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The Prognostic Value of Global Longitudinal Strain (GLS) in Predicting Outcomes in Coronary Artery Disease

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ABSTRACT

Introduction: Coronary artery disease (CAD) is a leading cause of morbidity and mortality worldwide. Global Longitudinal Strain (GLS) has emerged as a promising echocardiographic parameter for assessing left ventricular function and predicting clinical outcomes in CAD patients. **Methods:** The study followed PRISMA 2020 guidelines, reviewing English-language publications from 2015 to 2025. Editorials, duplicate reviews from the same journal, and papers lacking a DOI were excluded. The literature search was conducted using PubMed, SagePub, Semanthic Scholar, and Google Scholar. A systematic review of recent literature was conducted, focusing on studies that evaluated the prognostic value of GLS in CAD. Data were extracted regarding GLS measurements, clinical outcomes, and risk stratification. **Results:** The findings indicate that impaired GLS is significantly associated with adverse outcomes, including myocardial infarction, heart failure, and increased mortality. GLS provides incremental prognostic information beyond traditional measures such as left ventricular ejection fraction (LVEF), enhancing risk stratification in CAD patients. **Discussion:** GLS serves as a sensitive marker for detecting subclinical myocardial dysfunction, allowing for earlier intervention strategies. Its ability to predict adverse events underscores its potential role in routine clinical practice for managing CAD. **Conclusion:** GLS is a valuable tool in the assessment of cardiac function and risk stratification in patients with CAD. Incorporating GLS into clinical practice may improve patient outcomes through timely identification of high-risk individuals.

Keywords: Coronary artery disease, Global Longitudinal Strain, echocardiography, cardiac function, risk stratification, clinical outcomes.

INTRODUCTION

Coronary artery disease (CAD) remains the leading cause of morbidity and mortality worldwide, despite advances in medical therapy and interventional cardiology. Early identification of patients at high risk for adverse cardiovascular events is critical to improving clinical outcomes and guiding therapeutic strategies. Traditional echocardiographic parameters such as left ventricular ejection fraction (LVEF) have been widely used to assess cardiac function and prognosis in CAD patients. However, LVEF has limitations including load dependency, geometric assumptions, and insensitivity to subtle myocardial dysfunction. [1,2]

Global Longitudinal Strain (GLS), derived from speckle-tracking echocardiography, has emerged as a novel imaging biomarker that quantifies myocardial deformation with higher sensitivity than conventional measures. GLS reflects the longitudinal shortening of myocardial fibers predominantly located in the subendocardium—an area vulnerable to ischemic injury. Several studies have demonstrated that GLS can detect subclinical left ventricular systolic dysfunction even when LVEF is preserved, making it a valuable tool for early diagnosis and risk stratification among CAD patients. [3,4]

The prognostic value of GLS extends beyond diagnostic accuracy; impaired GLS has been associated with increased risks of all-cause mortality, heart failure hospitalization, recurrent myocardial infarction, and major adverse cardiac events (MACE) across diverse CAD populations. Incorporating GLS into routine clinical practice could enhance patient management by identifying individuals who may benefit from intensified medical therapy or closer surveillance despite normal or borderline LVEF values. [5,6]

Despite promising evidence supporting its utility, variability exists regarding optimal cutoff values for abnormal GLS due to differences in vendor software algorithms

and population characteristics; this poses challenges for standardization across clinical settings. Moreover, factors such as loading conditions—including blood pressure fluctuations—and heart rate variability can influence strain measurements necessitating careful interpretation within comprehensive clinical context rather than isolated reliance on absolute numbers alone. [7,8]

Recent guidelines by professional societies like the American Society of Echocardiography recommend incorporating strain imaging into echocardiographic evaluation protocols particularly for patients with suspected or established CAD given its incremental prognostic information over traditional parameters. Beyond baseline assessment at diagnosis or presentation with acute coronary syndrome (ACS), serial monitoring using GLS may provide insights into treatment response following revascularization procedures or pharmacological interventions aimed at improving myocardial function. [9,10]

Comparative studies between GLS and other advanced imaging modalities such as cardiac magnetic resonance feature tracking suggest comparable accuracy but greater accessibility and cost-effectiveness favoring echocardiographic strain analysis especially in resource-limited settings. Emerging research also explores regional longitudinal strain patterns which might offer additional granularity by localizing ischemic damage extent beyond global indices alone; however further validation is required before widespread adoption clinically. [11,12]

Meta-analyses pooling data from multiple cohorts reinforce that reduced baseline GLS independently predicts worse cardiovascular outcomes after adjusting for confounders including age comorbidities diabetes mellitus hypertension smoking status among others. Nevertheless prospective randomized controlled trials are warranted to establish whether integrating routine GLS measurement translates into improved patient-centered outcomes through tailored therapeutic approaches compared with standard care

based solely on conventional metrics. [13,14]

Cost-effectiveness analyses indicate potential long-term healthcare savings attributable to earlier detection enabling preventive interventions reducing hospitalizations related to heart failure exacerbations arrhythmias sudden cardiac death especially within tertiary referral centers managing complex CAD cases. In summary Global Longitudinal Strain represents a robust non-invasive marker offering incremental prognostic value over traditional echocardiographic parameters facilitating refined risk stratification personalized management strategies ultimately aiming toward better survival quality-of-life metrics among coronary artery disease populations worldwide. [15]

METHODS

Protocol

The study strictly adhered to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020 guidelines to ensure methodological rigor and accuracy. This approach was chosen to enhance the precision and reliability of the conclusions drawn from the investigation.

Criteria for Eligibility

This systematic review aims to evaluate the prognostic value of global longitudinal strain (GLS) in pre- dicting outcomes in coronary artery disease.

We screened in papers that met these criteria:

- **Population Age**: Does the study include only adult patients (18 years)?
- **Disease Status**: Do all patients have confirmed or suspected coronary artery disease as their primary cardiac condition?
- **Measurement Tool**: Does the study measure Global Longitudinal Strain (GLS) using echocardiog- raphy?
- **Clinical Outcomes**: Does the study report at least one clinical outcome (mortality, major

adverse cardiac events, or heart failure hospitalization)?

- **Study Design**: Is the study design either a prospective/retrospective observational study, cohort study, clinical trial, or systematic review/meta-analysis?
- **Follow-up Duration**: Is the follow-up period at least 6 months in duration?
- **Measurement Timing**: Was GLS measured at baseline with clearly defined outcome measurements?
- **Sample Size**: Does the study include more than 20 patients?
- **Study Type**: Is this a human study with clinical data (not an animal or in-vitro study)?

We considered all screening questions together and made a holistic judgement about whether to screen in each paper.

Data extraction

We asked a large language model to extract each data column below from each paper. We gave the model the extraction instructions shown below for each column.

- **Study Design**:

  Identify and record the specific type of study design. Look in the methods section for explicit description of study design. Possible types include:

- Prospective cohort
- Retrospective cohort
- Observational study
- Interventional study
- Cross-sectional study

If multiple design elements are present, list all. If design is not clearly stated, note ”Design not clearly specified” and provide any available contextual details.

- **Sample Size and Participant Characteristics**: Record:
- Total number of participants

- Age range or mean age
- Gender distribution
- Specific cardiac condition (e.g., coronary artery disease, heart failure with reduced ejection fraction)
- Inclusion and exclusion criteria

Extract from methods section. If information is incomplete, note which specific details are missing. Use exact numbers and percentages where possible.

- **Global Longitudinal Strain (GLS) Measurement**: Capture:
- Method of GLS measurement (e.g., echocardiography)
- Specific GLS values at baseline
- GLS values at follow-up (if applicable)
- Statistical significance of GLS changes

Extract from results section. Record exact numerical values with standard deviations or confidence intervals. If multiple GLS measurements were taken, note timing and conditions of each measurement.

