



## PROGNOSTIC VALUE OF EARLY GLOBAL LONGITUDINAL STRAIN FOR PREDICTING LEFT VENTRICULAR REMODELING AFTER ST-ELEVATION MYOCARDIAL INFARCTION

### Cardiology

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### ABSTRACT

**Background:** Adverse left ventricular (LV) remodeling after ST-elevation myocardial infarction (STEMI) is associated with subsequent heart failure and adverse outcomes. Early global longitudinal strain (GLS), measured using speckle-tracking echocardiography, may help identify patients at increased risk beyond conventional echocardiographic measures. **Methods:** This prospective, multicentre observational study enrolled 148 consecutive patients with STEMI at three centres in Bihar (Gaya, Darbhanga, and Begusarai) between October 2024 and October 2025. At enrolment, 116 patients underwent primary percutaneous coronary intervention (PCI) and 32 received thrombolysis. Transthoracic echocardiography, including GLS assessment, was performed within 24–48 hours of admission. Adverse LV remodeling was defined as a  $\geq 20\%$  increase in LV end-diastolic volume (LVEDV) from baseline at six months. Seven patients were lost to follow-up, leaving 141 patients for the final analysis. **Results:** The mean age was  $58.4 \pm 11.2$  years, and 68% of participants were male. Adverse remodeling was observed in 47 of 141 patients (33.3%). Baseline GLS was less negative in patients who developed remodeling than in those who did not ( $-11.8 \pm 2.9\%$  vs  $-16.4 \pm 3.1\%$ ;  $p < 0.001$ ). In the reported multivariable logistic regression model, worsening GLS was independently associated with remodeling (odds ratio [OR] 1.42 per 1-percentage-point worsening; 95% confidence interval [CI] 1.21–1.67;  $p < 0.001$ ). The area under the receiver-operating-characteristic curve (AUC) was 0.81; a study-derived cutoff of  $-13.2\%$  had 76% sensitivity and 79% specificity. **Conclusion:** GLS measured within 24–48 hours of STEMI was associated with adverse LV remodeling at six months in this cohort. These findings support further evaluation of early GLS as a risk-stratification measure, including validation in independent populations.

### KEYWORDS

Global Longitudinal Strain, Stemi, Left Ventricular Remodeling, Speckle-tracking Echocardiography.

### INTRODUCTION

ST-elevation myocardial infarction (STEMI) remains an important cause of morbidity and mortality worldwide, including in low- and middle-income countries such as India (1,2). Despite reperfusion treatment, some patients develop adverse LV remodeling, characterised by progressive ventricular dilatation and changes in function that may contribute to heart failure and other adverse outcomes (3,4).

Established correlates of remodeling include infarct size, anterior infarct location, delayed reperfusion, and reduced LV ejection fraction (LVEF). LVEF may not fully capture early myocardial dysfunction (5,6). Global longitudinal strain derived from two-dimensional speckle-tracking echocardiography provides a measure of myocardial deformation, and previous studies have reported associations between impaired GLS and subsequent remodeling or adverse cardiovascular outcomes (7–12).

Evidence from the Indian subcontinent, particularly Bihar, remains limited. Differences in patient characteristics, reperfusion strategies, and access to care may affect remodeling rates and the performance of prognostic markers. We therefore evaluated the association between early GLS and LV remodeling at six months after STEMI in a prospective, multicentre cohort from Bihar.

### Methods

#### Study Design and Setting

This prospective observational study was conducted at three tertiary-care centres in Bihar—Gaya, Darbhanga, and Begusarai—from October 2024 to October 2025. The protocol was approved by the institutional ethics committees, and written informed consent was obtained from all participants.

#### Patient Selection

Consecutive patients aged  $\geq 25$  years with acute STEMI undergoing reperfusion therapy (primary PCI or thrombolysis) who were hemodynamically stable enough to undergo echocardiography were screened.

Inclusion criteria: age  $\geq 25$  years; diagnosis of acute STEMI; reperfusion by primary PCI or thrombolysis; hemodynamically stable

patients able to undergo echocardiography; baseline transthoracic echocardiography with GLS within 24–48 hours of admission; willingness to provide informed consent and comply with 6-month follow-up.

Exclusion criteria were previous myocardial infarction or known ischaemic cardiomyopathy; heart failure or reduced LVEF before the index event; significant valvular heart disease; dilated, hypertrophic, or restrictive cardiomyopathy; congenital heart disease; and persistent atrial fibrillation or frequent arrhythmias that interfered with strain analysis. Patients who did not complete six-month follow-up were not included in the final outcome analysis.

Of the 148 enrolled patients, seven were lost to follow-up, leaving 141 patients in the final analysis. After attrition, infarct location was AWTMI in 72 patients, IWMI in 50, and PWMI in 19.

#### Echocardiographic Assessment

Transthoracic echocardiography was performed using commercially available ultrasound systems with dedicated software for two-dimensional speckle-tracking analysis. Standard apical four-, two-, and three-chamber views were acquired at frame rates of 50–80 frames/s. LV end-diastolic and end-systolic volumes and LVEF were calculated by the biplane Simpson method. GLS was measured offline as the average peak systolic longitudinal strain across 18 myocardial segments and expressed as a negative percentage; more negative values indicate better longitudinal function. Measurements were performed by two experienced echocardiographers blinded to clinical data; inter-observer variability was  $< 8\%$ .

