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Original Article

Predictive Value of Preoperative Myocardial Strain Imaging on Post-CABG Recovery

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ABSTRACT

Background: Conventional left ventricular ejection fraction may not identify subtle myocardial dysfunction relevant to recovery after coronary artery bypass grafting. Global longitudinal strain provides a quantitative measure of myocardial deformation and may offer complementary prognostic information. Objective: To evaluate the association of preoperative global longitudinal strain with early postoperative cardiac output, intensive care unit stay, and complications following elective isolated coronary artery bypass grafting. Methods: This retrospective cohort study included 110 adults who underwent CABG at a tertiary cardiac centre in Central Punjab, Pakistan, between January 2022 and December 2024. Preoperative absolute GLS magnitude was classified as severely impaired (<11.0%), moderately impaired (11.1%–14.0%), or mild-to-preserved (>14.0%). Outcomes included early cardiac output, ICU stay, low cardiac output syndrome, new-onset atrial fibrillation, acute kidney injury, and a composite of postoperative complications. Group comparisons and adjusted regression analyses were performed. Results: ICU stay was 76.4 ± 20.5, 56.2 ± 14.8, and 49.1 ± 11.2 hours across severe, moderate, and mild-to-preserved GLS groups, respectively ($p < 0.001$). Corresponding cardiac output values were 3.9 ± 0.6, 4.6 ± 0.7, and 5.1 ± 0.7 L/min ($p < 0.001$). Low cardiac output syndrome occurred in 36.0%, 10.4%, and 0.0%, respectively ($p < 0.001$). Each one-percentage-point reduction in absolute GLS magnitude was associated with greater odds of postoperative complications (adjusted OR = 1.45, 95% CI: 1.12–1.88; $p = 0.005$). Conclusion: Impaired preoperative GLS was associated with poorer early recovery after CABG independently of baseline ejection fraction. Prospective validation is required before routine GLS-guided perioperative management can be recommended. Keywords: Coronary Artery Bypass Grafting; Global Longitudinal Strain; Speckle-Tracking Echocardiography; Cardiac Output; Low Cardiac Output Syndrome; Intensive Care Unit; Postoperative Complications.

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INTRODUCTION

Coronary artery bypass grafting remains an established revascularization procedure for patients with advanced coronary artery disease; however, early postoperative recovery varies considerably among patients undergoing otherwise comparable surgical procedures. Some patients develop low cardiac output syndrome, new-onset atrial fibrillation, acute kidney injury, or prolonged intensive care unit stays, whereas others recover without major early complications. Accurate preoperative identification of patients at increased risk may support perioperative planning, postoperative monitoring, and efficient allocation of critical-care resources.

Conventional preoperative cardiac assessment relies heavily on left ventricular ejection fraction and established clinical risk factors. Although left ventricular ejection fraction provides important information about global systolic performance, it is influenced by ventricular geometry, loading conditions, heart rate, and image quality. It may therefore remain within a preserved or mildly reduced range despite the presence of clinically meaningful abnormalities in myocardial contractility. This limitation is particularly relevant in patients with chronic ischemic heart disease, in whom longitudinally oriented subendocardial myocardial fibres may become dysfunctional before substantial changes in global ventricular volume are detectable.

Global longitudinal strain derived from speckle-tracking echocardiography provides a quantitative measure of longitudinal myocardial deformation and may identify subtle systolic dysfunction that is not fully reflected by ejection fraction. Strain imaging has increasingly been used in perioperative echocardiography because it permits assessment of intrinsic myocardial mechanics and may provide additional information regarding ventricular functional reserve (1). Impairment of global longitudinal strain has also been associated with adverse cardiovascular outcomes across several cardiac populations, supporting its potential role as a prognostic imaging marker (2).

Evidence concerning the prognostic value of global longitudinal strain in patients undergoing coronary artery bypass grafting remains comparatively limited. Previous research has demonstrated that impaired preoperative global longitudinal strain may be associated with subsequent cardiovascular events after CABG (3). Nevertheless, fewer studies have examined its relationship with immediate postoperative recovery outcomes, including early cardiac output, low cardiac output syndrome, acute postoperative complications, and duration of intensive care unit admission. In addition, conventional risk models may not fully account for myocardial deformation abnormalities that exist independently of left ventricular ejection fraction (3-7).

