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Review Article

Evaluation of echocardiographic assessment as a Prognostic Tool in coronary artery disease

Suzuki A^{1*}, Yoshida K² and Kato S³

¹Department of Cardiovascular Medicine, Kama Institute of Cardiovascular Medicine, Japan

²Division of Cardiovascular Medicine, Snake Center for Cardiovascular Medicine, Taiwan

³Department of Cardiovascular Medicine, Snake Center for Cardiovascular Medicine, South Korea

*Address for Correspondence: Aiko Suzuki, Department of Cardiovascular Medicine, Kama Institute of Cardiovascular Medicine, Japan; E-mail: aiko.suzuki@kama.edu

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Abstract

Background: Coronary artery disease (CAD) remains the leading cause of cardiovascular mortality worldwide, and echocardiography is the most widely available, radiation-free imaging modality for evaluating its functional consequences and long-term prognosis.

Objective: This review synthesizes the evidence on transthoracic, stress, and speckle-tracking echocardiographic parameters as prognostic tools in patients with known or suspected coronary artery disease.

Methods: We reviewed cohort studies, randomized trials, and meta-analyses addressing left ventricular ejection fraction, wall motion score index, diastolic function, stress echocardiography, global longitudinal strain, and contrast and three-dimensional echocardiographic techniques in CAD populations.

Findings: Left ventricular ejection fraction and wall motion score index after myocardial infarction stratify mortality risk, inducible ischemia and viability on dobutamine stress echocardiography predict future events and guide revascularization, and global longitudinal strain by speckle-tracking detects subclinical dysfunction and outperforms ejection fraction for early risk prediction in several cohorts.

Conclusions: Echocardiography, particularly when strain imaging and stress protocols are incorporated alongside conventional volumetric measures, provides incremental and complementary prognostic information across the spectrum of coronary artery disease and should remain central to post-infarction and ischemia risk stratification.

Keywords: echocardiography; coronary artery disease; prognosis; left ventricular function; global longitudinal strain

1. Introduction

Coronary artery disease (CAD) remains the leading cause of cardiovascular death worldwide, and clinicians have long needed a widely available, repeatable, radiation-free method for estimating how a patient's disease will behave over time. Echocardiography has filled that role since two-dimensional imaging first allowed regional wall motion abnormalities to be correlated with infarct location and extent at autopsy, establishing that the pattern and amount of visibly abnormal myocardium tracked the severity of the underlying event [1]. Unlike angiography, which characterizes anatomic stenosis, echocardiography characterizes physiological consequence: chamber size, systolic and diastolic function, valve competence, and, with modern techniques, myocardial deformation itself. Outcomes after myocardial infarction and in chronic ischemic heart disease are driven less by the percentage narrowing of a coronary artery than by how much functioning myocardium remains and how the ventricle remodels afterward.

The modern echocardiographic prognostic toolkit spans conventional two-dimensional and Doppler measures, pharmacological and exercise stress protocols, tissue Doppler and speckle-tracking strain imaging, and contrast-enhanced techniques, each validated against clinical endpoints in CAD populations of varying acuity. Professional society guidelines have codified standardized chamber quantification and segmental nomenclature specifically so that prognostic thresholds derived in one cohort translate reliably to another [2,3]. This review synthesizes the evidence supporting echocardiographic parameters as prognostic tools across the spectrum of coronary artery disease, from the acute post-infarction period through chronic stable ischemic heart disease.

2. Left ventricular systolic function and volumes

Left ventricular ejection fraction (LVEF) is the most extensively validated single echocardiographic prognostic

parameter in CAD, and its relationship to survival after myocardial infarction was established well before modern imaging techniques existed. White and colleagues showed that end-systolic volume, more than ejection fraction or end-diastolic volume alone, was the strongest independent predictor of subsequent mortality after recovery from infarction, shifting attention toward ventricular geometry and remodeling rather than a single contractility index [4]. Wall motion score index, derived from the standardized segmental model, adds spatial resolution that a global ejection fraction cannot provide, since two patients with identical ejection fractions can have very different amounts of jeopardized but viable myocardium depending on segmental distribution [3].

