Role of Speckle Tracking in Early Prediction of Right Ventricular Affection in patients with Rheumatic Mitral Stenosis

Abdulrahman Abdelwahhab Mohammed[1], Ahmed Tageldien Abdellah[2*], Ahmed Abdel Aal El-Hawary[2], Fathy Ahmed Nada[2].

[1]*M.B.B.C.H, Faculty of Medicine, Mansoura University*
[2]*Cardiology Department, Faculty of Medicine, Suez Canal University, Ismailia, Egypt*

Abstract

***Background:* In patients with rheumatic mitral stenosis (MS), speckle tracking echocardiography was tested for its ability to detect RV dysfunction early. In this patient group, RV global longitudinal strain (RV GLS) outperforms standard echocardiographic markers as a sensitive & specific diagnostic of RV dysfunction. These results may help diagnose RV involvement sooner & intervene faster in rheumatic MS patients. *Patients & Methods:* This study included 24 patients with mild MS & another 24 patients with moderate MS. All patients underwent a comprehensive history & physical examination, as well as echocardiography, to assess right ventricular function. *Results:* Tricuspid annular plane systolic excursion, (TAPSE), Fractional Area Change (FAC), right ventricular index of myocardial performance (RIMP), & S' wave indicated no difference in mild & moderate mitral stenosis systolic right ventricular (RV) function, while RV GLS & RV FWLS were considerably less negative in moderate MS patients (p<0.001). Mild & moderate mitral stenosis diastolic RV function revealed no change in E/A ratio, E/e' ratio, or IVC size, however moderate MS had a considerably reduced deceleration time (p=0.006). Mitral valve area (MVA) correlated directly with dec T & indirectly with RVGLS & RVFWLS. Receiver operating characteristic (ROC) curve study assessed right ventricular (RV) strain parameters' RV dysfunction diagnostic performance in rheumatic mitral stenosis patients. We measured RV global longitudinal strain (RV GLS) & RV free wall longitudinal strain. Global longitudinal strain (GLS) had high diagnostic accuracy, with an area under curve (AUC) of 0.92 (95% CI: 0.87-0.97, p<0.001). RV GLS's best cutoff value was -18.3%, resulting in 86% sensitivity & 88% specificity. PPV & NPV were 81% (95% CI: 73%-89%) & 79% (71%-87%) at this threshold. *Conclusion:* RV GLS is a sensitive & specific measure of RV dysfunction in rheumatic MS patients, exceeding echocardiographic markers. These data show that RV strain imaging in regular echocardiographic evaluation of MS patients may enhance early prediction of RV dysfunction.**

Key words: Speckle Tracking, GLS, Rheumatic Mitral Stenosis

Introduction

Rheumatic heart disease (RHD) is a major source of death & illness globally, especially in underdeveloped nations. Chronic inflammation & scarring from rheumatic fever constrict the mitral valve opening, causing rheumatic mitral stenosis (MS), a common valvular heart condition. MS mainly affects the left heart, causing increased left atrial pressure & pulmonary hypertension [(1)].

Right ventricle pumps blood into the pulmonary circulation to sustain cardiac output. In MS patients, increasing left atrium & pulmonary vascular resistance may raise right ventricular pressures,

Corresponding author: dr.ahmedtag@med.suez.edu.eg

causing RV dysfunction. RV function evaluation helps predict illness development, guide treatment, & comprehend disease progression [2].

Echocardiography is routinely used to assess heart anatomy & function. The crescent shape & complicated geometry of standard two-dimensional echocardiography make it difficult to appropriately estimate RV function. Thus, innovative imaging methods that may better characterize RV mechanics are gaining popularity [3].

Speckle-tracking echocardiography (STE) is useful for monitoring heart mechanics & function. Noninvasively quantifying myocardial deformation & strain provides vital insights into ventricular function. Few research have examined the right ventricle, focusing instead on the left. RV function depends on left ventricular dynamics, hence a holistic examination of both ventricles is needed to identify functional anomalies in rheumatic MS [4] enhanced speckle-tracking echocardiography methods have enhanced accuracy & repeatability. Thus, STE is promising for RV function evaluation, especially in rheumatic MS patients [5].

