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Left ventricular diastolic dysfunction after first Acute Myocardial Infarction with respect to time and long-term implications

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Abstract

Background: LV diastolic dysfunction contributes to signs and symptoms of heart failure and LV diastolic dysfunction is associated with increased mortality rates in patients chronic heart failure independent of systolic function after acute myocardial infarction. This study was planned to calculate the mean change in LV diastolic function at 3 months and 1 year after MI from baseline. **Materials and Methods:** This hospital-based retrospective observational study was carried out in a tertiary care facility at Jaipur. Data of total 75 patients of acute MI who got admitted from 1st April 2022 to 30th September 2022 was collected retrospectively. Baseline and follow up data of clinical evaluation of all patients visits at 3 and 12 months along with Two-Dimensional Echocardiography for assessment of Diastolic Dysfunction was obtained from the records and analysed. **Result:** The mean age of cases was 63±11 years. Male to female ratio was 2.9:1. Patients with normal, impaired relaxation, or restrictive LV diastolic Doppler filling were categorized in 38.7%, 40%, and 21.3% respectively. In patients with normal filling pattern early and late mitral peak flow velocity, E/A ratio, and mitral E-wave deceleration time were without significant changes during 12 months of follow-up. In patients with impaired relaxation E/A ratio, mitral E deceleration time, isovolumetric relaxation time, and peak pulmonary venous systolic and diastolic flow velocity were unchanged during follow-up. **Conclusion:** Patients exhibiting early diastolic dysfunction symptoms develop LV dilatation and in-hospital congestive heart failure. Patients who developed this LV filling abnormality or who had a prolonged restrictive LV filling pattern were linked to higher NYHA class scores and hospital readmissions for heart failure during follow-up.

Keywords: Acute MI, Diastolic Dysfunction, NYHA grading, E/A ratio

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Introduction

There is a highly increased risk for subsequent fatal and nonfatal cardiovascular events among the survivors of acute myocardial infarction (MI). This increased risk is associated with severity of left ventricular dysfunction.[1] Various clinical studies have proven the progressive nature of left ventricular enlargement and dysfunction after a myocardial

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infarction.[2,3] Left ventricular (LV) systolic function is a well-established predictor of morbidity and mortality following acute myocardial infarction.[4]

In recent years, it has been increasingly apparent that LV diastolic dysfunction contributes to signs and symptoms of heart failure and LV diastolic dysfunction is associated with increased mortality rates in patients chronic heart failure independent of systolic function.[5] LV diastolic dysfunction has been reported in the subacute and late phase after myocardial infarction and it is becoming increasingly clear that abnormalities of diastolic function during acute myocardial infarction (AMI) have a major role in affecting the prognosis.[6] LV diastolic dysfunction is difficult to assess on basis of clinical examination including chest radiography and electrocardiography.[7] Doppler echocardiography has become a well accented practical and safe non-invasive method for diagnosis of LV diastolic dysfunction, this can provide accurate and comprehensive assessment of left ventricle systolic and diastolic function.[8]

Diastolic function grades: LV diastolic function ranges from normal (Grade 0) to impaired relaxation (Grade I), to pseudonormal (Grade II), to restrictive (Grade III), and irreversibly restrictive (Grade IV). LV relaxation and left atrial pressures (LAp) increase from Grades 0 to IV, as does LA volume. Mitral valve inflow (MVI), tissue Doppler imaging, Valsalva manoeuvre, flow propagation velocity (Vp) and pulmonary venous flow are all helpful in distinguishing Grades of LV diastolic function and should be used together for an integrated approach to the assessment of diastolic function.[9]