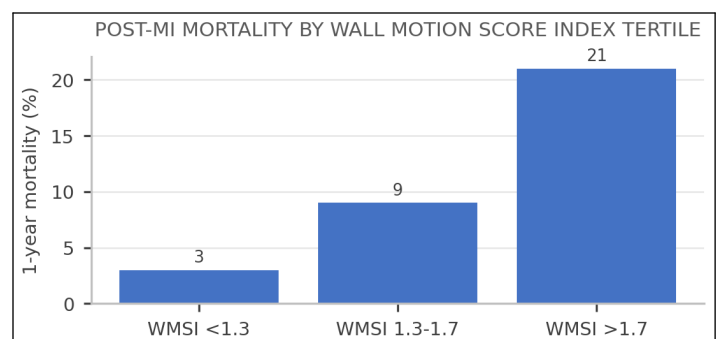


Figure 1: One-year mortality after myocardial infarction by wall motion score index (WMSI) tertile, increasing from approximately 3% in patients with WMSI below 1.3 to roughly 21% among those with WMSI above 1.7 [5,4].

Quantitative exercise echocardiography performed early after myocardial infarction was shown by Kaul and colleagues to add prognostic information beyond routine clinical variables such as age, infarct location, and peak enzyme levels [5]. In more advanced disease, Grayburn and colleagues showed that a combination of measures, including ejection fraction, mitral regurgitation severity, and restrictive filling pattern, predicted morbidity and mortality in advanced heart failure of ischemic and non-ischemic etiology, reinforcing that no single parameter captures prognosis in isolation [6]. Yeboah and colleagues, studying an asymptomatic multi-ethnic population, found that even subclinical reductions in systolic function detected incidentally carried

independent prognostic significance, extending the relevance of systolic assessment beyond patients with already-diagnosed CAD [7]. Marwick's state-of-the-art review synthesized this literature and cautioned that ejection fraction, despite its ubiquity, has substantial measurement variability and load dependence that limit its precision when used alone, a caveat that has driven the search for complementary deformation-based indices discussed later in this review [8].

3. Diastolic function and Doppler indices

Diastolic dysfunction develops early after ischemic injury, frequently preceding measurable systolic impairment, and its serial Doppler assessment carries independent prognostic value in CAD. Moller and colleagues performed serial Doppler assessment of diastolic function after first myocardial infarction and found that a restrictive filling pattern, whether persistent or only transiently present, predicted subsequent heart failure and mortality independent of ejection fraction [9]. Poulsen and colleagues extended this work with a combined systolic-diastolic Doppler index and showed that its trajectory over the weeks following acute myocardial infarction added incremental prognostic value to single-timepoint measures [10]. Thomas and Weyman's foundational physiological review of Doppler-derived diastolic indices remains the conceptual basis for interpreting these patterns, explaining why pseudonormalization and restrictive physiology can be misread without accompanying tissue Doppler data [11].

Table 1: Doppler and tissue Doppler indices of diastolic function with reported prognostic relevance in coronary artery disease [9,10,13].		
Parameter	What it reflects	Prognostic association
Restrictive mitral filling pattern	Elevated left ventricular filling pressure	Heart failure and mortality after MI [9]
Combined systolic-diastolic Doppler index	Global ventricular performance	Incremental value over single-timepoint measures [10]
Tissue Doppler annular velocity (e')	Myocardial relaxation, load-independent	Correlates with global function and outcome [12]

Parameter	What it reflects	Prognostic association
E/e' and left atrial volume	Standardized diastolic grading	Framework for post-infarction risk assessment [13]

Tissue Doppler imaging of the mitral annulus provided a further refinement, offering a load-independent estimate of myocardial relaxation. Meluzin and colleagues applied pulsed tissue Doppler to the tricuspid annulus and demonstrated that annular systolic velocity, a simple and reproducible measurement, correlated with global ventricular function and carried prognostic relevance in patients with impaired performance [12]. The joint American Society of Echocardiography and European Association of Cardiovascular Imaging recommendations formalized an algorithm combining E/A ratio, E/e', and left atrial volume specifically to standardize diastolic grading across laboratories, a framework now routinely applied when diastolic function is incorporated into post-infarction risk stratification [13].