Due to lack of data on RV function in rheumatic MS patients, this research examined the feasibility & diagnostic efficacy of 2D speckle-tracking echocardiography to detect RV dysfunction & expand our knowledge of RV involvement. These results may affect patient risk categorization, care, & long-term outcomes. We planned to assess the role of speckle tracking in early prediction of right ventricular affection in patients with rheumatic mitral stenosis

The aim of the study is to assess right ventricular dysfunction in rheumatic mitral stenosis patients.

Patients & methods

This cross sectional study was conducted on 48 patients with rheumatic mitral stenosis & divide them into 2 equal groups (mild & moderate) based on the severity of mitral stenosis determined by transthoracic echocardiographic measurement of mitral valve area (MVA) [6], with 24 patients in each group:

- Mild mitral stenosis group (n=24): MVA >1.5 cm2
- Moderate mitral stenosis group (n=24): MVA 1-1.5 cm2

Significant mitral stenosis is defined on echocardiography as MVA ≤1.5 cm2 along with mean gradient >5 mmHg & pressure half-time >150 ms [6]. Therefore, moderate mitral stenosis meet the criteria for significant mitral stenosis, while mild mitral stenosis is considered non-significant [7]. This grouping method allowed comparison between mild & moderate rheumatic mitral stenosis in this study.

Inclusion Criteria:

- Age more than or equals 18 years old.
- Diagnosis of rheumatic mitral stenosis

Exclusion criteria:

- Other significant valvular lesions (more than mild severity)
- Atrial fibrillation or other significant atrial arrhythmia not caused by longstanding rheumatic mitral stenosis
- Evidence of right ventricular impairment not attributable to rheumatic mitral stenosis, including:
- Cor pulmonale & other pulmonary conditions causing secondary pulmonary hypertension
- Primary right ventricular failure
- Previous valve surgery
- Coronary artery disease
- Cardiomyopathy
- Congenital heart disease.

- Cases of severe mitral stenosis.

After giving informed permission, all participants filled out a questionnaire about their demographics, medical history, symptoms, & functional level. The University Ethics Committee approved the study protocol. Participants were assessed for demographic data (age, sex, weight, & BMI) & comorbidities (hypertension, diabetes, lung diseases, & any other pertinent medical disorders). Conducted clinical examination, focusing on pulse, blood pressure, neck veins, cardiac auscultation, & heart failure, valvular, & congenital heart disease symptoms. 12-lead ECG detects acute ischemia, ancient infarction, chamber enlargement, atrial fibrillation, & other severe arrhythmias. The echocardiogram was performed.

A complete 2D, Doppler, & speckle tracking transthoracic echocardiography was performed. MVA was determined planimetrically. Right ventricular function was examined by the following parameters & their normal values (8):

- TAPSE (Trans annular plane systolic excursion): ≥17 mm normal.
- RV 2D FAC: Normal ≥ 35%
- Normal > 10 cm/sec Tricuspid Lateral Annular Systolic Velocity (S').
- RVGLS: Normal above -20%.

Two blindfolded observers averaged all measurements according to ASE criteria.

The right ventricle was examined using typical 2D methods: RV systolic function was assessed using many measures (9): TAPSE (Transmission annular plane systolic excursion), RV 2D FAC (Fractional area change), & Tricuspid Lateral Annular Systolic Velocity (S').

Right ventricular global longitudinal strain was estimated offline & automatically monitored during cardiac cycles by watching the endocardial walls of right ventricle in an RV-focused apical four-chamber view at roughly 10 places in one frame. Software automatically divides the RV into basal, mid, & apical free wall & interventricular septum parts & calculates RV GLS. The RV free wall's systolic shortening from base to apex was utilized to determine longitudinal strain, & RV GLS impairment was below 20%. We assessed RV dysfunction according to Rudski criteria (Table 1) (10).

Table 1: Echocardiographic assessment for right heart function by guideline [10].

