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Changes of left ventricle function and mechanics in rheumatic mitral stenosis patients

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Abstract

Background: The correlation between rheumatic mitral valve (MV) alterations and left ventricle (LV) geometry and function has been controversial.
Aim: The aim of this prospective study was to establish changes of LV using 2D echocardiography (2DE) and two dimensional speckle tracking imaging (2DSTI).
Methods: 2DE was performed in 22 patients with mitral stenosis and 23 controls. Clinical data (NYHA functional class, coexisting diseases, medical treatment) were collected. MV area, LV end-diastolic diameter, indices of LV end-diastolic and systolic volume, LV ejection fraction (EF), diameter of left atrium (LA), LA volume, pulmonary artery systolic pressure were evaluated. LV global longitudinal strain (GLS) was assessed by 2DSTI. Parameters were analyzed by SPSS software.
Results: Reduced LV EF and LV GLS was found in MS patients ($p<0.001$), while LV diastolic diameter and volume index did not differ between groups ($p=0.6$ and $p=0.84$). The correlation between MV area and LV GLS, LA volume and the velocity of TV regurgitation was revealed. The smaller MV area (<1,4 cm2) correlated with lower LV GLS ($r=-0.436$, $p=0.042$), lower LV EF ($r=0.533$, $p=0.01$), more dilated LA ($p=0,025$) and higher TV regurgitation velocity ($r=-0,579$, $p=0,005$). There was no significant correlation found between MV area and LV end diastolic diameters and volumes ($p=0.2$ and $p=0.3$), as well as RV diameter and RV longitudinal function parameters.
Conclusions: LV GLS and LV EF was lower in rheumatic MS group patients when compared to control group and was related to the severity of valve stenosis.

Keywords: rheumatic mitral stenosis; left ventricle function; two dimensional speckle tracking imaging; left ventricle global longitudinal strain;

Introduction

Pathogenetically MS hemodynamics has not been related to LV volume or pressure overload [1]. However, LV systolic dysfunction has been reported in MS [1-4]. Despite this fact, the impact of the stenotic mitral valve on intrinsic LV myocardial contractility remains an issue of debate for over 3 decades, especially due to evaluation of subclinical LV dysfunction [5]. There is still controversy whether LV dysfunction in this context is a result of functional or myocardial factors. Evidence from early studies suggested that impaired LV systolic function may be due to rheumatic myocardial fibrosis, especially of the basal LV segments or as a consequence of scarring of subvalvular apparatus, reduction of LV compliance, abnormal right-left septal interaction, increased afterload and reduced LV filling [6]. Nevertheless, other evidences reveal that in patients with isolated MS, ventricular contractility is normal [3,7].

Within the development of this progressive study, we tried to assess changes of LV geometry, function and mechanics as well as pulmonary artery pressure in rheumatic MS, using 2D echocardiography speckle tracking based LV global longitudinal strain, in addition to evaluating the changes of LV myocardial deformation parameters in this group of patients.

Methods

This was a prospective study. A sample of 22 patients who underwent 2DE in the tertiary teaching hospital, Department of cardiology, at the Lithuanian University of Health Sciences, between the period of May 2016 and December 2018, were enrolled. The research was approved by LSMU bioethical center, the ethics committee of the hospital, Nr. BECMF-140. The control group consisted of 23 age and gender matched persons with normal valvular function. Ischaemic heart disease, history of myocardial infarction, arrhythmia during the strain analysis, insufficient tracking segments were exclusion criteria. Clinical data including NYHA functional classification, medical history (atrial fibrillation, arterial hypertension, diabetes mellitus) were reviewed attentively for all the selected subjects. We analyzed MS group patients for the impact of MV area on LV geometry, function and mechanics. 8 patients had MV area >1,4 cm^2, 14 patients - ≤1,4 cm^2.