The impaired relaxation pattern of transmitral flow, is characterized by a prolonged isovolumetric relaxation time (usually >100 msec), a smaller E wave peak, with a prolonged deceleration time (DT >200–220 msec), an increased A wave peak, and a lower E/A ratio (<1). In patients with pseudonormal or normalized pattern (degree II diastolic dysfunction), transmitral flow is similar to normal, but pulmonary flow S velocity peak is reduced, S/D ratio is <1, Ar velocity peak and duration are increased; Ar-mitral A difference is ≥20–30 msec, reflecting high filling pressure. Restrictive filling pattern, or degree III of diastolic dysfunction is characterised by advanced degrees of diastolic dysfunction and the progressive increase of mean left atrial pressures, a very high E wave and a low A wave usually occur at transmitral flow, with E/A ratio >2, associated with reduced DT (<150 msec); IRVT is also shorter than normal (<60 msec). In some pathologic states, due to severe abnormalities of diastolic properties of the ventricular walls and a marked increase in filling pressure, the restrictive pattern cannot respond to load manipulations (reversible to irreversible or fixed).[10,11]

This study was planned with the objective of calculating the mean change in LV diastolic function at 3 months and 1 year after MI from baseline, to predict the prognosis in terms of congestive heart failure based on independent factors including type of LV filling defect.

Methodology

This hospital-based retrospective observational study was carried out in a tertiary care facility at Jaipur under the Department of Cardiology. Data of patients who got admitted in the department from 1st April 2022 to 30th September 2022 was collected retrospectively, and completed in March 2022.

Sample size- Sample of 75 cases of acute MI was adequate at 95% confidence and 80% power to predict the prognosis on the basis of six independent factor including LV filling defect, NYHA Grade of HF Symptoms, DM, hypertension, smoking, dyslipidaemia. After considering 20% attrition or loss to follow up, sample size was further enhanced to 100 cases. Patients who were admitted after acute MI during the defined study period were our study population and data of first 75 patients (fulfilling our inclusion and exclusion criteria) was retrieved from the records which are well mentioned at the treatment facility. Acute MI was defined as patients having Trop-I >0.017 and/or electrocardiographic evidence of MI (ST

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elevation >1 mm in contiguous leads or subendocardial injury pattern), and typical chest pain at examination. Patients with age of less than 40 years or more than 65 years, having history of previous MI, with arrhythmias and/or valvular heart disease, were excluded from the study. Informed consent was obtained from each patient telephonically before the enrolment. Data of clinical history, past history, and routine investigations was retrieved from the records of patients. Data of Trans Thoracic Echocardiography of patients at the time of admission was also obtained. Follow up data of clinical evaluation of all patients visits at 3 and 12 months after Index event along with Two-Dimensional Echocardiography for assessment of Diastolic Dysfunction was obtained from the records. On the basis of clinical heart failure on admission or during the first week of hospitalization, patients were divided into 2 groups. Group 1 patients had no signs of congestive heart failure (Killip class I). Group 2 had clinical signs of congestive heart failure (Killip class II-IV) and were prescribed intravenous diuretics during the first week.

Statistical Analysis: Data thus collected was entered in Microsoft Excel spreadsheet. Continuous/Quantitative data was summarised in the form of mean and standard deviation, and significance of difference between two means was analysed using student's t test. Discrete/Qualitative data was summarised in form of proportion, and significance of difference in proportion was analysed using chi-square test. Subgroup analysis was conducted to predict the prognosis. Binary logistic regression was conducted. The level of significance would be kept at 95% for all statistical analysis.

Results

In our study the mean age of cases was 63±11 years. Male to female ratio was 2.9:1. Proportion of cases with diabetes and hypertension was 10.7% and 21.3% respectively. And table I depicts the other baseline characteristics of the patients. Patients with normal, impaired relaxation, or pseudonormal/restrictive LV diastolic Doppler filling were categorized in 38.7% (n = 29), 40% (n = 30), and 21.3% (n = 16) of the cases, respectively. Table II represents the echocardiographic LV systolic and diastolic variables of patients with normal, impaired relaxation, and restrictive LV filling at day 1, and it indicated that difference in mean LA, EDVI, ESVI, E, and IRT was statistically significant at day 1 between study groups ($p<0.05$).