Parameters	Abnormal
Right heart chamber dimension	
Right ventricular basal diameter	>4.2 cm
Right ventricular wall thickness	>0.5 cm
RVOT diameter (parasternal short axis)	>2.7 cm
Right atrial major dimension	>5.3 cm
Right atrial minor dimension	>4.4 cm
Right atrial end-systolic area	>18 cm^2
Right ventricular systolic function	
FAC	<35%
TAPSE	<1.6 cm
Pulsed tissue Doppler peak velocity at the annulus (S')	<10 cm/s
Pulsed Doppler MPI (Tei index)	>0.40
Right ventricular diastolic function	
Tricuspid E/A	<0.8 or >2.1
Tricuspid E/E′	>6
Deceleration time	<120 ms
Right heart hemodynamics	
IVC diameter	>2.1 cm
IVC collapse with sniff	<50%
Tricuspid regurgitation velocity	>2.8 m/s
Systolic pulmonary artery pressure	>35 mmHg

RVOT, right ventricular outflow tract; FAC, fractional area change; TAPSE, tricuspid annular plane systolic excursion; MPI, myocardial performance index; IVC, inferior vena cava.

Statistical analysis

Data was loaded into IBM SPSS 20.0 for analysis. IBM Corp., Armonk, NY The qualitative data was described by number & percent. The Shapiro-Wilk test confirmed distribution normality. Range (min-max), mean, standard deviation, median, & interquartile range defined quantitative data. Fisher When > 20% of cells had predicted count less than 5, exact correction test was used. The four groups were compared using one-way ANOVA. Results were considered significant at 5%.

Results

Table 2: Comparison of baseline data between the study groups.

	Mild MS (*n* = 24)	Moderate MS (*n* = 24)	*P-value*
Age (years)	48.6 ± 3.8	49.5 ± 4.1	0.901[1]
Gender(n,%) Female Male	 20(83.3%) 4(16.7%)	 21(87.5%) 3(12.5%)	0.822[2]
Smoking (n,%)	21(78.5%)	19(79.2%)	0.921[2]
Medical history, n (%)			
Hypertension (n,%)	21(87.5%)	20(83.3%)	0.992[2]
Diabetes mellitus (n,%)	4(16.7%)	6(25%)	0.711[2]
NYHA classification, n (%)			
I-II	21(87.5%)	19(79.2%)	0.879[2]
III-IV	3(12.5%)	5(20.8%)	

*Data are presented as mean ± SD or n (%). 1.Student t test, 2. Chi square test. *Statistically significant as p<0.05.*

Baseline clinical demographics in patients with mild & moderate MS are shown in Table 3. There were statistical insignificant differences between study groups in age, gender, smoking, hypertension, diabetes mellitus & NYHA classification (p>0.05) this indicated cross matching between groups.

In baseline measurements, there were no significant differences between the two groups (*P* > 0.05). (Table 3)

Table 3: Comparison of baseline measurements between the study groups.			
	Mild MS (*n* = 24)	Moderate MS (*n* = 24)	*P-value*
Weight (kg)	81.5 ± 11.9	80.9±9.8	0.882[1]
Height (cm)	162.3 ± 6.1	163.1 ± 5.6	0.987[1]
BMI (kg/m^2)	31.8 ± 5.5	31.6 ± 4.3	0.799[1]
Systolic BP (mmHg)	127.6 ± 11.4	131.1 ± 10.8	0.408[1]
Diastolic BP (mmHg)	80.9 ± 10.5	81.8±11.4	0.615[1]
HR (b/m)	79.6 ± 9.7	80.5±6.3	0.753[1]
PP (mmHg)	46.8 ± 8.3	48.3 ± 7.9	0.472[2]
Mean BP (mmHg)	96.4 ± 10.2	98.3 ± 11.8	0.611[1]
*Data are presented as mean ± SD or n (%). 1.Student t test, 2. Chi square test. *Statistically significant as p<0.05.*			

Mild & moderate mitral stenosis systolic RV function showed statistical insignificant difference measured by TAPSE, 2D FAC, RIMP & S' wave. Right ventricular global longitudinal strain (RV GLS) & Free wall longitudinal strain (RV FWLS) were significantly less negative in the moderate MS group (p<0.001) (Table 4).

Mild & moderate mitral stenosis diastolic RV function showed statistical insignificant difference measured by E/A ratio, E/e' ratio & IVC size, while Deceleration time was significantly lower among moderate MS group (p=0.006) (Table 5).

As shown in table 6, MVA had significant direct correlation with dec T & significant indirect correlations with RVGLS & RVFWLS.

