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Original Article

Decreased Systolic Left Atrial Strain Measures Correlate With the Valve Area Among Patients With Severe Mitral Stenosis

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ABSTRACT

Background: Rheumatic heart disease is the main cause of mitral stenosis in developing countries. The assessments of left atrial deformation have yielded promising results in the evaluation of atrial function and the prediction of the long-term outcomes of many cardiac diseases. In this study, we sought to assess peak left atrial longitudinal strain (PALS) measures in patients with severe rheumatic mitral stenosis and to evaluate its variations regarding different valve areas.

Methods: Patients with severe symptomatic rheumatic mitral stenosis were recruited for the study. Mitral valve planimetry was performed via 3D evaluations using the multiplanar reconstruction method. PALS was measured by speckle-tracking echocardiography.

Results: Eighty-four patients were enrolled in the study. The mean PALS was 11.18 ± 6.40% among the patients. The PALS measures were significantly higher in the patients in the sinus rhythm than in the group with atrial fibrillation (12.32 ± 6.38% vs 9.04± 5.74%; P = 0.03). The left atrial strain measures had a significant correlation with the mitral valve area and a significant reverse correlation with the left atrial volume index (r = 0.3, P = 0.08 and r = 0.28, P = 0.02, respectively). No significant difference was demonstrated in the PALS measures between the patients with the Wilkin score of 8 or less (32%, 25 patients) and those with the Wilkin score of 9 or more (67%, 55 patients).

Conclusions: Peak systolic left atrial strain was severely reduced in our patients with severe mitral stenosis. The severity of longitudinal strain impairment correlated with the valve area; however, it did not have a significant relationship with the Wilkin score of the valve. ***(Iranian Heart Journal 2020; 21(2): 21-26)***

KEYWORDS: Mitral stenosis, Rheumatic heart disease, Speckle-tracking, Left atrial strain

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It is estimated that about 30 million young people have chronic rheumatic heart disease worldwide, of whom a third have mitral stenosis. The majority of these patients live in developing countries. [1]

As the left atrium (LA) is the direct adjacent chamber to the diseased valve, it is significantly affected by its hemodynamic effects. The remodeling and enlargement of the chamber, stagnation of the blood flow, thrombosis formation, and atrial arrhythmias are some of the recognized consequences. [2, 3]

LA deformation assessments have yielded promising results in the evaluation of atrial function. They have also been proposed as the potential predictors of the long-term outcomes of many cardiac diseases. [4-6] There are a few studies that have analyzed LA deformation parameters among rheumatic valve diseases. In this study, we aimed to assess the peak systolic LA longitudinal strain measures in a group of patients with severe rheumatic mitral stenosis and to assess its variations regarding different valve areas and the severity of rheumatic involvement.

METHODS

This study was conducted in Rajaei Cardiovascular, Medical, and Research Center, affiliated with Iran University of Medical Sciences. Patients with a diagnosis of rheumatic mitral stenosis of severe intensity (defined as a mitral valve area < 1.5 cm^2 based on the latest valvular disease guidelines [7]) who were also symptomatic were recruited for the study. Patients with concomitant valvular lesions with moderate or more intensity (including mitral regurgitation) or left ventricular ejection fraction of 40% or less were excluded. Eighty-four patients were enrolled in the study from March 2018 to March 2019.

The study protocol was approved by the institutional ethics committee, and written informed consent was obtained from all the patients.

