RESEARCH ARTICLE

Correlation of In-Hospital Outcome with Myocardial Performance Index and Left Ventricular Systolic Function

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Abstract

Introduction: Acute myocardial infarction (AMI) remains the leading cause of morbidity and mortality worldwide. Left ventricular dysfunction is a common consequence of acute coronary events and has important prognostic implications. In hospital complications of myocardial infarction include arrhythmia, heart failure, post infarction angina and death.

Objective: To assess the Correlation of in-hospital outcome with myocardial performance index and left ventricular systolic function.

Methods: This cross-sectional analytical study was conducted in Dpt. Of Cardiology, Mymensingh Medical College Hospital, Mymensingh, Bangladesh from October 2023 to March 2024. Total 100 patients who sustained first attack of ST elevated myocardial infarction were included in the study considering inclusion and exclusion criteria. Purposive sampling was done using a structured case record form. Study population was divided into three groups to study and compare myocardial performance index (MPI) with left ventricular systolic function depicted as left ventricular ejection fraction (LVEF).

Results: Total 100 patients were included considering inclusion and exclusion criteria. Majority of the study population were in the 41-50 years age group. Then 51-60 years group & 31-40 years group subsequently. Statistical analysis showed significant age difference between the groups (p<0.05). Majority of the study population were male (87.5%). Statistical analysis showed significant sex difference between the groups (p<0.001). It showed group-III people were more obese than rest of the groups. Statistical analysis showed significant difference between the groups (p<0.05). It showed majority of the study population were dyslipidaemic & hypertensive. Then diabetic, current smoker & asthmatic. Statistical analysis showed diabetic, dyslipidaemia, smoking & bronchial asthma were significantly different between the groups (p<0.05). It showed group-III were high in total cholesterol, LDL, HDL & triglyceride. Statistical analysis showed significant difference between the groups (p<0.05). Troponin-I & BNP level of the study population. It showed people of the group-III had the

highest level of Troponin-I & NT- pro BNP level. Statistical analysis showed significant difference between the groups (p<0.05). Majority of the lowest indices of cardiac function & highest MPI level. On the other hand, group-I study population had the highest indices of cardiac function but lowest MPI level. Statistically significant difference was found between the groups (p<0.05). ST segment resolution <50% causes more complications than ST segment resolution >50%. Out of 100 patients who had LVEF <40%, mean LV MPI value was 0.53 as compared with a mean LV MPI of 0.50 in patients with LVEF >40% at the time of presentation. Even though this difference was not significant at the time of presentation, a significant difference was found on the 5th day (MPI 0.43 in LVEF <40% group, compared to 0.49 among those with LVEF >40% (p=0.031). **Conclusion:** Myocardial performance index was also able to give a hint for adverse cardiac events during the hospital stay. ST-elevation myocardial infarction patients, poor left ventricular ejection fraction and higher myocardial performance index at presentation and on 5th day significantly correlated with in-hospital outcome. Myocardial performance index was also able to give a hint for adverse cardiac events during the hospital stay.

Keywords: Left ventricular ejection fraction, Myocardial performance index, ST elevated myocardial infarction.