Echocardiographic evaluation was performed by a single experienced cardiologist using commercially available system (Vivid Seven, General Electric-Vingmed Ultrasound AS, Horten, Norway), with a 3.5 MHz transducer, according recommendations of the American Society of Echocardiography [8,9]. All the patients were examined in the left lateral decubitus position using TTE with two dimensional, continuous wave doppler and speckle tracking echocardiographic modalities. Many variables were calculated including diameters of LV, LA, RA, RV, indices of LV end diastolic and systolic volumes. Parameters to determine global LV systolic function: LV end systolic volume (LVESV), LV end diastolic volumes (LVEDV) were determined from the four and two chamber views using the modified Simpson's rule and LVEF was calculated using the following formula: EF = (EDVESV)/EDV. To compare between individuals with different body size, chamber measurements were indexed to basal surface area (BSA). Analysis of RV systolic function included: fractional area change (FAC), DTI-derived tricuspid lateral annular systolic velocity wave (S'), tricuspid annular plane systolic excursion (TAPSE) from apical 4 chamber view. Pulmonary artery systolic pressure (sPAP) was derived from tricuspid regurgitant jet velocity using Bernoulli equation. Mean pulmonary artery (PA) pressure approximated by the PA acceleration time (AT). Peak longitudinal global LV strain using speckle tracking echocardiography measured in three standard apical views (2C, long axis view, 4C) and calculated as an average of three apical views.

Mitral valve area was assessed directly through 2D planimetry in parasternal short-axis view at the tip of leaflet as well as by Doppler evaluation. Pressure half time (P1/2t) was assessed - the time interval between the maximum mitral gradient in early diastole and the time point where the gradient becomes half of the peak initial value, expressed in milliseconds. Valve area is inversely related to the decline of the velocity of diastolic transmitral blood flow. MVA was derived using an empirical formula: MVA = 220/P1/2t cm2. P1/2t was derived by tracing the slope of deceleration of E wave on Doppler spectral display of transmitral flow, and the valve area was calculated automatically by the software [10,11].

All data were evaluated in Microsoft Excel and IBM SPSS Statistics (SPSS Inc, Chicago, IL, USA). The level of significance was accepted when the p value was less than 0.05 ($p < 0.05$). Continuous variables were expressed as mean ± SD. To compare control group with study subjects, Mann-Whitney test was used. Correlation between continuous variables were tested by nonparametric Pearson correlation analysis.

Results

The study examined 22 patients with mitral stenosis. MV area was calculated as 1.22±0.2 cm2, with medium gradient in diastole 10.3±0.7mmHg. High proportion were females (95.5%) with mean age 63.5 [57.0-75.8]. The frequency of coexisting diseases (diabetes mellitus, arterial hypertension, dyslipidemia) did not differ between groups. Analyzing NYHA functional class in MS patients - II NYHA functional class was diagnosed in 13 (61,9%), while III-IV functional class was found in 8 (38,1%) of the group patients. 68% of the MS group patients had paroxysmal atrial fibrillation, though during the echocardiographic investigation all the patients were in sinus rhythm. The patients reported taking cardiovascular agents, the used agents were Beta blockers (82%), diuretics (77%), anticoagulants (64%) and ACEi (55%). Clinical characteristics parameters of patients group and control group are detailed in Table 1.

Analyzing the echocardiographic parameters of LV geometry and function we found that LV diastolic diameters and volumes did not differ between groups, but end systolic volume was higher and LVEF was lower in MS group patients (Table 2) as well as LV GLS (-14.9±3.34% in MS group vs -24.7±1.69% in control group, p<0.001) (Figure 1a). LA diameter as well as LA volume index was increased when compared with control group data (p<0.001) (Table 3). While analyzing right heart geometry and function we concluded that though indices of RV longitudinal function (TAPSE and s') as well as parameter of global RV function (FAC) were within normal values, though they were statistically significantly lower when compared with control group data (Table 4). sPAP was higher in MS group (Table 4).

The significant correlation between MV area and LV function parameters, LA volumes and the velocity of TV regurgitation (Figures 1b, 2) was revealed. The smaller MV area correlated with lower LV global longitudinal strain, lower LV EF, more dilated LA and higher TV regurgitation velocity. There was no significant correlation found between MV area and LV end diastolic diameters and volumes (p=0.2 and p=0.3), as well as RV diameter and RV longitudinal function parameters.