The entire study population underwent transthoracic and transesophageal echocardiographic examination. All the echocardiographic examinations were performed by a single fellow of echocardiography using an Epiq 7C ultrasound machine (Philips Medical Systems, Netherlands). The echocardiographic measurements were carried out based on the latest guidelines. [8, 9] LA volume was calculated via the biplane disc summation technique (Figure 1B and 1C). An average of the measurements of each value in 5 beats was reported. Mitral valve planimetry was performed by 3D evaluation using the multiplanar reconstruction method in all the patients. The strain measurements were performed via the speckle-tracking method in our study. LA strain during the reservoir phase, known as peak systolic left atrial longitudinal strain (PALS), was measured as the difference in the strain value at mitral valve opening minus ventricular end-diastole. The peak systolic LA longitudinal strain value was calculated as the average of the values measured in the 4- and 2-chamber views after the manual tracing of the LA borders and the auto-calculation of the measures with the Q-lab software (Philips Medical Systems, Netherlands) (Fig. 1A). [10]

Statistical Analysis

The statistical analyses were performed with SPSS, version 15) (SPSS Inc, Chicago, Illinois). Mean values, standard deviations, and frequencies were used for the descriptive analysis. For the evaluation of the distribution of the data, the one-sample Kolmogorov–Smirnov test was employed. The Mann–Whitney *U* test was used for the statistical comparisons of the quantitative variables between 2 groups. The Kruskal-Wallis test was utilized for the comparisons of the variables between more than 2 groups.

The Bland–Altman method and the interclass correlation (ICC) were used to test reliability between 2 echocardiographic ejection fraction measurements. The Spearman or Pearson correlation coefficient was used to measure the strength of the linear relationship between the variables. A *P* value of less than 0.05 was considered significant.