A clearer understanding of the relationship between preoperative global longitudinal strain and early postoperative outcomes could improve clinical risk assessment. Patients with impaired myocardial deformation may possess reduced myocardial reserve and may consequently be more vulnerable to the physiological effects of cardiopulmonary bypass, ischemia–reperfusion injury, systemic inflammation, and perioperative changes in ventricular loading. Identification of this vulnerability before surgery may help clinicians anticipate the need for closer hemodynamic surveillance and prolonged critical-care support. However, the incremental predictive contribution of global longitudinal strain should be evaluated cautiously and independently of established clinical, echocardiographic, and intraoperative risk factors (8-11).

This study therefore evaluated the association of preoperative global longitudinal strain with early functional recovery among adults undergoing elective isolated coronary artery bypass grafting. The principal outcomes were postoperative cardiac output, intensive care unit stay duration, and early postoperative complications, including low cardiac output syndrome, new-onset atrial fibrillation, and acute kidney injury. It was hypothesized that a lower absolute magnitude of preoperative global longitudinal strain, indicating more severe myocardial deformation impairment, would be independently associated with lower early postoperative cardiac output, prolonged intensive care unit stay, and a greater risk of postoperative complications after adjustment for relevant baseline and operative characteristics.

MATERIALS AND METHODS

A retrospective cohort study was conducted using electronic medical records and archived cardiovascular imaging data from a tertiary-care cardiac centre in Central Punjab, Pakistan. The study involved the review of historical records of patients who underwent coronary artery bypass grafting between January 2022 and December 2024. Data extraction, verification, and statistical analysis were performed from May to December 2025. As the investigation relied exclusively on previously recorded clinical information, no direct patient contact or alteration of routine clinical management occurred (12-16).

The study population comprised adults with coronary artery disease who underwent elective isolated coronary artery bypass grafting with cardiopulmonary bypass. Patients were eligible when complete preoperative echocardiographic records were available, including a quantitative global longitudinal strain measurement obtained within two weeks before surgery, together with adequate postoperative hemodynamic and intensive care documentation. Patients were excluded if they underwent emergency surgery, had undergone previous coronary revascularization or cardiac surgery, received concomitant valvular or aortic surgery, had severe renal failure requiring hemodialysis, had severe uncorrected pulmonary hypertension, or had incomplete records for the principal exposure or postoperative outcomes. Consecutive records meeting the eligibility criteria during the defined review period were assessed, and 110 complete patient records were included in the final analysis (16).

The minimum sample size was estimated using an anticipated correlation of 0.30 between preoperative myocardial strain and early postoperative cardiac output, a two-sided significance level of 5%, and a statistical power of 80%. This calculation yielded a minimum requirement of 85 patients. The final analytical sample was increased to 110 complete records to improve the precision of the estimates and compensate for records that could not be used because of incomplete exposure or outcome information.

Data were extracted independently by two trained clinical reviewers using a structured electronic data-collection form. The principal exposure was preoperative left ventricular global longitudinal strain measured by speckle-tracking echocardiography. Global longitudinal strain was analysed as a continuous variable using its absolute magnitude so that lower absolute values represented more severe impairment. For descriptive and group-comparison analyses, patients were additionally classified into severely impaired, moderately impaired, and mild-to-preserved strain groups according to the thresholds used in the clinical database: an absolute GLS magnitude of less than 11.0%, 11.1%–14.0%, and greater than 14.0%, respectively. The reviewers applied the same eligibility criteria and variable definitions throughout the extraction process, and discrepancies were resolved by reassessment of the original electronic record.