1. Introduction

Acute myocardial infarction (AMI) remains the leading cause of morbidity and mortality worldwide. Left ventricular dysfunction is a common consequence of acute coronary events and has important prognostic implications. In hospital complications of myocardial infarction include arrhythmia, heart failure, post infarction angina and death.[1] Conventional echocardiographic indices that are routinely applied for the estimation of cardiac function face a number of limitations. The ejection fraction, the most reliable estimator of systolic function, is prone to significant inaccuracies when the elliptical cardiac chamber is transformed to a spherical one. Myocardial performance index (MPI) is an echocardiographic parameter that represent both left ventricular systolic and diastolic function that might provide substantial information essential to guide management and prognosis after AMI.[2] According to the heart disease and stroke statistics update 2016 of the American Heart Association (AHA), the estimated annual incidence of coronary attack in America is approximately 660000 new attacks and 305000 recurrent attacks[3]. The systolic dysfunction is reflected in a decrease in left ventricular ejection fraction and a prolongation of the pre-ejection and shortening of the ejection phases of the cardiac cycle,[4,5,6] Traditionally, assessment of left ventricular systolic function is concentrated on measurement of left ventricular ejection fraction (LVEF) which is load dependent and sensitive to the preload and after-load. However, myocardial performance index (MPI) demonstrates supremacy over older established indexes. Recent studies have documented the frequent coexistence of systolic and diastolic dysfunction in people.[7] ST-elevation myocardial infarction (STEMI) is a leading cause of cardiovascular death and thus accounts for a high burden on health care services worldwide. The diastolic dysfunction is reflected in alterations in pattern of the inflow velocity of the left ventricle in early and late diastole[8,9] as well as the prolongation of the relaxation phase of the cardiac cycle[10]. Left ventricular (LV) systolic function is an important prognostic factor, associated with increased mortality in patients with STEMI.[11,12] LV function is measured by Two-dimensional (2D) echocardiography, M-mode echocardiography, Doppler echocardiography, and 3D echocardiography, both during systole as well as diastole.[13] A LV function is assessed by LV systolic function and diastolic function. The myocardial performance index (MPI) is a simply measurable Doppler derived index of combined systolic and diastolic myocardial performance, which is reported to be useful for evaluating the prognosis after acute MI.[14,15] The present study investigated whether the MPI can be used to predict left ventricular functional outcome in patients with early recanalization after acute anterior MI, as well as the optimum time to measure the index for predicting left ventricular outcome.

2. Materials and Methods

This cross-sectional analytical study was conducted in Dpt. Of Cardiology, Mymensingh Medical College Hospital, Mymensingh, Bangladesh from October 2023 to March 2024. Total 100 patients who sustained first attack of ST elevated myocardial infarction were included in the study considering inclusion and exclusion criteria. Purposive sampling was done using a structured case record form. Study population was divided into three groups to study and compare myocardial performance index (MPI) with left ventricular systolic function depicted as left ventricular ejection fraction (LVEF). Group-I comprised of 30 patients with mild LV systolic dysfunction (LVEF:

45-54%). Among them 25 were males, 10 were females having mean age of 52.44±13.55 years. Group-II consisted of 50 patients with moderate LV systolic dysfunction (LVEF: 35-44%). Among them 54 were male & 06 were females having mean age of 54.48±10.45 years. Group-III consisted of 20 patients with severe LV systolic dysfunction (LVEF :< 35%). Among them 17 were males & 03 females having mean age of 56.50±10.40 years. All the study subjects were selected on the basis of following inclusion and exclusion criteria.

2.1 Inclusion Criteria

1) Patients with first attack of ST segment elevation myocardial infarction.

2.2 Exclusion Criteria:

1. Patients with valvular heart disease and congenital heart disease.

2. Patients had major non- cardiovascular disorder causing elevation of Troponin-I such as severe renal impairment, prolonged immobilization, major surgery, chest trauma, myocarditis (pericarditis), acute pulmonary embolism, prolonged tachyarrhythmia.

3. Any systemic infection.

4. Patients were under chemotherapy on discovery of malignancy.

5. Patient not willing to get themselves enrolled in study.

Before examination a detailed briefing about the purpose of the study was given to the subjects and written consents were taken for all of the study population. Total 50 cases were enrolled in the study after qualifying the inclusion & exclusion criteria.

Study procedures: All patients received guideline directed medical therapy at the time of admission. All patients were undergone for either primary PCI or thrombolytic (Tenecteplase or Streptokinase). All patients underwent conventional estimation of ejection fraction and LV end- systolic volume by a Bi-plane modified Simpson's method at the time of presentation, immediately after thrombolysis (120 minutes) and before discharge on 3rd to 6th days. They were followed-up during the period of hospitalization and monitored for the occurrence of recurrent ischemia, acute left ventricular failure, different types of arrhythmias (like sinus tachycardia, sinus bradycardia, ventricular tachycardia, ventricular fibrillation etc.), acute mechanical complication (like mitral regurgitation), hospital stay and death.

Echocardiographic examination: A complete two-dimensional pulsed wave, continuous wave and colour flow Doppler echocardiographic examination using Vivid E9 Pro of General Electronics Inc. Limited, USA was performed[18,19]. Left ventricular dimensions were measured at mid-ventricular level from the two- dimensional guided M-mode echocardiogram obtained by directing the cursor perpendicularly to the para sternal short axis view. Left ventricular ejection fraction (LVEF) was measured by using Bi-plane modified Simpson's volumetric method because of pronounced segmental asynergy in some patients.

