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ORIGINAL RESEARCH

Pattern of Global Longitudinal Strain Recovery Following Percutaneous Coronary Intervention in Acute Coronary Syndrome: A Prospective Observational Study

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ABSTRACT

Aim: This study aimed to investigate the pattern of Global Longitudinal Strain (GLS) changes following percutaneous coronary intervention (PCI) in patients with acute coronary syndrome (ACS)subtypes. **Materials and method:** In this prospective observational study, 119 patients with ACS who underwent PCI were enrolled, with 109 completing follow-up. GLS measurements were performed using 2D speckle tracking echocardiography at baseline and 12-month follow-up.Comparisons between groups were performed using Chi-square test. P value <0.05 was considered as statistically significant throughout the analysis. **Results:** The study population (mean age 55.32 ± 11.47 years, 84% male) showed significant differences in baseline GLS across ACS types (ST-elevation myocardial infarction (STEMI): 12.05 ± 0.239, non-ST-elevation myocardial infarction (NSTEMI): 12.99 ± 0.242, unstable angina: 13.08 ± 0.523; p=0.004). At 12-month follow-up, all groups showed improvement (STEMI: 14.76 ± 0.275, NSTEMI: 15.33 ± 0.245, unstable angina: 15.42 ± 0.647), with difference between groups no longer significant (p=0.285). The STEMI patients demonstrated the greatest GLS improvement (2.48 ± 0.113), followed by NSTEMI (2.22 ± 0.112) and unstable angina (1.62 ± 0.224; p=0.019). **Conclusion:** This study demonstrates significant improvements in GLS following PCI across all ACS types, with STEMI patients showing the most marked recovery despite having the lowest baseline values. These findings suggest that GLS monitoring may be valuable for assessing myocardial recovery post-PCI.

Keywords: Angina, unstable; Global longitudinal strain; Non-ST elevated myocardial infarction; Percutaneous Coronary Intervention; ST elevation myocardial infarction

INTRODUCTION

Cardiovascular disease remains one of the leading causes of mortality worldwide, with acute coronary syndrome (ACS) contributing significantly to this burden[1]. While percutaneous coronary intervention (PCI) has revolutionized the treatment of ACS by restoring blood flow through the culprit artery, patients continue to face considerable risk of major adverse cardiac events (MACE), with reported incidence rates varying from 4.2% to 51%[2,3]. A particular concern in ACS patients is the development of heart failure, which significantly impacts both morbidity and mortality[4-6]. Identifying high-risk patients early in their clinical course is crucial for implementing appropriate monitoring strategies and timely interventions. Such risk stratification not only improves patient outcomes but also offers substantial socioeconomic benefits through more targeted healthcare delivery[7].

Traditional echocardiographic assessment, including visual evaluation of regional and global myocardial function, has shown limited utility in predicting myocardial viability. However, recent advances in cardiac imaging have highlighted the potential of two-dimensional (2D) strain analysis in ACS. Specifically, Global Longitudinal Strain (GLS), measured through 2D speckle tracking echocardiography (STE), has

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emerged as a well-established predictor of heart failure[8-11]

While numerous studies have established the predictive value of GLS in cardiac disease progression[3,7], there is limited research exploring the clinical significance of serial GLS measurements in monitoring cardiac function and determining long-term outcomes.Also, understanding the patterns of GLS may enable earlier identification of high-risk patients post-ACS, potentially leading to more timely interventions and improved outcomes. Therefore, this study aims to investigate the pattern of GLS changes following PCI in patients with ACS subtypes.

MATERIALS AND METHOD

Study Design and Population

This prospective observational study was conducted in the Department of Cardiology at our tertiary care hospital. The study population included adult patients (≥18 years) diagnosed with Acute Coronary Syndrome (ACS) according to the Fourth Universal Definition of Myocardial Infarction who underwent Percutaneous Coronary Intervention (PCI). Patients were excluded from the study if they had inadequate echocardiographic image quality, presented with non-sinus rhythm and pregnant women.A total of 119 patients meeting the predefined inclusion criteria were enrolled in the study. Due to lost to follow-up in 10 patients due to death 109 patients were investigated the pattern of GLS.

