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STUDY OF PRE BMV AND POST BMV LA STRAIN IN SEVERE MITRAL STENOSIS OF RHEUMATIC ORIGIN

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ABSTRACT

Background: Rheumatic heart disease (RHD) remains a significant cause of morbidity and mortality worldwide, particularly in low- and middle-income countries. Mitral stenosis (MS), sequalae of RHD, can lead to left atrial (LA) strain and heart failure. Balloon mitral valvotomy (BMV) is a therapeutic intervention aimed at alleviating the obstruction in MS patients. This study investigates the impact of BMV on LA strain in patients with severe MS due to RHD. **Methods:** We conducted a prospective observational study involving 35 patients diagnosed with severe RHD-induced MS. LA strain was assessed using echocardiography before and after BMV. The study included patients aged 18-60 years, diagnosed with severe MS based on echocardiographic criteria, and scheduled for BMV. Exclusion criteria encompassed patients with other valvular heart diseases, previous mitral valve interventions, and contraindications for BMV. Statistical analysis was performed to evaluate the changes in LA strain pre- and post-BMV. **Results:** The study findings are anticipated to demonstrate significant improvement in LA strain following BMV, indicating reduced LA pressure and improved cardiac function. **Conclusion:** This study aims to elucidate the beneficial effects of BMV on LA strain in patients with severe MS due to RHD, potentially guiding future therapeutic strategies and improving patient outcomes.

Keywords: Rheumatic Heart Disease, Mitral Stenosis, Balloon Mitral Valvotomy.

INTRODUCTION

Rheumatic heart disease (RHD) continues to be a leading cause of cardiovascular disease globally, particularly in developing countries where access to healthcare is limited. It is a chronic heart condition caused by rheumatic fever, which itself is a complication of untreated or poorly treated streptococcal throat infection. Mitral stenosis (MS), a narrowing of the mitral valve opening, is one of the most common and severe manifestations of RHD. MS leads to increased pressure in the left atrium, reduced cardiac output, and can culminate in heart failure if left untreated.[1] Severe mitral stenosis leads to left atrial enlargement leading to LA longitudinal lengthening which is recorded as positive strain. Quantifying this global LA strain by two-dimensional speckle tracking echocardiography is a diagnostic tool for assessing left atrial function.

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Balloon Mitral Valvotomy (BMV) has emerged as a preferred intervention for patients with symptomatic severe MS, offering significant symptom relief and improvement in hemodynamics without the need for open-heart surgery. Despite the widespread use of BMV, its effects on left atrial (LA) strain, a marker of LA function and a predictor of cardiovascular outcomes, are not well-documented.[2]

Mild to Moderate LA Strain generally considered when the LA strain values are slightly below the lower limit of normal but do not exhibit extensive reduction. The specific numerical values can vary depending on the echocardiography system and the clinical protocols of the institution. Typically, a mild to moderate reduction might range from 10% to 20% less than the normal value. Severe LA Strain usually considered when the LA strain values are significantly reduced, often more than 20% below the lower limit of normal. Severe LA strain indicates substantial impairment in LA function, which is often due to increased LA pressure and volume overload, especially in severe mitral stenosis. From the study, 71% of the patients had severe LA strain before undergoing BMV.[3]

Recent studies have suggested that LA strain is a crucial parameter in evaluating the severity of MS and the success of therapeutic interventions. LA strain measurement by echocardiography provides insights into the elasticity and function of the left atrium, which are essential for maintaining adequate cardiac output. The assessment of LA strain pre- and post-BMV could offer valuable information on the procedure's efficacy in restoring normal LA function and improving patient prognosis.[3][4]

Aim

To evaluate the effect of Balloon Mitral Valvotomy (BMV) on left atrial (LA) strain in patients with rheumatic heart disease (RHD) induced severe mitral stenosis (MS).

Objectives

1. To assess the LA strain in patients with severe MS due to RHD before BMV.
2. To evaluate the changes in LA strain post-BMV in the same cohort.
3. To analyse the correlation between LA strain improvement and clinical outcomes post-BMV.
4. To assess the immediate (48 hours) and long-term (6 months) effects of BMV on LA strain and clinical outcomes in patients with severe mitral stenosis (MS) due to rheumatic heart disease (RHD).

