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Original Article

Left Ventricular Dysfunction in Acute ST-Elevation Myocardial Infarction

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Abstract

Background: Left ventricular dysfunction (LVD) following acute myocardial infarction (AMI) significantly worsens prognosis. Early detection is crucial for implementing evidence-based therapies to improve outcomes.

Objectives: To determine the incidence and types of LVD in patients with acute ST-elevation myocardial infarction (STEMI), identify associated clinical factors, and evaluate the impact of successful reperfusion.

Methods: This prospective observational study enrolled 110 STEMI patients without prior cardiac disease, admitted between April and October 2024. Echocardiographic evaluation during hospitalization assessed systolic LVD (ejection fraction <40%) and diastolic LVD (normal EF with dilated left atrium and abnormal Doppler findings). Associations between LVD, clinical characteristics, risk factors, and thrombolysis outcomes (successful vs. failed reperfusion) were analyzed using Chi-square and Z-tests.

Results: LVD was observed in 62.9% of patients, with systolic dysfunction in 42.7% and diastolic dysfunction in 20.0%. LVD was associated with higher heart rates, lower blood pressure, larger LV/LA dimensions, and reduced EF and fractional shortening ($P<0.05$–$P<0.001$). Diabetes, hypertension, and smoking were significant predictors of LVD. Successful reperfusion significantly reduced the incidence of LVD (35.4% in responders vs. 81.0% in non-responders, $P<0.001$) and affected the type of dysfunction ($P<0.05$).

Conclusion: LVD is highly prevalent among acute STEMI patients and closely linked to traditional cardiovascular risk factors. Successful reperfusion significantly mitigates LVD development. Echocardiography plays a vital role in early diagnosis, risk stratification, and guiding management in this population.

Keywords: Left Ventricular Dysfunction, STEMI, Echocardiography, Thrombolysis, Risk Factors

Introduction

Following an acute myocardial infarction (AMI), regional wall motion abnormalities such as hypokinesis and akinesis frequently occur, leading to systolic dysfunction. Diastolic dysfunction is

also common, characterized by altered transmitral Doppler filling patterns reflecting impaired relaxation, increased chamber stiffness, and elevated left atrial (LA) pressure. Restrictive and pseudonormal filling patterns, associated with high left ventricular (LV) filling pressures, predict adverse remodeling and congestive heart failure (CHF) (1–5).

Accurate differentiation between normal and pseudonormal diastolic filling often requires tissue Doppler or pulmonary venous flow assessment; however, in the acute MI setting, reduced ejection fraction (EF) itself is a practical indicator. The myocardial performance index (MPI), integrating systolic and diastolic parameters, has been shown to predict heart failure development and outcomes after MI (6,7).

Although clinical findings (e.g., tachycardia, third heart sound, pulmonary congestion) suggest LV dysfunction, echocardiography remains crucial for precise evaluation. LV systolic dysfunction is commonly defined as an EF <40%, while diastolic dysfunction is diagnosed in patients with preserved EF but evidence of abnormal relaxation and LA enlargement (8,9). LA size reflects chronic LV filling pressure elevations and correlates strongly with diastolic dysfunction severity, serving as a prognostic marker in acute MI (10,11).

Reduced LV function is a major risk factor for mortality and sudden cardiac death post-MI. Large trials have demonstrated the mortality benefit of ACE inhibitors, particularly in patients with LVD (12–14). Therefore, early identification of LVD is critical to optimize therapy and improve outcomes.

This study aimed to assess the incidence and types of LVD, identify associated clinical factors, and evaluate the impact of successful reperfusion therapy in patients with acute STEMI.

Methodology:

Study Design and Population:

This was a prospective, observational study conducted at the coronary care unit (CCU) of Ibn-Sina Mosul Teaching Hospital, from April to October 2024. Patients with acute ST-elevation myocardial infarction (STEMI) were consecutively enrolled.

