link between MVA and all strain measurements, with GLS having the greatest correlation coefficient ($r = 0.56$, $p < 0.001$). The connection between left ventricular rotation measurements and planimetric MVA was not statistically significant.

However, in the study that assessed left and right ventricular deformation in severe mitral stenosis patients who were having balloon mitral valvuloplasty, discovered that MS patients had a decreased LV GLS despite having a normal LVEF. Nonetheless, no link between MS severity and LV strain measurements was discovered [13].

It is possible to predict clinical events associated with MS, such as the onset of AF or signs of heart failure, based on a reduction in LV strain. According to Barros-Gomes et al. [14] after balloon mitral valvoplasty, the global longitudinal strain of the LV is a significant prognostic indicator that correlates strongly with mortality or reintervention. This observation, however, is restricted to those with severe MS. Furthermore, previous studies have established LV strain as a prognostic indicator for the advancement of heart failure in DM patients or chemotherapy-induced dilated cardiomyopathy, among others [15].

## Limitations

Our research has many limitations. Initially, the research was conducted at a single center utilizing a small sample size. Second, we did not measure other strain parameters as circumferential and radial strain. Third, we did not assess the prognostic role of global longitudinal strain in the studied patients. Therefore, further studies with follow up of the patients are required. Last, interobserver and intraobserver variability was not assessed.

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