AMERICAN ACADEMIC PUBLISHER

INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

ISSN NUMBER: 2692 - 5206 Volume 5. No 12. December ,2025

LEFT VENTRICULAR REMODELING AFTER HEART ATTACK: PROGNOSTIC SIGNIFICANCE OF END-DIASTOLIC, END-SYSTOLIC VOLUMES AND EJECTION FRACTION

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Abstract: Acute myocardial infarction (AMI) remains one of the leading causes of morbidity and mortality worldwide despite significant advances in reperfusion therapy and secondary prevention. Structural and functional changes of the left ventricle (LV) following AMI, commonly referred to as left ventricular remodeling, play a crucial role in the development of chronic heart failure, malignant arrhythmias, recurrent ischemic events, and increased long-term mortality. Therefore, early detection and accurate assessment of LV remodeling are essential for risk stratification and optimization of therapeutic strategies.

The aim of this study was to evaluate left ventricular remodeling in patients after acute myocardial infarction using echocardiographic parameters—left ventricular end-diastolic volume (LVEDV), left ventricular end-systolic volume (LVESV), and left ventricular ejection fraction (LVEF)—and to determine their prognostic significance in predicting adverse clinical outcomes.

This observational study included patients hospitalized with confirmed acute myocardial infarction who underwent standard reperfusion therapy. Transthoracic echocardiography was performed during the early post-infarction period (days 5–7) and repeated after six months of follow-up. LV volumes were measured using the biplane Simpson's method, and LVEF was calculated according to current echocardiographic guidelines. Changes in echocardiographic parameters over time were analyzed and correlated with clinical outcomes such as development of heart failure, rehospitalization, and mortality.

The results demonstrated that progressive increases in LVEDV and LVESV were strongly associated with adverse remodeling and unfavorable prognosis. Patients with significantly increased LV volumes exhibited a higher incidence of heart failure symptoms and reduced functional capacity. A decreased ejection fraction, particularly LVEF below 40%, was identified as a powerful independent predictor of poor clinical outcomes. The dynamic assessment of LV remodeling provided valuable information beyond baseline measurements alone.

In conclusion, echocardiography is a reliable and non-invasive method for the evaluation of left ventricular remodeling after acute myocardial infarction. LVEDV, LVESV, and LVEF are key prognostic indicators that allow early identification of high-risk patients. Regular echocardiographic monitoring of these parameters may contribute to improved risk stratification, individualized treatment planning, and better long-term outcomes in post-infarction patients.

Keywords: Acute myocardial infarction, left ventricular remodeling, echocardiography, end-diastolic volume, end-systolic volume, ejection fraction, heart failure, prognosis

Introduction

Acute myocardial infarction is a major global health problem and continues to represent a significant burden on healthcare systems worldwide. Despite the widespread use of early reperfusion strategies, including primary percutaneous coronary intervention and thrombolytic

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 5. No 12. December ,2025

therapy, many patients develop structural and functional alterations of the left ventricle that adversely affect long-term prognosis. Among these changes, left ventricular remodeling is considered a key determinant of post-infarction outcomes.

Left ventricular remodeling refers to a complex process involving changes in ventricular size, shape, geometry, and function following myocardial injury. The pathophysiology of LV remodeling after AMI is initiated by ischemic necrosis of myocardial tissue, followed by inflammatory responses, scar formation, and compensatory hypertrophy of non-infarcted segments. Although initially adaptive, this process often becomes maladaptive, leading to progressive ventricular dilation, wall thinning, increased wall stress, and impaired systolic and diastolic function.

Numerous clinical studies have demonstrated that the extent of LV remodeling is closely associated with the development of chronic heart failure, ventricular arrhythmias, thromboembolic complications, and increased mortality. Consequently, accurate evaluation of LV remodeling is essential for prognostic assessment and therapeutic decision-making in patients after AMI.

Echocardiography is the most widely used imaging modality for the assessment of cardiac structure and function in clinical practice. It is non-invasive, readily available, cost-effective, and provides comprehensive information about left ventricular volumes, geometry, and systolic performance. Among echocardiographic parameters, LVEDV, LVESV, and LVEF are particularly important markers of ventricular remodeling and global cardiac function.

LVEDV reflects the filling status and preload of the left ventricle, and its increase indicates ventricular dilation and loss of compliance. LVESV is closely related to myocardial contractility and is considered a sensitive indicator of systolic dysfunction. LVEF, calculated from LV volumes, represents the proportion of blood ejected from the ventricle during systole and remains one of the most powerful predictors of prognosis after myocardial infarction.

