What Does Myocardial Work Offer Beyond Strain?

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Introduction

In contemporary cardiovascular imaging, one of the methods that has gained significant relevance by adding diagnostic and prognostic information is speckle-tracking–derived Longitudinal Strain, particularly the assessment of left ventricular Global Longitudinal Strain (GLS). However, although GLS evaluates global myocardial deformation of the left ventricle, it is highly dependent on loading conditions, which may interfere with the accurate interpretation of its results. In this context, an emerging technique has been introduced, also derived from speckle tracking: Myocardial Work (MW). Compared with strain, MW offers the advantage of mitigating afterload bias by incorporating systemic arterial pressure into longitudinal strain analysis, generating Pressure–Strain Loops (PSL) throughout the cardiac cycle. Thus, MW quantifies not only the extent of longitudinal myocardial deformation but also the load under which this deformation occurs, providing refined diagnostic insight into ventricular function. The methodology is based on the work of Russell *et al*., who validated the PSL area as a noninvasive index of myocardial work and also introduced the concept of wasted work resulting from contractile discoordination.[1] In clinical practice, four global indices are derived: Global Work Index (GWI), Global Constructive Work (GCW), Global Wasted Work (GWW), and Global Work Efficiency (GWE = GCW / [GCW + GWW]) (Figure 1). Table 1 shows normal reference values for myocardial work and its indices derived from the Normal Reference Ranges for Echocardiography (NORRE) study of the European Association of Cardiovascular Imaging (EACVI).[2]

How Is Load Incorporated Into Strain?

In most cases, the Left Ventricular (LV) pressure curve is estimated using brachial systolic blood pressure measured by a cuff during the examination, synchronized with mitral and aortic valve opening and closing times. In conditions in which systemic systolic blood pressure does not reflect intraventricular pressure, such as Aortic Stenosis (AS), true afterload can be estimated by adding the mean transvalvular systolic aortic gradient to systemic systolic blood pressure, allowing noninvasive estimation of LV systolic pressure.[3-5] LV longitudinal strain is obtained by speckle tracking using apical three-, two-, and four-chamber views to estimate GLS. (Figura 2) By incorporating load into longitudinal myocardial deformation, MW helps determine whether reduced longitudinal strain values are due solely to increased afterload or reflect true intrinsic myocardial contractile dysfunction, which is something GLS alone cannot distinguish.[1,5]

Keywords

Echocardiography; Coronary Artery Disease; Aortic Valve Stenosis; Cardiac Resynchronization Therapy

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DOI: https://doi.org/10.36660/abcimg.20250103i

Additional Diagnostic Value of Myocardial Work in Current Clinical Scenarios

1) Coronary Artery Disease (CAD)

In patients with preserved Left Ventricular Ejection Fraction (LVEF) and no resting regional wall motion abnormalities, GWI outperformed GLS in discriminating significant CAD. In the study by Edwards et al., the area under the ROC curve for global GWI was 0.786 versus 0.693 for GLS; a cutoff value of 1,810 mmHg% yielded a sensitivity of 92% and a specificity of 51% for detecting CAD, highlighting the greater sensitivity of MW in patients with single-vessel disease.[3] In such cases, GLS may be normal at rest, whereas MW demonstrates greater sensitivity for CAD screening by incorporating afterload.[3]

2) After ST-segment elevation myocardial infarction

Within the first 24–48 hours after Percutaneous Coronary Intervention (PCI) for anterior ST-segment elevation myocardial infarction (STEMI), myocardial segments exposed to high afterload may exhibit reduced strain values without a proportional loss of constructive work, which is a compensatory pattern that GLS alone cannot identify. Recent studies show that in this setting, myocardial constructive work (both segmental and global) was a better predictor of regional and global functional recovery compared with LVEF, GLS, and wall motion scores.[4] Additionally, patients with in-hospital complications exhibited lower absolute values of global GCW and GWI and higher N-terminal pro–B-type natriuretic peptide (NT-proBNP) levels, underscoring the prognostic role of MW.[4] Preserved global GCW in the Left Anterior Descending Artery (LAD) territory, despite reduced absolute strain values, suggests myocardial viability and a higher likelihood of contractile recovery. Conversely, markedly reduced GCW values indicate a higher risk of persistent contractile dysfunction and adverse outcomes[4] (Figure 3).