The principal postoperative outcomes were cardiac output measured during the first 24 hours after surgery, duration of intensive care unit admission in hours, and occurrence of at least one early postoperative complication. Individual complications evaluated were low cardiac output syndrome, new-onset atrial fibrillation, and acute kidney injury documented during the initial postoperative admission. Postoperative cardiac output values were obtained from available hemodynamic-monitoring or echocardiographic records. Intensive care unit duration was calculated from postoperative ICU admission to documented ICU discharge. The composite complication outcome represented the occurrence of one or more of the prespecified complications; patients experiencing multiple complications were counted once in the composite analysis, while each event was retained separately for complication-specific analyses.

Demographic, clinical, echocardiographic, and intraoperative variables were also extracted as potential confounders. These included age, sex, body mass index, hypertension, type 2 diabetes mellitus, baseline left ventricular ejection fraction, number of bypassed vessels, aortic cross-clamp time, and total cardiopulmonary bypass duration. Exposure and outcome information was obtained from the preoperative echocardiographic archive, operative records, intensive care monitoring charts, laboratory records, and postoperative clinical documentation. Uniform eligibility criteria were applied to consecutive records to reduce selection bias, while standardized extraction procedures and reassessment of discrepant entries were used to reduce information and transcription errors.

Records lacking either the principal exposure or a principal outcome were excluded from the corresponding analysis. The extent of missing information was evaluated for all covariates before multivariable modelling. Variables with available complete data were preferentially included in the adjusted models to reduce distortion of estimates caused by incomplete documentation. Continuous variables were examined graphically for distributional characteristics and summarized as mean ± standard deviation when approximately normally distributed. Categorical variables were summarized as frequencies and percentages.

Data were analysed using IBM SPSS Statistics version 26.0. Differences in continuous postoperative outcomes across the three global longitudinal strain categories were assessed using one-way analysis of variance, with appropriate post hoc comparisons when the overall test was statistically significant. Associations between categorical strain groups and postoperative complications were examined using the chi-square test or an exact test when expected cell frequencies were insufficient. Multivariable linear regression was used to assess the association between continuous absolute global longitudinal strain and intensive care unit stay duration, while multivariable logistic regression was used to evaluate the association between global longitudinal strain and the occurrence of at least one early postoperative complication. The adjusted models included clinically relevant variables available in the dataset, including age, baseline left ventricular ejection fraction, and cardiopulmonary bypass duration. Regression estimates were interpreted for each one-percentage-point reduction in the absolute magnitude of global longitudinal strain. Model assumptions, residual patterns, influential observations, and multicollinearity between global longitudinal strain and left ventricular ejection fraction were evaluated before final interpretation. Effect estimates were reported with 95% confidence intervals, and a two-sided p-value of ≤ 0.05 was considered statistically significant.

All extracted data were de-identified before analysis and were stored in password-protected electronic files accessible only to the research team. Patient names, medical-record numbers, and other direct identifiers were not included in the analytical dataset, and the study involved no intervention or direct contact with patients.

RESULTS

A total of 110 patients undergoing elective isolated coronary artery bypass grafting were included in the analysis. The mean age was 62.4 ± 7.8 years, and 79 patients (71.8%) were male. The mean body mass index was 27.2 ± 3.4 kg/m^2, while the mean preoperative left ventricular ejection fraction was 44.5 ± 6.2%. Hypertension was present in 86 patients (78.2%), and 46 (41.8%) had type 2 diabetes mellitus. The mean aortic cross-clamp and cardiopulmonary bypass durations were 64.2 ± 14.5 and 98.6 ± 22.1 minutes, respectively (Table 1).

Table 1. Demographic, Clinical, and Operative Characteristics of the Study Population

Characteristic	Overall (N = 110)
Age, years	62.4 ± 7.8
Male sex	79 (71.8)
Body mass index, kg/m^2	27.2 ± 3.4
Left ventricular ejection fraction, %	44.5 ± 6.2
Hypertension	86 (78.2)
Type 2 diabetes mellitus	46 (41.8)
Aortic cross-clamp duration, minutes	64.2 ± 14.5
Cardiopulmonary bypass duration, minutes	98.6 ± 22.1

Data are presented as mean ± standard deviation or n (%).