Data Collection and Echocardiographic Analysis

Baseline clinical characteristics and coronary angiogram findings were collected and documented for all patients. Echocardiographic examinations were performed using a VIVID 7 Ultrasound system (GE Healthcare, Horten, Norway) equipped with 3.5 MHz transducers. All echocardiographic images were stored in a GE Healthcare image vault for offline analysis using Echopac version 113 and version 202 (GE Healthcare, Horten, Norway).

Left ventricular dimensions were measured from the parasternal long-axis view at the level of the mitral valve tips. For strain analysis, measurements were obtained from the apical 4-chamber view. The left ventricle was segmented into 18 regions (6 segments per view) for comprehensive analysis. Global Longitudinal Strain (GLS) was calculated as the mean of the peak systolic longitudinal strain values from all 18 segments. The GLS measurements were reported as absolute values.

Follow-up and Strain Analysis

Follow-up echocardiographic examinations were performed at 12 months post-intervention. Delta GLS was defined as the difference between baseline GLS and follow-up GLS measurements.

Statistical analysis

The statistical analysis was performed using SPSS software. Categorical variables were expressed as number and percentage and continuous variables were expressed as Mean ± SD. Comparisons between groups were performed using Chi-square test. P value <0.05 was considered as statistically significant throughout the analysis.

RESULTS

A total of 119 patients were included in the study. The mean age of the study population was 55.32 ± 11.47 years. The majority of patients were male (n=100, 84.0%) compared to female patients (n=19, 16.0%). Regarding cardiovascular risk factors, 38.7% (n=46) of patients had hypertension, 32.8% (n=39) had diabetes mellitus, and 37.0% (n=44) were smokers. In terms of acute coronary syndrome (ACS) presentation, ST-elevation myocardial infarction (STEMI) was the most common diagnosis, occurring in 56.3% (n=67) of patients, followed by non-ST-elevation myocardial infarction (NSTEMI) in 37.8% (n=45), and unstable angina in 5.9% (n=7) of patients. **Table 1** detailed baseline characteristics in patients ACS who underwent PCI.

Regarding the revascularization strategy **(Table 2)**, among the 109 patients who underwent intervention, complete vessel revascularization was performed in the majority of cases (n=83, 76.1%), while culprit-only revascularization was done in 22 patients (20.2%). Coronary artery bypass grafting (CABG) was performed in 4 patients (3.7%) who were deemed more suitable for surgical revascularization based on their coronary anatomy and clinical presentation.

In **Table 3** the analysis of left ventricular ejection fraction (LVEF) in across different types of ACS showed a statistically significant association (Chi-square=27.30, p<0.0001). Among STEMI patients, the majority (59.7%, n=40) had moderately reduced LVEF (40-50%), while 31.3% (n=21) had severely reduced LVEF (<40%), and only 9.0% (n=6) had preserved LVEF (>50%). Whereas NSTEMI patients showed a different distribution, with 48.9% (n=22) having preserved LVEF, 40.0% (n=18) having moderately reduced LVEF, and 11.1% (n=5) having severely reduced LVEF.

