Original Article

Prognostic Value of Global Longitudinal Strain Measured by 2D Speckle-Tracking Echocardiography in Patients With ST-Segment Elevation Myocardial Infarction

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ABSTRACT

Background: ST-elevation myocardial infarction (STEMI) is a severe form of coronary artery disease, marked by myocardial necrosis because of complete coronary artery occlusion. Despite advances in treatment, STEMI remains a leading cause of morbidity and mortality globally. Left ventricular systolic dysfunction is a significant predictor of outcomes after STEMI, with global longitudinal strain (GLS) being a promising prognostic marker. This study investigated the prognostic value of GLS measured by speckle-tracking echocardiography (STE) in patients with STEMI treated within 24 hours of onset.

Methods: This prospective observational study included 50 hemodynamically stable patients with STEMI (mean age, 56 [SD, 11] years) admitted to Mansoura University for primary percutaneous coronary intervention or thrombolytic therapy. GLS was measured within 48 hours after revascularization. Patients were followed for 6 months to assess major adverse cardiac events (MACE).

Results: The median time to presentation was 3 hours, and 69 patients received thrombolytic therapy. Mean ejection fraction was 54 (SD, 8)%, and mean GLS was –11.5 (SD, 3.5). MACE occurred in 24 patients (48%). Diabetes was significantly more common in those with MACE (52% vs 24%; $P = 0.044$). No significant differences were found in other clinical or laboratory variables. GLS was a significant predictor of adverse outcomes.

Conclusions: GLS measured by 2D STE is a valuable prognostic tool in patients with STEMI, providing insight into future cardiac events and functional recovery. ***(Iranian Heart Journal 2026; 27(1): 52-62)***

KEYWORDS: ST-elevation myocardial infarction; global longitudinal strain; speckle-tracking echocardiography; prognostic value; acute myocardial infarction

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Globally, coronary artery disease (CAD) remains the leading cause of mortality. Among its clinical presentations, ST-elevation myocardial infarction (STEMI) represents the most critical and life-threatening form. Myocardial necrosis, the hallmark of acute myocardial infarction (AMI), is precipitated by an unstable ischemic syndrome. Clinically, STEMI is characterized by ischemic symptoms, particularly chest pain or discomfort, accompanied by ST-segment elevation on electrocardiography (ECG) and elevated troponin levels, indicative of complete coronary artery occlusion.[1]

Despite notable advances in treatment and prognosis, AMI persists as a leading cause of morbidity and mortality globally. This progress can be attributed to several key developments, including enhanced risk stratification, the broader adoption of invasive management strategies, the establishment of care systems emphasizing prompt revascularization via percutaneous coronary intervention (PCI) or thrombolysis, advancements in anticoagulant and antiplatelet therapies, and increased application of secondary prevention strategies, particularly statins.[2]

Left ventricular (LV) systolic function is widely acknowledged as a key determinant of prognosis after AMI.[3] Echocardiographic evaluation of global and regional LV systolic function predominantly relies on two widely accepted and recommended measures: left ventricular ejection fraction (LVEF) and wall motion score index (WMSI).[4] Despite their clinical utility, these measurements have inherent limitations. The biplane assessment of LVEF is often challenging because of suboptimal endocardial border delineation, making the process less reproducible and time-consuming.[5]

Accordingly, LVEF may not accurately reflect myocardial injury in cases where remote segments undergo compensatory hyperkinesis, masking dysfunction in the infarcted zone. WMSI, which evaluates regional systolic function, serves as an alternative; however, its interpretation is semiquantitative and highly reliant on operator expertise.[6]

LV systolic performance is a complex interplay of circumferential shortening, longitudinal contraction, and radial myocardial thickening. Strain and strain rate assessment has emerged as an advanced technique for evaluating LV functional integrity after AMI.[7] These indices leverage 2D speckle-tracking imaging, providing an automated assessment of myocardial function and enabling angle-independent quantification of deformation within a 2D plane.[8] In addition, this method allows for precise discrimination between active and passive myocardial motion while overcoming the frame-rate limitations associated with tissue Doppler imaging.[9]

Global longitudinal strain (GLS) has been extensively investigated as a superior prognostic indicator compared with LVEF in assessing cardiac events, functional recovery, and irreversible myocardial remodeling after AMI.[10]

Post-revascularization 2D strain analysis has been investigated as a predictive tool for the transmural extent of infarction, myocardial viability, adverse events, and LV remodeling in patients with acute coronary syndrome. Thus, 2D strain analysis serves as a valuable tool for risk stratification and for identifying potential predictors of future clinical outcomes.[11]

The present study aimed to assess the prognostic value of GLS measured by speckle-tracking echocardiography (STE) within 24 hours of acute STEMI.

