

# Global Longitudinal Strain:

## A Game-Changer in Cardiac MRI Assessment

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# Introduction

In the evolving landscape of cardiovascular imaging, Global Longitudinal Strain (GLS) has emerged as a sophisticated biomarker that transcends the limitations of traditional ejection fraction measurements. This advanced metric, derived from cardiac MRI feature tracking or echocardiographic speckle tracking, provides clinicians with unprecedented insight into myocardial mechanics, enabling earlier disease detection, more accurate risk stratification, and refined therapeutic decision-making.

## Understanding Global Longitudinal Strain

Global Longitudinal Strain represents the percentage change in myocardial fiber length during the cardiac cycle, specifically measuring the shortening of the left ventricle from base to apex during systole. Expressed as a negative value, a normal GLS typically ranges from -18% to -22%, with more negative values indicating better contractile function. Unlike ejection fraction, which primarily reflects radial function and chamber geometry, GLS directly quantifies the deformation of myocardial tissue, offering a window into subtle contractile dysfunction that may precede changes in conventional parameters.

The strain measurement captures the longitudinal mechanics of the subendocardial fibers, which are particularly vulnerable to ischemia, fibrosis, and other pathological processes. This anatomical specificity makes GLS an exceptionally sensitive marker of early myocardial disease.

## Clinical Significance in Cardiac Assessment

### Superior Sensitivity to Subclinical Dysfunction

One of the most compelling attributes of GLS is its ability to detect myocardial impairment when ejection fraction remains preserved. In numerous cardiovascular conditions, including hypertensive heart disease, diabetes-related cardiomyopathy, and early-stage heart failure with preserved ejection fraction (HFpEF), GLS abnormalities manifest long before LVEF declines below 50%. This early detection window creates opportunities for timely intervention and potentially disease modification.

Studies have consistently demonstrated that patients with "normal" ejection fractions but impaired GLS exhibit significantly higher rates of adverse cardiovascular events, underscoring the inadequacy of relying solely on volumetric measurements for risk assessment.

### Reproducibility and Technical Advantages

Cardiac MRI-derived GLS benefits from the superior spatial resolution, tissue characterization capabilities, and reproducibility inherent to magnetic resonance imaging. Unlike ejection fraction, which can be influenced by loading conditions, heart rate, and geometric assumptions, GLS provides a relatively load-independent assessment of intrinsic myocardial contractility. The feature-tracking methodology employed in cardiac MRI eliminates issues related to acoustic windows and operator dependency that occasionally limit echocardiographic strain measurements.

# Prognostic Value Across the Cardiovascular Spectrum

## Heart Failure Prognostication

In both ischemic and non-ischemic cardiomyopathy, GLS serves as a powerful independent predictor of mortality and heart failure hospitalization. Patients with GLS values less negative than -12% face substantially elevated risk of adverse outcomes, even after adjustment for ejection fraction, NT-proBNP levels, and other established risk markers. The incremental prognostic value of GLS over LVEF alone has been validated across diverse heart failure phenotypes, including HFrEF, HFmrEF, and HFpEF (reduced, mildly-reduced and preserved Ejection Fraction).

Particularly noteworthy is the utility of GLS in predicting response to cardiac resynchronization therapy (CRT). Baseline GLS, regional strain patterns, and the presence of mechanical dys-synchrony assessed through strain imaging help identify patients most likely to benefit from CRT implantation, potentially reducing non-responder rates.

## Post-Myocardial Infarction Risk Stratification

Following acute myocardial infarction, GLS provides comprehensive risk stratification superior to infarct size or LVEF alone. Reduced GLS in remote myocardial segments (away from the infarct zone) indicates diffuse subclinical disease and portends higher risk of subsequent heart failure and ventricular arrhythmias. The combination of infarct characterization through late gadolinium enhancement (LGE) imaging and functional assessment via GLS creates a powerful prognostic framework.

Serial GLS measurements during post-MI follow-up can track adverse remodelling and identify patients requiring intensified medical therapy or early consideration for device implantation.