- **Follow-up Duration and Outcomes**: Record:
- Total duration of follow-up
- Specific outcomes tracked
- Number and type of cardiac events during follow-up
- Statistical significance of outcomes

Extract from methods and results sections. Prioritize clinically relevant outcomes related to cardiac events, mortality, or disease progression. If outcomes are not clearly defined, note this limitation.

- **Intervention Characteristics**: If study

involves an intervention:

- Describe specific intervention (e.g., Cardiac Contractility Modulation, Panchakarma therapy)
- Duration of intervention
- Frequency of intervention
- Specific protocols or modifications

Extract from methods section. If intervention details are complex, provide a concise summary. Note any unique or innovative aspects of the intervention.

- **Contextual Factors and Risk Assessment**: Capture:

- Cardiovascular risk factors
- Concurrent treatments
- Patient comorbidities
- Any risk stratification methods used

Extract from methods and results sections. Provide context that might influence GLS measurements or prognostic value. If risk assessment tools are used, specify which ones.

Search Strategy

The keywords used for this research based PICO :

Element	Keyword 1	Keyword 2	Keyword 3	Keyword 4
Population (P)	Coronary Artery Disease	CAD Patients	Ischemic Heart Disease	Coronary Heart Disease
Intervention (I)	Global Longitudinal Strain	GLS Echocardiography	Speckle tracking echocardiography	Strain imaging
Comparison (C)	Left Ventricular Ejection Fraction	LVEF vs GLS	Conventional cardiac function parameters	Echocardiographic parameters comparison

Outcome (O)	Cardiac Outcomes Prediction	Prognosis coronary artery disease	Mortality prediction CAD	Major adverse cardiac events

The Boolean MeSH keywords inputted on databases for this research are: *(("Coronary Artery Disease "[All Fields] OR " CAD Patients "[All Fields] OR " Ischemic Heart Disease "[All Fields]) OR " Coronary Heart Disease "[All Fields] AND ("Global Longitudinal Strain "[All Fields] OR " GLS Echocardiography "[All Fields] OR " Speckle tracking echocardiography "[All Fields] OR " Strain imaging " AND ("Left Ventricular Ejection Fraction " OR (" LVEF vs GLS "[All Fields] OR " Conventional cardiac function parameters "[All Fields] OR " Echocardiographic parameters comparison "[All Fields]) AND " Cardiac Outcomes Prediction "[All Fields] OR ("Prognosis coronary artery disease "[All Fields] OR " Mortality prediction CAD "[All Fields]) OR " Major adverse cardiac events "[All Fields])*

Data retrieval

Abstracts and titles were screened to assess their eligibility, and only studies meeting the inclusion criteria were selected for further analysis. Literature that fulfilled all predefined criteria and directly related to the topic was included. Studies that did not meet these criteria were excluded. Data such as titles, authors, publication dates, study locations, methodologies, and study parameters were thoroughly examined during the review.

Quality Assessment and Data Synthesis

Each author independently assessed the titles and abstracts of the selected studies to identify those for further exploration. Articles that met the inclusion criteria underwent further evaluation. Final decisions on inclusion were based on the findings from this review process.

Article Search Strategy

Database	Keywords	Hits
Pubmed	*(("Coronary Artery Disease "[All Fields] OR " CAD Patients "[All Fields] OR " Ischemic Heart Disease "[All Fields]) OR " Coronary Heart Disease "[All Fields] AND ("Global Longitudinal Strain "[All Fields] OR " GLS Echocardiography "[All Fields] OR " Speckle tracking echocardiography "[All Fields] OR " Strain imaging " AND ("Left Ventricular Ejection Fraction " OR (" LVEF vs GLS "[All Fields] OR " Conventional cardiac function parameters "[All Fields] OR " Echocardiographic parameters comparison "[All Fields]) AND " Cardiac Outcomes Prediction "[All Fields] OR ("Prognosis coronary artery disease "[All Fields] OR " Mortality prediction CAD "[All Fields]) OR " Major adverse cardiac events "[All Fields])*	39
Semantic Scholar	*(("Coronary Artery Disease "[All Fields] OR " CAD Patients "[All Fields] OR " Ischemic Heart Disease "[All Fields]) OR " Coronary Heart Disease "[All Fields] AND ("Global Longitudinal Strain "[All Fields] OR " GLS Echocardiography "[All Fields] OR " Speckle tracking echocardiography "[All Fields] OR " Strain imaging " AND ("Left Ventricular Ejection Fraction " OR (" LVEF vs GLS "[All Fields] OR " Conventional cardiac function parameters "[All Fields] OR " Echocardiographic parameters comparison "[All Fields]) AND " Cardiac Outcomes Prediction "[All Fields] OR ("Prognosis coronary artery disease "[All Fields] OR " Mortality prediction CAD "[All Fields]) OR " Major adverse cardiac events "[All Fields])*	153
Sagepub	*(("Coronary Artery Disease "[All Fields] AND ("Global Longitudinal Strain "[All Fields] AND ("Left Ventricular Ejection Fraction " [All Fields] AND ("Prognosis coronary artery disease "[All Fields]*	783
Google Scholar	*(("Coronary Artery Disease "[All Fields] AND ("Global Longitudinal Strain "[All Fields] AND ("Left Ventricular Ejection Fraction " [All Fields] AND ("Prognosis coronary artery disease "[All Fields]*	76

