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Original Research Article

Right Ventricular Strain as a Marker of Disease Severity in Mitral Stenosis and Its Implications in Pregnancy: A Prospective Observational Study

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Abstract:

Introduction: Mitral stenosis (MS) is a progressive valvular disease that significantly affects the right ventricular (RV) function. RV strain, assessed using speckle-tracking echocardiography, has emerged as a sensitive marker for evaluating RV dysfunction. This study aimed to evaluate the role of RV strain as a marker of disease severity in MS and its implications in pregnant and non-pregnant patients for guiding early treatment.

Methods: This prospective observational study included 60 patients with moderate to severe MS, including 24 pregnant women. Patients underwent detailed echocardiographic evaluations including RV strain, TAPSE, and fractional area change (FAC), RV tissue Doppler. RV strain abnormalities were categorized and correlated with MS severity and outcome.

Results: Abnormal RV strain was observed in 63.3% of the patients and 54.2% of the pregnant women. Patients with severe MS had significantly impaired RV strain compared with those with moderate MS ($p < 0.001$). Post-BMV and RV strain values improved significantly, highlighting their role in monitoring the treatment response. Conventional parameters, such as TAPSE and FAC, RV tissue Doppler remained normal in all patients, underscoring the superior sensitivity of RV strain in detecting subclinical RV dysfunction.

Conclusion: RV strain is a cost-effective, non-invasive marker for the early detection of RV dysfunction in MS. It provides valuable insights into disease severity and treatment response, particularly in high-risk groups, such as pregnant women. Integrating RV strains into routine evaluation can improve risk stratification and early management.

Keywords: Mitral Stenosis, Right Ventricular Strain, Speckle-Tracking Echocardiography, Balloon Mitral Valvuloplasty.

Introduction

Mitral stenosis (MS) is a progressive valvular heart disease characterized by the narrowing of the mitral valve orifice, typically resulting from chronic rheumatic fever. [1] The obstruction of blood flow from the left atrium to the left ventricle leads to elevated atrial pressure, pulmonary congestion, and subsequent right ventricular (RV) strain due to pulmonary hypertension. [2]

Over time, the increased afterload on the RV impairs its function, resulting in RV dysfunction, a key determinant of prognosis in MS patients. [3] In pregnancy, the hemodynamic changes characterized by increased cardiac output and blood volume exacerbate the challenges caused by MS, often worsening RV dysfunction. [4] Timely identification of RV involvement is critical in managing MS, particularly in pregnant women, as it holds prognostic implications for both maternal and fetal outcomes. [5]

Assessing right ventricular (RV) function is challenging due to its intricate anatomy, limiting routine evaluations. To address this, various indices, including strain and strain rate, have been developed to quantify RV function. Myocardial strain, a measure of tissue deformation, is calculated as a percentage change. The 2D speckle tracking method enables the quantification of strain and strain rate, assessing global and regional myocardial function without relying on Doppler signals. Traditional echocardiographic parameters, such as tricuspid annular plane systolic excursion (TAPSE) and fractional area change (FAC), RV tissue Doppler are widely used to assess RV function. However, these metrics may not detect early, subclinical changes in myocardial performance. [6] Recent advancements emphasize the utility of RV strain imaging, which provides a sensitive measure of myocardial deformation, offering insights into subclinical dysfunction not captured by conventional methods. [7]

Right ventricular strain facilitates the detection of subtle changes preceding overt RV failure. This advantage is particularly significant in MS patients, where early RV dysfunction correlates with worsening hemodynamics and poor outcomes. [8] Moreover, in pregnancy, where rapid physiological changes impose additional stress on the cardiovascular system, the ability to detect and quantify early RV impairment could guide clinical decision-making and optimize maternal-fetal outcomes. [9] By contextualizing RV strain within the management of MS, this study aims to provide strong evidence supporting its incorporation into routine echocardiographic evaluation.