The mean preoperative absolute global longitudinal strain magnitude was 14.2 ± 2.6%. Twenty-five patients (22.7%) had severely impaired GLS, defined as an absolute magnitude of <11.0%; 48 (43.6%) had moderately impaired GLS of 11.1%–14.0%; and 37 (33.6%) had mild-to-preserved GLS of >14.0% (Table 2).

Table 2. Distribution of Preoperative Global Longitudinal Strain Categories

GLS category	Absolute GLS magnitude, %	n (%)
Severely impaired	<11.0	25 (22.7)
Moderately impaired	11.1–14.0	48 (43.6)
Mild to preserved	>14.0	37 (33.6)
Total	—	110 (100.0)

GLS, global longitudinal strain. A lower absolute GLS magnitude indicates greater impairment of longitudinal myocardial deformation.

The mean postoperative intensive care unit stay for the overall cohort was 58.4 ± 18.2 hours, and the mean cardiac output measured during the first 24 postoperative hours was 4.6 ± 0.8 L/min. At least one early postoperative complication occurred in 38 patients (34.5%). Low cardiac output syndrome occurred in 14 patients (12.7%), new-onset atrial fibrillation in 20 (18.2%), and acute kidney injury in 8 (7.3%). Because individual complication categories were not mutually exclusive, the sum of individual events exceeded the number of patients experiencing at least one complication.

Postoperative recovery differed substantially across the preoperative GLS categories. Mean ICU stay was longest among patients with severely impaired GLS at 76.4 ± 20.5 hours, compared with 56.2 ± 14.8 hours in the moderately impaired group and 49.1 ± 11.2 hours in the mild-to-preserved group. The overall difference was statistically significant, with a large effect size ($F[2,107] = 24.78$, $p < 0.001$; $\eta^2 = 0.317$). Compared with the mild-to-preserved group, patients with severely impaired GLS remained in the ICU for a mean of 27.3 additional hours (95% CI: 18.2–36.4). The severe group also had a 20.2-hour longer mean ICU stay than the moderate group (95% CI: 10.8–29.6), while the moderate group remained in the ICU 7.1 hours longer than the mild-to-preserved group (95% CI: 1.5–12.7).

Early postoperative cardiac output demonstrated a corresponding gradient across the GLS categories. Mean cardiac output was 3.9 ± 0.6 L/min in the severely impaired group, 4.6 ± 0.7 L/min in the moderately impaired group, and 5.1 ± 0.7 L/min in the mild-to-preserved group ($F[2,107] = 23.32$, $p < 0.001$; $\eta^2 = 0.304$). Compared with patients with mild-to-preserved GLS, those with severely impaired GLS had a mean cardiac output that was 1.2 L/min lower (95% CI: 0.9–1.5). Cardiac output was also 0.7 L/min lower in the severe group than in the moderate group (95% CI: 0.4–1.0) and 0.5 L/min lower in the moderate group than in the mild-to-preserved group (95% CI: 0.2–0.8).

Table 3. Early Postoperative Outcomes According to Preoperative Global Longitudinal Strain

Postoperative outcome	Severely impaired GLS (n = 25)	Moderately impaired GLS (n = 48)	Mild-to-preserved GLS (n = 37)	Test statistic	p-value
ICU stay, hours	76.4 ± 20.5	56.2 ± 14.8	49.1 ± 11.2	$F(2,107) = 24.78$	<0.001
Cardiac output, L/min	3.9 ± 0.6	4.6 ± 0.7	5.1 ± 0.7	$F(2,107) = 23.32$	<0.001
Low cardiac output syndrome	9 (36.0)	5 (10.4)	0 (0.0)	$\chi^2(2) = 17.82$	<0.001
New-onset atrial fibrillation	7 (28.0)	9 (18.8)	4 (10.8)	$\chi^2(2) = 2.98$	0.225
Acute kidney injury	4 (16.0)	3 (6.3)	1 (2.7)	$\chi^2(2) = 4.04$	0.132

Data are presented as mean ± standard deviation or n (%). Continuous outcomes were compared using one-way analysis of variance. Categorical outcomes were compared using Pearson's chi-square test. GLS, global longitudinal strain; ICU, intensive care unit.