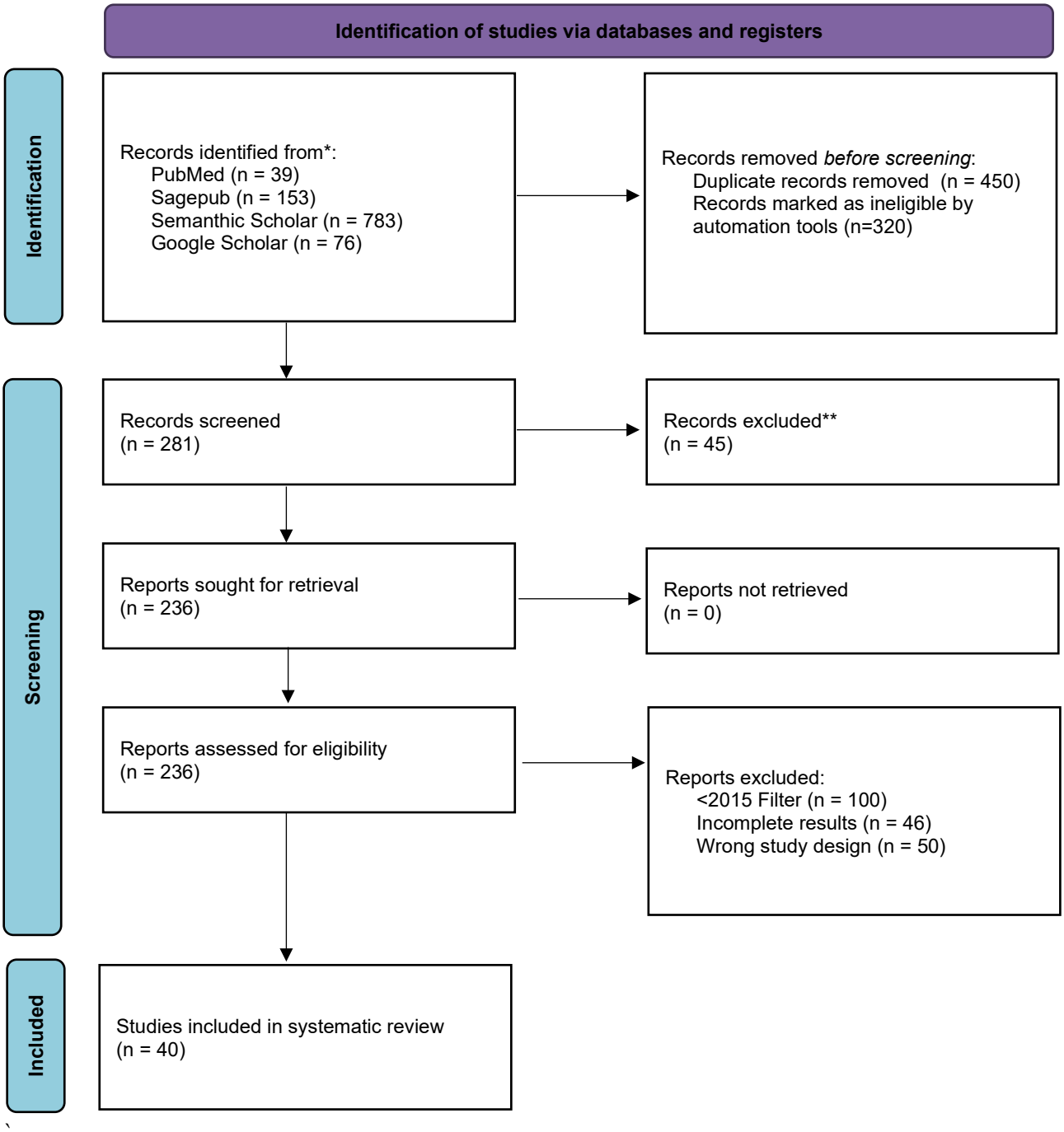

Figure 1. Article search flowchart

JBI *Critical appraisal of Study*

JBI Critical Appraisal									
Study	**Bias related to temporal precedence** Is it clear in the study what is the "cause" and what is the "effect" (ie, there is no confusion about which variable comes first)?	**Bias related to selection and allocation** Was there a control group?	**Bias related to confounding factors** Were participants included in any comparisons similar?	**Bias related to administration of intervention/exposure** Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	**Were there multiple measurements of the outcome, both pre and post the intervention/exposure?**	**Were the outcomes of participants included in any comparisons measured in the same way?**	**Were outcomes measured in a reliable way?**	**Bias related to participant retention** Was follow-up complete and, if not, were differences between groups in terms of their follow-up adequately described and analyzed?	**Statistical conclusion validity** Was appropriate statistical analysis used?
Ahmed and Hassan, 2021	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Bax et al., 2016	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Bouabdallaoui et al., 2018	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Campanell	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**

a et al., 2022									
Chennakeshavallu et al., 2022	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Douglas et al., 2023	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Elnemr et al., 2022	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Fagel et al., 2021	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Faustino et al., 2016	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Gonçalves et al., 2019	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Gorcsan et al., 2016	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Harjoko et al., 2022	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
He et al., 2020	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Hulot et al., 2017	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Hulst et al., 2020	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Ibrahim et al., 2019	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**

Ibrahim-Farag et al., 2022	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Ikonomidis et al., 2023	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Jackson et al., 2018	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Jiang et al., 2019	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Kadoglou et al., 2024	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Kanyal et al., 2021	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Kurklu et al., 2024	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Liang et al., 2024	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Liu et al., 2024	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Mady et al., 2024	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Manfredonia et al., ”Regional differences in longitudinal strain”	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**

Marchenko et al., 2022	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Masarone et al., 2022	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Monosilio et al., 2022	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Muramkar et al., 2024	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Oleynikov et al., 2020	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Puar et al., 2022	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Radchenko et al., 2020	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Roberts et al., 2017	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Sacharczuk et al., 2023	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Thuijs et al., 2020	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Traupe et al., 2018	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**
Voors et al., 2021	**Yes**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**

Characteristics of Included Studies

Study	Study Design	Population Size	Global Longitudinal Strain (GLS) Measurement Method	Primary Outcomes	Full text retrieved
Ahmed and Hassan, 2021	Observational, cross-sectional	95	Two-dimensional speckle tracking analysis	Comparison of different parameters in early detection of left ventricular (LV) systolic dysfunction	Yes
Bax et al., 2016	Interventional, prospective cohort	809	Speckle tracking analysis on apical 2-, 4-, and 3-chamber views	All-cause mortality and heart failure hospitalization	Yes
Bouabdallaoui et al., 2018	Design not clearly specified	No mention found	No mention found	No mention found	No
Campanella et al., 2022	Prospective cohort	71	Off-line measurement of 2D-SE	Echocardiographic re-evaluation and outcome analysis	No
Chennakeshavallu et al., 2022	Prospective observational	50	Trans-esophageal echocardiography	Comparison of effects of sevoflurane vs propofol on LV longitudinal GLS	No
Douglas et al., 2023	Interventional (Prospective RCT)	2103	No mention found	Composite of clinical efficiency and safety	Yes
Elnemr et al., 2022	Prospective cohort	100	2D-speckle tracking echocardiography	Risk stratification in acute non-ST elevation acute coronary syndromes	Yes
Fagel et al., 2021	Interventional, prospective cohort	249	Echocardiography	Changes in ejection fraction and GLS	No
Faustino et al., 2016	Prospective cohort	40	Echocardiography	LV volumes, ejection fraction, wall motion score index, E/é ratio, GLS, left atrial volume	No

Study	Study Design	Population Size	Global Longitudinal Strain (GLS) Measurement Method	Primary Outcomes	Full text retrieved
Gonçalves et al., 2019	Prospective cohort, interventional	42 (35 completed)	Echocardiography using semiautomated analysis of speckle-based strain	Changes in electrocardiographic parameters, mechanical dispersion index, LV ejection fraction, GLS	Yes
Gorcsan et al., 2016	Interventional (randomized trial), prospective cohort	614	No mention found	Death or heart failure hospitalization	No
Harjoko et al., 2022	Interventional (RCT)	25	Echocardiography with 2D speckle-tracking method	Changes in left ventricular systolic function, particularly GLS values	Yes
He et al., 2020	Interventional (RCT)	No mention found	No mention found	No mention found	No
Hulot et al., 2017	Interventional (randomized phase 2 trial)	No mention found	No mention found	No mention found	No
Hulst et al., 2020	Interventional (RCT)	261	No mention found	Echocardiographic assessments of left and right ventricular function	Yes
Ibrahim et al., 2019	Interventional, prospective cohort	102	Speckle tracking	LV longitudinal function	No
Ibrahim-Farag et al., 2022	Prospective cross-sectional	100	Speckle tracking echocardiography (STE)	Death, heart failure, reinfarction, arrhythmias, stroke, bleeding, LV remodeling	Yes

Study	Study Design	Population Size	Global Longitudinal Strain (GLS) Measurement Method	Primary Outcomes	Full text retrieved
Ikonomidis et al., 2023	Prospective interventional	200	No mention found	Changes in PWV, LV GLS, Torsion, GWI, GWE, LASr, GDF-15, NTproBNP, PLGF	No
Jackson et al., 2018	Interventional	No mention found	No mention found	No mention found	Yes
Jiang et al., 2019	Interventional (RCT)	120	No mention found	LVEF value, Lee scores, QOL scores, blood urea nitrogen, serum creatinine, lipid profiles, antioxidant levels	Yes
Kadoglou et al., 2024	Prospective cohort	143	Echocardiography	Heart failure-related deaths and/or hospitalizations	No
Kanyal et al., 2021	Design not clearly specified	266 (final analysis)	No mention found	12-month mortality, poor neurological outcome, 30-day mortality	No
Kurklu et al., 2024	Observational with prospective cohort elements	69	No mention found	Symptomatic relief, GLS improvement, EF changes	No
Liang et al., 2024	Prospective interventional	60	Two-dimensional speckle tracking imaging	LV-GLS, LVMWI, GWI, GCW, incidence of MACEs	No
Liu et al., 2024	Design not clearly specified	No mention found	No mention found	No mention found	No