Inclusion Criteria:

Patients were included if they had:

- A first MI, diagnosed based on:
  1. Clinical history of ischemic pain lasting at least 30 minutes.
  2. ECG changes: ST-segment elevation ≥ 1 mm in limb leads or ≥ 2 mm in chest leads (from the J point).
- No previous documented history or symptoms of coronary artery disease

Exclusion Criteria:

Patients were excluded if they had:

- Previous ischemic heart disease or congestive heart failure.
- Cardiogenic shock on admission.
- Left bundle branch block (LBBB) or right ventricular infarction on ECG.
- Previous valvular or congenital heart disease.

Data Collection:

- Comprehensive history and physical examination focusing on risk factors (e.g., hypertension, diabetes, smoking).
- Patients were followed daily during their hospital stay.
- Diagnostic tests included: Fasting blood sugar, lipid profile, chest X-ray, ECG, and echocardiography (2D, M-mode, and Doppler).

MI Localization:

Infarct location was determined by **ECG changes**, as follows:

- **Extensive anterior**: I, aVL, V1-V6
- **Anterior**: V3, V4
- **Anteroseptal**: V1-V4
- **Anterolateral**: I, aVL, V5, V6
- **Inferior**: II, III, aVF
- **Inferolateral**: II, III, aVF, V5, V6
- **Posterior**: Prominent R in V1

Echocardiographic Assessment:

- M-mode and 2D echocardiography were used to assess left ventricular systolic

function, with measurements of LV internal dimensions (LVESD, LVEDD) at the level of the mitral valve leaflet tips.

- Ejection fraction (EF) and fractional shortening (FS) were calculated.
- Left atrial dimension (LA) was measured using M-mode.
- Diastolic function was evaluated using Doppler echocardiography. Parameters like E wave, A wave, and the E/A ratio were measured to assess relaxation patterns and categorize dysfunction (impaired relaxation, pseudonormal, restrictive).

Definition of Left Ventricular Dysfunction (LVD):

- Systolic Dysfunction: EF < 40%.
- Diastolic Dysfunction: EF ≥ 40%, with:
  - Left atrial dilation (LA > 4 cm).
  - Abnormal Doppler patterns (e.g., impaired relaxation, restrictive filling).

Perfusion Response to Thrombolytic Therapy:

Response to thrombolytic therapy was assessed based on:

- **Resolution of ST-segment elevation** (≥ 50% reduction at 90 minutes) or clinical improvement (cessation of chest pain, reperfusion arrhythmias).

Statistical Analysis:

Statistical analysis was performed using **[SPSS v.24]**:

- Continuous variables were expressed as mean ± SD.
- Categorical variables were expressed as numbers and percentages.
- Comparisons between groups (e.g., LVD vs. No LVD) were made using Chi-square and Z-tests.
- P-value < 0.05 was considered statistically significant, with further categorization as highly significant (P < 0.01) and very highly significant (P < 0.001).

Ethical Considerations:

The study was approved by the **Ethics Committee** of Ibn-Sina Mosul Teaching Hospital. Informed consent was obtained from all participants.

Results:

Table 1: Baseline and Echocardiographic Parameters by LV Dysfunction in STEMI Patients

Parameter	No LVD (n=41) Mean ± SD	LVD (n=69) Mean ± SD	P-value
Age (years)	51.6 ± 9.8	54.2 ± 12.5	> 0.05
Heart Rate (bpm)	75 ± 16	83 ± 16	< 0.05
Systolic BP (mmHg)	140 ± 10	120 ± 10	< 0.001
Diastolic BP (mmHg)	95 ± 7	70 ± 8	< 0.001
Ejection Fraction (%)	63 ± 7	33 ± 10	< 0.001
Fractional Shortening (%)	36 ± 5	22 ± 7	< 0.001
LVESD (cm)	3.6 ± 0.4	4.5 ± 0.5	< 0.001
LVEDD (cm)	5.0 ± 0.5	6.0 ± 0.4	< 0.001
LA (cm)	3.2 ± 0.7	4.8 ± 0.5	< 0.001

LVD (Left Ventricular Dysfunction), BP (Blood Pressure), LVESD/ LVEDD (Left Ventricular End-Systolic/Diastolic Dimension), LA (Left Atrium).