METHODS

Design and Population

This prospective observational study was conducted at the Mansoura Acute Coronary Registry and included 50 patients with hemodynamically stable, low clinical risk

acute STEMI who were treated with either primary PCI or emergent thrombolytic therapy. The study was approved by the Research Ethics Committee of Mansoura University. Before enrollment, all participants provided informed consent after being informed of the study's aim and procedures.

Inclusion criteria were patients with acute STEMI, characterized by unrelenting chest pain lasting 30 to 60 minutes with specific ECG changes, including ST elevation in two or more contiguous leads or left bundle branch block. Patients underwent revascularization within 24 hours of admission through either primary PCI or emergent thrombolytic therapy at the Specialized Internal Medical Hospital, Mansoura University.

Exclusion criteria were patients presenting more than 24 hours after the onset of maximal chest pain, those with a history of congestive heart failure, coronary artery bypass grafting (CABG), or chronic kidney disease, and individuals with hemodynamic instability, including those on mechanical support or with in-hospital death. Moreover, patients with active infectious, inflammatory, or immunologic diseases, previous abnormal ventricular function, left bundle branch block, atrial fibrillation with rapid ventricular response, paced rhythm, moderate or severe valvular heart disease, or poor echocardiographic windows were excluded.

Evaluations

Patients were evaluated through detailed history taking, including personal details (age, sex, and occupation), chest pain characteristics (site, radiation, severity, duration, and associated symptoms), and risk factors for CAD (hypertension, diabetes mellitus, smoking, and a family history of CAD). Clinical examination involved assessing heart rate, blood pressure, heart auscultation for murmurs or abnormal sounds, and signs of heart failure. A standard 12-lead ECG was performed on admission and every 6 hours for the first 24 hours, then daily. Biochemical assessments, including cardiac biomarkers, were conducted on admission, and methods of reperfusion (primary PCI or thrombolytic therapy) were recorded. For primary PCI patients, coronary angiography details, affected vessels, thrombolysis in myocardial infarction (TIMI) scores, and lesion descriptions were documented.

Echocardiography

After successful revascularization, all patients underwent echocardiographic assessment within 48 hours. Two-dimensional conventional echocardiography was conducted using a Vivid 9 system, with standard M-mode and 2D images obtained from parasternal and apical views. The biplane Simpson method was employed to determine LVEF after tracing of LV end-diastolic and end-systolic volumes.

Strain and strain rate analysis was performed with speckle-tracking software to assess peak systolic longitudinal strain and strain rate from apical two-chamber, four-chamber, and long-axis views. The LV endocardial border was traced manually, and GLS was calculated as the average value from 18 segments across the three apical views.

Echocardiography and GLS Measurement

All patients underwent transthoracic echocardiographic evaluation within 48 hours after successful revascularization, using a GE Vivid 9 ultrasound system (GE Healthcare, USA). Standard 2D grayscale images were acquired from the parasternal long- and short-axis views, as well as apical four-chamber, two-chamber, and three-chamber views. LVEF was calculated using the biplane Simpson method.

GLS was assessed with STE via EchoPAC software (GE Healthcare). The endocardial borders were manually traced in each apical view at end-systole, and the software automatically tracked the motion of

myocardial speckles throughout the cardiac cycle. Peak systolic longitudinal strain was obtained for each of the 18 left ventricular segments, and GLS was calculated as the average of these segmental values. All measurements were performed offline by an experienced cardiologist who was blinded to the clinical data and patient outcomes.

Follow-Up

Patients were monitored for 6 months after discharge to evaluate major adverse cardiac events (MACE), including all-cause mortality, hospital readmission for congestive heart failure, reinfarction, and stroke. Additional outcomes evaluated included potential revascularization through CABG, New York Heart Association (NYHA) classification, and Canadian Cardiovascular Society (CCS) classification. Data were recorded to assess the prognostic value of GLS measured by 2D STE.