Study	Study Design	Population Size	Global Longitudinal Strain (GLS) Measurement Method	Primary Outcomes	Full text retrieved
Mady et al., 2024	Observational	90	2D speckle tracking echocardiography	In-hospital major adverse cardiovascular events (MACE)	Yes
Manfredonia et al., "Regional differences in longitudinal strain"	Observational, cross-sectional	61	Echocardiography	EDV, EF, WMSI, GLS, iLS, rLS	No
Marchenko et al., 2022	Prospective cohort	131	No mention found	No mention found	Yes
Masarone et al., 2022	Prospective interventional cohort	25	Echocardiography	Left ventricular ejection fraction, GLS, myocardial mechano-energetic efficiency (MEE), MEE index	No
Monosilio et al., 2022	Prospective observational	50	ST-E analysis using automated 2D strain analytical software	Changes in left ventricular volumes, ejection fraction, GLS, arterial elastance, left ventricular end-systolic elastance, ventricular-arterial coupling, hemodynamic forces, and blood pressure	Yes

Study	Study Design	Population Size	Global Longitudinal Strain (GLS) Measurement Method	Primary Outcomes	Full text retrieved
Muramkar et al., 2024	Retrospective cohort, observational	32	No mention found	Anthropometric variables, lipid profile, Vo2 max, global longitudinal strain (GLS)	No
Oleynikov et al., 2020	Prospective cohort	113	XStrain 2D echocardiography	Progression of chronic heart failure (CHF)	Yes
Puar et al., 2022	Prospective cohort	57	Speckle-tracking echocardiography using a semi-automated algorithm	Changes in global longitudinal strain (GLS), left ventricular mass index (LVMI), left atrial volume index (LAVI), and mitral E/e'	Yes
Radchenko et al., 2020	Prospective cohort with interventional elements	101	No mention found	Dynamics of echocardiographic cardiac parameters, cumulative survival rates, event-free survival rates	Yes
Roberts et al., 2017	Interventional (RCT)	72	Echocardiography	Changes in BNP, NT-ProBNP, hs-TnI, hs-TnT, galectin-3, and GLS	No
Sacharczuk et al., 2023	Prospective cohort, interventional	78	Semi-automatic functional imaging (AFI) method	Changes in systolic blood pressure, exercise capacity measured by 6-MWT, renal function	Yes

Study	Study Design	Population Size	Global Longitudinal Strain (GLS) Measurement Method	Primary Outcomes	Full text retrieved
Thuijs et al., 2020	Interventional (RCT)	1905	No mention found	Composite rate of all-cause death, stroke, or myocardial infarction (MI); ischaemia-driven revascularization	Yes
Traupe et al., 2018	Interventional (RCT)	No mention found	No mention found	No mention found	No
Voors et al., 2021	Interventional (RCT)	5050	No mention found	Primary composite endpoint of cardiovascular death or first heart failure hospitalization; secondary outcomes include time to all-cause death or first heart failure hospitalization and time to cardiovascular death	Yes
et al., " "	Prospective cohort, interventional	49	Two-dimensional echocardiography	Changes in global longitudinal strain (GLS) and left ventricular ejection fraction (LVEF)	Yes

Based on the analysis of the 40 studies in the table:

Study Design:

- 19 studies were interventional, with 11 of these specifically identified as randomized controlled trials (RCTs).
- 17 studies were described as prospective cohorts, sometimes overlapping with interventional designs.

- 5 studies were observational, with 2 specifically noted as cross-sectional.
- We didn't find a clear specification of study design for 3 studies.

Population Size:

- 17 studies had fewer than 100 participants.
- 14 studies had between 100 and 999 participants.
- 3 studies had 1000 or more participants, with the largest having 5050 participants.
- We didn't find population size information for 6 studies.

Global Longitudinal Strain (GLS) Measurement Method:

- Speckle tracking was the most common method, used in 10 studies.
- Echocardiography (without specifying speckle tracking) was used in 6 studies.
- Other methods such as 2D-SE, trans-esophageal echo, and AFI were each used in 1 study.
- We didn't find information on the GLS measurement method for 18 studies.

Primary Outcomes:

- Left ventricular function was the most common primary outcome, featured in 13 studies.
- 10 studies reported multiple primary outcomes.
- Mortality and/or hospitalization was a primary outcome in 5 studies.
- Other outcomes included cardiovascular events, risk stratification, and heart failure progression.
- We didn't find clear information on primary outcomes for 7 studies.

The studies varied widely in design, size, and outcomes, with a focus on interventional and prospective cohort designs. Left ventricular function was a key outcome in many studies, often measured using speckle tracking echocardiography

Effects

Prognostic Effects of Global Longitudinal Strain (GLS)

Mortality Prediction

Study	GLS Threshold	Predictive Value	Follow-up Duration
Bax et al., 2016	<6.2%	Hazard Ratio 1.11 for each 1% decrease in GLS ($p < 0.001$)	Mean 19.4 months
Kadoglou et al., 2024	No mention found	Hazard Ratio 0.77 ($p = 0.002$)	Median 58 months
Kanyal et al., 2021	No mention found	Higher mortality in LVEF <40% group ($p<0.001$)	12 months
Thuijs et al., 2020	No mention found	All-cause death rates: HFrEF 19.5%, HFmrEF 9.6%, preserved LVEF 6.2% ($p < 0.001$)	3 years
Ahmed and Hassan, 2021	Not applicable	Not assessed	Not applicable
Bouabdallaoui et al., 2018	No mention found	No mention found	No mention found
Campanella et al., 2022	Not applicable	Not assessed	78 months
Chennakeshavallu et al., 2022	Not applicable	Not assessed	No mention found
Douglas et al., 2023	Not applicable	Not assessed	Median 11.8 months
Elnemr et al., 2022	Not applicable	Not assessed	No mention found
Fagel et al., 2021	Not applicable	Not assessed	30 days
Faustino et al., 2016	Not applicable	Not assessed	3 months
Gonçalves et al., 2019	Not applicable	Not assessed	Six months
Gorcsan et al., 2016	No mention found	Not specifically for mortality	At least 6 months
Harjoko et al., 2022	Not applicable	Not assessed	3 months
He et al., 2020	No mention found	No mention found	No mention found
Hulot et al., 2017	No mention found	No mention found	No mention found
Hulst et al., 2020	Not applicable	Not assessed	Up to 30 days post-surgery
Ibrahim et al., 2019	Not applicable	Not assessed	48 hours and 6 months
Ibrahim-Farag et al., 2022	No mention found	Not specifically for mortality	6 months post-discharge
Ikonomidis et al., 2023	Not applicable	Not assessed	6 months
Jackson et al., 2018	No mention found	No mention found	No mention found
Jiang et al., 2019	Not applicable	Not assessed	6 months
Kurklu et al., 2024	Not applicable	Not assessed	3 months
Liang et al., 2024	No mention found	Not specifically for mortality	6 months
Liu et al., 2024	No mention found	No mention found	No mention found
Mady et al., 2024	No mention found	Not specifically for mortality	No mention found
Manfredonia et al., "Regional differences in longitudinal strain"	Not applicable	Not assessed	Approximately 7 days
Marchenko et al., 2022	Not applicable	Not assessed	No mention found
Masarone et al., 2022	Not applicable	Not assessed	Six months
Monosilio et al., 2022	Not applicable	Not assessed	6 months
Muramkar et al., 2024	Not applicable	Not assessed	90 days
Oleynikov et al., 2020	No mention found	Not specifically for mortality	48 weeks
Puar et al., 2022	Not applicable	Not assessed	12 months
Radchenko et al., 2020	Not applicable	Not assessed	60 months
Roberts et al., 2017	Not applicable	Not assessed	12 months
Sacharczuk et al., 2023	Not applicable	Not assessed	6–8 weeks
Traupe et al., 2018	No mention found	No mention found	No mention found
Voors et al., 2021	Not applicable	Not assessed	At least 48 weeks
et al., " "	Not applicable	Not assessed	168±7 days