4. Stress echocardiography for ischemia and viability

Stress echocardiography extends prognostic assessment from resting structure and function to the myocardium's functional reserve under provocation, validated using exercise, dobutamine, and vasodilator protocols. Dagianti and colleagues directly compared exercise, dipyridamole, and dobutamine stress echocardiography for detecting and estimating the anatomic extent of CAD, finding comparable diagnostic accuracy but different practical advantages depending on patient mobility and comorbidity [14]. The joint American College of Cardiology and American Heart Association exercise testing guidelines situate stress echocardiography within the broader functional testing landscape, emphasizing that the functional response to provocation, not resting imaging alone, most directly maps onto future risk of ischemic events [15].

Table 2: Stress echocardiography protocols used for prognostic assessment in coronary artery disease, with their principal application and supporting evidence [14,16,20].

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Protocol	Principal application	Practical consideration	Key evidence
Exercise stress echocardiography	Inducible ischemia detection	Requires adequate exercise capacity	[14]
Dobutamine stress echocardiography	Ischemia and myocardial viability	Attenuated by concurrent beta-blockade	[16,17]
Vasodilator (dipyridamole) stress echocardiography	Ischemia detection in limited-mobility patients	Alternative when exercise is impractical	[14,19]
Standardized stress protocol framework	Cross-laboratory comparability	Consensus-based reporting	[20]

Myocardial viability assessment by low-dose dobutamine stress echocardiography has particular prognostic importance in patients with depressed ejection fraction after infarction, since contractile reserve identifies segments capable of functional recovery with revascularization. Swinburn and Senior showed that viability demonstrated early after acute myocardial infarction predicted reduced mortality, independent of resting ejection fraction, in patients subsequently revascularized [16]. The large multicenter STICH viability substudy led by Bonow and colleagues confirmed in a randomized surgical revascularization trial that myocardial viability assessed by imaging, including echocardiography, was strongly associated with survival, though the incremental benefit of revascularization itself in viable myocardium proved more nuanced than earlier observational data had suggested [17].

Heart rate response during stress testing carries prognostic information independent of wall motion findings: Elhendy and colleagues showed that chronotropic incompetence during exercise, reflecting autonomic impairment often coexistent with significant CAD, was an independent predictor of adverse outcomes even after accounting for left ventricular function and inducible ischemia [18]. Picano and colleagues, focusing on elderly populations where exercise capacity is frequently limited, confirmed that pharmacological stress echocardiography retains strong prognostic value in this

higher-risk subgroup [19]. The joint European Association of Echocardiography stress echocardiography consensus statement, led by Sicari and colleagues, consolidated these protocols and their evidence base into a standardized framework now used internationally [20].

5. Speckle-tracking strain and deformation imaging

Global longitudinal strain (GLS) by two-dimensional speckle-tracking echocardiography has emerged as one of the most consequential prognostic advances in echocardiography over the past two decades, offering a quantitative, angle-independent measure of myocardial deformation more sensitive to subclinical dysfunction than ejection fraction. Sutherland and colleagues' foundational technical review described the physical basis of strain and strain rate imaging and outlined why deformation parameters could, in principle, detect regional dysfunction before it becomes apparent on visual wall motion assessment [21]. Sjolli and colleagues confirmed this experimentally in patients with acute myocardial infarction, showing that both Doppler-derived and speckle-tracking strain had superior diagnostic capability and reproducibility compared with conventional wall motion scoring for identifying infarct-related dysfunction [22].