Low cardiac output syndrome was observed in 36.0% of patients with severely impaired GLS and 10.4% of those with moderately impaired GLS, whereas no cases occurred in the mild-to-preserved group ($\chi^2[2] = 17.82$, $p < 0.001$). The risk of low cardiac output syndrome was approximately 3.46 times higher in the severe group than in the moderate group (risk ratio = 3.46, 95% CI: 1.30–9.21). A risk ratio comparing the severe and mild-to-preserved groups was not directly estimable without a continuity correction because no events occurred in the mild-to-preserved group.

New-onset atrial fibrillation occurred in 28.0%, 18.8%, and 10.8% of patients in the severe, moderate, and mild-to-preserved GLS groups, respectively. Although the frequency increased progressively with worsening GLS, the overall association did not reach statistical significance ($\chi^2[2] = 2.98$, $p = 0.225$). Acute kidney injury occurred in 16.0% of the severe group, 6.3% of the moderate group, and 2.7% of the mild-to-preserved group; this difference was also not statistically significant ($\chi^2[2] = 4.04$, $p = 0.132$). In the adjusted linear regression analysis, preoperative GLS remained associated with ICU stay after adjustment for age, baseline left ventricular ejection fraction, and cardiopulmonary bypass duration. Each reduction in the absolute magnitude of GLS was associated with a longer postoperative ICU stay, with a reported adjusted standardized coefficient of $\beta = 0.42$ (95% CI: 0.18–0.66; $p = 0.002$). In the adjusted logistic regression model, each one-percentage-point reduction in absolute GLS magnitude was associated with greater odds of experiencing at least one early postoperative complication (adjusted OR = 1.45, 95% CI: 1.12–1.88; $p = 0.005$) (Table 4).

Table 4. Unadjusted and Adjusted Associations Between Preoperative Global Longitudinal Strain and Early Postoperative Outcomes

Exposure	Outcome	Analysis	Effect estimate (95% CI)	p-value
GLS category	ICU stay	One-way ANOVA	$\eta^2 = 0.317$	<0.001
GLS category	Cardiac output	One-way ANOVA	$\eta^2 = 0.304$	<0.001
Severe vs moderate GLS	Low cardiac output syndrome	Risk ratio	3.46 (1.30–9.21)	0.013
Continuous absolute GLS	ICU stay		$\beta = 0.42$ (0.18–0.66)	0.002
Continuous absolute GLS	At least one postoperative complication		OR = 1.45 (1.12–1.88)	0.005

The linear and logistic regression models were adjusted for age, baseline left ventricular ejection fraction, and cardiopulmonary bypass duration. The reported regression estimates were interpreted per one-percentage-point reduction in the absolute magnitude of GLS. β denotes the reported adjusted standardized regression coefficient. η^2, eta squared; CI, confidence interval; GLS, global longitudinal strain; ICU, intensive care unit; OR, odds ratio.

Overall, worsening preoperative GLS was associated with a clinically and statistically important deterioration in early post-CABG recovery. The most pronounced differences were observed in ICU stay and postoperative cardiac output, for which GLS category explained approximately 31.7% and 30.4% of the observed variation, respectively. Low cardiac output syndrome was concentrated among patients with severely impaired myocardial deformation, while atrial fibrillation and acute kidney injury showed directionally similar but statistically non-significant gradients. After adjustment for age, left ventricular ejection fraction, and cardiopulmonary bypass duration, impaired GLS remained associated with prolonged intensive care requirements and increased odds of early postoperative complications.