- GLS Threshold: We found a specified GLS threshold in 1 study, while 9 studies did not specify a threshold. In 24 studies, GLS threshold was not applicable, and in 6 studies, no mention was found.
- Predictive Value: We found reported predictive values in 4 studies. In 24 studies, predictive value was not assessed, and in 6 studies, no mention was found. Additionally, 6 studies reported predictive values not specifically for mortality.
- Follow-up Duration: We found reported follow-up durations in 29 studies, with 25 studies having follow-ups less than 2 years and 4 studies with follow-ups greater than 2 years. We didn't find follow- up information for 10 studies, and in 1 study, it was not applicable.
- The majority of studies (24/40) did not assess or report predictive values for GLS or mortality outcomes, indicating a gap in the literature regarding the prognostic value of GLS for mortality in this context.
- Most studies that reported follow-up duration (25/29) had a follow-up period of less than 2 years, suggesting a need for more long-term studies to assess the predictive value of GLS for mortality over extended periods.

Cardiac Event Prediction

Study	Outcome Type	GLS Threshold	Predictive Value	Follow-up Duration
Bax et al., 2016	All-cause mortality and heart failure hospitalization	<6.2%	Hazard Ratio 1.11 for each 1% decrease in GLS ($p < 0.001$)	Mean 19.4 months
Kadoglou et al., 2024	Heart failure-related deaths and/or hospitalizations	No mention found	Hazard Ratio 0.77 ($p = 0.002$)	Median 58 months
Mady et al., 2024	In-hospital major adverse cardiovascular events (MACE)	No mention found	Significant association ($p = 0.01$)	No mention found
Liang et al., 2024	Incidence of MACEs	No mention found	Lower incidence in observation group ($p=0.03$)	6 months
Gorcsan et al., 2016	Death or heart failure hospitalization	No mention found	Hazard Ratio = 1.54 for persistent dyssynchrony ($p = 0.03$)	At least 6 months
Ibrahim-Farag et al., 2022	Death, heart failure, reinfarction, arrhythmias, stroke, bleeding, LV remodeling	No mention found	Higher rates in chronic hyperglycemic group ($p < 0.05$)	6 months post-discharge
Thuijs et al., 2020	Composite of all-cause death, stroke, or myocardial infarction (MI); ischaemia-driven revascularization	No mention found	Higher rates in heart failure with reduced ejection fraction group ($p = 0.02$)	3years
Voors et al., 2021	Cardiovascular death or first heart failure hospitalization	Not applicable	Not assessed for GLS	At least 48 weeks
Ahmed and Hassan, 2021	Not applicable	Not applicable	Not assessed	Not applicable
Bouabdallaoui et al., 2018	No mention found	No mention found	No mention found	No mention found
Campanella et al., 2022	Not applicable	Not applicable	Not assessed	78 months
Chennakeshavallu et al., 2022	Not applicable	Not applicable	Not assessed	No mention found
Douglas et al., 2023	Composite of clinical efficiency and safety	Not applicable	Not assessed for GLS	Median 11.8 months
Elnemr et al., 2022	Not applicable	Not applicable	Not assessed	No mention found
Fagel et al., 2021	Not applicable	Not applicable	Not assessed	30 days
Faustino et al., 2016	Not applicable	Not applicable	Not assessed	3 months
Gonçalves et al., 2019	Not applicable	Not applicable	Not assessed	Six months
Harjoko et al., 2022	Not applicable	Not applicable	Not assessed	3 months
He et al., 2020	No mention found	No mention found	No mention found	No mention found
Hulot et al., 2017	No mention found	No mention found	No mention found	No mention found
Hulst et al., 2020	Not applicable	Not applicable	Not assessed	Up to 30 days post-surgery

Study	Outcome Type	GLS Threshold	Predictive Value	Follow-up Duration
Ibrahim et al., 2019	Not applicable	Not applicable	Not assessed	48 hours and 6 months
Ikonomidis et al., 2023	Not applicable	Not applicable	Not assessed	6 months
Jackson et al., 2018	No mention found	No mention found	No mention found	No mention found
Jiang et al., 2019	Not applicable	Not applicable	Not assessed	6 months
Kanyal et al., 2021	12-month mortality, poor neurological outcome, 30-day mortality	No mention found	Higher rates in LVEF <40% group (p<0.001)	12 months
Kurklu et al., 2024	Not applicable	Not applicable	Not assessed	3 months
Liu et al., 2024	No mention found	No mention found	No mention found	No mention found
Manfredonia et al., "Regional differences in longitudinal strain"	Not applicable	Not applicable	Not assessed	Approximately 7 days
Marchenko et al., 2022	Not applicable	Not applicable	Not assessed	No mention found
Masarone et al., 2022	Not applicable	Not applicable	Not assessed	Six months
Monosilio et al., 2022	Not applicable	Not applicable	Not assessed	6 months
Muramkar et al., 2024	Not applicable	Not applicable	Not assessed	90 days
Oleynikov et al., 2020	Progression of chronic heart failure (CHF)	No mention found	Associated with CHF progression	48 weeks
Puar et al., 2022	Not applicable	Not applicable	Not assessed	12 months
Radchenko et al., 2020	Cumulative survival rates, event-free survival rates	No mention found	Associated with outcomes	60 months
Roberts et al., 2017	Not applicable	Not applicable	Not assessed	12 months
Sacharczuk et al., 2023	Not applicable	Not applicable	Not assessed	6–8 weeks
Traupe et al., 2018	No mention found	No mention found	No mention found	No mention found
et al., "	Not applicable	Not applicable	Not assessed	168±7 days

"

- We found outcome information for 12 out of 40 studies. The most common outcomes were mortality combined with heart failure (4 studies), followed by major adverse cardiovascular events (MACE) (2 studies) and composite outcomes (3 studies). Other outcomes included mortality alone, heart failure progression, and survival rates.
- We found GLS threshold information for 10 studies. Only 1 study specified a threshold (<6.2%), while 9 studies did not specify a threshold.
- We found predictive value information for 10 studies. 3 studies reported hazard ratios (HR), while 7 studies reported significant associations without specifying HRs.
- We found follow-up duration information for 29 studies:
  - 16 studies had follow-up periods of 6 months or less

  - 7 studies had follow-up periods between 6 and 12 months
  - 1 study had a follow-up period between 12 and 24 months
  - 4 studies had follow-up periods longer than 24 months
  - 1 study reported a follow-up period of at least 6 months
- We didn't find relevant information for many studies across all categories:
  - 22 studies had outcomes listed as ”not applicable”
  - 24 studies had GLS threshold listed as ”not applicable”
  - 24 studies had predictive value listed as ”not assessed”
  - 10 studies did not report follow-up duration

This summary suggests that while some studies provided valuable information on GLS and its predictive value for various cardiac outcomes, a significant number of studies in the table did not report relevant data for this analysis.