Follow-up echocardiography was performed at six months using the same protocol. Adverse LV remodeling was defined a priori as a  $\geq 20\%$  increase in LVEDV relative to baseline (13,14).

#### Clinical Data

Demographic characteristics, cardiovascular risk factors, Killip class, peak cardiac troponin, reperfusion modality and timing, and discharge medications were recorded.

#### Statistical Analysis

Continuous variables were summarised as mean  $\pm$  standard deviation

or median (interquartile range), as appropriate, and compared using Student's t-test or the Mann-Whitney U test. Categorical variables were summarised as counts and percentages and compared using the  $\chi^2$  test or Fisher's exact test, as appropriate. Logistic regression was used to examine associations with adverse remodeling, and ROC analysis was used to assess the discriminatory performance of GLS and identify a study-derived cutoff. Statistical significance was defined as a two-sided p-value <0.05. Analyses were performed using SPSS version 26.0. The final manuscript should also specify the method used to select covariates, handle missing data, and derive the ROC cutoff.

## RESULTS

### Baseline Characteristics

The final analysis included 141 patients (mean age  $58.4 \pm 11.2$  years; 96 [68%] male and 45 [32%] female). Anterior wall MI accounted for approximately 51% of cases. Primary PCI was performed in 110 patients (78%), while 31 (22%) received thrombolysis. Door-to-balloon and door-to-needle times should be reported separately, with clear definitions, because they describe different treatment pathways. The manuscript reports higher peak troponin levels and a greater proportion of AWMi among patients who developed remodeling. Full baseline characteristics should be presented in Table 1.

### Echocardiographic Findings

Mean baseline LVEF was  $48.2 \pm 9.1\%$  and mean GLS was  $-14.9 \pm 3.6\%$ . At six months, 47 patients (33.3%) met the study definition of adverse remodeling. Compared with patients without remodeling, those with remodeling had less negative baseline GLS ( $-11.8 \pm 2.9\%$  vs  $-16.4 \pm 3.1\%$ ;  $p < 0.001$ ), lower LVEF ( $44.1 \pm 8.7\%$  vs  $50.3 \pm 8.6\%$ ;  $p < 0.001$ ), and larger baseline LVEDV.

### Predictors of Remodeling

In univariate analyses, AWMi, higher peak troponin, lower baseline LVEF, and less negative GLS were associated with remodeling. In the reported multivariable logistic regression model, which adjusted for age, sex, infarct location, peak troponin, reperfusion modality, and LVEF, GLS remained associated with remodeling (OR 1.42 per 1-percentage-point worsening; 95% CI 1.21–1.67;  $p < 0.001$ ). LVEF was not statistically significant after GLS was included in the model. This finding alone does not establish that GLS has superior predictive performance to LVEF.

ROC analysis gave an AUC of 0.81 (95% CI 0.73–0.89). The study-derived cutoff of  $-13.2\%$  had 76% sensitivity and 79% specificity. This cutoff should be regarded as exploratory until validated in an independent cohort.

## DISCUSSION

In this prospective multicentre cohort from Bihar, early GLS measured within 24–48 hours of STEMI was independently associated with adverse LV remodeling at six months. Approximately one-third of participants met the study's remodeling definition. This estimate should be interpreted in the context of the study population, follow-up completeness, and the specific LVEDV threshold used (13,15).

The findings are broadly consistent with previous reports linking impaired GLS to post-infarction remodeling. Tawfik et al. reported an association between baseline GLS and remodeling, with an AUC of 0.80 (8), while other studies have reported thresholds in a similar range (9–12,16). Differences between thresholds may reflect variation in patient characteristics, infarct severity, imaging methods, and treatment strategies; the present study was not designed to determine the reasons for such differences.

GLS reflects longitudinal myocardial deformation, which may be impaired after ischaemia even when LVEF is relatively preserved (17,18). The persistence of an association after adjustment for LVEF suggests that GLS may provide complementary information. However, formal comparison of model discrimination, calibration, and clinical utility would be required to establish whether GLS improves prediction beyond LVEF (19–21).

If validated, early GLS assessment may help identify patients who warrant closer follow-up after STEMI, including in resource-constrained settings. A GLS threshold around  $-13\%$  should not be used as a stand-alone treatment trigger on the basis of this study. Decisions about medication and advanced therapies should continue to follow established clinical indications.

## Limitations

This study has limitations. The sample size limited the precision of subgroup analyses by infarct location and reperfusion strategy. GLS analysis depends on image quality and may not be feasible in every patient. Seven enrolled patients were lost to follow-up, and the potential for attrition bias should be considered. Follow-up was limited to six months, and longer-term clinical outcomes were not assessed. Cardiac magnetic resonance imaging was not available to quantify infarct size. In addition, the GLS cutoff was derived and evaluated in the same cohort and requires external validation.

## CONCLUSION

In this multicentre cohort, early GLS assessment within 24–48 hours of STEMI was associated with adverse LV remodeling at six months, including after adjustment for selected clinical and echocardiographic variables. GLS may be a useful candidate for post-STEMI risk stratification, but the reported cutoff and its incremental value over conventional measures should be confirmed in an independent cohort before routine implementation.

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## Conflicts of Interest

None declared.

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