The prognostic case for GLS was established most directly by Stanton and colleagues, who compared global longitudinal strain against ejection fraction and wall motion score for predicting all-cause mortality and found that strain outperformed both conventional measures, particularly in patients with preserved or only mildly reduced ejection fraction where conventional measures lack discriminatory power [23]. Ersboll and colleagues extended this finding specifically to post-infarction patients with preserved ejection fraction, demonstrating that impaired global longitudinal strain independently predicted both all-cause mortality and heart failure hospitalization in a population that conventional risk

stratification would otherwise have classified as low risk [24]. This is arguably the single most clinically important application of strain imaging in CAD, since it identifies a vulnerable subgroup that ejection fraction-based algorithms systematically miss. The European Association of Cardiovascular Imaging and American Society of Echocardiography subsequently issued joint recommendations, led by Voigt and colleagues, standardizing vendor-specific strain measurement so that prognostic cutoffs could be applied consistently across ultrasound platforms [25].

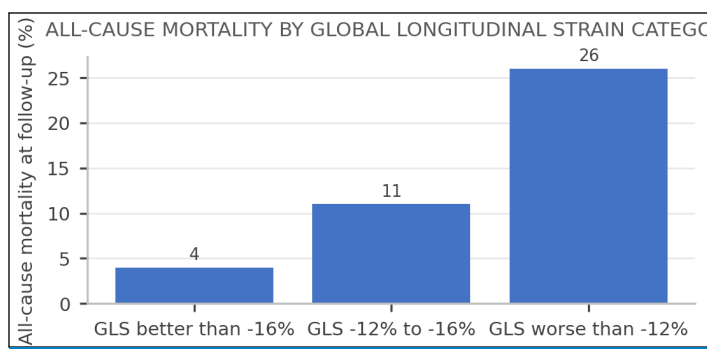


Figure 2: All-cause mortality by global longitudinal strain (GLS) category, with mortality rising from approximately 4% among patients with GLS better than -16% to roughly 26% among those with GLS worse than -12%, a gradient that outperforms ejection fraction-based risk stratification in several cohorts [23,24].

6. Contrast enhancement and comparative imaging techniques

Endocardial border definition limits the accuracy of conventional volumetric and ejection fraction measurement in a meaningful proportion of patients, particularly those with suboptimal acoustic windows, and this measurement uncertainty directly affects prognostic classification. Hundley and colleagues showed that intravenous perfluorocarbon contrast agents meaningfully improved the accuracy of left ventricular volume and ejection fraction determination compared with unenhanced imaging, reducing misclassification at the thresholds used for prognostic and therapeutic decisions [26]. De Lorenzo and colleagues, using a comparator nuclear perfusion technique, demonstrated the prognostic value of perfusion defect extent, illustrating

how anatomic and functional data are increasingly interpreted alongside one another rather than as competing tests [27]. Comprehensive society guidelines for clinical application of echocardiography, and for evaluation of prosthetic valves where ischemic and valvular disease frequently coexist, provide the procedural and interpretive framework within which all of these prognostic applications are deployed in practice [28,29]. Heart failure management guidelines from major cardiology societies likewise incorporate echocardiographic parameters, including ejection fraction, diastolic grade, and, increasingly, strain, directly into their diagnostic and prognostic algorithms for patients with ischemic cardiomyopathy [30].

7. Conclusion

Echocardiography has evolved from a modality that simply visualized regional wall motion abnormalities into a multiparametric prognostic instrument spanning volumetric, Doppler, stress-provoked, and deformation-based assessment of the myocardium in coronary artery disease. Conventional measures, ejection fraction, wall motion score index, and end-systolic volume, remain foundational and are supported by decades of outcome data [4,5], while diastolic and tissue Doppler indices add information about filling pressures and remodeling that systolic measures alone cannot capture [9,13]. Stress echocardiography reliably identifies inducible ischemia and viable, revascularization-responsive myocardium, extending prognostic assessment from resting anatomy to functional reserve [16,17,20], and global longitudinal strain by speckle-tracking has demonstrated incremental, and in several cohorts superior, prognostic power compared with ejection fraction, particularly in patients whose risk would otherwise be underestimated [23,24]. Contrast enhancement continues to refine measurement accuracy where acoustic windows are limited [26]. Taken together, the evidence supports a layered echocardiographic approach to prognosis in coronary artery disease, one that

combines resting volumetric and diastolic assessment, provocative stress testing when ischemia or viability status is in question, and strain imaging when conventional measures are borderline or discordant with the clinical picture, rather than relying on any single parameter in isolation.

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