Doppler examination: The mitral velocity inflow pattern was recorded from the apical four chamber view with the Pulsed wave Doppler sample volume positioned at the tip of mitral leaflets during diastole. Following this the left ventricular outflow velocity was recorded from the apical long axis view with the pulsed wave Doppler sample volume positioned just below the aortic annulus. Doppler colour flow imaging was used to semi- quantitate mitral regurgitation.

Echo/ Doppler measurements: For echo/ Doppler parameters three consecutive beats were measured and averaged for each parameter. Figure 1 shows a schema for analysis of Doppler time intervals. Mitral closure-to-opening interval (a) is the time from the cessation to the onset of mitral in-flow. Ejection time (ET) was measured as the duration of left ventricular outflow (b). Isovolumetric Contraction Time (ICT) + Isovolumetric Relaxation Time (IRT) were obtained by subtracting 'b' from 'a' and an index: (ICT+IRT)/ET was derived as (a-b)/b. To compare this index to traditional parameters IRT, ICT and Pre-ejection period (PEP) were also measured. IRT was measured as (c- d) by subtracting the interval between the Electrocardiography (ECG) R wave and the cessation of left ventricular outflow from the interval (c) between the R wave and the onset of mitral flow. ICT was obtained by subtracting IRT from (a-b). PEP was measured from the onset of the QRS waveform to the onset of left ventricular outflow. Reported normal range for LV myocardial performance index is 0.39±0.05. MPI values greater than 0.45, were considered abnormal. Mitral regurgitation was diagnosed by color Doppler echocardiography and the severity of mitral regurgitation semi- quantitated from the area of the maximum regurgitant jet.[15]

2.3 Statistical Method and analysis

Continuous data were expressed as mean ± SD. Categorical data were analyzed with x^2 test. Student's t'' test was used for analysis of continuous variables.

Comparison between groups was done by unpaired t-test. The data were processed and analyzed by computer software SPSS (Statistical package for social science) Version 23. Level of significance was considered as p value less than 0.05 (p < 0.05).

3. Results

Table 1. *Demographic characteristics of the study population (n=100)*

Age	Group 1		Group 2		Group 3		Total	
	N	%	N	%	N	%	N	%
20-30	3	2.50	2	1.66	1	0.83	6	5.0
31-40	5	4.16	10	8.34	2	1.66	17	14.17
41-50	12	10.0	28	23.33	5	4.16	45	37.5
51-60	6	5.0	8	6.66	11	9.17	25	20.84
61-70	7	5.83	4	3.33	3	2.50	14	11.66
71-80	6	5.0	3	2.50	2	1.67	11	9.17
81-90	0	0.0	1	0.83	1	0.83	2	1.66
Sex								
Male	29	24.16	53	44.17	24	20.0	106	88.33
Female	8	6.67	4	3.33	2	1.66	14	11.67
Anthropometric Parameter								
BMI	24.84±3.37		25.77±3.75		26.06±4.99		0.015s	

Total 100 patients were included considering inclusion and exclusion criteria. Table 1 showed the age distribution of the study population. Majority of the study population were in the 41-50 years age group. Then 51-60 years group & 31-40 years group subsequently. Statistical analysis showed significant age difference between the groups (p<0.05). Majority of the study population were male (87.5%). Statistical analysis showed significant sex difference between the groups (p<0.001). It showed group-III people were more obese than rest of the groups. Statistical analysis showed significant difference between the groups (p<0.05).

Table 2. *Risk factor analysis of the study population (n=100)*

Risk factor	Group 1		Group 2		Group 3		Total	
	N	%	N	%	N	%	N	%
HTN	8	6.67	40	33.33	23	19.16	71	59.16
DM	12	10.0	15	12.5	31	25.83	58	48.33
F/H of CAD	1	0.83	3	2.5	19	15.83	23	19.16
Smoker	8	6.67	42	35.0	23	19.16	73	60.83
DLP	13	10.8	14	11.67	50	41.67	77	64.16
Bronchial Asthma	3	2.5	2	1.67	1	0.83	6	5.0

s means significant, ns means not-significant

Table 2 showed the risk factor analysis of the study population. It showed majority of the study population were dyslipidaemic & hypertensive. Then diabetic, current smoker & asthmatic. Statistical analysis showed diabetic, dyslipidaemia, smoking & bronchial asthma were significantly different between the groups (p<0.05).