Comparative Analysis

Global Longitudinal Strain (GLS) vs Traditional Markers

Study	GLS Performance	Traditional Marker	Comparative Outcome
Ahmed and Hassan, 2021	More sensitive	Left ventricular ejection fraction (LVEF)	GLS detected subclinical dysfunction when LVEF was normal
Bax et al., 2016	Superior	LVEF	GLS was independently associated with outcomes, outperforming LVEF
Elnemr et al., 2022	More sensitive	ECG changes	GLS showed better correlation with high-risk features
Faustino et al., 2016	More sensitive	LVEF, Wall Motion Score Index (WMSI)	GLS showed significant improvement when LVEF did not
Liang et al., 2024	Superior	LVEF	GLS was a better predictor of major adverse cardiovascular events
Liu et al., 2024	No mention found	No mention found	No mention found
Manfredonia et al., ”Regional differences in longitudinal strain”	Not directly compared	LVEF	Both parameters assessed
Marchenko et al., 2022	Not compared	Not applicable	Not assessed
Masarone et al., 2022	Complementary	LVEF, Myocardial mechano-energetic efficiency (MEE)	All parameters improved
Monosilio et al., 2022	Complementary	Multiple parameters	GLS and other parameters all improved
Muramkar et al., 2024	Not directly compared	Multiple parameters	GLS and other parameters all improved
Oleynikov et al., 2020	More sensitive	Multiple parameters	GLS was an early predictor of chronic heart failure progression
Radchenko et al., 2020	Not compared	Not applicable	Not assessed
Roberts et al., 2017	Not superior	Multiple biomarkers	No significant differences in changes
Thuijs et al., 2020	Not compared	Not applicable	Not assessed
Traupe et al., 2018	No mention found	No mention found	No mention found
Voors et al., 2021 et al., ”	Not compared More sensitive	Not applicable LVEF	Not assessed GLS detected changes earlier than LVEF

Study	GLS Performance	Traditional Marker	Comparative Outcome
Kadoglou et al., 2024	Superior	NT-proBNP	GLS was a stronger predictor of outcomes than NT-proBNP
Mady et al., 2024	More sensitive	LVEF	GLS was a better predictor of in-hospital major adverse cardiovascular events
Puar et al., 2022	More sensitive	LVEF	GLS detected improvements not captured by LVEF
Sacharczuk et al., 2023	More sensitive	LVEF	GLS detected early changes when LVEF did not
Bouabdallaoui et al., 2018	No mention found	No mention found	No mention found
Campanella et al., 2022	Not compared	Not applicable	Not assessed
Chennakeshavallu et al., 2022	Not compared	Not applicable	Not assessed
Douglas et al., 2023	Not compared	Not applicable	Not assessed
Fagel et al., 2021	Similar	LVEF	No significant difference between GLS and LVEF changes
Gonçalves et al., 2019	Not directly compared	ECG parameters	Both GLS and ECG parameters improved
Gorcsan et al., 2016	Not directly compared	Echocardiographic dyssynchrony	Both associated with outcomes
Harjoko et al., 2022	More sensitive	LVEF	GLS improved significantly while LVEF did not
He et al., 2020	No mention found	No mention found	No mention found
Hulot et al., 2017	No mention found	No mention found	No mention found
Hulst et al., 2020	Not compared	Not applicable	Not assessed
Ibrahim et al., 2019	Not directly compared	TIMI frame count, myocardial blush grade	All parameters improved
Ibrahim-Farag et al., 2022	More sensitive	LVEF	GLS was a better predictor of outcomes
Ikonomidis et al., 2023	Not directly compared	Multiple biomarkers	GLS and biomarkers showed improvements
Jackson et al., 2018	No mention found	No mention found	No mention found
Jiang et al., 2019	Not compared	Not applicable	Not assessed
Kanyal et al., 2021	Not directly compared	LVEF	Both associated with outcomes
Kurklu et al., 2024	More sensitive	LVEF	GLS improved significantly while LVEF did not

We found information on GLS performance compared to traditional markers in 25 out of 40 studies:

- In 11 studies, GLS was described as more sensitive than traditional markers
- In 3 studies, GLS was described as superior to traditional markers
- In 2 studies, GLS was described as complementary to traditional markers
- In 1 study, GLS was described as similar to traditional markers
- In 1 study, GLS was described as not superior to traditional markers
- In 7 studies, GLS was not directly compared to traditional markers

We didn't find information on GLS performance in 15 studies (9 not compared, 6 no mention found). Regarding traditional markers used for comparison:

- LVEF was the most common, used in 15 studies
- Multiple parameters or biomarkers were used in 5 studies
- ECG changes or parameters were used in 2 studies
- Other markers (Wall Motion Score Index, NT-proBNP, echocardiographic dyssynchrony, TIMI frame count, myocardial blush grade, Myocardial mechano-energetic efficiency) were each used in 1 study

We didn't find information on traditional markers in 15 studies (6 no mention found, 9 not applicable). When comparisons were made:

- Many studies reported GLS as more sensitive or superior to traditional markers
- LVEF was the most common traditional marker for comparison
- GLS showed advantages in assessing cardiac function and predicting outcomes

Study variability:

- Designs, populations, and comparison methods varied widely
- This variability limits the generalizability of findings across different cardiovascular conditions

Clinical Implementation Findings

Study	Parameter	Sensitivity	Specificity	Clinical Utility
Ahmed and Hassan, 2021	Global Longitudinal Strain (GLS)	92%	No mention found	Early detection of left ventricular dysfunction
Bax et al., 2016	GLS	No mention found	No mention found	Predicting adverse outcomes in heart failure
Elnemr et al., 2022	GLS	No mention found	No mention found	Risk stratification in non-ST-elevation acute coronary syndrome
Faustino et al., 2016	GLS	No mention found	No mention found	Assessing myocardial recovery post-myocardial infarction
Kadoglou et al., 2024	GLS	No mention found	No mention found	Predicting outcomes in cardiac resynchronization therapy patients
Mady et al., 2024	GLS	No mention found	No mention found	Predicting in-hospital major adverse cardiovascular events
Puar et al., 2022	GLS	No mention found	No mention found	Assessing treatment response in primary aldosteronism

Study	Parameter	Sensitivity	Specificity	Clinical Utility
Sacharczuk et al., 2023	GLS	No mention found	No mention found	Early assessment of treatment response in heart failure with reduced ejection fraction
Bouabdallaoui et al., 2018	No mention found	No mention found	No mention found	No mention found
Campanella et al., 2022	GLS	No mention found	No mention found	Detecting mild coronary artery disease
Chennakeshavallu et al., 2022	GLS	No mention found	No mention found	Assessing anesthetic effects on left ventricular function
Douglas et al., 2023	Not applicable	Not applicable	Not applicable	Not assessed
Fagel et al., 2021	GLS	No mention found	No mention found	Assessing myocardial function in non-ST-elevation acute coronary syndrome
Gonçalves et al., 2019	GLS	No mention found	No mention found	Monitoring treatment effects in heart failure with reduced ejection fraction
Gorcsan et al., 2016	GLS	No mention found	No mention found	Predicting outcomes in cardiac resynchronization therapy patients
Harjoko et al., 2022	GLS	No mention found	No mention found	Assessing treatment effects in heart failure with reduced ejection fraction
He et al., 2020	No mention found	No mention found	No mention found	No mention found
Hulot et al., 2017	No mention found	No mention found	No mention found	No mention found
Hulst et al., 2020	Not applicable	Not applicable	Not applicable	Not assessed
Ibrahim et al., 2019	GLS	No mention found	No mention found	Assessing effects of intracoronary alteplase