3) Aortic valve stenosis

In severe aortic valve stenosis, strain has major limitations in distinguishing reduced longitudinal myocardial deformation

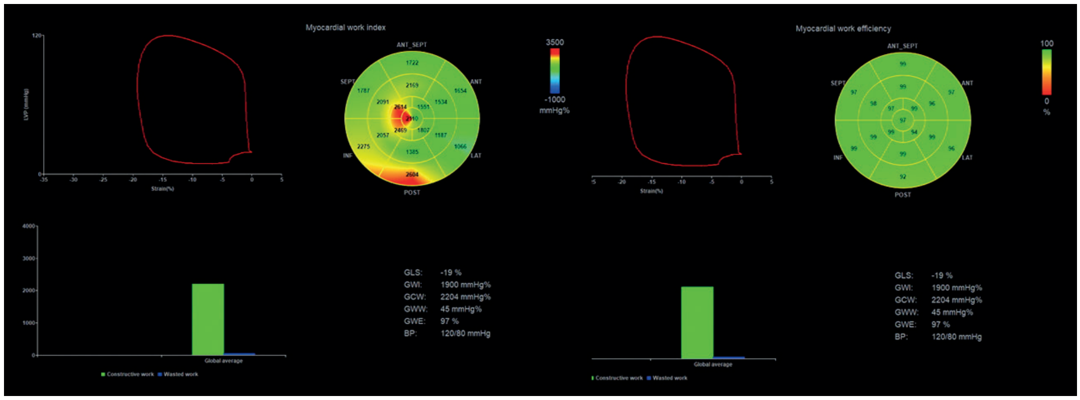

Figure 1 – *Polar map of myocardial work index displaying GLS, GWI, GCW, GWW, GWE, and systemic arterial pressure at the time of the examination.*

Table 1 – Normal reference values for myocardial work in men and women derived from the NORRE study of the EACVI.[2]

	Total	Male	Female
Number of patients	(n = 226)	(n = 85)	(n = 141)
GWI (mm Hg%)	1.896 ± 308	1.849 ± 295	1.924 ± 313
GCW (mm Hg%)	2.232 ± 331	2.228 ± 295	2.234 ± 352
GWW (mm Hg%)	78.5 (53 –122.2)	94 (61.5 –130.5)	74 (49.5 – 111)
GWE (%)	96 (94 – 97)	95 (94 – 97)	96 (94 – 97)

