Evaluation of Left Ventricular Function in Patient with Rheumatic Mitral Stenosis by Using Speckle Tracking Echocardiography

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Abstract

Background: Rheumatic heart disease (RHD) remains a significant health burden in many parts of the world, particularly in developing countries. Rheumatic mitral stenosis (MS) is one of the most common manifestations of RHD, characterized by the narrowing of the mitral valve orifice due to chronic inflammation and fibrosis. The aim of this study was to assess left ventricular systolic function in patients with rheumatic mitral stenosis by speckle tracking echocardiography.

Methods: This was a single center, cross sectional, comparative study that was conducted at the cardiology department of Benha University Hospital from July 2019 to July 2021 on with isolated rheumatic mitral stenosis and preserved LV function. All patients were subjected to full history taking including age, gender and cardiovascular risk factors including smoking, hypertension, and diabetes. NYHA functional classification and clinical examination: including heart rate, systolic and diastolic blood pressure, chest and heart auscultation. D- Laboratory investigations, ECG and Transthoracic Echocardiography (TTE).

Results: There was no statistically significant difference observed among the studied group regarding the age (p=0.368). The gender distribution showed varying proportions of males (14%, 8%, and 24%) and females (86%, 92%, and 76%) in the Moderate MS, Severe MS, and Control groups, respectively, but no statistically significant difference in gender distribution was found among the groups (p=0.317).

Conclusions: Speckle tracking echocardiography is a reliable and effective tool for evaluating left ventricular systolic function in patients with rheumatic mitral stenosis. This non-invasive technique allows for a comprehensive assessment of myocardial mechanics, providing valuable information beyond traditional echocardiographic parameters.

Keywords: Left Ventricular, Rheumatic Mitral Stenosis, Speckle Tracking Echocardiography.

1. Introduction

Rheumatic heart disease (RHD) remains a significant health burden in many parts of the world, particularly in developing countries. Rheumatic mitral stenosis (MS) is one of the most common manifestations of RHD, characterized by the narrowing of the mitral valve orifice due to chronic inflammation and fibrosis [1]. It leads to impaired left ventricular (LV) function and can result in various clinical manifestations, including heart failure, arrhythmias, and systemic embolization [2,3].

Accurate assessment of LV systolic function is crucial for the management and prognostication of patients with rheumatic MS [4]. Traditionally, echocardiography has been the primary modality used for evaluating LV function. However, conventional echocardiographic parameters such as ejection fraction (EF) and fractional shortening (FS) have limitations, as they are load-dependent and may not accurately reflect subtle changes in myocardial mechanics [5,6].

With the advancement of imaging technology, speckle tracking echocardiography (STE) has emerged as a promising tool for the assessment of LV function. STE allows for the quantitative analysis of myocardial deformation by tracking speckles, or small acoustic markers, within the myocardial tissue. It provides objective measurements of strain and strain rate, which are indicators of myocardial contractility and regional LV function [7,8].

In recent years, there has been growing interest in the application of STE in various cardiac conditions, including ischemic heart disease, dilated cardiomyopathy, and valvular heart disease. However, limited data exist regarding its utility in patients with rheumatic MS. Given the unique pathophysiological characteristics of rheumatic MS, with chronic inflammation and fibrosis affecting the subendocardial layers of the myocardium, the evaluation of LV function using STE in these patients may provide valuable insights into the disease process and aid in clinical decision-making [9,10].

Therefore, the aim of this study was to assess left ventricular systolic function in patients with rheumatic mitral stenosis using speckle tracking echocardiography.

2. Materials and Methods

This was a single center, cross sectional, comparative study that was conducted at the cardiology department of Benha University Hospital from July 2019 to July 2021. A total

of 125 patients with rheumatic mitral stenosis were evaluated.

Inclusion criteria were patients with isolated rheumatic mitral stenosis and preserved LV function.

Exclusion criteria were other significant valve disease, congenital heart disease, ischemic heart disease, reduced ejection fraction (EF>50%), pericardial disease, diabetic patients, and segmental wall motion abnormalities.