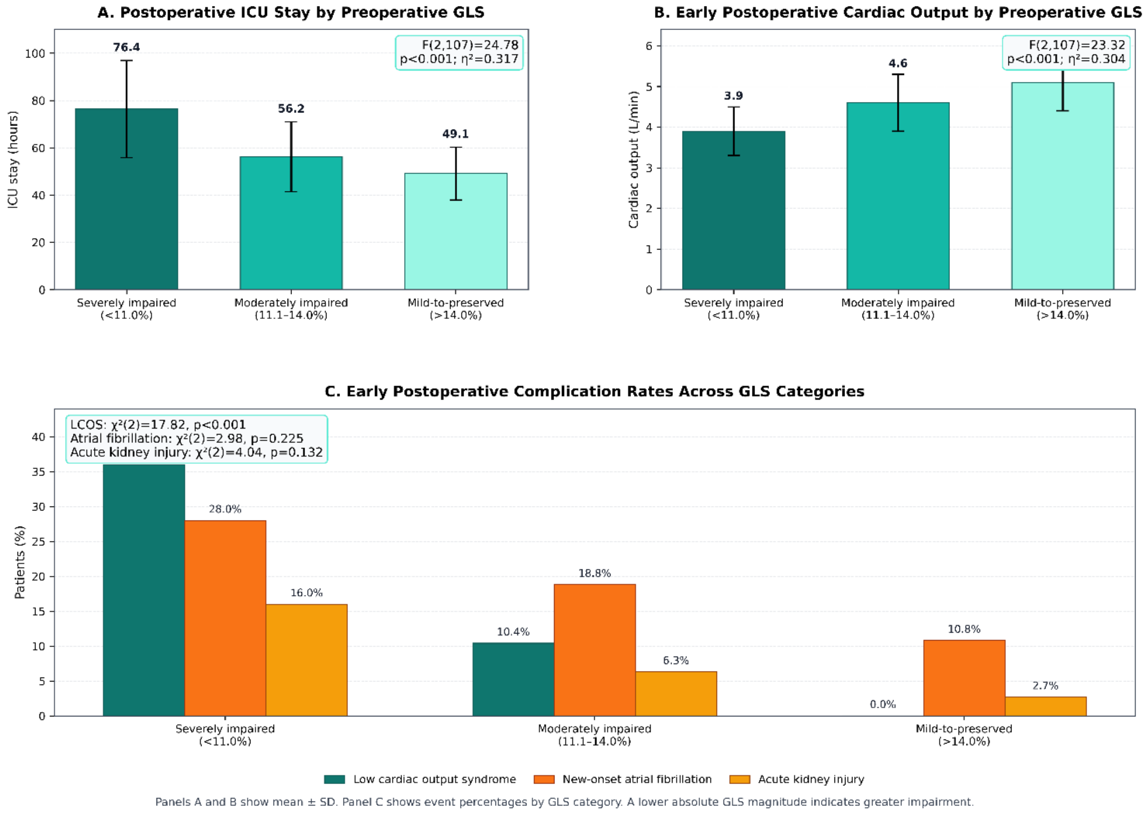

Figure 1. Association of Preoperative Global Longitudinal Strain With Early Recovery After Coronary Artery Bypass Grafting. Panel A shows a progressive increase in postoperative intensive care unit stay with worsening preoperative global longitudinal strain, from 49.1 ± 11.2 hours in the mild-to-preserved group to 76.4 ± 20.5 hours in the severely impaired group ($F[2,107] = 24.78$, $p < 0.001$; $\eta^2 = 0.317$). Panel B demonstrates a corresponding reduction in early postoperative cardiac output, from 5.1 ± 0.7 L/min in the mild-to-preserved group to 3.9 ± 0.6 L/min in the severely impaired group ($F[2,107] = 23.32$, $p < 0.001$; $\eta^2 = 0.304$). Panel C presents complication rates across the GLS categories. Low cardiac output syndrome increased from 0.0% in the mild-to-preserved group to 36.0% in the severely impaired group ($\chi^2[2] = 17.82$, $p < 0.001$), whereas the gradients observed for new-onset atrial fibrillation and acute kidney injury did not reach statistical significance. Error bars in Panels A and B represent standard deviations. GLS, global longitudinal strain; ICU, intensive care unit.