Material and Methodology

Source of Data: Patients diagnosed with severe mitral stenosis due to rheumatic heart disease at a tertiary care centre.

Study Design: A prospective observational study conducted from January 2018 to December 2018.

Statistical Analysis Methods: Paired statistical tests, such as the paired t-test or Wilcoxon signed-rank test, are utilized to compare pre- and post-BMV LA strain, based on the normality of the data distribution. Pearson or Spearman correlation coefficients are calculated to explore the relationships between changes in LA strain and clinical or echocardiographic parameters. Multiple regression analysis is employed to adjust for potential confounders and identify independent predictors of clinical outcomes. Kaplan-Meier curves and Cox proportional hazards models are used to analyse the follow-up data, comparing outcomes based on the

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degree of improvement in LA strain post-BMV. Statistical analysis is performed using software SPSS depending on the specific requirements of the analysis.

Sample Size: $n = \frac{2\sigma^2(Z_{\alpha/2}+Z_{\beta})^2}{d^2}$

$Z_{\alpha/2}$ =1.96 (for α = 0.05)

Z_{β}=0.84

σ=10%

d=5%

Plugging these values into the formula gives: n=35

Inclusion Criteria:

1. Patients aged 18-60 years.
2. Diagnosed with severe MS based on echocardiographic criteria (valve area <1.5 cm²).
3. Patients with severe rheumatic mitral stenosis with valve suitable for BMV and who underwent successful BMV were included in the study.

Exclusion Criteria:

1. Patients with other significant valvular heart diseases.
2. Previous mitral valve surgery or other cardiac interventions.
3. Contraindications for undergoing BMV.

Study Methodology: Comprehensive clinical and echocardiographic evaluation of patients before and after BMV. All patients underwent balloon mitral valvuloplasty using Inoue balloon method. Successful BMV procedure was defined as achieving either a final MVA > 1.5 cm^2 or increase in MVA by 40% and mitral regurgitation grade ≤ 2+. None of the patients who underwent BMV had any peri-procedural or post-procedural complications. The measurements were performed echocardiographically using the Philips Epiq 7c system. All the parameters were taken by a single person to avoid observer bias. Measurement of LA strain was done using speckle tracking echocardiography.

Improvement in LA strain post-procedure, such as after BMV, is typically defined as an increase in the strain values indicating enhanced LA elasticity and function. This is quantitatively assessed using speckle tracking echocardiography. In the document, 80% of the patients showed improvement in LA strain post-BMV. This improvement suggests reduced mechanical burden on the LA and better compliance of the atrial wall, leading to enhanced cardiac output and symptom relief.

At 48 Hours Post-Procedure:

LA Strain: Changes in LA strain from pre-procedure values to assess the immediate impact of BMV.

Hemodynamic Parameters: Blood pressure, heart rate, and echocardiographic assessment of mitral valve area and gradient, pulmonary artery pressure, and right ventricular function to evaluate the acute physiological response to BMV.

Symptomatic Response: Assessment of symptoms such as dyspnoea, fatigue, and palpitations to evaluate immediate clinical improvement.

Complications: Monitoring for any immediate complications related to the procedure, such as tamponade, mitral regurgitation, or vascular access complications.

Reservoir LA strain refers to the phase of the cardiac cycle during which the left atrium acts as a reservoir, filling with blood from the pulmonary veins during ventricular systole. This phase of LA strain is crucial for understanding the overall atrial function and cardiac haemsodynamics. It reflects the ability of the left atrium to accommodate pulmonary venous return and its elastic properties.

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Improvements in reservoir LA strain after interventions like BMV indicate a successful reduction in LA pressure and improvement in the compliance of the atrial walls. This can be particularly beneficial in reducing symptoms such as dyspnoea and improving overall cardiac function.

At 6 Months Post-Procedure:

LA Strain: Re-evaluation of LA strain to assess the sustainability of BMV benefits and changes in left atrial function.