Table 1. The clinical baseline characteristics of the patients

Variable	Total, n=45	MS group n=22	Control group n=23	P value
Gender, n (%) Men/Women	4(8,9)/41(91,1)	1(4,5)/21(95,5)	3 (13,0)/ 20 (87)	0,608
Age, Median [25-75%], years	59,0 [55,0-65,5]	63,5 [57,0-75,8]	58 [54,0-59,0]	0,003
Body surface area [25-75%], m^2		1,82 [1,76-1,92]	1,8 [1,74-1,89]	0,72
Diabetes mellitus, n (%)	4 (8,9)	1 (4,5)	3 (13,0)	0,608
Arterial hypertension, n (%)	11 (24,4)	7 (31,8)	4 (17,4)	0,26
Dyslipidaemia, n (%)	15 (33,3)	6 (27)	9 (39,1)	0,399

Table 2. LV geometry and function parameters between the groups

Variables	Groups		P value
	MS group (n=22)	Control group (n=23)	
	Median [25-75%]		
LV EDD (mm)	46,0 [43,0-50,3]	48,6 [42,8-50,3]	0,666
LV EDDi (mm/m^2)	26,8 [24,5-29,2]	25,9 [24,6-27,5]	0,525
LV EDV (ml)	88,5 [72,5-115,5]	84,0 [74,0-100,0]	0,593
LV EDVi (ml/m^2)	47,8 [39,9-59,6]	48,8 [41,6-56,2]	0,842
LV ESV (ml)	42,0 [38,0-57,0]	29,5 [24,8-36,0]	0,001
LV ESVi (ml/m^2)	23,7 [21,0-30,7]	17,4 [14,0-20,4]	<0,001
LV EF (%)	51,5 [50,0-55,0]	64,0 [61,0-74,0]	<0,001

LV – left ventricle, EDD – end diastolic diameter, EDDI – end diastolic diameter index, EDV – end diastolic volume, EDVi – end diastolic volume index, ESV – end systolic volume, ESVi – end systolic volume index, EF – ejection fraction, p value – analyzed with non-parametric Mann-Whitney test for two independent sample volumes

Table 3. Diameters and volumes of left and right atriums between the groups

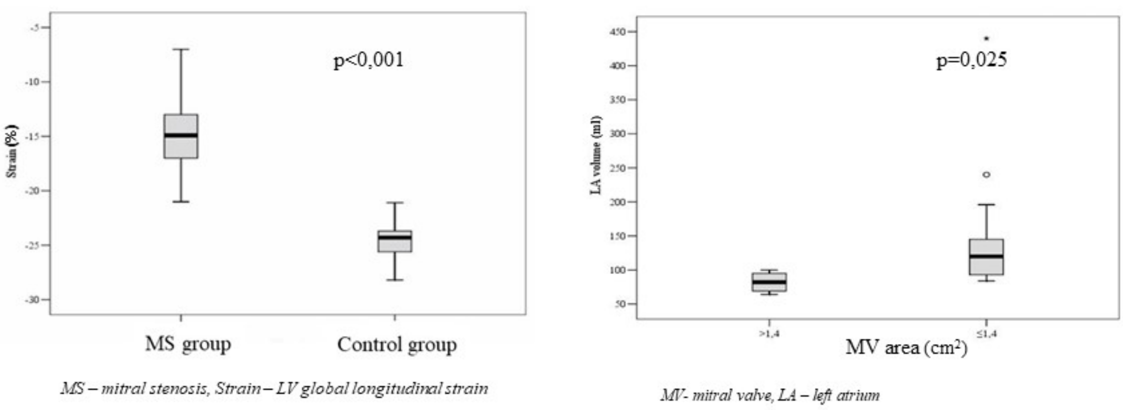
Parameters	Groups		P value
	MS group (n=22)	Control group (n=23)	
	Median [25-75%]		
RA diameter (mm)	40,0 [38,0-44,5]	34,0 [30,0-38,0]	<0,001
LA diameter (mm)	48,5 [15,8-56,0]	32,6 [30,0 -36,4]	<0,001
LA volume (ml)	100,0 [91,0-142,5]	47,0 [40,0-58,0]	<0,001
LA volume index (ml/m^2)	56,0 [48,3-81,1]	26,2 [21,9-31,4]	<0,001

