Section: Cardiology

Original Research Article

A HOSPITAL BASED PROSPECTIVE STUDY TO ASSESS OF REDUCED LEFT ATRIAL FUNCTION IN MITRAL STENOSIS WITH COMPARISON TO NORMAL AGE/SEX POPULATION BY TISSUE DOPPLER AND STRAIN IMAGING AND ALSO EVALUATE THE EFFECT OF BMV ON LA FUNCTION AT TERTIARY CARE CENTRE

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Corresponding Author:
Dr. Abhishek Karmveer,
Email: drabhishekkarmveer@yahoo.com

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Anurag Sharma[1], Rakesh Mahla[2], Abhishek Karmveer[3]

[1]Senior Resident, Department of Cardiology, JLN Medical College, Ajmer, Rajasthan, India.
[2]Professor, Department of Cardiology, JLN Medical College, Ajmer, Rajasthan, India.
[3]Ex Assistant Professor, Department of Cardiology, GMC, Kota, Rajasthan, India.

Abstract

Background: Mitral stenosis (MS) is characterized by narrowing of the mitral valve orifice. Doppler imaging is relatively independent of preload and after load changes and enable quantitative assessment of LA contractile function. Current study plan for assessment of left atrial function in Mital stenosis which is reduced in comparison to normal age/sex match population, by tissue Doppler and strain imaging, and also assess the effect of BMV on LA function. **Materials and Methods:** This is a hospital-based study done on twenty patients with severe Mitral Stenosis in sinus rhythm and 20 ages matched in controls were enrolled in the study in a tertiary care center, Ajmer, Rajasthan, India during one-year period. All patients were subjected to thorough history taking, full clinical examination, 12 lead ECG, full 2D, M mode & Doppler transthoracic echocardiographic study in standard precordial views. Left Atrial regional function and deformation properties were studied using Tissue Doppler Velocities, Strain imaging, before and after 24 hrs of balloon mitral vulvotomy and all details were plotted in tables and statistically analyzed. **Result:** Left ventricular systolic and diastolic dimensions and Left Ventricular Ejection Fraction were comparable in both the groups, no significant difference seen in M mode parameter of LV in both groups. Severe Mitral stenosis showed a lower ventricular end Systolic Strain as measured at Atrial Septum (12.7±7.4% vs 31.2±9.3%; p<0.001) and Left Atrial Lateral Wall (19.2±8.89% vs 29.9±11.7%; p<0.05). Global LA Strain (14.64±0.88 vs 34.28±3.71 P<0.05). A significant inverse correlation was found between Left Atrial Systolic Strain as measured at atrial septum (p<0.001) and left atrial maximum volume. A similar correlation was also found between left atrial Lateral wall Systolic Strain and maximum LA volume (p<0.001). **Conclusion:** We concluded that there was significant difference in the left atrial strain between pre & post-balloon mitral valvotomy; however, it did not reach normal value. So, it needs to be further studied if the left atrial strain further improves during mid- and long-term follow-up and also if this correlates with the reduction in atrial fibrillation and thrombus formation.

INTRODUCTION

The left atrium has an important role in modulating left ventricular filling, contributing up to a third of cardiac output.[1] The left atrium has additionally been identified as an important biomarker of cardiovascular disease and adverse cardiovascular outcomes.[2,3] While previously left atrial (LA) size was utilised, the role of LA function as a biomarker is increasingly being evaluated,[4] both independently and also in combination with LA size.[5-7] However, LA function is complex, comprising of three main components: reservoir function in systole when blood fills the left atrium, as a conduit in early diastole corresponding to passive left ventricular filling and as an active contractile chamber in late diastole.[8,9]

Mitral stenosis (MS) is characterized by narrowing of the mitral valve orifice. It is the most commonly involved valve in rheumatic heart disease which usually presents with dilation of left atrium leads to disorganization of the atrial muscle fibres and fibrosis of the left atrium (LA).[10,11] The thickening begins from the tips of the leaflet and it progresses to commissural fusion, calcification and fusion of the chordate, in the later stages reduces the opening of mitral valve.[12] Treatment for mitral stenosis involves medical therapy, percutaneous mitral valvuloplasty and surgical therapy.[13] Since a few decades, balloon mitral valvotomy (BMV) has become the treatment of choice for patients with symptomatic rheumatic MS. Rheumatic heart disease (RHD) is a major health problem in developing countries and leads to significant comorbidities. In mitral stenosis (MS), the combination of an increase in LA pressure and an intense atrial inflammatory response secondary to the underlying rheumatic carditis is accompanied by a progressive increase in interstitial fibrosis of the atrial wall with disorganization of atrial muscle bundles, LA dysfunction, and subsequently LA dilatation.[14]