Statistical Analysis

Statistical analysis and data management were performed using SPSS, version 28 (IBM, Armonk, NY, USA). The normality of quantitative variables was assessed using the Shapiro-Wilk test and visual inspection. Based on normality, quantitative data were summarized as mean (SD) for normally distributed variables and median (range) for non-normally distributed variables. Categorical data were presented as frequencies and percentages. Independent *t* tests were utilized to compare normally distributed quantitative variables, while the Mann-Whitney *U* test was applied to non-normally distributed data. Categorical variables were analyzed using the chi-square or Fisher exact test, as appropriate. Spearman correlation analysis was drawn upon to assess associations between variables. Multivariate logistic regression analysis was used to identify predictors of major events, with odds ratios (ORs) and 95% confidence intervals (Cis) calculated. All statistical tests were 2-tailed, and a *P* value less than 0.05 was considered statistically significant.

RESULTS

Mean age was 56 (SD, 11) years, with substantial male predominance (87.5%). Body mass index (BMI) was 28.6 (SD, 4.7), and about two-thirds were smokers (64.6%). Over one-third had hypertension (43.8%) or diabetes (37.5%), while 12.5% had dyslipidemia and 20.8% had a positive family history. The most common presentation was anterior STEMI (58.3%). Laboratory results showed that hemoglobin was 14.1 (SD, 1.5), creatinine was 0.9 (range, 0.7-2.4), cholesterol was 196 (SD, 38), low-density lipoprotein was 125 (SD, 33), and high-density lipoprotein was 38 (SD, 7). Triglyceride was 178 (range, 56-359), and about half the patients had positive troponin. Creatine kinase-MB (CKMB) was 59 (range, 14-870).

Presentation time was 3 hours (range, 0.5-18 hours), and time to reperfusion was 5 hours (range, 0–19 hours). Thrombolytic therapy was the most common reperfusion method (68.8%), followed by PCI (31.3%). EF was 54% (SD, 8%), and E/A ratio was 0.73 (range, 0-2.93). About two-thirds of patients had segmental wall motion abnormalities (SWMA) (62.5%), and GLS was -11.5 (SD, 3.5). The most frequently affected vessels were the left anterior descending artery (LAD) and diagonals (73.3% each), with total vessel occlusion in 60% of cases. Prior to reperfusion, most patients had TIMI grade 0 (53.3%), whereas after reperfusion, TIMI grade III was most common (80%) (Table 1).

One-quarter had heart failure (25%), 12.5% experienced reinfarction, and mortality was 10.4%. Half the patients had MACE, and one-third were rehospitalized. Only 8.3% underwent CABG. NYHA classification was NYHA I (55.8%), and CCS classification was class I (67.4%) (Table 1).

Table 1. Presentation time, reperfusion characteristics, echocardiographic and global longitudinal strain findings, angiographic findings, and follow-up of the studied patients

Variable		Value
Time of presentation (h)		3 (0.5 - 18)
Time of reperfusion (h)		5 (0 - 19)
Reperfusion Method	Thrombolysis	33 (68.8%)
	PCI	15 (31.3%)
Ejection fraction (%)		54 (8)
E/A ratio		0.73 (0 - 2.93)
SWMA		30 (62.5%)
GLS		-11.5 (3.5)
LAD involvement		11 (73.3%)
LCX involvement		2 (13.3%)
RCA involvement		2 (13.3%)
PDA involvement		2 (13.3%)
PL involvement		2 (13.3%)
Diagonals involvement		11 (73.3%)
OMs involvement		2 (13.3%)
Lesion Description	Focal	4 (26.7%)
	Long	2 (13.3%)
	Total	9 (60%)
TIMI Prereperfusion	TIMI 0	8 (53.3%)
	TIMI I	3 (20%)
	TIMI II	3 (20%)
	TIMI III	1 (6.7%)
TIMI Postreperfusion	TIMI II	3 (20%)
	TIMI III	12 (80%)
Heart failure		12 (25%)
Reinfarction		6 (12.5%)
Mortality		5 (10.4%)
Major events		23 (47.9%)
Rehospitalization		19 (39.6%)
CABG		4 (8.3%)
NYHA Classification	NYHA I	24 (55.8%)
	NYHA II	15 (34.9%)
	NYHA III	4 (9.3%)
CCS Classification	Class I	29 (67.4%)
	Class II	8 (18.6%)
	Class III	6 (14%)