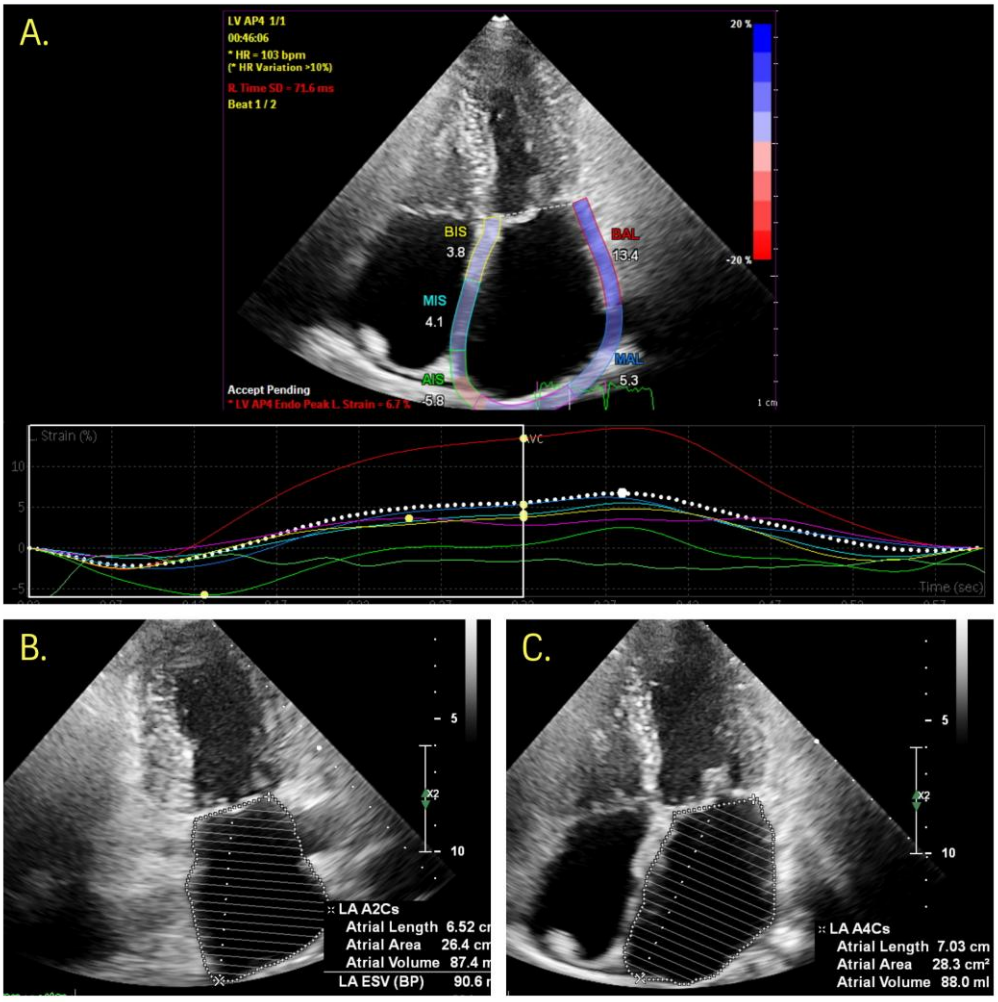

Figure 1-A. Calculation of peak systolic left atrial longitudinal strain by speckle-tracking B and C. Calculation of left atrial volume via the biplane disc summation technique in the 2- and 4-chamber transthoracic views.

RESULTS

Eighty-four patients with severe symptomatic mitral stenosis were enrolled in the study. The mean age of the participants was 48.46 ± 11.73 years. Male patients (n =15) accounted for 17% of the population. At the time of visit, 22% (n =19) of the patients had atrial fibrillation.

The conventional echocardiographic data of the patients are summarized in Table 1. The mean PALS, calculated as an average of the 2- and 4- chamber view measures, was 11.18 ± 6.40% (mean PALS in the 4-chamber view = 11.07 ± 6.43% and mean PALS in the 2-chamber view = 11.49 ± 6.89%). There was a strong correlation between the measures in the 2- and 4-chamber measurements ($r = 0.93$, $P < 0.001$).

Table 1: Echocardiographic data of the study population

	Mean	SD
MVA(CM^2)	0.97	0.23
MG(mm Hg)	8.69	4.99
PHT(ms)	194.21	52.70
S'(cm/s)	11.20	2.89
TAPSE(mm)	20.5	3.38
SPAP(mm Hg)	43.21	13.03
LAVi(mm)	55.33	16.99
LVID(cm)	4.60	0.53
LVEF(%)	56.54	7.89

LAVi, Left atrial volume index; LVID, Left ventricular internal diameter; LVEF, Left ventricular ejection fraction; MG, Mean gradient; MVA, Mitral valve area; PHT, Pressure half time; S', Right ventricular peak systolic Doppler velocity; SPAP, Systolic pulmonary pressure; TAPSE, Tricuspid annular peak systolic excursion

The average PALS measures were significantly higher in the patients in the sinus rhythm than in the group with atrial fibrillation (12.32 ± 6.38% vs 9.04 ± 5.74%; $P = 0.03$).

LA strain measures had a significant correlation with the mitral valve area and a significant reverse correlation with the LA volume index ($r = 0.3$, $P = 0.08$ and $r = 0.28$, $P = 0.02$, respectively). Nonetheless, there was no significant correlation between the LA strain measures and the systolic pulmonary pressure of the patients.

No significant difference was demonstrated in the PALS measures between the patients with the Wilkin score of 8 or less (32%, 25 patients) and the ones with the Wilkin score of 9 or more (67%, 55 patients).

DISCUSSION

Rheumatic disease is the most common etiology of mitral stenosis in developing countries. Rheumatic changes lead to the calcification and thickening of the leaflets and the valvular apparatus. Nevertheless, it is believed that the disease process also involves the heart chambers. The LA is the chamber most affected by mitral stenosis. The enlargement, remodeling, and stiffening of the walls lead to the impairment of the chamber's function. [1, 2] In this article, we evaluated PALS, which is one of the novel parameters recommended for the evaluation of LA function. We demonstrated a significant and severe decrease in the PALS of the patients with severe mitral stenosis compared with the suggested reference values (11.18 ± 6.40% in our study population vs the recommended normal range [> 39%] [95% CI: 38 to 41%]) according to the latest systematic review by Pathan et al. [11] Moreover, based on the significant correlation found between the PALS measures and the mitral valve area ($r = 0.3$, $P = 0.08$), we demonstrated that the smaller the valve area becomes, the more LA function aggravates. There was also a significant reverse correlation between the LA volume index and PALS.