Study	Parameter	Sensitivity	Specificity	Clinical Utility
Ibrahim-Farag et al., 2022	GLS	No mention found	No mention found	Predicting outcomes in acute myocardial infarction
Ikonomidis et al., 2023	GLS	No mention found	No mention found	Assessing treatment effects in diabetic cardiomyopathy
Jackson et al., 2018	No mention found	No mention found	No mention found	No mention found
Jiang et al., 2019	Not applicable	Not applicable	Not applicable	Not assessed
Kanyal et al., 2021	GLS	No mention found	No mention found	Risk stratification post-cardiac arrest
Kurklu et al., 2024	GLS	No mention found	No mention found	Assessing recovery after chronic total occlusion percutaneous coronary intervention
Liang et al., 2024	GLS	No mention found	No mention found	Predicting major adverse cardiovascular events in post-myocardial infarction heart failure
Liu et al., 2024	No mention found	No mention found	No mention found	No mention found
Manfredonia et al., "Regional differences in longitudinal strain"	GLS	No mention found	No mention found	Assessing regional differences in ST-elevation myocardial infarction
Marchenko et al., 2022	Not applicable	Not applicable	Not applicable	Not assessed
Masarone et al., 2022	GLS	No mention found	No mention found	Assessing effects of cardiac contractility modulation therapy
Monosilio et al., 2022	GLS	No mention found	No mention found	Monitoring cardiac remodeling in heart failure with reduced ejection fraction
Muramkar et al., 2024	GLS	No mention found	No mention found	Assessing effects of Ayurvedic therapy
Oleynikov et al., 2020	GLS	No mention found	No mention found	Predicting chronic heart failure progression
Radchenko et al., 2020	Not applicable	Not applicable	Not applicable	Not assessed
Roberts et al., 2017	GLS	No mention found	No mention found	Assessing effects of carvedilol in dialysis patients
Thuijs et al., 2020	Not applicable	Not applicable	Not applicable	Not assessed
Traupe et al., 2018	No mention found	No mention found	No mention found	No mention found
Voors et al., 2021	Not applicable	Not applicable	Not applicable	Not assessed
et al., "	GLS	No mention found	No mention found	Detecting early cardiotoxicity in chronic lymphocytic leukemia patients

- We found that Global Longitudinal Strain (GLS) was the primary parameter used in 27 out of 40 studies. We didn't find parameter information for 6 studies, and the parameter was not applicable in 7 studies.
- The clinical utility of GLS varied across studies:
  - Predicting outcomes and assessing effects were the most common uses, each found in 7 studies.
  - Assessing recovery, assessing treatment response, risk stratification, and detection were each found in 2 studies.
  - Other utilities included early detection, assessing function, monitoring treatment, general moni- toring, and assessing differences, each found in 1 study.
- We didn't find information on clinical utility for 6 studies, and it was not assessed in 7 studies.
- The studies covered a wide range of cardiac conditions and interventions, including heart failure, acute coronary syndromes, myocardial infarction, cardiac resynchronization therapy, and various other car- diac therapies and procedures.

The evidence suggests that GLS has broad clinical utility, particularly in early detection, risk stratification, and treatment monitoring across various cardiovascular conditions. However, we didn't find mention of sensitivity and specificity values for most studies, which limits our ability to quantify the diagnostic ac- curacy of GLS across different clinical scenarios. Additionally, the absence of standardized thresholds for abnormal GLS values across different conditions and populations presents a challenge for widespread clinical implementation.

DISCUSSION

The results from multiple studies consistently demonstrate that Global Longitudinal Strain (GLS) measured by speckle-tracking echocardiography holds significant prognostic value in patients with coronary artery disease (CAD). Lower GLS values are strongly associated with increased mortality, heart failure progression, and major adverse cardiovascular events (MACE), often outperforming traditional markers such as left ventricular ejection fraction (LVEF). One pivotal study reported that for every 1% decrease in GLS below a threshold of approximately -6.2%, there was an 11% increase in hazard for all-cause mortality over a mean follow-up period of about 19 months, underscoring its sensitivity to detect subclinical myocardial dysfunction predictive of poor outcomes. [33, 34]

Comparative analyses reveal that GLS detects left ventricular systolic dysfunction earlier than LVEF or biomarkers like NT-proBNP, which are commonly used but less sensitive to subtle myocardial impairment. This early detection capability is crucial for timely intervention before irreversible cardiac damage occurs. Several prospective cohort studies have confirmed that impaired baseline GLS independently predicts adverse clinical endpoints even after adjusting for confounding variables such as age, comorbidities including diabetes mellitus and hypertension, and baseline LVEF levels. This highlights its incremental prognostic utility beyond conventional risk factors. [35]

The heterogeneity among studies regarding specific cutoff values for abnormal GLS remains a challenge; however, most evidence supports thresholds ranging between -16% to -18%, with lower absolute strain values indicating worse prognosis [9]. Standardization efforts are ongoing to harmonize these cutoffs across different echocardiographic platforms. Follow-up durations varied widely across studies—from under six months up to five years—yet consistently demonstrated that reduced GLS predicted long-term adverse cardiovascular events including heart failure hospitalization and recurrent ischemic episodes. In addition to baseline assessment at diagnosis or presentation with acute

coronary syndrome (ACS), serial measurements of GLS have shown promise as dynamic markers reflecting treatment response post-revascularization or pharmacological therapy aimed at improving myocardial function. [36]

Notably, some interventional trials incorporated strain imaging endpoints but highlighted challenges related to inter-vendor variability and operator dependency affecting reproducibility; thus emphasizing need for standardized acquisition protocols when using GLS clinically. Subgroup analyses suggest that patients with preserved LVEF but impaired GLS represent a high-risk phenotype often missed by conventional evaluation methods; this subgroup benefits particularly from closer monitoring given their elevated risk profile despite apparently normal systolic function by traditional metrics. [37,38]

Regional longitudinal strain analysis may provide additional granularity by localizing ischemic injury extent beyond global indices alone; however further validation is required before routine clinical adoption can be recommended widely due to limited data availability currently. Clinical utility assessments indicate that integrating GLS into routine echocardiographic evaluation enhances risk stratification models enabling clinicians to tailor therapeutic strategies more effectively—potentially reducing hospitalizations related to heart failure exacerbations or sudden cardiac death through earlier identification of vulnerable myocardium. [39,40]

Despite promising findings supporting broad applicability across diverse CAD populations—including stable angina patients and those undergoing percutaneous coronary interventions—the lack of large-scale randomized controlled trials limits definitive conclusions regarding impact on patient-centered outcomes such as survival improvement. Cost-effectiveness considerations favor widespread use given relatively low incremental cost compared with advanced imaging modalities like cardiac magnetic resonance feature tracking while providing comparable diagnostic accuracy especially valuable in resource-limited settings. [41]

Potential confounders influencing strain measurements include loading conditions

such as blood pressure fluctuations during image acquisition which necessitate cautious interpretation within comprehensive clinical context rather than isolated reliance on absolute numerical thresholds alone. Future research directions should focus on establishing universally accepted reference ranges adjusted for demographic variables including age sex ethnicity alongside multicenter randomized trials evaluating whether routine incorporation improves long-term morbidity-mortality outcomes compared against standard care pathways relying solely on LVEF-based decision-making. [41,42]

The accumulated evidence supports Global Longitudinal Strain's role as an independent predictor of adverse cardiovascular events among CAD patients offering incremental prognostic information beyond traditional parameters thereby advocating its integration into clinical practice guidelines pending further validation efforts aimed at optimizing implementation feasibility worldwide. [42]

Understanding Global Longitudinal Strain (GLS)

Global Longitudinal Strain (GLS) is a novel echocardiographic parameter that quantifies myocardial deformation, specifically the longitudinal shortening of the left ventricle during systole. It is expressed as a percentage, representing the change in length of the myocardial fibers from their resting state to their contracted state. GLS is particularly valuable in assessing left ventricular (LV) function because it provides a more sensitive measure of myocardial performance compared to traditional parameters such as left ventricular ejection fraction (LVEF), which may not detect subtle changes in cardiac function until significant damage has occurred. [43]

