Does Speckle Tracking Echocardiography Predict Left Ventricular Dysfunction in Patients with Severe Mitral Regurgitation?

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Abstract

Background: Speckle tracking echocardiography (STE) allows for the detailed assessment of myocardial deformation, providing early detection of cardiac impairment before traditional measures.

Objectives: This study investigated the predictive value of STE in identifying left ventricular dysfunction (LVD) in patients with severe MR.

Patients and methods: This prospective observational study enrolled 70 patients aged 18 years or older, both sexes, who were diagnosed with severe mitral regurgitation (MR). The patients were divided into Group I, Severe MR/LVD patients, and Group II, Severe MR without LVD.

Results: LV global longitudinal strain (GLS) and brain natriuretic peptide can significantly predict LVD (AUC = 0.838 and 0.713 respectively) at cut-off (>-20 and >145 respectively) had (86.36 and 72.73% respectively) sensitivity and (68.75 and 62.5% respectively) specificity. There was a positive correlation between BNP and LVEF (P =0.003) and a negative correlation between brain natriuretic peptide and LV global longitudinal strain (P =0.009).

Conclusions: STE, particularly GLS, can effectively predict LVD in patients with severe MR. STE offers valuable insights into myocardial function, enabling early detection of subclinical LVD.

Keywords: Severe Mitral Regurgitation; Left Ventricular Dysfunction; Speckle Tracking Echocardiography; Global Longitudinal Strain; Brain natriuretic peptide.

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Introduction

Mitral regurgitation (MR) is the most prevalent valvular heart disease, with severe forms often necessitating mitral valve replacement (MVR) surgery **(Casey et al., 2023)**. While the majority of identified individuals are asymptomatic, severe MR is linked to increased morbidity and death if left untreated **(Hamid et al., 2024)**.

While advancements in surgical procedures and adherence to guidelines have improved outcomes, the long-term development of left ventricular dysfunction (LVD) following MVR remains a significant concern **(Saber et al., 2024)**. Untreated MR can lead to chronic volume overload, ultimately leading to LVD and heart failure **(Welman et al., 2024)**.

Accurate and early prediction of LVD in patients with severe MR is crucial for timely intervention and optimal patient management. Assessment of LV may be carried out by either conventional echocardiogram or by speckle tracking echocardiography (STE) **(Pastore et al., 2022)**.

Conventional echocardiographic parameters aren't sensitive enough to detect early subclinical changes in myocardial functions **(Dell'Angela and Nicolosi, 2024)**. As a result, advanced echocardiographic techniques, such as STE, have emerged as valuable tools for more detailed and sensitive assessment of myocardial mechanics **(Xu et al., 2022)**.

STE is a practical and noninvasive approach for quantitatively evaluating cardiac function, enabling the measurement of strain values. Numerous studies have been published in the past five years indicating the application of STE for identifying subtle alterations in the ventricles. It offers prognostic insights for multiple cardiovascular diseases, which may not be observed by conventional echocardiography **(Shanishwara et al., 2022;Althunayyan, 2023)**.

Brain natriuretic peptide (BNP) is a myocardial cell-released hormone, and its increase indicates higher left atrial and ventricular pressures. It has been found to have an essential predictive value in several heart disorders **(Gallo et al., 2020)**.

Given the importance of early detection and prediction of LVD in patients with severe MR, this study aimed to investigate the role of STE in predicting LVD in these patients.

Patients and methods

This prospective observational study enrolled 70 cases aged 18 years or older, both sexes, diagnosed with severe MR. The diagnosis was based on the presence of a regurgitant volume exceeding 60 milliliters per beat, a regurgitant fraction exceeding 50%, and an effective regurgitant orifice area (EROA) exceeding 0.40 square centimeters **(Patel et al., 2021)**.

The study was performed between July 2023 and January 2025 after the ethical approval of AL-Azhar University Hospital's ethical committee in Egypt Informed written consent was obtained from the patient.