Colour tissue Doppler analysis was able to evaluate segmental LA function,[15] demonstrating temporal changes with improved LA function following cardioversion.[16] However, using these measures mandates the presence of sinus rhythm (SR). The LA function index (LAFI) was derived to evaluate LA function even in atrial fibrillation (AF).[17] Additionally, volumetric measures including the LA ejection fraction (LAEF) and LA expansion index (LAEI) have been utilised, both in SR and AF.[18]

More recently, strain analysis has been utilised for evaluation of LA function.[19] Strain evaluates myocardial deformation while strain rate examines the rate of change in strain, and can be measured throughout the cardiac cycle, thereby enabling the evaluation of LA reservoir function (in systole) and conduit and contractile function (in diastole). Assessment of LA strain represent a simple accurate and reproducible technique to evaluate LA function, but there are no specific guidelines regarding its measurement (i.e, gating on QRS vs p wave), standardization of methodology and development of LA specific software algorithum, that is essential for advancement of both future research and clinical application. Many studies like Barros-Gomes S et a (2017),[19] Saad A et al (2016),[20] and Rohani A et al (2017),[21] have been done on assessment of LA function in mitral stenosis by tissue doppler study and strain imaging and they found tissue Doppler imaging is relevant to the non-invasive evaluations of regional tissue contractility and volume data and tissue Doppler imaging is relatively independent of preload and after load changes, and enable quantitative assessment of LA contractile function.[21] Current study plan for assessment of left atrial function in Mital stenosis which is reduced in comparison to normal age/sex match population, by tissue Doppler and strain imaging, and also assess the effect of BMV on LA function.

MATERIALS AND METHODS

This is a hospital-based study done on twenty patients with severe Mitral Stenosis in sinus rhythm and 20 ages matched with no cardiovascular risks' factors, no any cardiac disease and not on any cardiac medications in controls were enrolled in the study in a tertiary care center, Ajmer, Rajasthan, India during one-year period.

In Mitral Stenosis group patients with isolated severe Mitral Stenosis (with no other significant valvular lesions) in sinus rhythm, planned for Balloon Mitral Valvotomy were included.

Exclusion Criteria

Patients of Mitral Stenosis not suitable for Balloon Mitral Valvotomy, patients with Atrial Fibrillation, with more than mild Aortic or Mitral regurgitation (pre or post Balloon Mitral Valvotomy), patients undergoing Balloon Mitral Valvotomy as an emergency procedure, patients who had undergone Closed Mitral Valvotomy or Balloon Mitral Valvotomy or any form of cardiac surgery in the past, patients with Coronary Artery Disease, Hypertension & Diabetes Mellitus, patients with poor echo windows or incomplete study were excluded.

All patients were subjected to thorough history taking, full clinical examination, 12 lead ECG, full 2D, M mode & Doppler transthoracic echocardiographic study in standard precordial views. Left Atrial regional function and deformation properties were studied using Tissue Doppler Velocities, Strain imaging, before and after 24 hrs of balloon mitral vulvotomy and all details were plotted in tables and statistically analyzed.

Echocardiographic and Doppler Studies

Each individual included in the study underwent standard transthoracic echocardiogram and Tissue Doppler imaging in PHILIPS EPIQ 7c Diagnostic ultrasound system with help of Automated cardiac motion quantification (ACMQ) Software. For all study subjects two dimensional, M-mode, conventional Doppler echocardiographic measurements and strain parameter were performed under ECG gated echocardiography, according to guidelines of American Society of Echocardiography. MVA was calculated by planimetry and Pressure Half Time. Color flow Doppler was used to detect presence of valvular regurgitation.

Tissue Doppler imaging was performed in apical four chamber view by placing the sample volume at midpoint of Interatrial Septum and Lateral left atrial wall. Peak early diastolic velocity (E') and late diastolic velocity (A') were recorded. A high frame rate (>110 frame/sec) was selected for the study. Special case was taken for correct alignment of the Doppler beam parallel to Interatrial septum. Doppler measurements were obtained during end expiration. An appropriate velocity scale was chosen to avoid data aliasing.