Analysis of GLS across different types of ACS revealed significant differences in baseline measurements but not in follow-up values**(Table 4)**. The STEMI patients demonstrated the lowest baseline GLS (-12.05 ± 0.239 %), followed by NSTEMI (-12.99 ± 0.242 %) and unstable angina patients (-13.08 ± 0.523 %), with these differences being statistically significant (p=0.004). At follow-up, although all groups showed improvement, with STEMI patients achieving -14.76 ± 0.275 %, NSTEMI patients -15.33 ± 0.245 %, and unstable angina patients -15.42 ± 0.647 %, the differences between groups were no longer significant (p=0.285).**Figure 1**illustrates thepattern of change in GLS among the study

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population. When analysing the mean change in GLS across various clinical parameters in **Table 5**.The type of ACS emerged as the only factor showing statistical significance (p=0.019), with STEMI patients demonstrating the greatest improvement (2.48 ± 0.113 %), followed by NSTEMI (2.22 ± 0.112 %) and unstable angina (1.62 ± 0.224 %). Other clinical factors including gender (p=0.34), hypertension (p=0.21), diabetes (p=0.12), and smoking status (p=0.63) did not show significant associations with GLS improvement. Patients receiving complete vessel revascularization showed a trend toward greater GLS improvement (2.37 ± 0.814 %) compared to culprit-only intervention (2.25 ± 0.892 %) and those without intervention (1.75 ± 0.352 %).

Table 1: Baseline characteristics of patients with ACS who underwent PCI

Variables	N=119 patients
Mean Age, years	55.32 ± 11.47
Gender	
Male	100 (84.0)
Female	19 (16.0)
Hypertension	46 (38.7)
Diabetes	39 (32.8)
Smoking	44 (37.0)
Known CAD	7 (5.9)
Type of ACS	
STEMI	67 (56.3)
NSTEMI	45 (37.8)
Unstable angina	7 (5.9)

The data are represented in mean ± SD or n (%).
ACS:Acute coronary syndrome; CAD: Coronary artery disease; NSTEMI:Non-ST elevated myocardial infarction; STEMI:ST elevated myocardial infarction

Table 2: Revascularization strategy in patients with ACS

Revascularization strategy	N=109 patients
Complete vessel	83 (76.1)
Culprit	22 (20.1)
CABG	4 (3.7)

The data are represented in n (%).
CABG: Coronary artery bypass grafting

Table 3: Distribution of left ventricular ejection fraction across different types of ACS

Type of ACS	Left Ventricular Ejection Fraction (N=119 patients)			Chi Square	P-value
	< 40 % (n=26 patients)	40-50 % (n=61 patients)	> 50 % (n=32 patients)		
STEMI	21 (31.3)	40 (59.7)	6 (9.0)	27.30	<0.0001
NSTEMI	5 (11.1)	18 (40.0)	22 (48.9)		
Unstable angina	0 (00.0)	3 (42.9)	4 (57.1)		

The data are represented in n (%). P value <0.05 consider as statistically significant.
ACS: Acute coronary syndrome; NSTEMI:Non-ST elevated myocardial infarction; STEMI:ST elevated myocardial infarction

Table 4: Comparison of GLS at baseline and follow-up across different types of ACS

Type of ACS	Baseline GLS% (N=109 patients)	Follow-up GLS% (N=109 patients)
STEMI	-12.05 ± 0.239	-14.76 ± 0.275
NSTEMI	-12.99 ± 0.242	-15.33 ± 0.245
Unstable angina	-13.08 ± 0.523	-15.42 ± 0.647
P value	0.004	0.285

The data are represented in mean ± SD. P value <0.05 consider as statistically significant.
ACS: Acute coronary syndrome; GLS: Global longitudinal strain; NSTEMI: Non-ST elevated myocardial infarction; STEMI:ST elevated myocardial infarction

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Table 5: Association between clinical variables and mean change in GLS in patients with ACS