Review of Literature

Yuce et al. (2010) investigated fragmented QRS (fQRS) as a marker for myocardial fibrosis and RV dysfunction in MS patients. The results demonstrated that fQRS was significantly associated with increased pulmonary artery pressure, larger right heart dimensions, and poorer functional status in patients with MS. The study concluded that fQRS could serve as a simple, non-invasive indicator of RV dysfunction and MS severity. [10]

Tanboğa et al. (2012) explored subclinical RV dysfunction in MS patients using 2D strain imaging. MS patients showed significantly lower RV strain (18.63 ± 6.3) and strain rate (1.37 ± 0.66) compared to controls (strain: 23.5 ± 7.2, strain rate: 1.72 ± 0.54; $p < 0.05$). The study demonstrated 2D strain imaging's effectiveness in detecting early RV dysfunction, regardless of MS severity. [11]

Younan et al. (2014) assessed RV dysfunction in moderate-to-severe MS using 2D strain imaging. Results showed significantly lower global longitudinal strain (GLS) and strain rate (GLSr) in MS patients compared to controls (GLS: -19.67 ± 6.23 vs. -24.19 ± 3.25, $p < 0.001$; GLSr: -1.49 ± 0.87 vs. -1.91 ± 0.56, $p = 0.02$). The findings highlighted strain imaging as a sensitive tool for detecting subclinical RV dysfunction in MS. [12]

Kumar et al. (2014) investigated RV strain in severe MS patients before and after balloon mitral valvuloplasty (BMV). Results showed significantly impaired global RV strain pre-BMV, which improved post-BMV (e.g., GLS improved from -14.6 ± 3.2 to -18.3 ± 2.9, $p < 0.001$). TAPSE and FAC also increased significantly post-BMV, highlighting RV strain's value in assessing RV dysfunction and therapeutic response. [13]

Ladányi et al. (2021) used 3D echocardiography to examine RV mechanics in MS. Results showed reductions in RV ejection fraction (EF), GLS, and global circumferential strain (GCS) in MS patients compared to controls (e.g., GLS: $-16.6 \pm 4.07\%$ vs. $-23.32 \pm 2.82\%$, $p < 0.001$). These findings emphasized the utility of advanced imaging in identifying RV dysfunction and its patterns in MS. [14]

Aim

To evaluate the role of RV strain as a marker of disease severity in MS and its implications in pregnant and non-pregnant patients, with a focus on the correlation with traditional echocardiographic parameters and the differentiation of RV strain abnormalities across varying severities of MS.

Materials and Methods

Study Design and Study Duration: This was a prospective observational study involving 60 patients, including 24 antenatal care patients diagnosed with moderate-to-severe mitral stenosis. This Prospective study was carried out for one year between January 2024 and December 2024

Inclusion criteria

- Patients aged >18 years of age
- Asymptomatic patients with Moderate to Severe Mitral stenosis
- Absent to Mild Mitral Regurgitation

Exclusion criteria

- Symptomatic patients
- Patients with Moderate to severe Mitral Regurgitation
- Patients with Atrial fibrillation
- Patients with Pulmonary hypertension

Methods

The patients underwent detailed echocardiographic evaluation to assess the severity of mitral stenosis and RV function. RV fractional area change (FAC) and tricuspid annular plane systolic excursion (TAPSE) were calculated as per ASE guidelines. Peak systolic velocity at the lateral tricuspid annulus (S') was obtained from pulsed TDI, and the highest systolic velocity was recorded. RV strain was analysed as an advanced marker of RV performance, with values categorized as normal or abnormal based on predefined cut-off points. Data were collected for all patients, including age, sex, BMI, systolic/diastolic blood pressure, heart rate, and comorbidities (e.g., hypertension and diabetes). Echocardiographic parameters assessed included mitral valve area (planimetry), pressure half-time, peak/mean gradients, pulmonary systolic artery pressure, tricuspid annular plane systolic excursion, RV tissue Doppler velocity, fractional area change, and RV strain. The RV strain was categorized as normal or abnormal. RV strain abnormalities were categorized to analyse their correlations with disease severity and outcomes in both pregnant and non-pregnant patients.

Statistical analysis

Data were entered into Microsoft Excel and analysed using SPSS version 22.0. Descriptive statistics included the mean ± standard deviation for continuous variables and percentages for categorical variables.