## Valvular Heart Disease

In aortic stenosis, GLS has revolutionized timing of intervention. Patients with severe aortic stenosis who develop impaired GLS despite preserved ejection fraction demonstrate accelerated symptom onset and increased perioperative mortality if valve replacement is delayed. Current guidelines increasingly incorporate GLS assessment when determining optimal timing for aortic valve intervention, particularly in asymptomatic patients.

Similarly, in chronic mitral and aortic regurgitation, GLS helps distinguish between compensated myocardial adaptation and early contractile dysfunction, informing surgical timing decisions before irreversible myocardial damage occurs.

## Cardiotoxicity Monitoring

In the oncology population receiving potentially cardiotoxic chemotherapy, GLS has become the gold standard for early cardiotoxicity detection. A relative reduction in GLS of more than 15% from baseline, even with preserved ejection fraction, identifies patients at high risk for subsequent cardiomyopathy. This early recognition enables cardioprotective interventions, chemotherapy modification, or enhanced surveillance, potentially preventing overt heart failure.

# Disease Identification and Characterization

## Cardiomyopathy Phenotyping

GLS patterns contribute meaningfully to cardiomyopathy classification and characterization. Different cardiomyopathies exhibit distinctive strain signatures:

**Hypertrophic Cardiomyopathy (HCM):** Patients typically demonstrate regional strain reduction in hypertrophied segments with relative preservation in non-hypertrophied areas, creating heterogeneous strain patterns. Apical HCM shows characteristically impaired apical strain with preserved basal function. The presence of fibrosis on LGE imaging correlates strongly with strain reduction, and combined assessment enhances risk stratification for sudden cardiac death.

**Dilated Cardiomyopathy:** Generally exhibits globally reduced and homogeneous strain patterns. However, specific patterns may suggest etiology—for instance, relative preservation of basal segments suggests infiltrative disease, while epicardial-to-endocardial strain gradients may indicate inflammatory processes.

**Restrictive Cardiomyopathy:** Often shows preserved or only mildly reduced longitudinal strain despite severely impaired diastolic function, reflecting the predominant mechanical restriction rather than primary systolic dysfunction. When combined with atrial strain assessment, this pattern helps distinguish restrictive cardiomyopathy from constrictive pericarditis.

**Takotsubo Cardiomyopathy:** Demonstrates characteristic apical akinesis with hyperkinetic basal segments, creating a unique strain pattern that mirrors the wall motion abnormalities. The rapid normalization of strain parallels functional recovery and helps confirm the diagnosis during follow-up imaging.

### Infiltrative and Storage Diseases

Cardiac amyloidosis presents a distinctive "apical sparing" pattern, where longitudinal strain is relatively preserved at the apex but significantly impaired in basal and mid-ventricular segments. This pattern, quantified as a ratio of apical to basal strain, demonstrates excellent diagnostic accuracy for amyloidosis and helps distinguish it from other causes of left ventricular hypertrophy. When combined with T1 mapping and extracellular volume quantification on cardiac MRI, strain imaging enhances both diagnosis and subtype differentiation between AL (Light-Chain amyloidosis) and ATTR (Transthyretin amyloidosis) amyloidosis.

Fabry disease, sarcoidosis, and hemochromatosis each demonstrate strain abnormalities that, when integrated with tissue characterization sequences, improve diagnostic accuracy and disease monitoring.

### Myocarditis and Inflammatory Cardiomyopathy

In acute myocarditis, regional strain abnormalities often correspond to areas of myocardial edema and inflammation on T2-weighted imaging and LGE distribution. GLS provides quantitative assessment of functional impairment and tracks recovery during follow-up. The persistence of strain abnormalities despite normalization of inflammatory markers may indicate evolving fibrosis and helps identify patients requiring extended surveillance or advanced heart failure therapies.

# Value in Differential Diagnosis

## Distinguishing Constrictive Pericarditis from Restrictive Cardiomyopathy

This challenging clinical distinction benefits significantly from strain analysis. Constrictive pericarditis typically preserves longitudinal strain despite impaired filling, while restrictive cardiomyopathy shows reduced longitudinal strain. Additionally, constrictive pericarditis demonstrates characteristic annular velocities and respiratory variation that differ from restrictive patterns. **Combined MRI assessment including pericardial thickness evaluation, real-time cine imaging, and strain analysis substantially improves diagnostic accuracy.**

## Differentiating Ischemic from Non-Ischemic Cardiomyopathy

While LGE imaging remains the cornerstone for distinguishing ischemic from non-ischemic etiology, strain patterns provide complementary information. Ischemic cardiomyopathy typically demonstrates regional strain abnormalities corresponding to coronary territories, while non-ischemic dilated cardiomyopathy more commonly shows diffuse, global impairment. However, overlapping patterns necessitate integration with perfusion imaging, LGE distribution, and clinical context for definitive characterization.