Table I- Baseline characteristics of the cases

Variable	**AMI (n=75)**
Age (Years)	63±11
Sex (M/F)	56/19
Diabetes (%)	8(10.7)
Hypertension (%)	16(21.3)
Total Serum Cholesterol (mol/L)	7.2±1.2
Smoker (%)	61(81.3)
Heart rate (Beats/min)	75.4±9.2
SBP (mmHg)	132±31
DBP (mmHg)	82±13
Anterior infarction (%)	33(44)
Inferior/indeterminant infarction (%)	44(58.7)
Q-wave infarction (%)	51(68)
Thrombolysis (%)	56(74.7)
Trop- I	0.65±0.12
Time from chest pain onset to arrival to CCU (h)	3.6±1.1

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 12, 2023

Serial changes in patients with initial normal LV filling pattern

Heart rate dropped dramatically between day 1 and day 365 (76 ± 11 vs. 66 ± 10 beats/min, P <.01), whereas follow-up data showed no statistically significant changes in either systolic or diastolic blood pressure (SBP 129 ± 18 vs 125 ± 16 mm Hg; DBP 78 ± 16 vs 74 ± 14 mm Hg). Early and late mitral peak flow velocity, E/A ratio, and mitral E-wave deceleration time were without significant changes during 12 months of follow-up. Although it increased noticeably, the isovolumetric relaxation time (70 to 100 ms) stayed within normal limits. While the pulmonary diastolic venous peak flow velocity remained constant over the research, the systolic peak flow velocity increased dramatically. There were no appreciable changes in left atrial volume, ejection percentage, or size between the acute and chronic phases. On day 365, 12 (41.4%) patients had an initial normal LV filling pattern that changed to an impaired relaxation filling pattern, whereas 17 (58.6%) patients' initial normal LV filling pattern stayed the same.

Table II- Comparison of echocardiographic LV systolic and diastolic variables between patients with normal, impaired relaxation, and restrictive LV filling at day 1

Variable	**Normal**	**Impaired relaxation**	**Pseudonormal/ restrictive**	**P value***
	(n=29)	**(n=30)**	**(n=16)**	
LA (mm)	36±5	37±5	42±6	**<0.05**
EDVI (mL/m^2)	62±11	85±18	77±10	**<0.001**
ESVI (mL/m^2)	33±8	49±21	44±9	**<0.001**
E (cm/s)	61±15	49±18	56±15	**<0.05**
A (cm/s)	64±12	67±19	65±16	>0.05
E/A ratio	1.14±0.35	0.89±0.52	1.10±0.24	>0.05
IRT (ms)	76±11	109±22	81±29	**<0.001**
S (cm/s)	41±9	46±10	44±9	>0.05
D (cm/s)	36±8	37±8	39±8	>0.05
R (cm/s)	28±2	26±5	26±4	>0.05
*One Way ANOVA test was used for analysis.				

Impaired LV relaxation filling pattern

Heart rate was not changed significantly during follow-up from day 1 to day 365. Also there was no significant change in blood pressure from day 1 to day 365 (day 1 vs 365: SBP 139 ± 34 vs 136 ± 34 mm Hg, DBP 84 ± 19 vs 82 ± 17 mm Hg). E/A ratio, mitral E deceleration time, isovolumetric relaxation time, and peak pulmonary venous systolic and diastolic flow velocity were unchanged during follow-up. The difference between pulmonary venous flow reversal increased significantly. No significant difference of LV ejection fraction was observed at baseline or during follow-up from day 1 to day 365 (p>0.05).