RA – right atrium, LA – left atrium

Table 4. RV size, hemodynamics and function parameters between study groups

Parameters	Groups		P value
	MS group (n=22)	Control group (n=23)	
	Median [25-75%]		
TAPSE (mm)	21,0 [17,0-26,0]	26,9 [23,0-28,6]	0,004
FAC (%)	36,5 [30,2-39,9]	55,9 [51,9-63,0]	<0,001
S' (cm/s)	11,5 [9,5-14,7]	15,0 [14,0-17,0]	<0,001
RV diameter (mm)	34,0 [30,0-37,0]	31,3 [26,7-35,8]	0,047
TVR degree	2,0[1,4-2,5]	1,0 [0-1,0]	<0,001
PAS syst (mmHg)	50,0 [45,0-55,0]	28,0 [26,5-31,5]	<0,001

TAPSE – tricuspid annular systolic excursion, FAC – fractional area change, RV –right ventricle, S' – tricuspid lateral annular systolic velocity wave, TVR – tricuspid valve regurgitation, PAS syst – systolic pulmonary artery pressure



a b

Figure 1. (a) Comparing LV global longitudinal strain between groups, (b) Correlation between MVA and LA volume in MS patients.

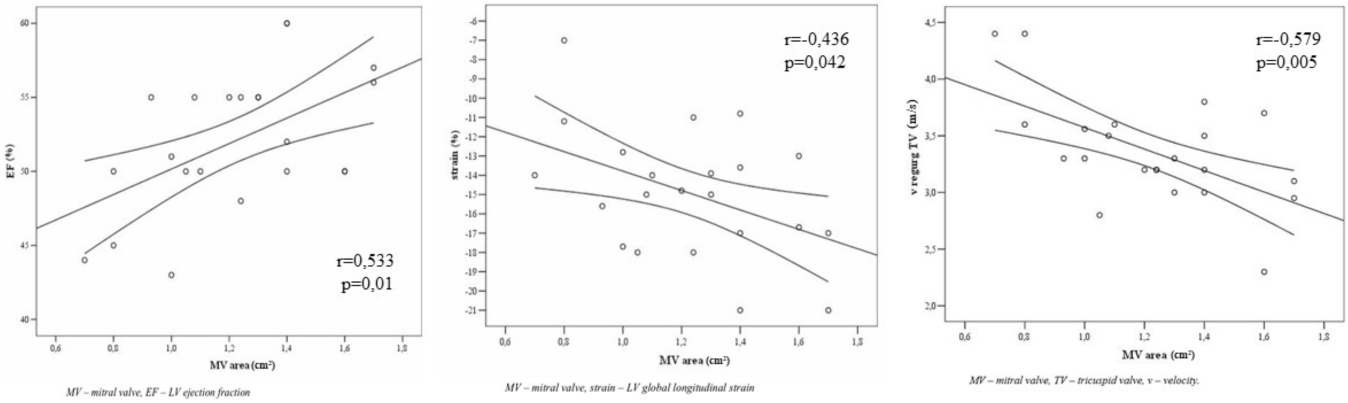


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Figure 2. Correlation between: (a) MVA and LVEF in MS patients, (b) MVA and LV global longitudinal strain in MS patients, (c) MVA and TV regurgitation velocity in MS patients.