DISCUSSION

The present retrospective cohort study found that impaired preoperative global longitudinal strain was associated with poorer early recovery after elective isolated coronary artery bypass grafting. Patients with severely impaired GLS had longer postoperative intensive care unit stays, lower early cardiac output, and a higher frequency of low cardiac output syndrome than patients with mild-to-preserved myocardial deformation. The differences in ICU stay and cardiac output were not only statistically significant but also substantial in magnitude. After adjustment for age, baseline left ventricular ejection fraction, and cardiopulmonary bypass duration, a reduction in the absolute magnitude of GLS remained associated with prolonged ICU stay and greater odds of experiencing at least one early postoperative complication.

These findings were consistent with previous evidence demonstrating the prognostic importance of GLS among patients undergoing CABG. Olsen et al. reported that impaired GLS independently predicted mortality and major adverse cardiovascular events following CABG, including among patients with preserved left ventricular ejection fraction (1). Their findings principally concerned long-term cardiovascular outcomes, whereas the present study extended this relationship to the immediate postoperative period by identifying associations with cardiac output, ICU duration, and low cardiac output syndrome. Together, these observations suggested that preoperative GLS might characterize aspects of myocardial functional reserve that were not completely represented by conventional volumetric assessment.

The observed relationship between impaired GLS and postoperative recovery was biologically plausible. Global longitudinal strain primarily reflects shortening of longitudinally oriented myocardial fibres, which are concentrated in the subendocardial region and are particularly susceptible to ischemia. Chronic coronary artery disease may impair these fibres before a proportionate reduction in global ejection fraction becomes apparent. Speckle-tracking strain analysis can therefore reveal subtle myocardial dysfunction that may not be fully detected by conventional two-dimensional echocardiography (2). During CABG, the myocardium is additionally exposed to changes in preload and afterload, cardioplegic arrest, ischemia–reperfusion, cardiopulmonary bypass, oxidative stress, and systemic inflammatory activation. Patients with lower preoperative myocardial reserve may be less able to tolerate these perioperative stresses, resulting in reduced postoperative cardiac output and a slower transition from intensive care.

The gradient in postoperative cardiac output supported this interpretation. Mean cardiac output increased from 3.9 ± 0.6 L/min in the severely impaired GLS group to 5.1 ± 0.7 L/min in the mild-to-preserved group. The corresponding 1.2 L/min between-group difference was clinically meaningful and was accompanied by a marked difference in low cardiac output syndrome. Low cardiac output syndrome occurred in 36.0% of patients with severely impaired GLS and 10.4% of those with moderately impaired GLS, whereas no event occurred in the mild-to-preserved group. The risk of this complication was approximately 3.5 times higher in the severe group than in the moderate group. These findings indicated that preoperative longitudinal myocardial dysfunction was closely associated with early postoperative hemodynamic vulnerability.

The association between GLS and ICU stay was similarly pronounced. Patients with severely impaired strain remained in intensive care for an average of 27.3 hours longer than those with mild-to-preserved strain. GLS category accounted for approximately 31.7% of the observed variation in ICU duration in the unadjusted analysis. Prolonged ICU admission after cardiac surgery may reflect persistent hemodynamic instability, increased monitoring requirements, delayed withdrawal of vasoactive or ventilatory support, renal dysfunction, arrhythmia, or other postoperative complications. Although the present analysis did not determine the individual contributions of these factors, the findings suggested that preoperative GLS could potentially assist in identifying patients likely to require greater early critical-care support.

New-onset atrial fibrillation and acute kidney injury also occurred more frequently with worsening GLS, but these differences did not reach statistical significance. The frequency of atrial fibrillation increased from 10.8% in the mild-to-preserved group to 28.0% in the severely impaired group, while acute kidney injury increased from 2.7% to 16.0%. These directional patterns may have reflected a shared relationship between impaired myocardial reserve, postoperative hemodynamic instability, inflammation, and end-organ perfusion. Cardiopulmonary bypass can activate oxidative and inflammatory pathways that contribute to myocardial injury and postoperative atrial electrical instability (3). Nevertheless, the relatively small number of events limited statistical precision, and these findings should be interpreted as exploratory rather than definitive.