Variables	Mean change in GLS % (N=109 patients)	P value
Gender		
Male	-2.29 ± 0.089	0.34
Female	-2.50 ± 0.652	
Hypertension		
Yes	-2.21 ± 0.120	0.21
No	-2.40 ± 0.105	
Diabetes		
Yes	-2.16 ± 0.139	0.12
No	-2.41 ± 0.096	
Smoking		
Yes	-2.27 ± 0.139	0.63
No	-2.35 ± 0.094	
Type of ACS		
STEMI	-2.48 ± 0.113	0.019
NSTEMI	-2.22 ± 0.112	
Unstable angina	-1.62 ± 0.224	
No. of vessel involved		
SVD	-2.42 ± 0.108	0.55
DVD	-2.24 ± 0.842	
TVD	-2.19 ± 0.793	
LM+TVD	1.40	
Non-obstructive CAD	-2.10 ± 0.70	
PTCA		
Complete vessel	-2.37 ± 0.814	0.30
Culprit	-2.25 ± 0.892	
Nil	-1.75 ± 0.352	

The data are represented in mean ± SD. P value <0.05consider as statistically significant

ACS:Acute coronary syndrome; CAD:Coronary artery disease; DVD: Double vessel disease; GLS: Global longitudinal strain; LM: Left main; NSTEMI:Non-ST elevated myocardial infarction; PTCA:Percutaneous transluminal coronary angioplasty; SVD: Single vessel disease; STEMI:ST elevated myocardial infarction; TVD: Triple vessel disease; TVD: Triple vessel disease

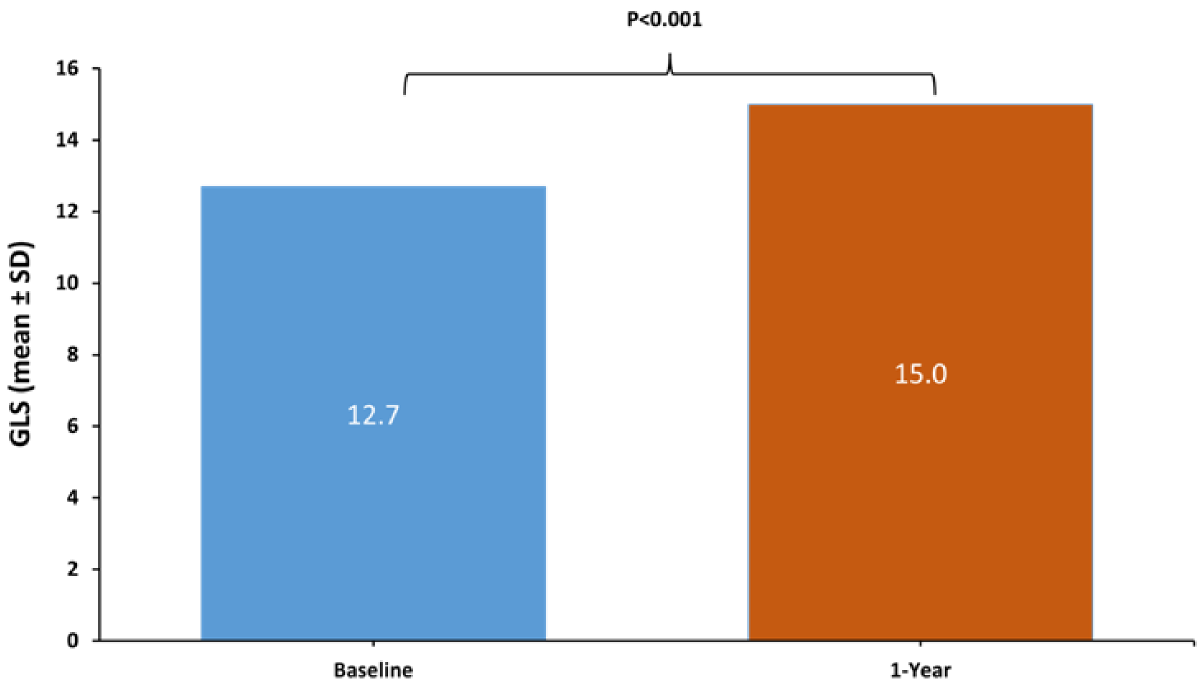

Figure 1: Pattern of change in GLS among the study population

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DISCUSSION

The present study investigated the patterns of GLS changes following PCI in patients with ACS.