The patients with congenital or acquired valvular disease, concomitant significant valve disorders, including severe aortic stenosis and severe aortic regurgitation, as well as hypertrophic cardiomyopathy, myocardial infarction, infiltrative cardiomyopathies, persistent or paroxysmal atrial fibrillation or frequent premature ventricular contractions, acute coronary syndrome, acute heart failure, and severe systemic hypertension were excluded from the study.

All patients underwent full history taking, clinical examination, laboratory tests, echocardiographic evaluations, and speckle-tracking strain investigation.

The patients were divided into two groups: Group I: severe MR/LVD patients, and Group II: severe MR without LVD.

Echocardiographic evaluations: Transthoracic echocardiography was conducted utilizing accessible devices with a 3.5 MHz transducer, GE vivid e95, per American College of Cardiology and American Heart Association (2014) standards **(Nishimura et al., 2014)**. Color-flow and continuous wave Doppler images were analyzed during LVD evaluation to determine mitral regurgitation severity. Proximal regurgitant jet width (vena contracta), EROA (using the proximal iso-velocity surface area method), and regurgitant volume were measured.

Speckle-tracking strain analysis: The longitudinal strain was evaluated from the 4-chamber, 3-chamber, and 2-chamber apical perspectives to assess myocardial wall shortening (negative strain) and lengthening (positive strain). After manually drawing the LV endocardial boundary in the end-systolic frame, the program automatically derived a strain curve from gray-scale pictures. The longitudinal and circumferential stresses were global strains, representing myocardial alterations rather than segmental averages. The peak strain was the strain curve's largest negative value during the cardiac cycle. The peak values from the three apical views were averaged to compute GLS **(Shanishwara et al., 2022)**.

The primary outcome was the GLS value to predict LVD. The secondary outcome was the correlation with clinical symptoms and biomarkers.

Sample size calculation: The sample size calculation was done by Med Calc Software Ltd v. 20 with 95% power, 5% confidence limit, and the expected area under the curve (AUC) of the receiver operating characteristic (ROC) curve of GLS value to predict LVD is at least 0.829 according to a previous study **(Shanishwara et al., 2022)**. The null hypothesis's AUC of the ROC curve was 0.6. Eight cases were added to overcome dropout, so 70 patients were recruited into the study.

Statistical analysis

The statistical analysis was performed using SPSS software version 27 (IBM, Armonk, NY, USA). To determine the normality of the data distribution, we used the Shapiro-Wilks test and created histograms. The findings were reported as means and standard deviations for quantitative parametric data, and the unpaired t-test was used for analysis. Qualitative variables were reported as frequencies and percentages, and their study was based on the Chi-square test or Fisher's exact test, as applicable. The diagnostic performance of each test was assessed using a ROC curve analysis. A two-tailed p-value < 0.05 was deemed statistically significant.

Results

The prevalence of patients with severe MR and LVD was 22 individuals, representing 31.4% of the total population. Demographic characteristics and vital signs were statistically insignificant between patients with severe MR and LVD and those without these conditions (**Table.1).**

Table 1. Demographic data, comorbidities, and vital signs of the studied groups

Variables		Group I (n=22)	Group II (n=48)	P
Age (years)		48.32 ± 15.64	49.52 ± 14.94	0.759
Sex	**Male**	8 (36.36%)	20 (41.67%)	0.674
	Female	14 (63.64%)	28 (58.33%)	
Comorbidities	**Diabetes mellitus**	4 (18.18%)	6 (12.5%)	0.714
	Hypertension	5 (22.73%)	7 (14.58%)	0.497
	Smoking	5 (22.73%)	9 (18.75%)	0.752
Heart rate (beats/min)		74.36 ± 8.57	76.33 ± 6.4	0.288

Systolic blood pressure (mmHg)	130.95 ± 11.55	128.31 ± 8.37	0.282
Diastolic blood pressure (mmHg)	78.77 ± 7.06	76.98 ± 6.02	0.277

Data are presented as mean ± SD.