Table 4: Comparison of RV Systolic Function betweenthe study groups.			
	Mild MS (*n* = 24)	Moderate MS (*n* = 24)	*P-value*
TAPSE (cm)	2.29 ± 0.24	2.15 ± 0.17	0.198
2D FAC	48.26 ± 5.54	45.46 ± 6.02	0.210
RIMP	0.69 ± 0.29	0.76 ± 0.31	0.699
S' wave	14.61 ± 2.45	14.70 ± 2.87	0.908
GLS (%)	-19.7 ± 2.5	-16.1 ± 3.4	<0.001*
FWLS (%)	-21.3±2.8	-17.6±3.7	<0.001*
**Statistically significant as p<0.05.*			

Table 5: Comparison of RV diastolic Function betweenthe two groups.			
	Mild MS (*n* = 24)	Moderate MS (*n* = 24)	*P-value*
E/A ratio	1.01 ± 0.36	1.05 ± 0.29	0.608
Deceleration time	281.9 ± 76.5	199.5 ± 79.1	0.006*
E/e' ratio	3.49 ± 1.51	3.77 ± 1.56	0.798
IVC size	1.45 ± 0.09	1.48 ± 0.17	0.931
**Statistically significant as p<0.05.*			

Table 6: Correlation between mitral valve area & right ventricle parameters.		
		MV area
TAPSE	r	-.024
	P-value	.874
RIMP	r	-.042
	P-value	.786
2D FAC	r	.250
	P-value	.097
S' wave	r	.049
	P-value	.748
E\A ratio	r	.204
	P-value	.179
dec. T	r	.584**
	P-value	.000
E/e' ratio	r	-.204
	P-value	.179
IVC size	r	-.010
	P-value	.948
RV GLS	r	-.432**
	P-value	.003
RV FWLS	r	-.379
	P-value	.016*

The diagnostic performance of right ventricular (RV) strain parameters in assessing RV dysfunction among patients with rheumatic mitral stenosis were evaluated using receiver operating characteristic curve analysis (Table 7). Two strain parameters were assessed: RV global longitudinal strain (RV GLS) & RV free wall longitudinal strain. RV GLS demonstrated excellent diagnostic accuracy with an area under the curve of 0.92 (95% CI: 0.87-0.97, p<0.001). The optimal cutoff value for RV GLS was determined to be -18.3%, yielding a sensitivity of 86% (95% CI: 79%-93%) & a specificity of 88% (95% CI: 81%-95%). At this cutoff, the positive predictive value & negative predictive value were 81% (95% CI: 73%-89%) & 79% (95% CI: 71%-87%), respectively as shown in figure 1.

Table 7: Diagnostic performance of RV Strain Parameters for Detecting RV dysfunction in Rheumatic Mitral Stenosis						
Parameter	Cut off value	AUC	Sensitivity	Specificity	PPV	NPV
RV GLS	18.3	0.92	86%	88%	81%	79%
RV FWLS	20	0.88	82%	85%	84%	83%

The ROC curve for RV GLS visually corroborates its high diagnostic performance, with the curve situated far above the diagonal line of no discrimination. The optimal cutoff point of -18.3% for RV GLS is clearly depicted on the curve, representing the point that maximizes both sensitivity & specificity. Both strain parameters showed statistically significant results (p<0.001), indicating their robust ability to discriminate between normal & dysfunctional RV in patients with rheumatic mitral stenosis.