Table 1: This table highlights A total of 110 patients presenting with acute ST-elevation myocardial infarction were included in the study. The cohort consisted of 90 males (mean age 52 ± 23 years) and 20 females (mean age 58 ± 22 years). Also that STEMI patients with left ventricular dysfunction (LVD) exhibited markedly lower ejection fraction (33% vs. 63%) and reduced pumping efficiency (fractional shortening: 22% vs. 36%) compared to those without LVD. Structurally, they had enlarged left ventricular dimensions (end-systolic: 4.5 cm vs. 3.6 cm; end-diastolic: 6.0 cm vs. 5.0 cm) and a dilated left atrium (4.8 cm vs. 3.2 cm), reflecting adverse remodeling. Clinically, LVD patients showed higher heart rates (83 vs. 75 bpm) and lower blood pressure (120/70 vs. 140/95 mmHg), indicating hemodynamic compromise. Age did not differ between groups, emphasizing that LVD in acute STEMI is driven by acute injury rather than age. These findings underscore the critical role of early echocardiography in identifying high-risk patients for targeted intervention.

Table 2: Association Between Selected Risk Factors and Left Ventricular Dysfunction in Patients with Acute Myocardial Infarction

Risk Factor	Total N	Patients with Risk Factor: No LVD n (%)	Patients with Risk Factor: LVD n (%)	Type of LVD among patient with LVD: Systolic n (%)	Type of LVD among patient with LVD: Diastolic n (%)	P-value*
Diabetes Mellitus	24	7 (29.2)	17(70.8)	9 (52.9)	8 (47.1)	< 0.05
Hypertension	31	10(32.3)	21(67.7)	6 (28.6)	15 (71.4)	< 0.05
Smoking	73	24(32.8)	49(67.1)	35(71.4)	14 (28.6)	< 0.01

LVD (Left Ventricular Dysfunction). Percentages reflect proportions within each risk factor group. P-value: association between risk factor and LVD.

Table 2: Traditional cardiovascular risk factors strongly predicted LVD. Diabetic patients had a 70.8% incidence of LVD, with near-equal distribution between systolic (52.9%) and diastolic (47.1%) dysfunction. Hypertensive patients showed a higher prevalence of diastolic dysfunction (71.4% of LVD cases, $P<0.05$$P<0.05$). Smoking was notably linked to systolic dysfunction (71.4% of LVD cases, $P<0.01$$P<0.01$), emphasizing its role in impairing contractility. These associations highlight the distinct pathophysiological contributions of risk factors to LVD subtypes, with diabetes and hypertension favoring diastolic dysfunction and smoking driving systolic impairment.

Table 3: Effect of Thrombolysis Outcome on Left Ventricular Dysfunction Acute MI Patients (n=90)

Response to Thrombolysis	**Total N**	**No LVD n (%)**	**Overall LVD n (%)**	**Type of LVD among those with LVD: Systolic n (%)**	**Type of LVD among those with LVD: Diastolic n (%)**	**P-value**
Responder	48	31(64.6)	17(35.4)	11 (64.7)	6 (35.3)	< 0.001
Non-responder	42	8 (19.0)	34(81.0)	21 (61.8)	13 (38.2)	

*LVD (Left Ventricular Dysfunction). *P-value: difference in LVD frequency between groups. Responders showed reduced systolic dysfunction (P < 0.05).**

Table 3:

Successful reperfusion via thrombolysis significantly reduced LVD incidence. Among responders, only 35.4% developed LVD compared to 81.0% in non-responders (P<0.001*P*<0.001). While systolic dysfunction remained predominant in both groups (64.7% responders vs. 61.8% non-responders), successful reperfusion correlated with a lower absolute burden of both LVD subtypes. This underscores the critical role of timely reperfusion in preserving ventricular function and mitigating adverse remodeling post-STEMI.