The study was conducted after being approved by the ethical relative committee and informed consent was obtained from all participants in this research.

All patients in the study had been subjected to A- Full history taking: Clinical information of patients had been recorded as age, gender and cardiovascular risk factors including smoking, hypertension, and diabetes. B- **NYHA functional classification, C- Clinical examination:** including heart rate, systolic and diastolic blood pressure, chest and heart auscultation. D- **Investigations: Laboratory investigations:** (CBC, lipid profile, liver and kidney function). **ECG:** Twelve-lend electrocardiogram at 25 mm/s speed and 1m V/10 mm calibration was recorded to detect the presence of ischemic changes as ST segment deviation (Transient elevation or depression) and T wave changes.

Transthoracic Echocardiography (TTE): Echocardiography was done using Vivid E 9 XD Clear, produced by GE Healthcare, with probe 4.2 MHz, 4V probe for all the patients in the left lateral position.

Conventional echocardiography:

Severity of mitral stenosis

In the parasternal short-axis view, planimetry was performed to measure the mitral orifice area, which is an important parameter for assessing mitral stenosis. Echocardiography is considered the primary diagnostic tool for mitral stenosis, as it allows visualization of a thickened and calcified mitral valve with a narrow and fish-mouth shaped orifice. Additionally, echocardiography can reveal diastolic doming of the anterior leaflet and thickening and calcification of the subvalvular apparatus. In the apical four-chamber view, two-dimensional color Doppler imaging was utilized to guide cursor placement in the turbulent area of transmitral flow. Continuous Doppler recordings were obtained to assess parameters such as mean transmitral pressure gradients, peak early diastolic and atrial systolic transmitral flow velocities, E/A ratio, and mitral valve area using the pressure half-time method. The severity of mitral stenosis was classified based on the mitral

valve area and transmitral valve mean gradient, categorizing it as mild, moderate, or severe. To determine the suitability of the mitral valve structure for percutaneous mitral balloon valvuloplasty, the Wilkins score was used. The score takes into account valve thickness, mobility, calcification, and subvalvular thickness, aiming to identify individuals at risk of developing severe mitral regurgitation after the intervention.

Pulmonary artery systolic pressure (PASP): PASP was estimated from the tricuspid regurgitant jet velocity using the modified Bernoulli equation and adding the estimated right atrial pressure (RAP) on the basis of inferior vena cava (IVC) diameter and collapsibility.

LA dimension: LA anteroposterior diameter was measured at the para sternal long axis view orthogonal to the aortic root, at the level of the sinus of Valsalva using the leading edge–to–leading edge convention.

LV function: The following m-mode parameters were obtained guided by parasternal long axis view; end-diastolic and end-systolic diameters of the LV, interventricular and posterior left ventricular wall thickness in systole and diastole. Left ventricular ejection fraction was measured.

Speckle tracking echocardiography: Three consecutive end-expiratory cardiac cycles were captured using harmonic imaging at a frame rate of 50-70 frames per second. Cardiac images were obtained from multiple views, including the apical four chamber, apical two chamber, apical long axis, and parasternal basal, mid, and apical views. Offline analysis of grayscale images was performed using 2D speckle tracking echocardiography (2D-STE). The endocardial border was manually traced in end-systole, and the software automatically tracked the myocardial region of interest. Strain curves were generated for different myocardial segments, including the basal, mid, and apical inferior septal wall, antero-lateral wall, anterior wall, infero-lateral wall, and antero-septal segments. The global longitudinal strain was calculated as the mean strain of all 17 segments.

Statistical analysis

The data collected for analysis in this study were processed using IBM SPSS software package version 22.0. Descriptive statistics were used to summarize the data, with qualitative data presented as numbers and percentages. For qualitative data comparison, the Chi-Square test was employed, with the Monte Carlo test serving as a correction when cells had counts less than 5 (>25% of the cells)

in tables larger than 2x2. In 2x2 tables with similar count limitations, the Fisher's Exact test was used. When comparing quantitative data between two groups, parametric tests such as the Student t-test were used for normally distributed data, while the Mann-Whitney U test was applied for non-parametric data. The significance level was set at 0.05.