Her et al [12] conducted a study on 50 patients with rheumatic heart disease 24 hours before surgery for mitral stenosis or regurgitation. They compared the strain measures of the LA with the actual degree of fibrosis in the pathologic specimens of the patients with the rheumatic involvement of the mitral valve. The authors demonstrated that LA global strain significantly correlated with the degree of LA fibrosis ($r = -0.55$, $P < 0.001$).

Ojaghi et al [13] designed a study in 2014 in order to compare LA reservoir function between patients with mitral stenosis, patients with mitral regurgitation, and a control healthy group. They concluded that the strain and strain rate of the LA were significantly decreased in the patients with mitral stenosis by comparison with mitral regurgitation and the control groups (mean PALS was 55.2 ± 55.8, 25.7 ± 21.8, and 48.3 ± 3 9.8 in the healthy group, mitral stenosis group, and mitral regurgitation group, respectively [$P = 0.000$]). The findings in that study are in concordance with our results. However, whereas Ojaghi and colleagues performed strain measurement via the tissue Doppler

method, we performed the measurements using the speckle-tracking method, which is the currently recommended method for strain evaluations. [10]

Nikdoust et al [14] evaluated 49 cases of severe mitral stenosis and evaluated early diastolic strain among them. By comparing the patients in atrial fibrillation and sinus rhythms, they demonstrated that in addition to blunted late diastolic strain, the patients with atrial fibrillation also had decreased early diastolic strain measures. Nikdoust and coworkers also used the Doppler method for strain measurements. In our study, we measured PALS, which is the systolic component of the atrial deformation cycle. This measure was also significantly lower in the patients with atrial fibrillation than in the ones with mitral stenosis in the sinus rhythm, denoting a decreased reservoir function.

LA strain values are known to be associated with the symptom severity and long-term outcomes of patients with mitral stenosis. In a study by Chien et al, [15] peak positive LA longitudinal strain (14.3% ± 6.6%, 10.6% ± 5.0%, and 8.7% ± 4.0%, in the New York Heart Association [NYHA] functional classes I, II, and III, respectively; P = 0.018), peak positive LA strain rate (1.6 ± 0.5, 1.3 ± 0.4, and 1.1 ± 0.4 s−1, %, in the NYHA classes I, II, and III respectively; P = .012), and diuretic use had a statistically significant role in determining symptom intensity. In a study on 100 asymptomatic patients with mitral stenosis, decreased PALS predicted the occurrence of atrial fibrillation in a 4-years follow-up of the patients. Caso et al [16] performed a 3-year follow-up on asymptomatic patients with mitral stenosis and showed significantly decreased atrial strain measures in these patients. The LA peak systolic strain rate was a predictor of adverse events—defined as symptoms, hospitalization, atrial fibrillation, thromboembolic events, and the need for surgery or commissurotomy. They concluded that the strain measures of the LA can be useful in decision-making for asymptomatic patients.

As the Wilkin score is used frequently to choose suitable cases for percutaneous transvenous mitral commissurotomy, [17] we hypothesized that by the evaluation of patients with an ideal score for intervention, a numeric cut point of PALS measure might be derived for patient selection based on strain measures. Be that as it may, we failed to demonstrate a significant correlation between the mitral valve score and LA longitudinal strain measures while comparing 2 groups of patients: a group with suitable scores (≤ 8) and a group with scores of 9 and more. We found that the severity of the rheumatic involvement of the valve and the subvalvular apparatus did not necessarily correlate with the degree of LA involvement in our patients with mitral stenosis. Therefore, an evaluation of LA functional indices might have additive values in the risk stratification and consequent management of patients.

CONCLUSIONS

LA remodeling is the main consequence of mitral stenosis. PALS was severely decreased in our patients with severe mitral stenosis. Our results also indicated that the severity of longitudinal strain impairment correlated with the valve area, while it did not have a significant relationship with the Wilkin score of the valve.

Limitations

The present investigation is an observational study and may, therefore, have been affected by selection bias. Lack of follow-up data was another limitation of the study.

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