PCI: percutaneous coronary intervention; RCA: right coronary artery; GLS: global longitudinal strain; E/A: ejection to atrial ratio; SWMA: segmental wall motion abnormality; LCX: left circumflex; PDA: posterior descending artery; PL: posterolateral, TIMI: Thrombolysis in Myocardial Infarction; CABG: coronary artery bypass grafting; LAD: left anterior descending; NYHA: New York Heart Association; CCS: Canadian Cardiovascular Society

Data are presented as median (min–max), mean (SD), and count (%).

Diabetes was significantly more prevalent in patients with major events (52.2% vs 24%; $P = 0.044$), while no notable variations were observed in other demographic and general characteristics. Patients with major events had significantly lower hemoglobin levels (13.6 [SD, 1.6] vs 14.6 [SD, 1.3]; $P = 0.016$), but no significant differences were found in other laboratory data. Additionally, there were no significant differences in presentation time ($P = 0.398$), reperfusion time ($P = 0.672$), or reperfusion method ($P = 0.613$) between those with and without major events (Table 2).

No significant differences were found between patients with and without major events regarding EF, E/A ratio, SWMA, and involvement of the LAD, left circumflex (LCX), right coronary artery (RCA), posterior descending artery (PDA), posterolateral branch (PL), diagonals, and obtuse marginal branches (OMs) (Table 3). Nonetheless, GLS showed borderline significance ($P = 0.05$) in those with major events. Further, lesion description and prereperfusion and postreperfusion TIMI grades did not significantly differ between the two groups (Table 3).

A multivariate logistic regression analysis was conducted, incorporating all variables significant at the univariate level. Results indicated that diabetes, hemoglobin, and GLS did not independently predict major events (Table 4).

A significant positive correlation was observed between GLS and EF ($r = 0.514$; $P < 0.001$). No significant correlations were observed between GLS and other parameters (Table 5).

Table 2. General characteristics, laboratory findings, presentation time, and reperfusion characteristics according to major events

Variable	Yes (Major Events)	No (Major Events)	*P*
Demographic Data			
Age (y)	59 (10)	53 (12)	0.054
Sex			
Male	18 (78.3%)	24 (96%)	0.091
Female	5 (21.7%)	1 (4%)	
Risk Factors			
BMI	28.9 (5.1	28.3 (4.3	0.645
Smoking	14 (60.9%)	17 (68%)	0.606
Hypertension	13 (56.5%)	8 (32%)	0.087
Diabetes mellitus	12 (52.2%)	6 (24%)	0.044*
Dyslipidemia	4 (17.4%)	2 (8%)	0.407
Family history	7 (30.4%)	3 (12%)	0.116
Presentation			
Anterior STEMI	14 (60.9%)	14 (56%)	0.857
Inferior STEMI	8 (34.8%)	9 (36%)	
Lateral STEMI	1 (4.3%)	2 (8%)	
Laboratory Data			
Hemoglobin (g/dL)	13.6 (1.6)	14.6 (1.3)	0.016*
Creatinine (mg/dL)	0.9 (0.7 - 2.4)	0.9 (0.7 - 1.6)	0.691
Cholesterol (mg/dL)	198 (40)	194 (37)	0.734
LDL (mg/dL)	128 (35)	122 (32)	0.510
HDL (mg/dL)	38 (7)	38 (7)	0.963
Triglycerides (mg/dL)	187 (56 - 300)	175 (77 - 359)	0.252
Positive troponin	12 (52.2%)	14 (56%)	0.790
CKMB (U/L)	59 (14 - 290)	55 (16 - 870)	0.650
Time and Reperfusion			
Time of presentation (h)	3 (1 - 18)	4 (0.5 - 12)	0.398
Time of reperfusion (h)	4.5 (0 - 19)	5 (0 - 14)	0.672
Reperfusion method			
Thrombolysis	15 (65.2%)	18 (72%)	0.613
PCI	8 (34.8%)	7 (28%)	

BMI: body mass index; STEMI: ST-elevation myocardial infarction; HDL: high-density lipoprotein; LDL: low-density lipoprotein; CKMB: creatine kinase-MB; PCI: percutaneous coronary intervention

Data are presented as median (min–max), mean (SD), and number (%).