Table III- Changes of echocardiographic variables of LV function among cases with initial normal LV filling pattern after acute MI

Variable	**Day 1 (n=29)**	**Day 90 (n=29)**	**Day 365 (n=29)**
LA (mm)	36±5	37±3	38±5
EDVI (mL/m^2)	62±11	65±12	64±13
ESVI (mL/m^2)	33±8	33±8	32±10
E (cm/s)	61±15	58±15	59±11
A (cm/s)	64±12	62±12	66±11
E/A ratio	1.14±0.35	0.99±0.32	0.96±0.29*
IRT (ms)	76±11	97±21*	96±20*

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 12, 2023

S (cm/s)	41±9	44±11	49±10*
D (cm/s)	36±8	37±9	38±8
R (cm/s)	28±2	26±6	26±5
*Paired t test was used for analysis in comparison to day 1 (p <0.5).			

Pseudonormal or restrictive LV filling pattern

Heart rate and blood pressure was significantly unchanged during the study time from day 1 to day 365. E/A ratio decreased significantly, whereas isovolumetric relaxation time increased significantly during 1-year follow-up. Peak pulmonary venous flow velocity reversal was unchanged during the time course of the study. A significant increase in systolic pulmonary venous peak flow velocity was observed, whereas the diastolic peak flow velocity decreased significantly during the study period. Left atrial dimension and LV end-diastolic volume index increased significantly.

Table IV- Changes of echocardiographic variables of LV function among cases with initial impaired relaxation LV filling pattern after acute MI

Variable	**Day 1 (n=30)**	**Day 90 (n=30)**	**Day 365 (n=30)**
LA (mm)	37±7	37±5	37±6
EDVI (mL/m2)	71±21	85±18*	88±22*
ESVI (mL/m2)	42±12	49±21	46±18
E (cm/s)	45±14	49±18	52±11*
A (cm/s)	70±18	67±19	67±20
E/A ratio	0.75±0.33	0.89±0.52	0.88±0.41
IRT (ms)	117±13	109±22	114±28
S (cm/s)	41±9	46±10	48±11
D (cm/s)	35±8	37±8	39±7*
R (cm/s)	28±5	26±5	25±4
*Paired t test was used for analysis in comparison to day 1 (p <0.5).			

During a 12-month follow-up period, two patients (6.7%) with impaired relaxation and three (18.7%) with initial pseudonormal/restrictive LV filling were admitted to the hospital due to heart failure; no patient with initial normal LV filling was hospitalised. Additionally, four of the patients underwent additional revascularization procedures without significant variation in LV filling groups. Five patients who showed a restricted or pseudonormal LV filling pattern before admission (n = 3) or during hospitalisation (n = 2) had cardiac deaths.

The development of congestive heart failure during hospitalisation and cardiac death during follow-up were significantly correlated with LV ejection fraction >45%, LV end-systolic and end-diastolic volume indexes, mitral E deceleration time ≤140 ms, E/A ratio ≥1.5, a difference between the duration of the A wave and duration of the pulmonary venous flow reversal ≤0, and age, according to univariate regression analysis.

Table V- Serial changes of echocardiographic variables of LV function among cases with initial pseudo normal or restrictive LV filling pattern after acute MI

Variable	**Day 1 (n=16)**	**Day 90 (n=16)**	**Day 365 (n=16)**
LA (mm)	37±5	42±6*	42±7*
EDVI (mL/m2)	69±12	77±10*	78±12*
ESVI (mL/m2)	39±8	44±9	43±10
E (cm/s)	64±11	56±15	53±14*

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 12, 2023

A (cm/s)	49±11	65±16*	62±12*
E/A ratio	1.53±0.34	1.10±0.24*	1.01±0.33*
IRT (ms)	62±14	81±29*	95±23*
S (cm/s)	36±9	44±9*	44±9*
D (cm/s)	46±10	39±8*	38±8*
R (cm/s)	31±4	26±4*	27±5*
*Paired t test was used for analysis in comparison to day 1 ($p < 0.5$).			