Table 3. *Sub-group analysis of dyslipidaemia among the study population (n=100)*

Lipid Profile	Group-I	Group-II	Group-III	p-Value
Total Cholesterol	175.64±35.70	195.02±38.63	207.39±37.18	<0.001s
LDL	132.11±22.72	142.91±18.33	160.91±47.60	<0.001s
HDL	55.55±5.47	54.64±6.86	45.27±7.28	<0.001s
Triglyceride	170.25±53.73	185.08±91.95	198.15±72.70	<0.018s

s means significant

Table 3 showed the sub-group analysis of dyslipidaemia among the study population. It showed group-III were high in total cholesterol, LDL, HDL & triglyceride.

Statistical analysis showed significant difference between the groups ($p<0.05$).

Table 4. *Cardiac profile of the study population (n=100)*

Cardiac Profile	Group-I	Group-II	Group-III	p value
Heart Rate	88.76±10.83	98.60±13.36	102.28±17.30	<0.001s
Systolic BP	156.01±20.99	147.90±21.13	137.34±18.14	<0.048s
Diastolic BP	99.90±12.63	89.57±12.45	85.82±10.16	<0.040s

Table 4 showed the cardiac profile among the study population. It showed all parameters are important factors to influence global cardiac function. Statistical analysis showed significant difference between the groups ($p<0.05$).

Table 5. *Cardiac biomarker level of the study population (n=100)*

Parameter	Group-I	Group-II	Group-III	p-Value
Troponin-I	8.94±4.97	16.41±9.58	36.37±17.64	<0.001s
NT- pro BNP	121.36±5.78	141.60±253.08	300.15±249.41	<0.001s

Table 5 showed the Troponin-I & BNP level of the study population. It showed people of the group-III had the highest level of Troponin-I & NT- pro BNP level. Statistical analysis showed significant difference between the groups ($p<0.05$).

Table 6. *Echo profile of the study population (n=100)*

Echo Parameters	Group-I	Group-II	Group-III	p-Value
LVEF	47.30±3.08	36.17±1.51	25.00±6.05	<0.001s
Ejection Time	423.84±46.19	393.76±40.27	297.17±48.28	<0.001s
ICT	94.89±17.32	98.69±16.70	88.24±15.55	<0.001s
IRT	96.09±19.45	108.38±19.54	99.26±17.88	<0.001s
MPI	0.32±0.15	0.45±0.05	0.75±0.18	<0.001s

Table 6 showed the echo parameters among the study population. It showed group-III of the study population had the majority of the lowest indices of cardiac function & highest MPI level. On the other hand, group-I study population had the highest indices of cardiac function but lowest MPI level. Statistically significant difference was found between the groups ($p<0.05$).

Table 7. *Mitral Regurgitation profile of the study population (n=100)*

Mitral Regurgitation	Group 1		Group 2		Group 3		Total	
	N	%	N	%	N	%	N	%
Severe	0	0.0	0	0.0	0	0.0	0	0.0
Moderate	0	0.0.	3	2.5	2	1.67	5	4.17
Mild	3	2.5	4	3.33	3	2.5	10	8.33
Trivial	9	7.5	28	23.33	18	15.0	55	45.83
Nil	21	17.5	20	16.67	9	7.5	50	41.67

Table-7 showed the mitral regurgitation profile among the study population. It showed majority had trivial to mild regurgitation. Statistically significant difference was found between the groups ($p<0.05$).