Table 3. Echocardiographic findings, GLS, and angiographic findings according to major events

Major Event	Yes	No	*P*
EF, mean (SD)	55 (9)	54 (9)	0.871
E/A ratio, median	0.7 (0 - 1.4)	0.8 (0.39 - 2.93)	0.096
SWMA, count (%)	16 (69.6%)	14 (56%)	0.332
GLS, mean (SD)	-10.5 (2.2)	-12.4 (4.2)	0.05*
LAD involvement, count (%)	6 (75%)	5 (71.4%)	1.0
LCX involvement, count (%)	0 (0%)	2 (28.6%)	0.2
RCA involvement, count (%)	2 (25%)	0 (0%)	0.467
PDA involvement, count (%)	2 (25%)	0 (0%)	0.467
PL involvement, count (%)	2 (25%)	0 (0%)	0.467
Diagonals involvement, count (%)	6 (75%)	5 (71.4%)	1.0
OMs involvement, count (%)	0 (0%)	2 (28.6%)	0.2
Lesion Description			
Focal (Count %)	2 (25%)	2 (28.6%)	1.0
Long, **count (%)**	1 (12.5%)	1 (14.3%)	

Total, **count (%)**	5 (62.5%)	4 (57.1%)	
TIMI prereperfusion			
TIMI 0, **count (%)**	4 (50%)	4 (57.1%)	1.0
TIMI I, **count (%)**	1 (12.5%)	2 (28.6%)	
TIMI II, **count (%)**	2 (25%)	1 (14.3%)	
TIMI III, **count (%)**	1 (12.5%)	0 (0%)	
TIMI Postreperfusion			
TIMI II, **count (%)**	2 (25%)	1 (14.3%)	1.0
TIMI III, **count (%)**	6 (75%)	6 (85.7%)	

EF: ejection fraction; SD: standard deviation; E/A ratio: E to A ratio; SWMA: segmental wall motion abnormality; GLS: global longitudinal strain; LAD: left anterior descending; LCX: left circumflex; RCA: right coronary artery; PDA: posterior descending artery; PL: posterolateral; OMs: obtuse marginal arteries; TIMI: Thrombolysis in Myocardial Infarction

Data are presented as median (min–max), mean (SD), and number (%).

Table 4. Multivariate logistic regression analysis to predict major events

	OR (95% CI)	*P*
Diabetes mellitus	1.879 (0.311 - 11.335)	0.492
Hemoglobin	0.82 (0.435 - 1.545)	0.538
GLS	0.897 (0.681 - 1.182)	0.441

OR: odds ratio; GLS; global longitudinal strain

Table 5. Correlation between GLS and other parameters

	GLS	
Variable	r	*P*
Age (y)	-0.092	0.534
BMI	-0.188	0.2
Hemoglobin	0.006	0.965
Creatinine	0.257	0.078
Cholesterol	0.053	0.723
LDL	0.031	0.832
HDL	-0.162	0.271
Triglycerides	0.005	0.976
CKMB	-0.202	0.168
Ejection fraction	.514	<.001*
E/A ratio	-0.037	0.801
Time of presentation	0.15	0.309
Time of reperfusion	0.166	0.26

* Significant
GLS: global longitudinal strain; BMI: body mass index; HDL: high-density lipoprotein; CKMB: creatine kinase-MB; LDL: low-density lipoprotein; EF: ejection fraction; E/A ratio: E to A ratio

DISCUSSION

AMI remains a leading cause of morbidity and mortality, despite advancements in risk stratification, invasive strategies, immediate revascularization, and secondary prevention with statins. [2] LV systolic function, assessed through EF and WMSI, is a key predictor of outcomes after AMI. [12]

GLS is an advanced, emerging modality that provides valuable insight into LV function after AMI, utilizing 2D speckle-tracking imaging for angle-independent myocardial deformation analysis. [13, 14]

GLS has been shown to be a superior marker to LVEF for predicting cardiac events and LV remodeling.[15] The current study evaluated the prognostic value of GLS, alongside other predictors, for MACE and complications, including mortality and readmissions, over a 6-month follow-up period after acute STEMI.