Discussion

According to controversial data about LV dysfunction in MS, this study analyzed changes of LV geometry, function and mechanics in rheumatic MS patients and the relation of MV area on LV systolic function, mechanics, the size of LA and pulmonary artery pressures. The results have shown that MV stenosis cause significant variations on the cardiac parameters that were measured by 2D echocardiography. One of the new echocardiographic modalities used in this study was 2D speckle tracking. This method is angle independent in the assessment of global ventricular function. Meta-analysis showed that the prognostic value of GLS has been evaluated as more accurate than LV EF, therefore, subclinical LV function impairment has been confirmed even with normal EF [12,13,14]. The LV GLS measurements were obtained and compared between MS patients and healthy control group. The results indicated that patients with MS had significantly decreased measurement of LV GLS when compared with control group (-14.9±3.34 vs -24.7±1.69, p<0.001). Similar results were identified by E. Bilen et al. who obtained depressed LV strain and strain rate values in 72 mitral stenosis patients who were enrolled in the study. However, the values did not vary among patients within different group when considering the severity of stenosis [3]. Current results support the theory that subclinical LV dysfunction observed in MS patients, would probably depend on myocardial factors as well as hemodynamic factors – we found moderately significant relation between MV area and LV GLS (r=-0,436, p=0,042), though correlation between LV GLS and MV area was not revealed in patients with rheumatic MS [15]. Parameters collected from conventional echocardiography

(LVEDV, LVEDD, LVESV, LVEF) showed some differences between compared groups. LV end diastolic diameter and volume did not differ between groups (p=0.2 and p=0.3), while LV ESV was higher (p<0.001) and LVEF was lower in MS patients (p<0.001) though the absolute numbers were in normal value range. M. A. Sowdagar and Y. V. Subba Reddy performed an observational study on 30 patients with severe mitral stenosis (MVA < 1.0 cm2), they observed the changes after successful PMV which was described as (MVA > 1.5 cm2). Results showed an increase in LVEDD and LVEF with a decrease in LVESD after successful repair [16]. This seemingly discloses increased left ventricular filling after alleviation of the obstruction which again validates the results of the study conducted. However, their study included only severe stenosis patients while ours has limited sample size so the results are generalized upon all MS patients. As anticipated, MS patients in comparison to control group, have revealed an increase in both LA diameter and volume; that can be clarified from chronic inflow reduction through the valve, which over time, causes gradual increase in loading pressure in the LA. Furthermore, atrial function can be altered in two ways, either from chronic loading pressure as it may cause fibrosis or from the potential chronic rheumatic inflammatory changes on the myocardium or can be from both [17]. Our data confirmed the significant correlation between LA volume and MVA. As a result a buildup of pulmonary artery systolic pressure develops which was proved in our results [18].

Study limitations

Several limitations of the study were discussed. First, a small sample size is a significant limitation. Accordingly, these results need to be reanalyzed and aggregated on a larger number of patients with MS. Second, the prognostic impact of LV dysfunction on MS surgery outcomes would be of great value.

Conclusions

1. LV global longitudinal strain and LV ejection fraction was lower in rheumatic MS group patients when compared to control group and was related to the severity of valve stenosis.

2. There was no significant correlation found between MV area and LV end diastolic diameter and volume indices, as well as RV diameter and RV longitudinal function parameters, but the relation was found between MV area and LA volume and velocity of tricuspid regurgitation.

Conflict of interest: None declared.

References

[1] Poyraz E, Oz TK, Zeren G, Guvenc TS, Donmez C, Can F, et al. Left ventricular mechanics in isolated mild mitral stenosis: a three dimensional speckle tracking study. Int J Cardiovasc Imaging 2017 Sep;33(9):1323-1330.

[2] Yildirimturk O, Helvacioglu FF, Tayyareci Y, Yurdakul S, Aytekin S. Subclinical left ventricular systolic dysfunction in patients with mild-to-moderate rheumatic mitral stenosis and normal left ventricular ejection fraction: an observational study. Anadolu Kardiyol Derg 2013 Jun;13(4):328-336.

[3] Bilen E, Kurt M, Tanboga I et al. “Severity of mitral stenosis and left ventricular mechanics: A speckle tracking study.” Cardiology. 2011;119:108–115.