LV end-diastolic and end-systolic diameter, EF, and GLS values were significantly elevated in group I than in group II (P<0.001). TAPSE was insignificantly different between both groups, (**Table.2).**

Table 2. Echocardiographic and global longitudinal strain parameters and brain natriuretic peptide of the studied groups

Variables	Group I (n=22)	Group II (n=48)	P
Echocardiographic parameters			
Circumferential peak strain (%)	-14.14 ± 6.16	-19.6 ± 5.43	**<0.001***
LV end-systolic diameter (mm)	33.36 ± 6.04	27.96 ± 3.2	**<0.001***
LVEF (%)	34.73 ± 4.99	52.31 ± 3.87	**<0.001***
TAPSE (cm)	2.26 ± 0.39	2.19 ± 0.43	0.474
Global longitudinal strain			
LV global longitudinal strain (%)	-16.68 ± 2.32	-20.04 ± 2.38	**<0.001***
Circumferential peak strain (%)	-14.14 ± 6.16	-19.6 ± 5.43	**<0.001***
Radial peak strain (%)	42.09 ± 10.53	45.02 ± 9.66	0.256
Basal rotation (°)	-4.45 ± 2.4	-6.1 ± 2.69	**0.017***
Apical rotation (°)	7.82 ± 2.86	12.94 ± 3.08	**<0.001***
Twist (°)	10.68 ± 4.04	20.21 ± 7.71	**<0.001***
Brain natriuretic peptide (pg/mL)	181.45 ± 63.72	131.9 ± 53.94	**0.001***

Data are presented as mean ± SD. LV: Left ventricular, LVEF: Left ventricular ejection fraction, TAPSE: Tricuspid Annular Plane Systolic Excursion. BNP: Brain natriuretic peptide. *Significant as P ≤0.05.

Circumferential peak strain, basal rotation, and BNP were significantly elevated in group I than in group II (P<0.05). Apical rotation and twist were significantly lower in group I than in group II (P<0.001). Radial peak strain was insignificantly different between both groups, (**Table.2**).

A positive correlation existed between BNP and LVEF (P = 0.003), whereas a negative correlation was seen between BNP and LV GLS (P = 0.009). **Table 3**

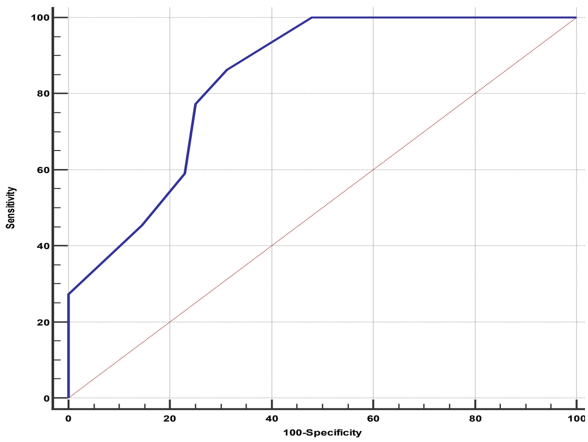
Table 3. Correlation between brain natriuretic peptide and (LVEF and LV global longitudinal strain) of the studied groups

Variables		Brain natriuretic peptide (pg/mL)
LVEF (%)	**r**	-0.344
	P	**0.003***
LV global longitudinal strain (%)	**r**	0.306
	P	**0.009***

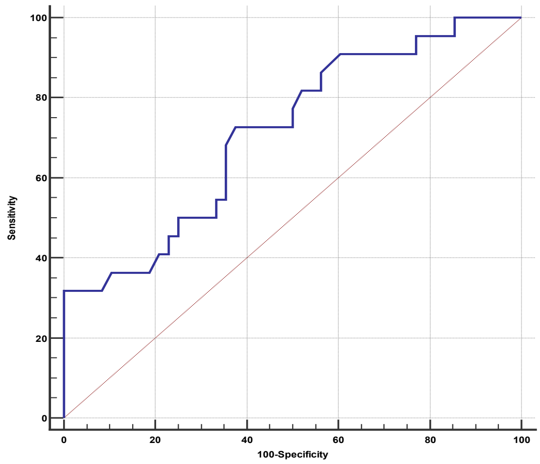
*Significant as P ≤0.05, r: Correlation coefficient, LV: Left ventricular, LVEF: Left ventricular ejection fraction