Atrial Strain Imaging

For Atrial strain imaging, apical four-, three-, and two-chamber views were obtained using standard 2D gray scale echocardiography with breath hold and stable electrocardiographic recording. The average of three cardiac cycles was recorded. The frame rate was set at 60–80 frames/s for Speckle-Tracking and frame rates between 100 and 140 frames per second for the assessment of tissue Doppler strain. For TDI Attempts were made to align the atrial wall parallel to the Doppler beam. For speckle tracking analysis three recorded cardiac cycles were analyzed. The region of interest (ROI) was defined, and single points were manually repositioned for optimal tissue-tracking. Similar to the tracking procedure used in STE, the ROI for TDI analysis was defined by the examiner and timed at end diastole and end-systole. Width and position of the area to be analyzed had to be adjusted manually. Sample volume was placed at mid Interatrial septum and mid Lateral wall of Left atrium in apical two chamber view and apical four chamber view. Mean Strain parameters were recorded at end diastole defined as peak of R wave in ECG and end systole defined as the end of T wave in ECG.[22]

Balloon Mitral Valvotomy Procedure

BMV procedures were performed under mild conscious sedation by Inoue balloon technique. The antegrade transvenous transseptal approach was used. Imaging modalities combined with fluoroscopy can help to guide the procedure, assess the results, and diagnose complications. Measurement of the mean LA pressure, LVEDP, transmitral valve gradient and pulmonary artery pressure were done for procedural monitoring of patient and assessment of BMV sucses. Planimetry method is a direct measurement of MVA by 2D echo. It was obtained by taking three consequent cycles of mitral valve level and measuring the area including commissures in mid diastole to get the maximum area. Doppler gradient was assessed in a normal acoustic apical four chamber view, as parallel alignment of ultrasound beam and mitral valve flow gives the maximum gradient. A fine acoustic window was used to get a well-defined Doppler signal so that peak velocity, peak pressure gradient (PPG) and mean pressure gradient (MPG) by velocity time interval (VTI) of mitral inflow were recorded. PPG was derived by the peak velocity whereas MPG was the relevant hemodynamic finding, which was influenced by the LA compliance and LV diastolic function. Tissue Doppler velocities, and Strain parameters were measured 24 hours after Balloon Mitral Valvotomy in manner similar to pre procedure evaluation.

Statistical Analysis: For statistical analysis data were analyzed by SPSS (version 27.0). Data had been summarized as mean and standard deviation for numerical variables and count and percentages for categorical variables.

RESULTS

Our study showed that the female was higher than male in both control and Mitral stenosis groups. In terms of age, the mean age of the study subjects was 29.36 ± 7.2 years. MVA of 20 mitral stenosis patient was (2DMVA=0.77±0.13 cm2). Left ventricular systolic and diastolic dimensions and Left Ventricular Ejection Fraction were comparable in both the groups, no significant difference seen in M mode parameter of LV in both groups. LA parameters of Mitral Stenosis patients were compared with healthy Controls. 2D Left Atrial parameters like M mode LA dimensions, maximum LA size in A4C, maximum and minimum LA volumes, were significantly higher in patients with mitral stenosis in comparison to controls. LA ejection fraction as calculated by modified Simpson's method was lower in Mitral Stenosis patients when compared to controls (23.5 ± 7.2 % vs 59.2 ± 6.3 %; p<0.001; MS vs Control). Tissue Doppler Imaging parameters of Left Atrial function like E' and A' Diastolic velocities showed significant lower value in Mitral Stenosis when compared to controls [Table 1].

Strain imaging parameters of Left Atrium, interatrial septum and lateral LA wall in patients with severe Mitral Stenosis were compared with controls. Severe Mitral stenosis showed a lower ventricular end Systolic Strain as measured at Atrial Septum (12.7±7.4% vs 31.2±9.3%; p<0.001) and Left Atrial Lateral Wall (19.2±8.89% vs 29.9±11.7%; p<0.05). Global LA Strain (14.64±0.88 vs 34.28±3.71 P<0.05) [Table 2]. Post BMV Tissue Doppler velocity remained unchanged as measured at interatrial septum however E' velocity at lateral wall improved significantly (7.8 ± 1.9 vs 9.7 ± 2.5; p<0.001: Pre BMV vs Post BMV) as shown in [Table 3]. A significant inverse correlation was found between Left Atrial Systolic Strain as measured at atrial septum (p<0.001) and left atrial maximum volume. A similar correlation was also found between left atrial Lateral wall Systolic Strain and maximum LA volume (p<0.001).