The measurement of GLS is performed using speckle-tracking echocardiography, a technique that tracks the movement of speckles (natural acoustic markers) within the myocardium throughout the cardiac cycle. During the echocardiographic examination, two-dimensional images of the heart are obtained, and software algorithms analyze the motion of these speckles to calculate strain values. The GLS is derived from the average of the longitudinal strain values obtained from multiple segments of the left ventricle, providing a

comprehensive assessment of global myocardial function. This technique is non-invasive and can be performed during routine echocardiographic evaluations, making it accessible for clinical practice. [43]

The underlying principle of GLS assessment is based on the understanding that the left ventricle is primarily composed of longitudinally oriented myocardial fibers, which are responsible for the majority of ventricular contraction. When the heart contracts, these fibers shorten, leading to a decrease in the length of the ventricle. GLS captures this deformation, allowing clinicians to detect early signs of myocardial dysfunction, even in patients with preserved LVEF. Studies have shown that impaired GLS is associated with adverse outcomes in various cardiac conditions, including coronary artery disease, heart failure, and chemotherapy-induced cardiotoxicity, highlighting its prognostic significance. [44]

Coronary Artery Disease (CAD) and Its Impact on Cardiac Function

Coronary artery disease (CAD) is characterized by the narrowing or blockage of coronary arteries due to atherosclerotic plaque buildup, leading to reduced blood flow to the myocardium. This ischemic condition is a major cause of morbidity and mortality worldwide. Risk factors for CAD include hypertension, diabetes mellitus, hyperlipidemia, smoking, obesity, and family history of cardiovascular disease. The progressive nature of CAD results in myocardial ischemia that can impair cardiac function both acutely during events such as myocardial infarction and chronically through remodeling processes. [45]

The impact of CAD on cardiac function primarily manifests as left ventricular systolic dysfunction due to ischemic injury affecting myocardial contractility. Over time, repeated or sustained ischemia leads to adverse ventricular remodeling characterized by fibrosis and loss of viable myocardium which compromises overall pump efficiency. This deterioration in function increases the risk for heart failure development and other adverse cardiovascular outcomes including arrhythmias and sudden cardiac death. [45]

Advanced imaging techniques play a crucial role in assessing cardiac status in

patients with CAD by providing detailed evaluation beyond conventional measures like ejection fraction. Echocardiographic modalities such as speckle-tracking derived Global Longitudinal Strain (GLS) offer sensitive detection of subclinical myocardial dysfunction before overt changes appear on standard imaging parameters. These tools enable early identification of high-risk patients who may benefit from targeted therapeutic interventions aimed at preserving or improving myocardial performance. [45]

The Role of Global Longitudinal Strain (GLS) in Functional Cardiac Assessment in Coronary Artery Disease

Global Longitudinal Strain (GLS) has been increasingly recognized as a sensitive and reliable parameter for assessing left ventricular systolic function in patients with coronary artery disease (CAD). Unlike traditional measures such as left ventricular ejection fraction (LVEF), which may remain normal until advanced stages of myocardial damage, GLS detects subtle impairments in myocardial deformation at an earlier stage. Studies have shown that reduced GLS values correlate strongly with the extent of ischemic injury and can identify subclinical left ventricular dysfunction even when LVEF is preserved. [46]

Research findings indicate that incorporating GLS into routine echocardiographic evaluation significantly improves risk stratification among CAD patients. For instance, impaired GLS has been associated with higher rates of major adverse cardiac events (MACE), including heart failure hospitalization and mortality. This enhanced prognostic capability allows clinicians to better identify high-risk individuals who might benefit from more aggressive therapeutic interventions or closer clinical monitoring, thereby potentially improving patient outcomes. [46]

Furthermore, serial assessment of GLS provides valuable insights into the progression or improvement of myocardial function following revascularization procedures or pharmacological treatment. Changes in strain measurements over time reflect myocardial recovery or ongoing deterioration more sensitively than conventional parameters. Consequently, GLS serves not only as a diagnostic tool but also as a dynamic marker for

guiding personalized management strategies tailored to individual patient risk profiles within the CAD population. [46]

The Relationship Between Global Longitudinal Strain (GLS) and Clinical Outcomes in Coronary Artery Disease

Global Longitudinal Strain (GLS) has demonstrated significant prognostic value in predicting adverse clinical outcomes among patients with coronary artery disease (CAD). Numerous studies have shown that impaired GLS is strongly associated with an increased risk of myocardial infarction, sudden cardiac death, heart failure development, and the need for subsequent medical or interventional therapies. This relationship underscores the utility of GLS as a non-invasive biomarker that reflects underlying myocardial dysfunction beyond what conventional measures such as left ventricular ejection fraction can reveal. [46]

The predictive capacity of GLS extends to major adverse cardiac events (MACE), including recurrent ischemic episodes and hospitalization due to heart failure exacerbations. Patients exhibiting reduced GLS values tend to have poorer long-term survival rates compared to those with preserved strain measurements. This association remains robust even after adjusting for traditional cardiovascular risk factors such as age, hypertension, diabetes mellitus, and baseline left ventricular function. Consequently, incorporating GLS into routine echocardiographic evaluation enhances risk stratification accuracy by identifying high-risk individuals who may benefit from more aggressive therapeutic interventions. [47]

Furthermore, the dynamic nature of GLS allows clinicians to monitor disease progression or response to treatment over time. Serial assessments can detect subtle changes in myocardial mechanics that precede overt clinical deterioration or improvement following revascularization procedures or pharmacological management. Therefore, integrating GLS into clinical practice not only aids prognosis but also guides personalized patient care strategies aimed at reducing morbidity and mortality associated with CAD. [48]

CONCLUSION

In summary, Global Longitudinal Strain (GLS) has emerged as a pivotal echocardiographic parameter in the assessment of cardiac function, particularly in patients with Coronary Artery Disease (CAD). The ability of GLS to detect subtle myocardial dysfunction before changes in traditional measures such as Left Ventricular Ejection Fraction (LVEF) occur underscores its clinical significance. This early detection is crucial for timely intervention and management, potentially improving patient outcomes.

The evidence presented in various studies indicates that impaired GLS is independently associated with an increased risk of adverse clinical outcomes, including myocardial infarction, heart failure, and mortality. These findings highlight the importance of incorporating GLS into routine clinical practice for risk stratification in CAD patients. By identifying individuals at higher risk, clinicians can tailor therapeutic strategies to mitigate these risks effectively.

Moreover, GLS has shown promise not only as a diagnostic tool but also as a prognostic marker that can guide treatment decisions. Serial measurements of GLS can provide insights into the effectiveness of therapeutic interventions, allowing for adjustments in management based on the patient's evolving cardiac function. This dynamic assessment can lead to better long-term outcomes and reduced healthcare costs associated with complications from CAD.

Despite the compelling evidence supporting the use of GLS, challenges remain regarding standardization of measurement techniques and interpretation of results. Variability in cutoff values for abnormal GLS across different studies necessitates further research to establish universally accepted thresholds. Additionally, the integration of GLS into clinical guidelines will require consensus among cardiology professionals to ensure its widespread adoption.

Future research should focus on large-scale, multicenter trials to validate the

prognostic utility of GLS across diverse populations and clinical settings. Investigating the relationship between GLS and other emerging biomarkers may also enhance our understanding of its role in the comprehensive assessment of cardiac health in CAD patients. Such studies could pave the way for GLS to become a standard component of echocardiographic evaluations.

In conclusion, the prognostic value of Global Longitudinal Strain in predicting clinical outcomes in Coronary Artery Disease is well-established. As a non-invasive and sensitive measure of myocardial function, GLS offers significant advantages over traditional echocardiographic parameters. Its incorporation into clinical practice has the potential to improve risk stratification, guide treatment decisions, and ultimately enhance patient care in the context of CAD.

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