3. Results

The demographic characteristics of the studied groups revealed comparable mean ages across the Moderate MS group (43.73 years, SD=9.14), Severe MS group (44.18 years, SD=10.23), and Control group (45.63 years, SD=8.06), with no statistically significant difference observed (p=0.368). The gender distribution showed varying proportions of males (14%, 8%, and 24%) and females (86%, 92%, and 76%) in the Moderate MS, Severe MS, and Control groups, respectively, but no statistically significant difference in gender distribution was found among the groups (p=0.317).

Table (1) Demographic characteristics among the studied groups

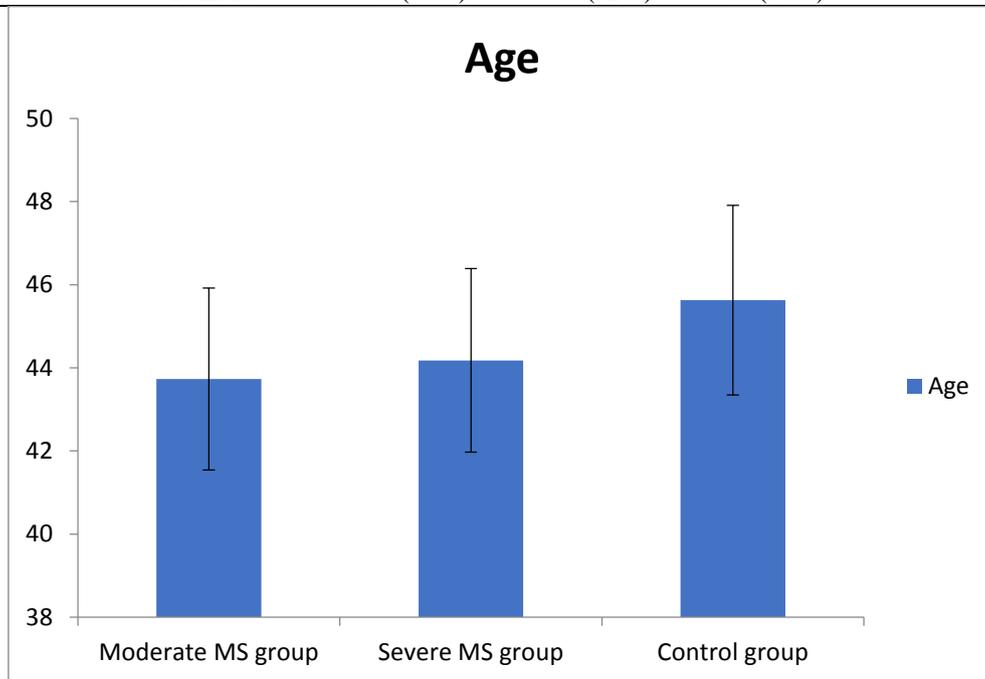|		Moderate MS group (No. = 50)	Severe MS group (No. = 50)	Control group (No. = 30)	P-value
Age (years)	Mean± SD	43.73± 9.14	44.18± 10.23	45.63± 8.06	0.368
Gender	Male	7(14%)	4 (8%)	12(24%)	0.317
	Female	43(86%)	46 (92%)	38(76%)	