LV GLS can significantly predict LVD (P<0.001 and AUC = 0.838) at cut-off >-20 with 86.36% sensitivity, 68.75% specificity, 55.9% positive predictive value (PPV) and 91.7% negative predictive value (NPV), (**Fig.1A).**

BNP can significantly predict LVD (P = 0.001 and AUC = 0.713) at cut-off >145 with 72.73% sensitivity, 62.5% specificity, 47.1% PPV and 83.3% NPV. **(Fig.1B).**



(A)



(B)

Fig.1. ROC curve of A) LV global longitudinal strain B) BNP in prediction of left ventricular dysfunction

Discussion

The accurate prediction of LVD is crucial in managing severe MR patients. Two key measures have been identified as significant predictors of LVD: LVGLS and BNP **(Katahira et al., 2024)**.

This research is the first to our knowledge to investigate the efficacy of BNP in predicting LVD in individuals with severe MR.

The primary discoveries from this research are that LVGLS can significantly predict LVD (P < 0.001 and AUC = 0.838) at cut-off >-20 with 86.36% sensitivity, 68.75% specificity, 55.9% PPV and 91.7% NPV.

In line with our results, Shanishwara et al. **(Shanishwara et al., 2022)** stated that GLS< -18% can significantly predict LVD (AUC = 0.829) with 80.3% sensitivity and specificity of 75.7%. Also, Kislitsina and collaborators **(Kislitsina et al., 2020)** illustrated that preoperative strain assessments in degenerative MR cases were significantly associated with better identifying underlying LVD. Moreover, Bijvoet et al. **(Bijvoet et al., 2020)** reported that LV-GLS serves as a predictor of LVD post-surgery in asymptomatic chronic MR patients. Additionally, Witkowski et al. **(Witkowski et al., 2013)** demonstrated that GLS >-19.9% can significantly predict long-term LVD with 90 sensitivity and specificity of 79%. Ueyama et al. **(Ueyama et al., 2023)** suggested that assessment of GLS should be incorporated into the management of patients with severe

In this study, BNP can significantly predict LVD (AUC = 0.713) at cut-off >145 with 72.73% sensitivity, 62.5% specificity, 47.1% PPV and 83.3% NPV.

Avcı Demır et al. **(Avcı Demır et al., 2020)** agreed with our findings and noted that in primary MR patients, plasma BNP levels may be beneficial in assessing subclinical LVD. Also, Alashi and collaborators **(Alashi et al., 2016)** stated that elevated BNP levels and impaired LVGLS independently forecasted postoperative LV systolic dysfunction.

Magne and collaborators **(Magne et al., 2012)** stated that BNP is a powerful predictor of cardiac issues in asymptomatic degenerative MR. Pizarro and collaborators **(Pizarro et al., 2009)** found that BNP at 105 pg/ml predicted asymptomatic MR.

This research has significant drawbacks, which should be considered when interpreting the results. The relatively small sample size may restrict the findings' generalizability. Prospective observational design limits the ability to establish causality between STE measurements and LVD. The study included only patients with severe MR, which may not indicate the larger population with MR. The study did not include long-term follow-up. Routine STE screening is advised for severe MR patients, especially those without overt LVD. STE findings should be integrated into clinical decision-making to inform treatment strategies and patient management.

Conclusions

STE, particularly GLS, can effectively predict LVD in patients with severe MR. STE offers valuable insights into myocardial function, enabling early detection of subclinical LVD.

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