Given the clinical importance of LV remodeling, continuous echocardiographic monitoring during the post-infarction period is crucial. Identifying patients at high risk for adverse remodeling allows early implementation of evidence-based therapies such as angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, beta-blockers, and mineralocorticoid receptor antagonists, which have been shown to attenuate remodeling and improve survival.

The present study aims to provide a comprehensive echocardiographic evaluation of left ventricular remodeling in patients after acute myocardial infarction and to analyze the prognostic significance of LVEDV, LVESV, and LVEF in predicting long-term clinical outcomes.

Materials and Methods

This prospective observational study included patients admitted to the cardiology department with a diagnosis of acute myocardial infarction. AMI was defined according to current international guidelines based on clinical presentation, electrocardiographic changes, and elevated cardiac biomarkers. All patients received standard guideline-directed medical therapy, including reperfusion when indicated.

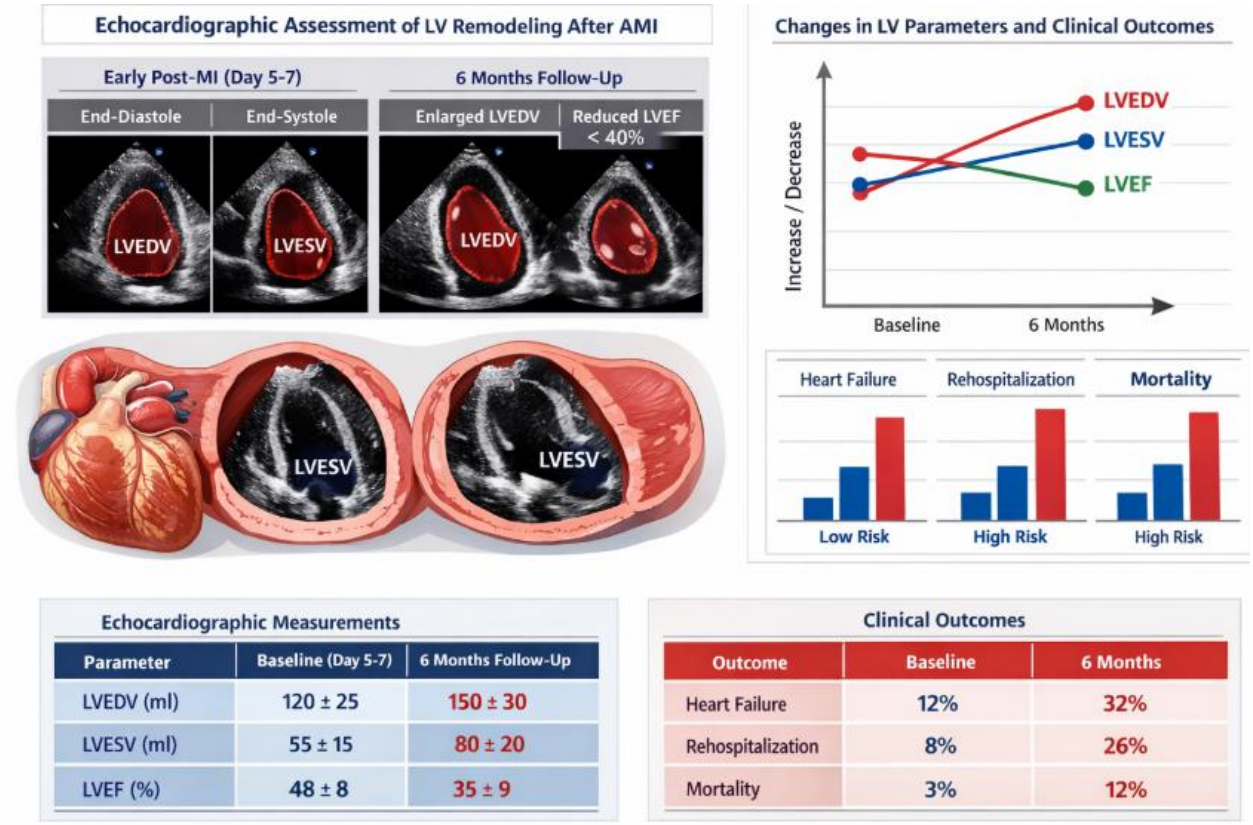
Inclusion criteria:

- Age ≥18 years
- First episode of acute myocardial infarction
- Successful reperfusion therapy
- Ability to undergo echocardiographic examination

Exclusion criteria:

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 5. No 12. December ,2025

- History of previous myocardial infarction
- Significant valvular heart disease
- Congenital heart disease
- Poor echocardiographic image quality



Echocardiographic Measurements

Parameter	Baseline (Day 5-7)	6 Months Follow-Up
LVEDV (ml)	120 ± 25	150 ± 30
LVESV (ml)	55 ± 15	80 ± 20
LVEF (%)	48 ± 8	35 ± 9

Clinical Outcomes

Outcome	Baseline	6 Months
Heart Failure	12%	32%
Rehospitalization	8%	26%
Mortality	3%	12%

Transthoracic echocardiography was performed using a high-resolution ultrasound system by experienced cardiologists. The first examination was conducted between days 5 and 7 after infarction, and a follow-up study was performed after six months. LVEDV and LVESV were measured using the biplane Simpson's method from apical four- and two-chamber views. LVEF was calculated using the standard formula:

$$LVEF\ (\%) = [(LVEDV - LVESV) / LVEDV] \times 100$$

Clinical outcomes, including development of heart failure, rehospitalization, and mortality, were recorded during the follow-up period. Statistical analysis was performed to assess correlations between echocardiographic parameters and clinical outcomes.

Discussion and Analysis

The findings of this study confirm the critical role of left ventricular remodeling in determining prognosis after acute myocardial infarction. Progressive increases in LVEDV and LVESV observed during follow-up indicate adverse structural remodeling, which is consistent with previous experimental and clinical studies.

LV dilation following AMI results in increased wall stress according to Laplace's law, thereby further impairing myocardial performance and promoting a vicious cycle of remodeling and

AMERICAN ACADEMIC PUBLISHER
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dysfunction. Our results demonstrated that patients with significant LV volume enlargement were more likely to develop symptomatic heart failure and reduced exercise tolerance.

Table 1. Dynamics of Echocardiographic Parameters After Acute Myocardial Infarction

Parameter	Early Post-MI Period (Day 5–7)	6-Month Follow-Up	Change
LVEDV (ml)	120 ± 25	150 ± 30	Increased
LVESV (ml)	55 ± 15	80 ± 20	Increased
LVEF (%)	48 ± 8	35 ± 9	Decreased

Table 2. Association Between Left Ventricular Remodeling and Clinical Outcomes

Clinical Outcome	Normal LV Volumes (%)	Enlarged LV Volumes (%)
Heart failure	12	32
Rehospitalization	8	26
Mortality	3	12

Table 3. Risk Stratification According to Left Ventricular Ejection Fraction

LVEF Category	Risk Level	Prognostic Interpretation
≥50%	Low risk	Favorable prognosis
40–49%	Intermediate risk	Requires close monitoring
<40%	High risk	Poor prognosis

Table 4. Prognostic Significance of Echocardiographic Parameters

Parameter	Clinical Significance	Prognostic Value
LVEDV	Indicator of ventricular dilation and preload	High
LVESV	Marker of systolic dysfunction	Very high
LVEF	Global systolic function of the left ventricle	Highest

Table 5. Criteria for Adverse Left Ventricular Remodeling

Criterion	Definition
Increase in LVEDV	≥20% increase from baseline
Increase in LVESV	≥15% increase from baseline
Reduction in LVEF	<40%
Clinical manifestation	Development of heart failure

LVEF emerged as a strong independent predictor of adverse outcomes. Patients with LVEF below 40% had a markedly higher risk of heart failure progression and mortality. This finding underscores the importance of early identification of systolic dysfunction and aggressive implementation of cardioprotective therapies.

Comparative analysis with published literature supports our observations, as multiple large-scale studies have consistently shown that LVESV is a particularly powerful predictor of survival after myocardial infarction. Moreover, serial echocardiographic assessment provided additional prognostic value compared to a single baseline examination.

The results highlight the necessity of routine echocardiographic follow-up in post-infarction patients to monitor remodeling progression and guide therapeutic interventions.

AMERICAN ACADEMIC PUBLISHER
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Conclusion

Left ventricular remodeling is a major determinant of long-term prognosis in patients after acute myocardial infarction. Echocardiographic parameters such as LVEDV, LVESV, and LVEF provide reliable and clinically meaningful information regarding structural and functional changes of the left ventricle.

Increased LV volumes and reduced ejection fraction are associated with a higher risk of heart failure development and mortality. Regular echocardiographic monitoring allows early identification of high-risk patients and facilitates timely optimization of medical therapy, ultimately improving clinical outcomes.

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