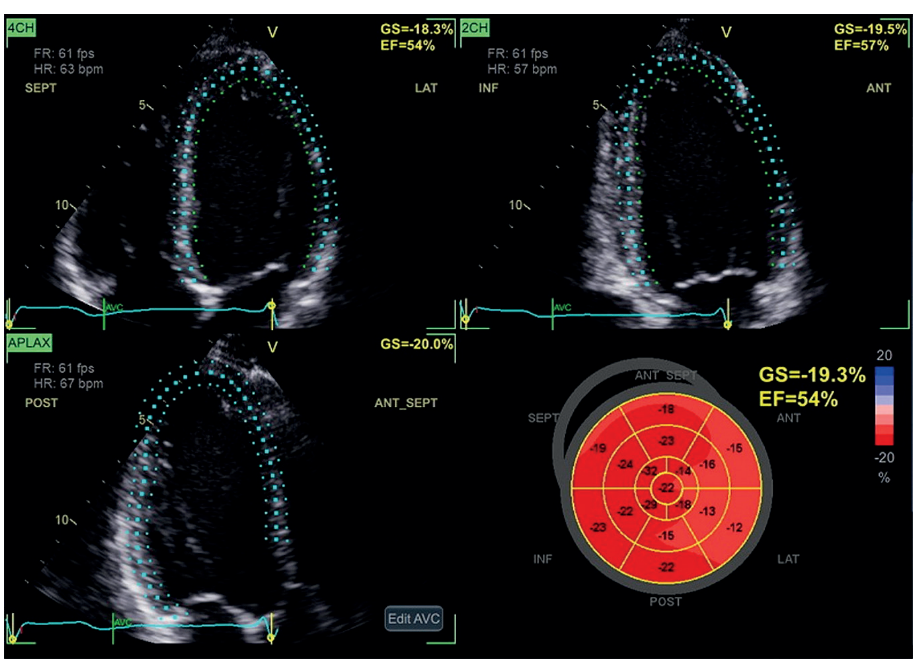

Figure 2 – *Apical four-, two-, and three-chamber views showing left ventricular longitudinal strain analysis derived from speckle tracking.*

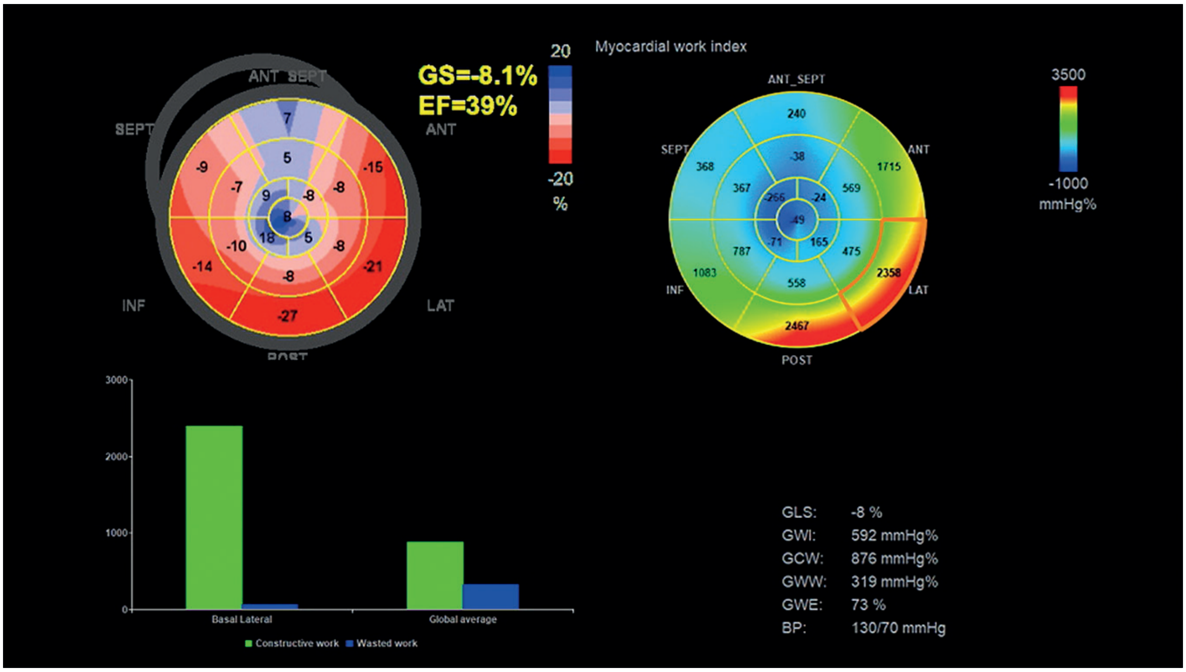

Figure 3 – *GLS and MW analysis in a patient with STEMI affecting the anteroseptal and apical segments of the left ventricle, showing significantly reduced GLS, LVEF, GCW, GWI, and GWE.*