[4] Sengupta SP, Amaki M, Bansal M, Fulwani M, Washimkar S, Hofstra L, et al. Effects of percutaneous balloon mitral valvuloplasty on left ventricular deformation in patients with isolated severe mitral stenosis: a speckle-tracking strain echocardiographic study. J Am Soc Echocardiogr 2014 Jun;27(6):639-647.

[5] Ozdemir A, Kaya C, Ozcan O et al. “Prediction of subclinical left ventricular dysfunction with longitudinal two-dimensional strain and strain rate imaging in patients with mitral stenosis.” Int. J. Cardiovasc. Imaging. 2010;26:397–404

[6] Colle JP, Rahal S, Ohayon J, Bonnet J, Le Goff G, Besse P, et al. Global left ventricular function and regional wall motion in pure mitral stenosis. Clin Cardiol 1984 Nov;7(11):573-580.

[7] Klein A and Carroll JD, “Left Ventricular Dysfunction and Mitral Stenosis.” Heart Fail. Clinc. 2006;2:443–452.

[8] Lang RM, Badano LP, Mor-Avi V et al. “Recommendations for cardiac chamber quantification by echocardiography in adults: An update from the American society of echocardiography and the European association of cardiovascular imaging.” Eur. Heart. J. Cardiovasc. Imaging 2015;16:233– 271.

[9] Mitchell C, Rahko PS, Blauwet LA et al. “Guidelines for performing a comprehensive

transthoracic echocardiographic examination in adults.” J. Am. Soc. Echocardiogr. 2018;32:1–64.

[10] Nishimura RA, Otto CM, Bonow RO et al. 2014 AHA/ACC guideline for the management of patients with valvular heart disease: Executive summary: A report of the American college of cardiology/American heart association task force on practice guidelines. 2014;63:2438-88.

[11] Baumgartner H, Hung J, Bermejo J et al. “Echocardiographic assessment of valve stenosis: EAE/ASE recommendations for clinical practice.” Eur. J. Echocardiogr.2009;10:1–25.

[12] Erturk M, Aksu H, Celik Oet al. “Evaluation of the effect of mitral stenosis severity on the left ventricular systolic function using isovolumic myocardial acceleration.” Cardiol. J. 2014;21:442–448.

[13] Kalam K, Otahal P, and Marwick TH. “Prognostic implications of global LV dysfunction: A systematic review and meta-analysis of global longitudinal strain and ejection fraction.” Heart. 2014;100:1673–1680.

[14]Dogan S, Aydin M, Gursurer M, Dursun A, Onuk T, Madak H. Prediction of subclinical left ventricular dysfunction with strain rate imaging in patients with mild to moderate rheumatic mitral stenosis. J Am Soc Echocardiogr 2006 Mar;19(3):243-248.

[15] Soesanto AM, Desandri DR, Haykal TM, and Kasim M. “Association between late gadolinium enhancement and global longitudinal strain in patients with rheumatic mitral stenosis.” Int. J. Cardiovasc. Imaging. 2018;35:781–789, 2018.

[16] Sowdagar MA and Subba Reddy YV, “Immediate impact of successful percutaneous balloon mitral valvuloplasty on right and left ventricular functions: An echocardiographic study using load independent tissue velocity imaging indices.” Indian Heart J. 2018;70:672–679.

[17] Her A, Choi E, Shim C et al. “Prediction of left atrial fibrosis with speckle tracking echocardiography in mitral valve disease: A comparative study with histopathology.” Korean Circ. J. 2012;42:311–318.

[18] Del Rio JM, Grecu L, and Nicoara A. “Right Ventricular Function in Left Heart Disease.” Cardiothorac. Vasc. Anesth. 2018;23:88–107. [23] Ahmed R, Kazmi N, Naz F et al. “Association Of Tricuspid Regurgitation And Severity Of Mitral Stenosis In Patients With Rheumatic Heart Disease.” J. Ayub Med. Coll. Abbottabad. 2016;28:373–