Results

The study included 60 participants, and the mean age of the study population was 45.52 ± 19.89 years. Of these, 63.3% were female (38 patients) and 36.7% were male (22 patients). Among the population, 66.7% had no comorbidities, 8.3% had systemic hypertension (SHTN), and 20% had type 2 diabetes mellitus (T2DM). Regarding the severity of mitral stenosis, 46.7% were classified as moderate (n = 28) and 53.3% as severe (n = 32). In terms of functional classification based on the New York Heart Association (NYHA) criteria, the majority of patients (86.7%) were classified as NYHA Class I, while 13.3% were classified as Class II. Anaemia was observed in 8.3% of the population (five patients), while the remaining 91.7% (55 patients) were non-anemic. None of the patients exhibited atrial fibrillation during the study, with 100% being free of this condition. Mitral regurgitation was mild in 43.3% of patients (26 patients), whereas 56.7% (34 patients) showed no evidence of regurgitation. When evaluating the RV strain, 63.3% of patients (38 patients) demonstrated abnormal RV strain, whereas 36.7% (22 patients) had normal RV strain (Table 1).

Table 1: Demographic and Clinical Characteristics of the Study Population

		No of patients	Percentage
Sex	Female	38	63.3%
	Male	22	36.7%
Comorbidities	SHTN	8	8.3%
	T2DM	15	20%
	Nil	40	66.7%
Mitral stenosis	Moderate	28	46.7%
	Severe	32	53.3%
NYHA class	I	52	86.7%
	II	8	13.3%
Anaemia	No	55	91.7%
	Yes	5	8.3%
Atrial fibrillation	Nil	60	100%
Mitral regurgitation	Mild	26	43.3%
	No	34	56.7%
RV strain	Abnormal	38	63.3%
	Normal	22	36.7%

The mean body mass index (BMI) of the study population was 22.67 ± 3.41 kg/m². The mean systolic blood pressure (BP) was 104.17 ± 15.10 mm Hg, while the mean diastolic BP was 70.17 ± 7.48 mm Hg. The average heart rate was 84.37 ± 10.54 beats per minute.

Echocardiographic parameters showed a mean pressure half-time (PHT) of 1.35 ± 0.38 seconds and a mean mitral valve area measured by planimetry of 1.36 ± 0.37 cm². The peak gradient across the mitral valve was 20.65 ± 4.93 mmHg, while the mean gradient was 10.80 ± 3.47 mmHg. The pulmonary systolic artery pressure (PSAP) had a mean value of 29.22 ± 8.01 mmHg.

The mean TAPSE was 19.63 ± 1.48 mm. The RV tissue Doppler velocity showed a mean value of 12.27 ± 1.44 cm/s, while the mean fractional area change (RV FAC) had a mean of 39.77 ± 2.18%. The mean right ventricular global longitudinal strain (RV strain) was 17.93 ± 1.58% (Table 2).

Table 2: Echocardiographic and Clinical Parameters

	Mean	Standard Deviation
BMI	22.67	3.41
SYSTOLIC BP	104.17	15.10
DASTOLIC BP	70.17	7.48
HEART RATE	84.37	10.54
PHT	1.35	0.38
PLANIMETRY	1.36	0.37
PEAK	20.65	4.93
MEAN	10.80	3.47
PSAP	29.22	8.01
TAPSE	19.63	1.48
RV TISSUE DOPPLER	12.27	1.44
RV FAC	39.77	2.18
RV STRAIN	17.93	1.58

The study included 24 pregnant patients with a mean age of 24.46 ± 3.97 years.
The mean gestational age of the patients was 21.17 ± 5.33 weeks. 54.2% (13 patients) were diagnosed with severe mitral stenosis, while 45.8% (11 patients) had moderate mitral stenosis. Similarly, 54.2% of pregnant patients demonstrated abnormal RV strain, and 45.8% had normal RV strain. The mean RV strain for pregnant patients was 18.50 ± 1.77 (Table 3).