Discussion

In this echocardiographic study, we discivered that LV diastolic dysfunction was frequently observed in individuals after acute MI. Initial 39% of the patients had initial normal diastolic mitral inflow characteristics, which most of the patients (59%) continued to have during follow-up. During follow-up, a subset of patients did, however, exhibit impaired relaxation filling pattern; no patient had pseudonormal or restrictive filling pattern. Forty percent of instances of acute MI had an impaired LV relaxation filling pattern, with the other twenty percent exhibiting a pseudonormal or restricted pattern. This finding is consistent with earlier research on MI patients, who have decreased early diastolic filling during acute ischemia following MI.[12-14]

Among patients with impaired relaxation filling pattern, transmitral LV filling characteristics did not alter, nevertheless, there was a drop in the pulmonary venous reversal peak flow velocity and an increase in the pulmonartolic flow velocity. This could suggest that patients with compromised relaxation filling dynamics frequently had acutely raised left atrial filling pressure, which could account for the fact that a large number of these patients experienced clinical heart failure while in the hospital. Our results also corroborate other research showing that patients with reduced left ventricular relaxation had slightly elevated left ventricular filling pressures and altered functional status. [15-16] Several of the transmitral and pulmonary venous flow parameters changed in patients with pseudonormal/restrictive LV filling characteristics throughout follow-up. Reduced filling pressures were indicated by several flow metrics that altered dramatically towards a nonrestrictive LV filling pattern. This is consistent with a study that showed LV compliance deteriorated soon after the onset of MI and improved throughout the first month.[17] Notably, atrial and LV end-diastolic dilatation both markedly increased during the follow-up period. This could be the result of the LV remodelling procedure or the initially high LV filling pressure. When compared to the other two LV filling patterns, patients with pseudonormal/restrictive LV filling characteristics showed an early, significant, and more dramatic LV dilatation. Significant increases in LV volume or a lower LV compliance due to marked myocardial ischemia could be the reason of the initial restricted filling dynamics.

It is well recognised that LV dilatation, scar formation, and hypertrophy occur during LV remodelling following MI, and that these changes can have varying effects on LV filling properties. Whether a dominance of poor relaxation (associated with LV hypertrophy) or lower compliance of the ventricle will be present after MI will depend in part on the balance between LV dilatation, scar formation, and hypertrophy. In contrast to patients with initial normal LV filling, individuals with poor relaxation and pseudonormal/restrictive LV filling showed a substantial dilatation of the LV (and atrial) cavity throughout follow-up.

Following MI, patients exhibited varying degrees of LV remodelling, as evidenced by the presence of patients with restricted LV filling pattern and impaired relaxation (the most prevalent patient characteristics). Patients who developed a restrictive or pseudonormal LV filling pattern at any point during their follow-up were linked to a higher risk of adverse events, including the development of congestive heart failure while hospitalised, a higher frequency of readmissions due to heart failure, a higher NYHA class, and cardiac death.

ISSN: 0975-3583,0976-2833 VOL14, ISSUE 12, 2023

These findings are suggestive of the fact that serial assessment of LV diastolic function might be of relevance in risk stratification after MI.[18-19] A shortened mitral E deceleration time (≤140 ms) best identified patients at risk of development of in-hospital congestive heart failure or cardiac death during 1 year of follow-up.

Conclusion

An early stage of MI is marked by the presence of LV diastolic dysfunction. Patients exhibiting early diastolic dysfunction symptoms develop LV dilatation and in-hospital congestive heart failure. Patients who developed this LV filling abnormality or who had a prolonged pseudonormal/restrictive LV filling pattern were linked to higher NYHA class scores and hospital readmissions for heart failure during follow-up. During a 12-month follow-up period, patients with a mitral E deceleration time of less than 140 ms were most likely to develop in-hospital congestive heart failure or die from cardiac arrest. Hence, assessment of mitral E deceleration time seems useful in the risk stratification in acute MI.

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ISSN: 0975-3583,0976-2833 VOL14, ISSUE 12, 2023

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