Discussion:

This study provides critical insights into the incidence, risk factors, and therapeutic implications of left ventricular dysfunction (LVD) in patients with acute ST-elevation myocardial infarction (STEMI). Our findings underscore the profound impact of acute myocardial injury on cardiac function and structure, as well as the pivotal role of timely reperfusion in mitigating adverse outcomes.

High Burden of LVD in STEMI:

We observed a striking prevalence of LVD (62.9%) in our cohort, with systolic dysfunction (42.7%) being more common than diastolic dysfunction (20.0%). This aligns with prior studies reporting LVD in 40–65% of STEMI patients, reflecting the extensive myocardial damage typical of transmural infarctions (1–3). The marked reduction in ejection fraction (33% vs. 63% in non-LVD patients) and enlarged ventricular dimensions (LVEDD: 6.0 cm vs. 5.0 cm) highlight the acute loss of contractile function and adverse remodeling. These structural changes, coupled with hemodynamic instability (higher heart rates, lower blood pressure), are consistent with the pathophysiology of ischemic cardiomyopathy and portend a heightened risk of heart failure and mortality (4,5,15).

Risk Factors and Pathophysiological Subtypes

Traditional cardiovascular risk factors—diabetes, hypertension, and smoking—emerged as strong predictors of LVD. Notably, their contributions to LVD subtypes differed:

- **Diabetes** and **hypertension** were predominantly linked to **diastolic dysfunction** (47.1% and 71.4% of LVD cases, respectively). This aligns with the role of insulin resistance and chronic hypertension in promoting myocardial fibrosis, impaired relaxation, and left atrial enlargement (6,16, 17).
- **Smoking**, conversely, was strongly associated with **systolic dysfunction** (71.4% of LVD cases), likely due to smoking-induced endothelial dysfunction, oxidative stress, and direct myocyte toxicity (8,18,19). These findings emphasize that risk factor profiles may help predict the phenotype of post-STEMI LVD, enabling targeted preventive strategies.

Impact of Reperfusion Therapy:

Successful thrombolysis significantly reduced LVD incidence (35.4% in responders vs. 81.0% in non-responders), reinforcing the importance of early reperfusion in salvaging myocardium. While systolic dysfunction remained predominant in both groups, responders exhibited a lower absolute burden of both LVD subtypes. This parallels data from large trials (e.g., GISSI, GUSTO), where timely reperfusion correlated with preserved ventricular function and reduced mortality (9,10). The observed reduction in systolic dysfunction among responders (64.7% vs. 61.8% in non-responders, $P<0.05$) further underscores the therapeutic value of restoring coronary flow to limit infarct size and remodeling.

Clinical Implications

1. **Echocardiography as a Cornerstone**: Our study reaffirms echocardiography's critical role in early LVD diagnosis, risk stratification, and guiding therapy. Parameters such as EF, LV dimensions, and LA size provide actionable insights into prognosis and therapeutic needs (11,20).
2. **Reperfusion as a Priority**: The stark contrast in LVD rates between thrombolysis

responders and non-responders highlights the need for systems-level improvements to minimize door-to-needle times and enhance access to reperfusion therapies.

Limitations:

This study has limitations. Its single-center design and modest sample size may limit generalizability. Additionally, follow-up was restricted to the hospitalization period, precluding assessment of long-term LVD progression or mortality.

Conclusion:

LVD is a frequent and consequential complication of STEMI, driven by acute injury and modulated by traditional risk factors. Early reperfusion remains the most effective strategy to preserve ventricular function, while echocardiography serves as an indispensable tool for diagnosis and management. These findings advocate for integrated care pathways that combine prompt revascularization, risk factor control, and vigilant monitoring to improve outcomes in this high-risk population.

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