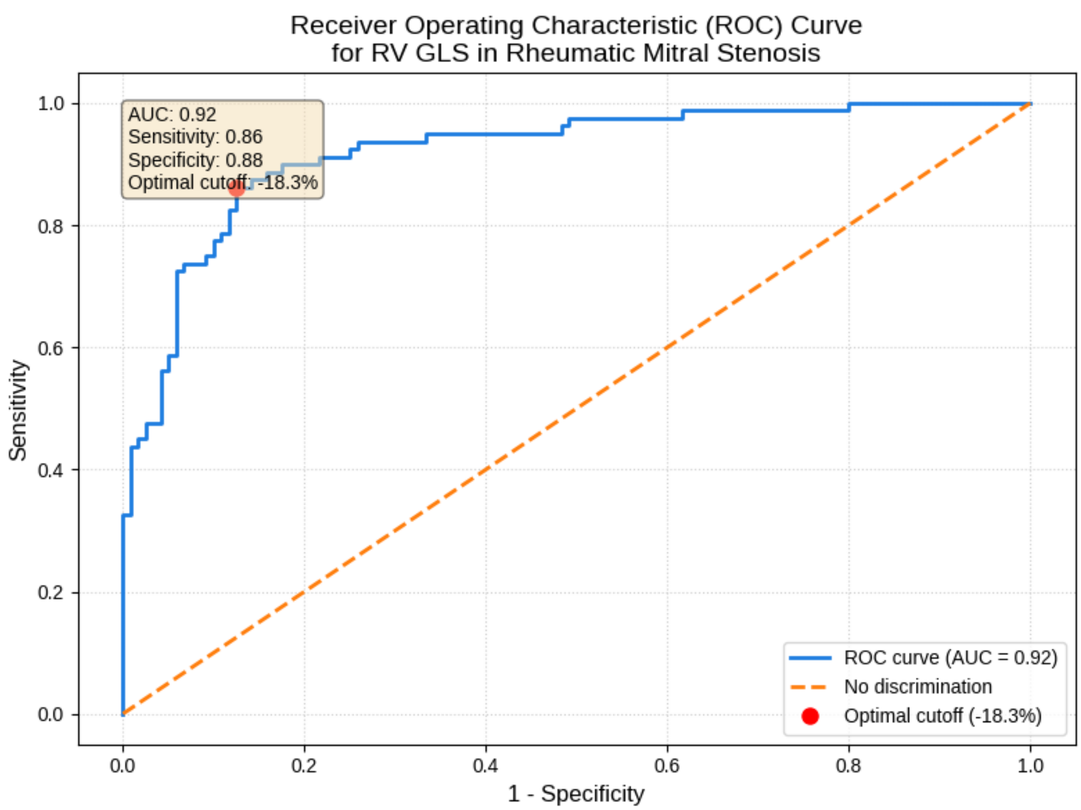

Figure 1: ROC Curve for RV GLS in Rheumatic MS

Discussion

Our study showed that speckle tracking differentiated RV dysfunction between mild & moderate mitral stenosis, & our study found RV GLS to be very accurate in differentiating RV dysfunction in mild versus moderate MS (AUC = 0.92, sensitivity 86%, specificity 88% at -18.3%). This performance beats RV FWLS (AUC = 0.88) & conventional parameters. RV GLS captures the complicated three-dimensional deformation of the RV, including the interventricular septum, which improves its accuracy. RV GLS detects RV impairment in rheumatic MS patients well, according to our ROC curve research.

Our research found no statistically significant change in RV function between mild & moderate mitral stenosis by TAPSE, 2D FAC, RIMP, & S' wave. In mild MS, right ventricular global longitudinal strain & free wall longitudinal strain was considerably less negative (p<0.001).

Surkova et al. (11) study had shown RV impairment in advanced MS. For instance, found comparable declines in traditional RV functional indices in severe MS patients. Mild & moderate mitral stenosis diastolic RV function revealed no statistical difference in E/A ratio, E/e' ratio, or IVC size, however moderate MS group had a considerably reduced deceleration time (p=0.006).

A case-control study of MS patients & healthy people with normal EF assessed 2D-STE. Both groups were evaluated for longitudinal strain & GLS. The absolute average GLS value was lower in MS patients than controls. In contrast, MS patients had considerably reduced baseline & mid-myocardial strain levels (12).

The ideal RV GLS cutoff value of -18.3%, with 86% sensitivity & 88% specificity, is similar to prior RV strain investigations in various cardiovascular diseases(13). RV FWLS' somewhat reduced but still strong diagnostic performance supports strain imaging in clinical practice.

These findings are consistent across diseases, suggesting RV GLS may be a reliable metric for RV function assessment in many clinical settings. RV GLS outperformed RV FWLS in our research (AUC 0.92 vs 0.88), suggesting it may be the best RV function parameter for MS patients. RV GLS is recommended as a quantitative measure of RV function (14). Septal deformation in RV GLS may improve RV mechanics evaluation, especially in interventricular dependency circumstances like MS with high left atrial pressures (14).

Conclusion

RV GLS is considered as a sensitive & specific measure for RV dysfunction in rheumatic MS patients, exceeding echocardiographic markers. These data show that RV strain imaging in regular echocardiographic evaluation of MS patients may enhance RV dysfunction identification & patient treatment.

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