Table 1: TDI parameters

Variable	Controls (n=20)	Mitral Stenosis (n=20)	p value
IAS Pulse Wave E' Velocity (cm/sec)	10.7 ± 3.8	7.6 ± 3.2	<0.05
IAS Pulse Wave A' Velocity (cm/sec)	10.3 ± 3.8	7.1 ± 2.7	<0.05
Left Atrial Lateral Wall Pulse Wave E' Velocity (cm/sec)	17.1 ± 3.5	7.6± 1.6	<0.001
Left Atrial Lateral Wall Pulse Wave A' Velocity (cm/sec)	14.23± 3.7	7.4 ± 3.3	<0.001

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Table 2: Left atrial Strain parameters in MS as compared to controls

Variable	Controls (n=20)	Mitral Stenosis (n=20)	p value
IAS Strain at Ventricular End Systole (%)	31.2 ± 9.3	12.7± 7.4	<0.001
IAS Strain at Ventricular Late Diastole (%)	-0.05 ± 0.33	0.04± 0.50	>0.05
Left Atrial Lateral Wall Strain at Ventricular End Systole (%)	29.9± 11.7	19.2± 8.89	<0.05
Left Atrial Lateral Wall Strain at Ventricular Late Diastole (%)	0.06± 0.68	0.02± 0.44	>0.05
GLA STRAIN (%)	34.28± 3.71	14.64±0.88	<0.05

Table 3: Tissue Doppler Velocities Pre and Post BMV

Variables	Pre BMV (n=20)	Post BMV (n=20)	p value
IAS Pulse wave E' Velocity (cm/sec)	7.7 ± 3.3	6.6 ± 2.8	>0.05
IAS Pulse wave A' Velocity (cm/sec)	7.3 ± 2.7	6.65 ± 2.2	>0.05
Left Atrial Lateral Wall Pulse Wave E' Velocity (cm/sec)	7.8 ± 1.9	9.7 ± 2.5	<0.001
Left Atrial Lateral Wall Pulse Wave A' Velocity (cm/sec)	7.4 ± 3.6	7.7± 2.2	>0.05

Table 4: Left atrial Strain parameters Pre and Post BMV

Variables	Pre BMV (n=20)	Post BMV (n=20)	p value
IAS Strain at Ventricular End Systole (%)	12.4± 7.3	19.3 ± 9.5	<0.05
IAS Strain at Ventricular Late Diastole (%)	0.04± 0.55	0.13 ± 0.76	>0.05
Left Atrial Lateral Wall Strain at Ventricular End Systole (%)	20.2± 9.3	24.5± 9.3	>0.05
Left Atrial Lateral Wall Strain at Ventricular Late Diastole (%)	0.03 ± 0.47	-0.13 ± 1.08	>0.05
GLA STRAIN (%)	14.32±0.88	19.52±5.89	. >0.05

DISCUSSION

LA function is an important emerging entity and carries significant clinical and prognostic implications. Assessment of LA strain represents a simple, accurate and reproducible technique to evaluate LA function. LA strain and strain rate parameters are more sensitive than conventional parameters of atrial function. Strain parameters demonstrate alterations prior to alterations in LA volumes with new data regarding its prognostic relevance emerging rapidly.

In the present study, females constituted about two-third the population. This was similar to the findings seen in the study conducted by Rohani et al. which also showed a high prevalence of female population in the study.10 In terms of the age, the mean age of the study subjects was 29.36 ± 7.2 years which was in concordance with a study conducted by Roushady et al. which reported the mean age of patients with MS as 31.9 ± 6.3 years.[23]

In our study even the velocities assessed at septum were lower in Mitral Stenosis group. This probably may be related to severity of Mitral Stenosis in patients included in the study. Mi Seung Shin et al,[24] in their study included patients with moderate to severe stenosis, whereas in our study all patients has severe Mitral Stenosis which could have resulted in more severe left atrial dysfunction and thus abnormal septal Tissue Doppler velocities. Post Balloon Mitral Valvotomy early diastolic Tissue Doppler velocity of Lateral LA wall improved whereas that of Interatrial Septum remained unchanged in our study. This may be attributed to; interatrial septum being more as compared to lateral LA wall. Sudden decrease in left atrial after load after BMV improves Lateral wall velocity within 24 hours after BMV which is a relatively free structure.

Biswarup Sarkar et al (2023),[25] found that atrial Tissue Doppler velocities, Strain imaging is a feasible method for assessment of left atrial function. It can be applied to evaluate impairment of atrial reservoir function in severe Mitral Stenosis. Balloon Mitral Valvotomy tends to normalize these abnormalities within 24 hours after the procedure. Global LA strain can be taken as an indicator of left atrial function, and its improvement following valvotomy may be taken as a good indicator of successful BMV.

CONCLUSION

We concluded that there was significant difference in the left atrial strain between pre & post-balloon mitral valvotomy; however, it did not reach normal value. So, it needs to be further studied if the left atrial strain further improves during mid- and long-term follow-up and also if this correlates with the reduction in atrial fibrillation and thrombus formation.

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