The mean age of our study population was 55.32 years, comparable to Miguel et al.'s study which reported a mean age of 58 years[12]. The coronary angiographic findings in present study aligned with previous literature, showing single vessel disease as the predominant presentation across all ACS subtypes, followed by double vessel disease[13].

Interestingly, while Miguel Angel et al. found a direct relationship between the number of involved coronary arteries and baseline left ventricular GLS reduction[12], our study did not demonstrate such an association. This disparity might be attributed to our study population's higher proportion of STEMI cases (59.57%) compared to their NSTE-ACS cohorts. Notably, our study provides unique insights into GLS changes across the ACS spectrum over a one-year follow-up period, addressing a significant gap in current literature.

We cannot entirely compare the present study to published literature since no previous study has assessed change in GLS after 1 year in patients with ACS who underwent PCI. There is no data available addressed to GLS across the spectrum of ACS.

Our findings support and extend previous research by Ravnkilde et al., who emphasized the value of GLS measurements in risk stratification for patients with ACS [7]. Similarly, Battula and colleagues' observation of GLS as a superior echocardiographic measurement for early risk assessment in STEMI patients aligns with our results[14]. Our study demonstrated a significant association between ACS type and GLS improvement at one-year follow-up, with STEMI patients showing the most substantial enhancement.

The baseline GLS in our study (-12.7 %) corresponded closely with Ravnkilde et al.'s findings[7]. However, the present study demonstrated a more pronounced improvement at follow-up, with a mean GLS of -15.30% and an overall improvement of 2.32%, compared to their reported follow-up GLS of -13.5% and mean improvement of 0.73%. This enhanced recovery might reflect advances in intervention techniques and timing of care delivery.

A particularly noteworthy finding was the pattern of GLS across different ACS types. The STEMI patients showed the lowest baseline GLS (-12.05 %), compared to NSTEMI (-12.99 %) and unstable angina (-13.08 %), with statistically significant differences (p=0.004). This aligns with the known pathophysiology of STEMI causing more severe initial myocardial damage[15]. However, follow-up values showed no significant differences between groups (p=0.285), suggesting effective recovery with appropriate intervention regardless of initial presentation.

The magnitude of GLS improvement varied significantly among ACS types (p=0.019), with STEMI patients showing the greatest improvement (2.48%), followed by NSTEMI (2.22%) and unstable angina (1.62%). These findings parallel Baron et al.'s study, where initially impaired ejection fraction and GLS improved from -11.9% to -14.8%[16]. Our results particularly highlight that STEMI patients with lower LVEF demonstrated lower baseline GLS compared to NSTEMI or unstable angina patients, who typically presented with normal or mid-range LVEF. Importantly, timely and appropriate intervention led to more substantial GLS improvement in STEMI patients compared to other groups.

LIMITATIONS

The study was conducted at a single tertiary care center, which may limit the generalizability of the findings. The relatively small sample size, particularly in the unstable angina group, may have limited the statistical power to detect smaller differences between groups.While basic clinical parameters were analysed, the study may not have accounted for all potential confounding factors that could influence GLS measurements, such as medication adherence, lifestyle modifications, and concurrent medical conditions.Longer-term follow-up could better elucidate the sustainability of GLS improvements and their relationship to clinical outcomes.

CONCLUSION

In conclusion, this study demonstrates a significant pattern of GLS improvement following PCI across the spectrum of ACS, with STEMI patients showing the most remarkable recovery despite having the lowest baseline values. The alignment of follow-up GLS values across all ACS types suggests effective myocardial functional recovery with timely intervention. Furthermore, the differential patterns of GLS improvement between ACS types highlight the potential utility of serial GLS measurements as a valuable tool for risk stratification and monitoring of post-PCI recovery. These findings support the incorporation of routine GLS assessment into clinical practice for optimizing post-ACS patient care.

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