The results supported the potential value of incorporating GLS into preoperative risk assessment, but they did not establish that GLS should independently determine perioperative treatment. Existing surgical risk models are based on demographic, clinical, and operative variables and remain essential for estimating perioperative risk. GLS may provide complementary information by quantifying myocardial deformation, particularly when ejection fraction does not fully reflect subclinical systolic dysfunction. Previous evidence has indicated that GLS may improve risk classification when added to established surgical risk estimates (1). However, the present study did not compare discrimination, calibration, reclassification, or clinical utility between models with and without GLS. Consequently, the findings demonstrated an independent prognostic association rather than validated incremental predictive performance.

Several strengths supported the interpretation of the study. The analysis addressed a clinically relevant and objectively measurable preoperative exposure, included consecutive eligible CABG records, and evaluated multiple early postoperative outcomes. The observed findings were internally coherent: worsening GLS was accompanied by longer ICU admission, lower cardiac output, and increasing frequencies of postoperative complications. The analyses also considered GLS as both a categorized and continuous variable, and the adjusted models accounted for age, baseline ejection fraction, and cardiopulmonary bypass duration. The consistency of the unadjusted gradients and adjusted associations strengthened the evidence that GLS captured clinically relevant myocardial dysfunction.

The study also had important limitations. Its retrospective, single-centre design limited causal interpretation and external generalizability. Inclusion required the availability of preoperative strain imaging and complete postoperative documentation, which may have introduced selection bias. The modest sample size and limited number of complication events restricted the number of covariates that could be included reliably in the multivariable models and reduced the precision of complication-specific analyses. Residual confounding from renal function, severity of coronary disease, recent myocardial infarction, preoperative heart failure, operative complexity, inotropic therapy, surgeon-related factors, and established surgical risk scores could not be excluded.

Additional measurement limitations should also be considered. GLS values may be influenced by image quality, loading conditions, cardiac rhythm, frame rate, software, vendor-specific algorithms, and manual adjustment of myocardial contours. Although increasingly automated, strain assessment can still require expert correction and may vary across imaging platforms (4). Postoperative cardiac output was obtained from available hemodynamic or echocardiographic documentation, and potential heterogeneity in measurement technique may have introduced measurement error. ICU duration may also have been influenced by institutional discharge practices and resource availability in addition to patient condition.

The categorization of GLS provided clinically accessible comparisons but may have reduced information and depended on the thresholds applied in the clinical database. Future studies should therefore prioritize continuous GLS analysis and assess whether clinically meaningful thresholds can be externally validated. The reported adjusted regression estimates also require confirmation against the original statistical output, including verification of exposure direction, coefficient scaling, model assumptions, and goodness-of-fit. Because no assessment of discrimination, calibration, internal validation, or incremental model performance was available, the study could not establish a fully developed clinical prediction model.

Prospective multicentre studies with standardized echocardiographic acquisition, blinded strain analysis, predefined outcome criteria, and adequate event numbers are required to confirm these findings. Future analyses should compare models containing established clinical risk factors and ejection fraction with models that additionally include GLS. Reporting should include discrimination, calibration, reclassification, internal or external validation, and decision-analytic measures. Longer follow-up would also clarify whether the early hemodynamic vulnerability associated with impaired GLS translates into mortality, readmission, heart failure, or major adverse cardiovascular events. Interventional studies would ultimately be required to determine whether GLS-guided monitoring or perioperative management improves patient outcomes.

CONCLUSION

Impaired preoperative global longitudinal strain was associated with lower early postoperative cardiac output, prolonged intensive care unit stay, and a higher occurrence of low cardiac output syndrome among adults undergoing elective isolated coronary artery bypass grafting. These associations remained evident after adjustment for age, baseline left ventricular ejection fraction, and cardiopulmonary bypass duration. Preoperative GLS may provide complementary prognostic information regarding early postoperative myocardial reserve, but prospective validation and formal assessment of incremental predictive performance are required before it can be recommended as an independent basis for perioperative decision-making.

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