Our study found a borderline significant relationship between age and postdischarge major events, with older patients more likely to experience adverse outcomes, although this lacked a strong correlation, possibly because of the small sample size. The findings align with McNamara et al, [16] which showed age was a significant factor in mortality. Regarding diabetes, a significant association was observed between diabetes and postdischarge major events, corroborating McNamara et al[16] and Schmitt et al, [17] who found higher mortality and recurrent MI rates in patients with diabetes. In contrast, no significant association was found between hypertension, smoking, dyslipidemia, or BMI and postdischarge events in our study. These results disagree with prior studies by McNamara et al, [16] Rallidis et al, [18] and Hedayatnia et al, [19] which reported significant associations, likely because of the smaller sample size in our study.

Our study found that lower hemoglobin levels at presentation were significantly associated with MACE, supporting findings by Lee WC et al [20] and McNamara et al, [16] which also linked anemia with worse outcomes. Still, no significant differences were observed between cardiac troponin or serum creatinine levels and the occurrence of MACE, contrasting with McNamara et al, [16] who reported significant associations between these markers and mortality.

This investigation found no substantial differences in time to presentation, time to reperfusion, or reperfusion method (fibrinolysis or primary PCI) between patients with and without MACE, consistent with previous research. The distribution of reperfusion methods between the groups showed no significant difference, with a similar percentage of patients treated with fibrinolysis and primary PCI in both groups.

The present study found no significant differences in EF, E/A ratio, or SWMA between patients with and without MACE, which contrasts with the identification of EF and WMSI as predictors of post–myocardial infarction outcomes by Asanuma and Nakatani. [21]

Regarding GLS, a borderline significant relationship was observed with MACE, supporting the finding by Woo et al [22] of the predictive value of GLS for MACE. Nevertheless, this contradicts Lacanin and Tucay, [23] who found no significant differences in strain parameters, and aligns with Antoni et al, [24] Ersbøll et al, [13] and Hung et al, [25] who reported the predictive ability of GLS for adverse outcomes, including mortality and heart failure.

In this study, no significant differences were found in vessel involvement or myocardial infarction location between patients with and without MACE. While the LAD and diagonal vessels were most frequently affected in both groups, there was no notable difference in the RCA or LCX involvement. These findings contrast with those in a study by Jánosi et al, [26] which highlighted the prognostic significance of specific vessels, particularly the right coronary artery and left main artery. Further, no significant association was observed between anterior and nonanterior infarctions and MACE, aligning with the findings by Scarparo et al. [27] The lack of significant results could be attributed to the small sample size of patients who underwent primary PCI.

The current study found a significant positive correlation between GLS and EF, with no significant correlations between GLS and other parameters. These results align with a meta-analysis by Kalam et al, [28]

which confirmed the prognostic significance of GLS over LVEF in patients with various cardiac conditions.

Multivariate logistic regression analysis showed that diabetes mellitus, serum hemoglobin level at presentation, and GLS were not independent factors for predicting MACE during the 6-month follow-up.

In our study, the majority of patients received thrombolytic therapy rather than primary PCI. This reflects real-world clinical practice at our institution during the study period, where access to 24/7 PCI services was limited because of infrastructural and logistical constraints. Such patterns are not uncommon in resource-limited settings, where thrombolysis remains the most feasible immediate reperfusion option. Furthermore, the relatively high mortality rate (10.4%) observed in our cases can be explained by several factors, including delayed patient presentation, reliance on thrombolysis instead of PCI in most cases, and the presence of substantial baseline cardiovascular risk factors among the study population. These elements collectively contribute to a higher risk profile and worse short-term outcomes.

The present study has several limitations, including its conduct at a single medical center, a small sample size of 50 patients, and a heterogeneous patient population with varying ischemic vascular territories.

CONCLUSIONS

The results of the current study underscore the prognostic value of GLS measured by 2D STE in patients with acute STEMI. Although clinical characteristics such as diabetes and hemoglobin levels were significantly associated with MACE, GLS showed potential as an important marker for assessing risk, as lower GLS values correlated with a higher incidence of MACE.

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Conflict of Interest: None to declare.

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