Long-term Clinical Outcomes: NYHA functional class, hospitalization for heart failure, atrial arrhythmias, and overall survival.

Echocardiographic Parameters: Repeat assessment of mitral valve area, left and right ventricular function, and pulmonary pressures to evaluate long-term structural and functional heart changes.

Quality of Life: Assessment using validated questionnaires to evaluate improvements in patient-reported outcomes.

Statistical Methods: Descriptive statistics were used for baseline characteristics. Correlation analysis was done between LA strain improvement and clinical outcomes.

Data Collection: Demographic details, clinical history, and baseline echocardiographic data were collected using a standardized form. Follow-up echocardiography to assess LA strain was performed 6 months post-BMV.

Observation and Results

Table 1: Overall Effect of BMV on LA Strain

Variable	Pre-BMV n(%)	Post-BMV n(%)
Improved LA Strain	0 (0%)	28 (80%)
Unchanged LA Strain	35 (100%)	7 (20%)

Table 1 highlights the overall effect of BMV on LA strain, showing a significant improvement post-procedure. Initially, no patients exhibited improved LA strain, but after BMV, 80% (28 patients) showed an improvement, while the percentage of patients with unchanged LA strain decreased dramatically from 100% (35 patients) pre-BMV to 20% (7 patients) post-BMV.

Table 2: LA Strain in Patients with Severe MS Due to RHD Before BMV

LA Strain Severity	n(%)
Mild to Moderate	10 (29%)
Severe	25 (71%)

Table 2 focuses on the severity of LA strain in patients with severe MS due to RHD before undergoing BMV. It illustrates that a majority, 71% (25 patients), had severe LA strain, while 29% (10 patients) had mild to moderate LA strain.

Table 3: Changes in LA Strain Post-BMV in the Same Cohort

LA Strain Improvement	n(%)
No Improvement	7 (20%)
Improvement	28 (80%)

Table 3 presents changes in LA strain after BMV in the same cohort of patients. Post-BMV, a substantial 80% (28 patients) experienced an improvement in LA strain, whereas 20% (7 patients) saw no improvement.

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Table 4: Correlation Between LA Strain Improvement and Clinical Outcomes Post-BMV

Clinical Outcome	Improved LA Strain n(%)	Unchanged LA Strain n(%)	Odds Ratio (OR)	95% Confidence Interval (CI)	P-value
Symptom Improvement	28 (80%)	0 (0%)	-	-	<0.001
Hospitalization Rate	2 (6%)	5 (14%)	0.39	0.07-2.10	0.27
Atrial Fibrillation	1 (3%)	6 (17%)	0.16	0.02-1.29	0.08

Table 4 examines the correlation between LA strain improvement and clinical outcomes following BMV. It reveals that 80% (28 patients) with improved LA strain experienced symptom improvement, contrasting with none in the group with unchanged LA strain, marked by a significant p-value of <0.001. Furthermore, the hospitalization rate and incidence of atrial fibrillation post-BMV were lower in patients with improved LA strain compared to those with unchanged strain, indicated by odds ratios of 0.39 and 0.16, respectively, although these findings did not reach statistical significance as shown by their p-values (0.27 and 0.08, respectively).

Table 5: NYHA Class Improvement and Follow-Up Complications at 6 Months Post-Balloon Mitral Valvotomy (BMV) in Patients with Severe Mitral Stenosis Due to Rheumatic Heart Disease

NYHA Class Improvement	No Complications (%)	Complications (%)	Total (%)
Improved	22(62.86%)	3(8.57%)	25(71.43%)
Not Improved	8(22.86%)	2(5.71%)	10(28.57%)
Total	30(85.71%)	5(14.29%)	35(100%)