due to adaptive response to increased afterload from deformation reduction caused by intrinsic myocardial dysfunction. MW provides incremental diagnostic value in this scenario. By appropriately estimating LV systolic pressure (adding the mean transvalvular systolic aortic gradient to systemic systolic blood pressure) and integrating it with LV longitudinal strain, GWI and GCW more accurately reflect the ventricle's ability to perform useful work under extremely high afterload. In a study of patients referred for Transcatheter Aortic Valve Implantation (TAVI), both GLS and MW were independently associated with heart failure symptoms (NYHA class III/IV); however, GLS showed weaker statistical correlation due to its load dependency. Clinically, this means that patients with similar GLS values may exhibit markedly different functional capacities. Patients with higher absolute GWI and GCW values tend to preserve mechanical efficiency despite elevated afterload and therefore present fewer symptoms, whereas lower values indicate incomplete adaptation and more pronounced symptoms. This more "physiological" interpretation supports a more refined discussion regarding optimal timing of intervention, particularly when LVEF remains preserved.[5]

4) Cardiac resynchronization therapy (CRT)

Response to CRT depends not only on correction of electromechanical delay but also on improvement in regional and global ventricular performance. In a retrospective cohort of 97 patients undergoing CRT, Total Constructive Work (CWtot), a global metric of constructive work, was an independent predictor of CRT response (left ventricular reverse remodeling at six months). A cutoff value of 1,057 mmHg% demonstrated good predictive performance, comparable to septal flash.[6] Additionally, the concept of wasted septal work (energy expended during paradoxical lengthening) correlated with mechanical inefficiency due to dyssynchrony. However, these are small, early studies that have not demonstrated clear superiority over pure strain-based metrics, highlighting the need for further investigation.[7] MW does not replace traditional criteria (QRS duration and morphology, presence of left bundle branch block, and scar burden) but may assist clinical decision-making in borderline cases.[8]

Interpreting MW as a Complement to GLS

MW and GLS are complementary tools that enable a more comprehensive assessment of myocardial deformation. GLS is an excellent technique for detecting subclinical systolic dysfunction, monitoring cardiotoxicity, tracking disease progression across multiple conditions, and providing prognostic information. MW emerges as an additional tool when loading conditions limit isolated GLS interpretation or when deformation needs to be translated into effective myocardial work. In hypertensive patients and those with aortic valve stenosis, MW mitigates afterload bias and prevents underestimation of systolic function. In suspected Coronary Arterial Disease (CAD) with normal conventional echocardiographic parameters of LV systolic function, reduced global MW values at rest increase suspicion of ischemia and support further diagnostic investigation.

After an anterior myocardial infarction, constructive work has prognostic value in predicting recovery of LV systolic function. In CRT candidates, higher absolute pre-implant constructive work values suggest preserved contractile reserve and a greater likelihood of reverse ventricular remodeling. Echocardiographic reports should ideally include both GLS and MW values, along with systemic blood pressure and heart rate at the time of examination, to enable more accurate interpretation of results.[9]

Myocardial Work and Its Limitations

Like speckle-tracking–derived longitudinal strain, MW measurement depends on adequate image quality for reliable speckle tracking. Furthermore, MW relies on noninvasive estimation of systemic blood pressure, requiring careful consideration in specific clinical contexts. As discussed, in patients with aortic valve stenosis, LV systolic pressure estimation must incorporate the mean transvalvular systolic aortic gradient. In other scenarios, such as fixed or dynamic obstructions, interpretation should be cautious. Logistical limitations also exist, as analysis is currently restricted to a single proprietary software platform, limiting broader dissemination across echocardiography laboratories. Finally, although studies demonstrate incremental value across multiple clinical settings, available evidence originates from a limited number of centers with relatively small sample sizes and short follow-up periods.[9]

Conclusion

Myocardial work provides incremental information beyond strain, with a fundamental role in assessing myocardial deformation under varying loading conditions. By integrating longitudinal myocardial deformation with systemic arterial pressure, MW delivers valuable insights into the effective work performed by the left ventricle throughout the cardiac cycle. In high afterload states, MW helps distinguish whether reduced absolute GLS values reflect intrinsic myocardial dysfunction. It also aids in predicting recovery of LV systolic function in STEMI patients treated with PCI and in identifying patients more likely to respond to CRT. Although broader standardization and multicenter validation are still needed, MW already offers meaningful incremental diagnostic and prognostic information.

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