## Athlete's Heart versus Pathological Hypertrophy

Elite athletes commonly develop left ventricular hypertrophy that must be distinguished from hypertrophic cardiomyopathy. Athletic adaptation typically maintains normal or supranormal GLS despite increased wall thickness, while pathological hypertrophy demonstrates reduced strain particularly in hypertrophied segments. This distinction, combined with LGE absence in athletes versus frequent fibrosis in HCM, helps resolve diagnostic uncertainty and prevent inappropriate athletic restriction.

## Integration into Clinical Workflow

The incorporation of GLS into routine cardiac MRI reporting requires standardized acquisition protocols, validated post-processing software, and institutional reference ranges. Most contemporary MRI scanners and workstations include feature-tracking modules that generate strain measurements from standard balanced steady-state free precession (bSSFP) cine sequences, eliminating the need for specialized acquisitions. HarmonyCVI has a separate dashboard for visualizing and quantifying the Global Longitudinal Strain across AHA standardized cardiac segments (17) using industry standard feature tracking methods for quantification. A bulls eye plot of GLS and segmental strain adds visual comparative analysis of the strain across all the segments.

Reporting include absolute GLS values, regional strain curves, and bull's-eye plots that display segmental strain distribution.

Comparison with age- and sex-adjusted reference values enhances clinical interpretation, as GLS demonstrates modest variation with age, sex, and ethnicity.

## Limitations and Considerations

Despite its advantages, GLS assessment has important limitations. Methodological differences between vendors, post-processing software variability, and the influence of temporal resolution on strain measurements necessitate attention to technical factors. Image quality remains critical, as poor endocardial border definition degrades strain accuracy. Additionally, while normal reference ranges have been established, institutional validation ensures appropriate interpretation.

GLS represents a single component of comprehensive myocardial deformation analysis. Circumferential strain, radial strain, and torsional mechanics provide additional insights in specific clinical scenarios. Right ventricular strain and atrial strain measurements expand the assessment beyond left ventricular longitudinal function.

## Future Directions and Emerging Applications

Ongoing research explores artificial intelligence and machine learning algorithms that integrate strain data with clinical variables, biomarkers, and multiparametric MRI findings to generate personalized risk predictions and therapeutic recommendations. Strain-based phenomapping of heart failure may enable precision medicine approaches that tailor therapies to specific mechanical and biological profiles.

Three-dimensional strain assessment, which captures myocardial deformation in all spatial dimensions simultaneously, promises more comprehensive evaluation of complex deformation patterns. Advanced techniques including strain rate imaging and layer-specific strain analysis further refine assessment of myocardial mechanics.

## Conclusion

Global Longitudinal Strain has matured from a research tool to an essential clinical metric that fundamentally enhances cardiac MRI assessment. Its ability to detect subclinical dysfunction, provide powerful prognostic information, characterize diverse cardiac pathologies, and aid in differential diagnosis makes GLS indispensable in modern cardiovascular imaging. As standardization improves and clinical evidence accumulates, GLS measurement will increasingly influence guideline recommendations and therapeutic decision-making across the spectrum of cardiovascular disease.

For the practicing cardiologist and radiologist, familiarity with GLS interpretation and integration into clinical reasoning represents not merely an advanced skill but an essential competency in delivering state-of-the-art cardiovascular care. The marriage of sophisticated tissue characterization inherent to cardiac MRI with the functional insights provided by strain imaging creates a comprehensive diagnostic and prognostic platform that serves our patients with unprecedented precision.

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*Note: This blog is intended for medical professionals and should not replace clinical judgment or guideline-directed medical therapy. Strain measurements should always be interpreted within the context of comprehensive clinical assessment, including history, physical examination, complementary imaging, and laboratory data.*