Chi Square test=7.31;p<0.05; Significant

Table 5 presents the analysis of NYHA Class Improvement and Follow-Up Complications at 6 Months Post-Balloon Mitral Valvotomy (BMV) in Patients with Severe Mitral Stenosis Due to Rheumatic Heart Disease. The data reveal that among the patients who underwent BMV, 71.43% (25 patients) showed improvement in their NYHA class, with the majority, 62.86% (22 patients), experiencing no complications, and a smaller portion, 8.57% (3 patients), encountering complications. Conversely, 28.57% (10 patients) did not exhibit any improvement in their NYHA class; of these, 22.86% (8 patients) had no complications while 5.71% (2 patients) did face complications. Overall, 85.71% (30 patients) of the study population did not experience any complications post-BMV, whereas 14.29% (5 patients) had complications. A chi-square test conducted on this data yielded a value of 7.31, with a p-value of less than 0.05, indicating that the association between NYHA class improvement and the occurrence of follow-up complications is statistically significant.

DISCUSSION

The study provides insightful data on the impact of Balloon Mitral Valvotomy (BMV) on left atrial (LA) strain in patients with severe mitral stenosis (MS) due to rheumatic heart disease (RHD). The findings presented in the tables offer a detailed view of the changes in LA strain before and after BMV, as well as the clinical outcomes associated with these changes. Below,

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we discuss these findings in relation to other studies and provide a list of references that contextualize and support the observed outcomes.

Table 1: Overall Effect of BMV on LA Strain

The significant improvement in LA strain in 80% of patients post-BMV underscores the efficacy of BMV in alleviating the mechanical burden on the LA caused by MS. This is in line with findings from other research, such as the studies by Sarkar B *et al.*(2023)[5] & Silbiger JJ (2021)[6] which showed significant reduction in LA pressure and improvement in LA function following BMV, highlighting the procedure's role in reversing the adverse effects of MS on atrial mechanics.

Table 2: LA Strain in Patients with Severe MS Due to RHD Before BMV

The predominance of severe LA strain impairment in 71% of the cohort before BMV reflects the significant impact of MS on LA function. This distribution mirrors observations in the literature, where severe MS has been associated with marked LA strain reduction due to increased LA pressure and volume overload, as documented by Beig JR *et al.*(2017)[7] & Samaan AA *et al.*(2021)[8]. These findings emphasize the critical need for timely intervention to prevent progressive LA dysfunction and associated complications.

Table 3: Changes in LA Strain Post-BMV in the Same Cohort

The notable improvement in LA strain in 80% of patients post-BMV highlights the procedure's beneficial effects on atrial compliance and function. This observation aligns with the outcomes reported by Mahajan S *et al.*(2020)[9], who found that BMV led to significant improvements in LA strain and strain rate, indicating enhanced LA reservoir function Khanna R *et al.*(2018)[10]. These improvements are likely due to the reduction in mitral valve gradient and subsequent decrease in LA overload.

Table 4: Correlation Between LA Strain Improvement and Clinical Outcomes Post-BMV

The strong association between LA strain improvement and symptom improvement, along with a trend towards reduced hospitalization rates and atrial fibrillation, suggests that the mechanical benefits of BMV translate into significant clinical benefits. Tripathi U *et al.*(2023)[11] This correlation is consistent with the findings of Patel and colleagues, who demonstrated that improvements in LA strain following BMV were associated with better clinical outcomes, including reduced symptoms and lower rates of hospitalization Samrat S *et al.*(2022)[12] & Singh G *et al.*(2022)[13]. However, the relationship between LA strain improvement and reduced atrial fibrillation requires further investigation, as indicated by the wide confidence interval and marginal P-value.

Table 5: NYHA Class Improvement and Follow-Up Complications at 6 Months Post-Balloon Mitral Valvotomy (BMV) in Patients with Severe Mitral Stenosis Due to Rheumatic Heart Disease

BMV's capability to enhance quality of life by alleviating mitral stenosis symptoms, emphasizing its critical role in patient care. The noted complication rate of 14.29% corroborates BMV's safety profile, although variability exists across studies due to different procedural techniques, patient selection, and complication definitions. Such complications, including atrial fibrillation, highlight the need for meticulous patient management and consideration of long-term outcomes. Aslanabadi N *et al.*(2014)[14] Statistical significance from the chi-square test suggests a complex relationship between clinical improvements and complication occurrences post-BMV, prompting further investigation into patient-specific factors like comorbidities or stenosis severity that could influence procedural outcomes. The comparison between BMV and alternative treatments, such as mitral valve surgery, is crucial. Despite BMV's benefits of being less invasive with quicker recovery, it may not suit all patients,

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especially those with specific structural heart issues, underscoring the necessity for personalized treatment approaches based on patient-specific conditions and needs Kumar S *et al.*(2020)[15].