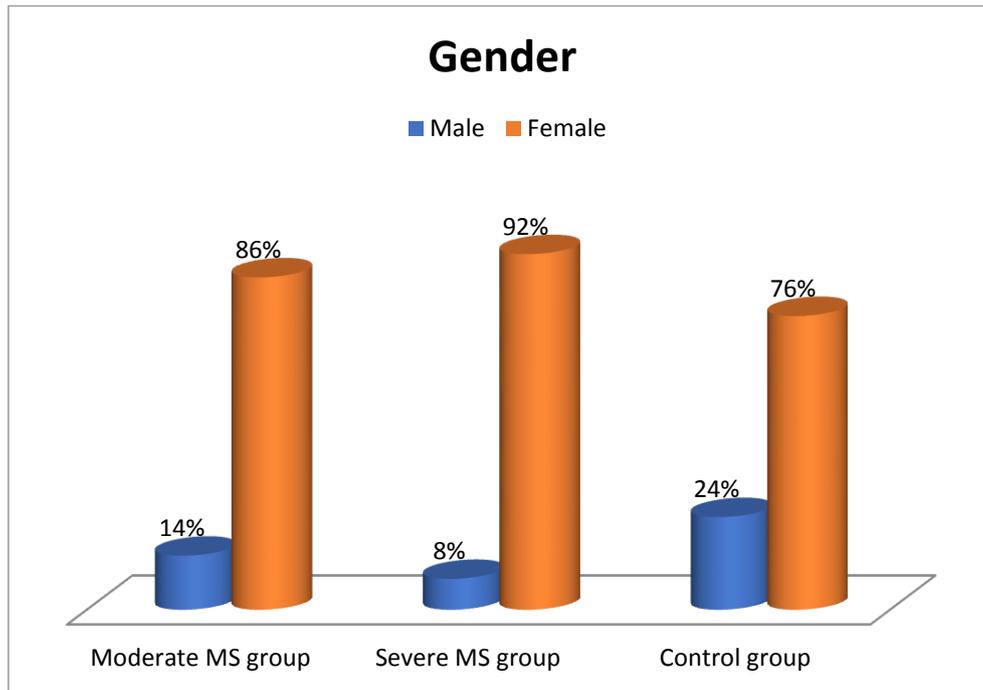**Fig. (1)** Boxplot comparing the study groups regarding age.

Fig. (2) Bar chart showing comparison between study groups regarding gender.

Also, there was no statistically significant difference between the two groups regarding history of hypertension (P=1.0), DM (P= 0.739) and smoking (P=0.472).
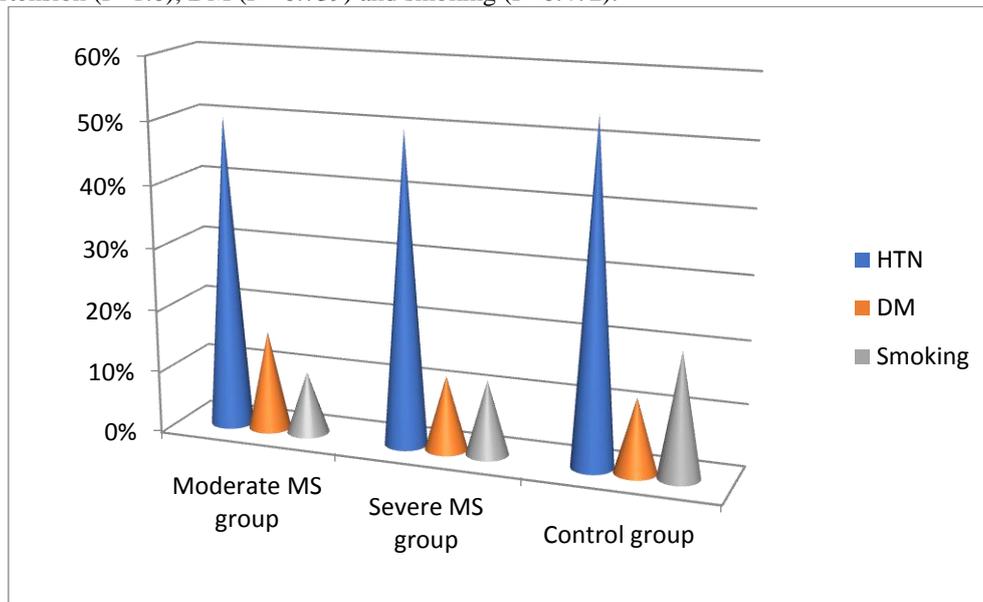

Fig. (3) Bar chart showing comparison between study groups regarding risk factors.