Table 8. *Group with ST segment resolution <50% and >50% at 120 minutes (n=100)*

	STR <50%	STR >50%	p-Value
Total number	34/120 (28.3%)	86/120(72.5%)	0.005
In-hospital complication	21/34 (61.8%)	24/86 (27.9%)	0.345ns
Acute left ventricular failure	04/34 (11.8%)	01/86 (1.2%)	0.001s
In-hospital arrhythmias	22/34 (64.7%)	16/86 (18.6%)	0.451ns
Post MI angina	9/34 (26.5%)	20/86 (23.3%)	0.653ns
Hospital stay (days)	8.0±2.1	4.5±1.3	0.81ns

MPI			
0'	0.56	0.55	0.364[ns]
120'	0.53	0.49	0.813[ns]
5th day	0.41	0.41	0.631[ns]
LVEF			
0'	48.1%	50.1%	0.453[ns]
120'	42.3%	52.1%	0.561[ns]
5th day	45.5%	54.3%	0.367[ns]
Mitral Regurgitation			
0'	21/34 (62.5%)	28/86 (32.6%)	0.94[ns]
120'	26/34 (75.0%)	20/86 (23.3%)	0.754[ns]
5th day	14/34 (41.2%)	11/86 (12.8%)	0.348ns
Death	02/34 (5.9%)	00/86 (0.0%)	0.453ns

s means significant ns means not significant

Table 8 shows that ST segment resolution <50% causes more complications than ST segment resolution >50%.

Table 9. *Total study population with MPI <0.5, 0.5-0.59 and >0.6 (n=100)*

	MPI <0.5	MPI 0.5-0.59	MPI >0.6
Total number	33/120 (27.5%)	33/120 (27.5%)	55/120 (45.8%)
In-hospital complication	17/33 (51.5%)	25/33 (75.8%)	36/55 (65.5%)
Acute left ventricular failure	02/33 (6.1%)	11/33 (20.0%)	15/55 (45.5%)
In-hospital arrhythmias	12/33 (36.4%)	12/33 (36.4%)	42/55 (74.5%)
Post MI angina	10/33 (30.3%)	8/33 (24.2%)	18/55 (32.7%)
Hospital stay (days)	5.1±1.3	6.2±3.5	9.0±3.2
LVEF			
0'	51.3%	43.1%	42.5%
120'	50.2%	46.2%	45.1%
5th day	47.5%	47.6%	41.2%
Mitral Regurgitation			
0'	12/33 (36.4%)	13/33 (39.4%)	20/55 (36.4%)
120'	14/33 (42.4%)	10/33 (30.3%)	12/55 (21.8%)
5th day	10/33 (30.3%)	07/33 (21.2%)	06/55 (10.9%)
Death	01/33 (3.0%)	03/33 (9.1%)	02/55 (3.6%)

s means significant, ns means not significant

Table 9 shows out of 100 patients who had LVEF <40%, mean LV MPI value was 0.53 as compared with a mean LV MPI of 0.50 in patients with LVEF >40% at the time of presentation. Even though this difference was not significant at the time of presentation, a significant difference was found on the 5th day (MPI 0.43 in LVEF <40% group, compared to 0.49 among those with LVEF >40% (p=0.031).

4. Discussion

In this study, we tried to assess global cardiac function which incorporates factors related to both systolic & diastolic function. Earlier studies showed isovolumic contraction time (ICT) & isovolumic relaxation time (IRT) reflect systolic & diastolic function of heart respectively.[16,17] They correspond with the active ventricular contraction & early relaxation.[18] Although individual measurements of ICT & IRT were required but MPI can be calculated from two easily measured Doppler time intervals (mitral closure-to-opening interval and ejection time). In these cases, 'duration of mitral closure-to-aortic-opening' and 'duration of aortic-closure-to mitral opening' are more appropriate variables to be considered. Global left ventricular performance is a function of both ventricular function & ejection. Numerous parameters are used to assess systolic or diastolic function till now. Since diastolic dysfunction is an integral part of systolic dysfunction [19,20] a measure of both combinedly may better reflect 'global' function rather assessing them isolately. In