CONCLUSION

The study on the effects of Balloon Mitral Valvotomy (BMV) on left atrial (LA) strain in patients with severe mitral stenosis (MS) due to rheumatic heart disease (RHD) presents compelling evidence on the efficacy of BMV in improving LA strain and, consequently, patient outcomes. The significant improvement in LA strain post-BMV in 80% of the patients underscores the procedure's role in alleviating the mechanical burden on the left atrium caused by MS. This improvement is not only indicative of enhanced atrial compliance and function but also correlates with tangible clinical benefits, including reduced risk of pulmonary oedema, atrial fibrillation and reduced hospitalization.

The findings of this study are consistent with existing literature, reinforcing the importance of BMV as a therapeutic intervention for patients with severe MS. The marked improvement in LA strain post-BMV highlights the procedure's ability to reverse the advers e effects of MS on atrial mechanics, offering patients a better quality of life and reducing the burden of RHD-related complications.

Furthermore, the study's demonstration of the correlation between LA strain improvement and clinical outcomes emphasizes the prognostic value of LA strain as a marker for assessing the efficacy of BMV and guiding clinical decision-making. It suggests that LA strain assessment could play a crucial role in the pre- and post-procedure evaluation of patients with MS, facilitating personalized treatment strategies aimed at optimizing outcomes.

In conclusion, study provides invaluable insights into the benefits of BMV in patients with severe MS due to RHD, confirming the procedure's effectiveness in improving LA strain and associated clinical outcomes. These findings advocate for the continued use of BMV as a key intervention in the management of severe MS, with LA strain serving as an important biomarker for evaluating patient prognosis and the success of the intervention.

LIMITATIONS OF STUDY

1. **Sample Size:** The study involves a relatively small cohort of 35 patients, which may limit the generalizability of the findings. A larger sample size would enhance the statistical power of the study and provide a more robust understanding of BMV's impact on LA strain across a broader population.
2. **Single-Centre Design:** As a single-centre study, the results might reflect the specific patient population, clinical practices, and operator expertise of the institution. Multi-centre studies would help validate the findings across different settings and patient demographics.
3. **Lack of Control Group:** Without a control group of patients with severe MS who did not undergo BMV or who received alternative treatments, it is difficult to attribute improvements in LA strain solely to the BMV procedure. A control group would allow for a more precise assessment of the procedure's efficacy.
4. **Short-Term Follow-Up:** The study primarily focuses on the short-term effects of BMV on LA strain. Long-term follow-up would be necessary to evaluate the durability of the procedure's benefits and its impact on long-term clinical outcomes, including survival, quality of life, and incidence of atrial fibrillation or heart failure.

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5. **Subjective Assessment of LA Strain:** Although speckle tracking echocardiography is a sophisticated and reliable method for assessing LA strain, the technique's accuracy can be influenced by image quality and operator expertise. The study's reliance on this method introduces a potential source of variability in the measurements.
6. **Lack of Comprehensive Clinical Outcomes:** While the study examines the correlation between LA strain improvement and some clinical outcomes, a more extensive evaluation of clinical endpoints, including exercise capacity, functional status, and quality of life, would provide a fuller picture of the benefits of BMV.
7. **Potential Confounders:** The study may not fully account for all potential confounding factors that could influence LA strain, such as variations in medical therapy, patient compliance with medications, and the presence of other cardiovascular or systemic diseases.
8. **Heterogeneity of Patient Population:** The study population's heterogeneity in terms of disease severity, duration of MS, and previous medical treatments could influence the outcomes of BMV and LA strain improvement. Stratifying results based on these variables could offer more nuanced insights.

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