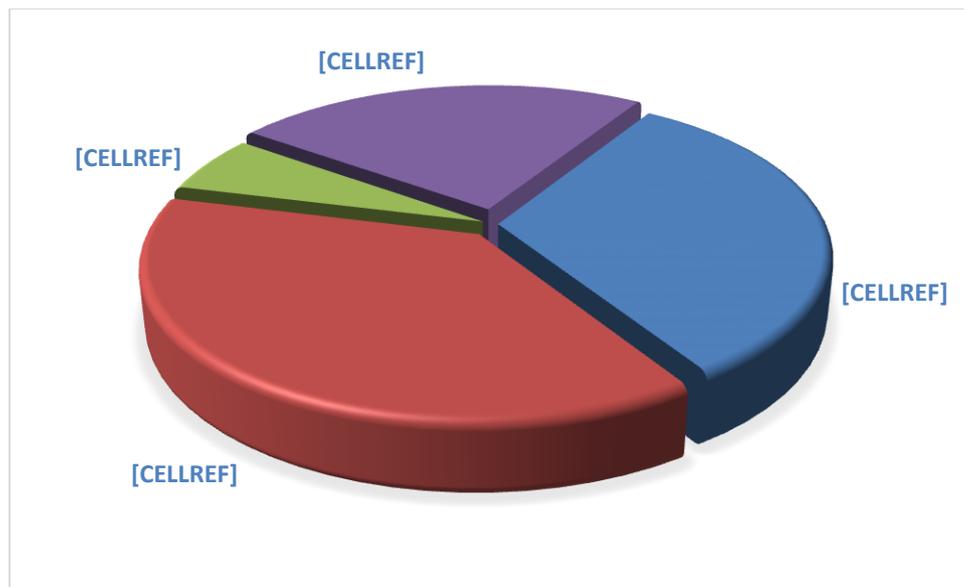More patients with severe MS had NYHA class II. However, patients with moderate MS had NYHA class I & II (P=0.005).
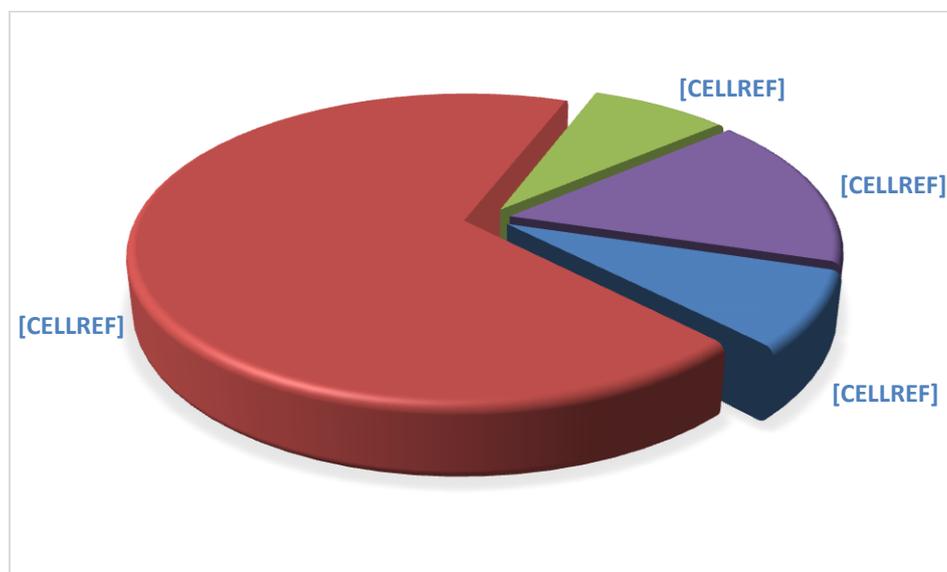
Fig. (4) NYHA classification in Moderate MS group

Fig. (5) NYHA classification in severe MS group

4. Discussion

The most common cause of mitral stenosis (MS) is rheumatic heart disease. Despite down trending prevalence, it still causes an important public health problem. MS is among the most common cardiovascular causes of mortality and morbidity after atherosclerotic heart diseases, especially in developing countries [11-13].