Table 3: Mitral Stenosis Severity and RV Strain in Pregnant Patients

		No of patients	Percentage
Mitral stenosis	Moderate	11	45.8%
	Severe	13	54.2%
RV strain	Abnormal	13	54.2%
	Normal	11	45.8%

Discussion

Our study highlights the utility of RV strain as a marker for assessing disease severity in MS and its implications in pregnant and non-pregnant populations. Our results showed that abnormal RV strain was more prevalent in patients with severe MS than in those with moderate MS, with 63.3% of the total population and 54.2% of the pregnant patients exhibiting abnormal strain. TAPSE, RV tissue Doppler, and RV FAC remained normal in all patients, emphasizing the greater sensitivity of RV strain for detecting subclinical RV dysfunction. Younan (2015) supports this finding, demonstrating that RV strain is significantly reduced in patients with MS, even when conventional RV function parameters remain normal. [12]

Our prospective study design allowed for a detailed analysis of RV strain across different severities of MS and patient populations. The inclusion of a high-risk group (pregnant women) provides unique insights into the potential utility of RV strain in obstetric cardiology. The single-centre nature of the study and relatively small sample size, particularly among pregnant patients, may limit generalizability. Furthermore, the lack of long-term follow-up limits the ability to assess the prognostic significance of RV strain in this population.

RV strain, as assessed by speckle-tracking echocardiography, has emerged as a sensitive marker for identifying subclinical RV dysfunction in mitral stenosis. Kumar et al. (2014) reported that patients with severe MS had significantly impaired global RV strain compared to healthy controls, with values of -9.07% ± 4.70% versus -14.67% ± 3.95%, respectively (p = 0.02). Post-BMV, global RV strain significantly improved to -11.24% ± 4.24% (p = 0.026), demonstrating the reversibility of RV dysfunction after reducing RV afterload through intervention. [13]

RV strain abnormalities have significant implications for maternal and fetal outcomes in pregnant women. Studies such as Ladányi et al. (2021) highlight distinct RV dysfunction patterns in MS patients using advanced imaging techniques, supporting the value of RV strain as an early diagnostic tool. [14] Incorporating RV strain into routine echocardiographic evaluations could improve risk stratification, guide management decisions, and potentially reduce adverse outcomes.

Despite its promise, the clinical application of RV strains remains debated. While RV strain abnormalities are well documented in MS, their prognostic value compared to traditional echocardiographic parameters such as TAPSE or FAC is not yet fully understood. Khanna et al. (2018) demonstrated significant RV strain improvement post-percutaneous mitral commissurotomy (PTMC), suggesting that RV strain could serve as a surrogate marker for treatment efficacy. [15] However, the long-term prognostic implications of residual RV strain abnormalities post-intervention remain unclear.

Future studies should evaluate the long-term prognostic significance of RV strain in MS, particularly in predicting mortality, heart failure, and other complications. Current guidelines suggest In patients with asymotomatic moderate to severe mitral stenosis, Transcatheter interventions can be done if there is new onset Atrial fibrillation or pulmonary pressures more than 50 mm hg. RV strain can detect early RV dysfunction and can be used as a marker to guide the patients for early Transcatheter interventions. Research focusing on pregnant populations is particularly important given the unique hemodynamic challenges due to pregnancy and the potential for RV strain to guide obstetric and cardiac care.

Our study adds to the growing body of evidence that supports RV strain as a sensitive and clinically valuable marker for assessing RV function in MS. By providing insights into its role in high-risk populations and its correlation with disease severity, this study highlights the importance of broader adoption of the RV strain in clinical practice and emphasizes the need for further research into its long-term implications.

Conclusion

This study highlights the utility of RV strain as an early marker of mitral stenosis severity. RV strain abnormalities were prevalent in patients with severe mitral stenosis. Traditional echocardiographic parameters were less sensitive in detecting subclinical right ventricular dysfunction than RV strain. Incorporating RV strain as an early marker of severity in asymptomatic mitral stenosis can guide timely percutaneous interventions, particularly in pregnant patients, to significantly reduce mortality and morbidity.

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