this study, we tried to assess global cardiac function which incorporates factors related to both systolic & diastolic function. Earlier studies showed isovolumic contraction time (ICT) & isovolumic relaxation time (IRT) reflect systolic & diastolic function of heart respectively.[21,21,23] They correspond with the active ventricular contraction & early relaxation [24]. Although individual measurement of ICT & IRT were required but MPI can be calculated from two easily measured Doppler time intervals (mitral closure-to-opening interval and ejection time). In case of, patients with mitral regurgitation ICT & IRT do not exist. In these cases, 'duration of mitral closure-to-aortic-opening' and 'duration of aortic-closure-to mitral opening' are more appropriate variables to be considered. However, for easy understanding in this study we used considered ICT & IRT. The rationale of the utility of MPI in the left ventricular dysfunction lies in the fact that (ICT+IRT)/ET corresponds with the important periods of contraction & relaxation of cardiac cycle. Calcium transportation at the myocellular level regulates the different cellular mechanisms of ICT & IRT.[25] Active myocardial processes are used to be suppressed in congestive heart failure and result in prolongation of active contraction & relaxation. Active contraction is reflected by an increase in ICT.[26] On the other hand, prolonged relaxation is initially associated with an increase in IRT but progressively worsening degree of ventricular dysfunction will influence this factor due to the involvement of other factors like left atrial pressure and the degree of mitral regurgitation.[27] Although due to the different factors, the present study proved that the sum of ICT & IRT proportionately increased as the left ventricular function depressed.[28,29,30] Ejection time (ET) was shorter in patients with severe left ventricular dysfunction compared to mild dysfunction. Thus, with worsening left ventricular dysfunction (ICT+IRT)/ET increases disproportionately to any change of individual components. Ejection fraction (EF) is the most commonly used index for the assessment of systolic function. It has served consistently as a good indicator of cardiovascular outcome and thus has great clinical relevance.[31] However, EF may not hold the true reflection of function in absence of normal shaped ventricles. [32] The adjunctive use of MPI may potentially provide useful support in these circumstances. Use of EF alone may erroneously assess the contractility and thus function in patients with mitral regurgitation.[33] Jacob et al, reported a total of 799 patients with acute myocardial infarction were found that an LV MPI value of >0.5 predicted low ejection fraction.[34,35]Generally,

arrhythmias are more common in STEMI. Majority of life-threatening arrhythmias were tachyarrhythmias with few bradyarrhythmia which were not statistically significant. This finding is also consistent with the previously reported incidences of arrhythmias in MI. Left ventricular failure was more common among lower LVEF & higher MPI which was statistically significant. Post- infarction angina occurred in patients, without any significant differences. These findings are understandable as wide area of infarction with more myocardial function loss and low LVEF is known to be associated more with LV failure.[36] About 73% of the patients had good reperfusion with thrombolytics (Tenecteplase or Streptokinase), as evident from STR >50% at 120 minutes. The patients who had STR <50% LV systolic dysfunction, in-hospital complications and arrhythmias were higher, without a significant difference except acute left ventricular failure. None of the other variables like MPI and MR were showing any significant difference. Patients with ST resolution <50%, showed better LVEF but more in-hospital complications which is contradictory to the finding from previous study.[37] This change may be due to the small sample size and the relatively small number of inhospital complications in this study group. The present study showed that, Tei index was significantly higher among patients in hospital than among patients after three months P<0.001 this in accordance to Karatzis et al.,[38] who demonstrated significant reduction during the early and late phases of MI of both LV and RV indices over time. The present study showed that, Tei index was significantly higher in patients complicated by heart failure than non complicated patients in hospital P<0.001. Left ventricular dysfunction results in the prolonging of both ICT and IRT, and in the shortening of ET. Thus, the Tei index is increased in patients with LV dysfunction and it was shown to be useful for assessing global LV function. In the present study Tei index value of 0.60 showed a sensitivity of 100% and a specificity of 89% for identifying patients complicated with heart failure. Ascione L,[39] studied The usefulness of the index in the detection of patients with mild to moderate heart failure. The Doppler index incorporated systolic and diastolic time intervals, is reproducible, easily obtained, and is not limited by LV geometry. Thus, the index is proposed as a measure of global ventricular function.

5. Conclusion

The conclusion of the study was that the myocardial performance index is a predictor of LV dilatation and

cardiac death after AMI. Myocardial performance index was also able to give a hint for adverse cardiac events during the hospital stay. ST-elevation myocardial infarction patients, poor left ventricular ejection fraction and higher myocardial performance index at presentation and on 5th day significantly correlated with in-hospital outcome. Myocardial performance index was also able to give a hint for adverse cardiac events during the hospital stay. The research team also appreciate its use to assess both systolic and diastolic myocardial function in patients with unstable angina as well as non- ST elevated myocardial infarction.

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