Left ventricle (LV) is claimed to be not hemodynamically affected by MS. However, some studies have shown LV dysfunction in patients with MS. However, neither predisposing factors nor early changes are clearly understood. In addition, most of these studies were performed in patients with severe MS and were performed by conventional two-dimensional echocardiography or left ventriculography [14,15].

With the introduction of deformation imaging which is superior to conventional echocardiographic parameters for detecting subclinical myocardial dysfunction, LV impairment can be assessed easier and better. Speckle tracking echocardiography (STE) is a deformation analysis technique that uses real-time datasets to monitor the region of interest in the myocardium, alleviating the technical problems caused by translation and rotational movements, free of geometric assumptions, and makes more satisfactory measurements [16].

The main aim of this study was to assess left ventricular systolic function in patients with rheumatic mitral stenosis by speckle tracking echocardiography.

Our study included 100 patients with isolated mitral stenosis who were compared with 30 control individuals.

Our study observed no statistically significant difference in age among the studied groups (p=0.368), which is consistent with Poyraz et al. [17] and Casas-Rojo et al. [18] where age was not a differentiating factor. Similarly, the gender distribution in our study did not show any statistically significant differences among the groups (p=0.317), aligning with the results reported in Poyraz et al. study [17]. These similarities in demographic characteristics across multiple studies strengthen the generalizability of our findings and highlight the consistency in the population profiles within the context of rheumatic mitral stenosis research.

In the present study, our analysis revealed no statistically significant difference between the two groups (Moderate MS and Severe MS) with regard to the history of hypertension (p=1.0), diabetes mellitus (p=0.739), and smoking (p=0.472). These findings suggest that these factors may not play a substantial role in differentiating between the severity groups of rheumatic mitral stenosis. This is in line with previous studies, such as Poyraz et al. [17] and Casas-Rojo et al. [18], which also reported non-significant associations between hypertension, diabetes mellitus, smoking, and the severity of mitral stenosis. These consistent results highlight the need for further exploration and consideration of other potential factors that may contribute to the progression and severity of rheumatic mitral stenosis.

Our study provides valuable insights into the evaluation of left ventricular systolic function in patients with rheumatic mitral stenosis using speckle tracking echocardiography.

The findings of our study contribute to the existing literature by demonstrating the utility of speckle tracking echocardiography as a non-invasive method for assessing myocardial mechanics in patients with mitral stenosis.

The evaluation of left ventricular systolic function using speckle tracking echocardiography offers a comprehensive assessment of myocardial mechanics, which goes beyond traditional echocardiographic parameters in patients with mitral stenosis.

Our study highlights the potential of speckle tracking echocardiography in detecting subtle changes in left ventricular systolic function, which may have important clinical implications for the management and prognostication of patients with rheumatic mitral stenosis.

The use of speckle tracking echocardiography allows for the quantification of global and regional left ventricular strain parameters, providing a more detailed assessment of myocardial function in patients with mitral stenosis.

The findings from our study suggest that speckle tracking echocardiography can aid in the early detection and monitoring of left ventricular dysfunction in patients with rheumatic mitral stenosis, potentially leading to improved risk stratification and treatment decisions.

Further studies are warranted to validate the utility of speckle tracking echocardiography in assessing left ventricular function in larger cohorts and to explore its prognostic value in patients with rheumatic mitral stenosis.

5. Conclusions

Speckle tracking echocardiography is a reliable and effective tool for evaluating left ventricular systolic function in patients with rheumatic mitral stenosis. This non-invasive technique allows for a comprehensive assessment of myocardial mechanics, providing valuable information beyond traditional echocardiographic parameters.

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