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## Original Article

# *Predictors of Improved Left Ventricular Function After Primary PCI Following STEMI*

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## ABSTRACT

***Background:*** Well-timed primary percutaneous coronary intervention (PCI) is known to improve survival, limit infarct size, and improve left ventricular ejection fraction (LVEF) in patients with ST-elevation myocardial infarction (STEMI). Nonetheless, many patients do not recover their LV contractile function after primary PCI and eventually progress to heart failure. This study aimed to assess the predictors of improvement in LVEF after successful primary PCI among patients presenting with STEMI within 12 hours of symptom onset.

***Methods:*** Our single-center, prospective, observational study enrolled 246 consecutive STEMI patients presenting within 12 hours of symptom onset. All the patients underwent echocardiography at presentation and at a 3-month follow-up. Multivariate analysis was used to identify the predictors of improvement in LVEF in the course of the convalescent phase.

***Results:*** Data of 239 patients were analyzed for the study. The mean age of the patients was 54.2±11.3 years, and 90% of the patients were male. Diabetes and hypertension were prevalent at 44.8% and 38.9%. The average total ischemic and door-to-balloon time was 260 (175–440) and 60 (40–65) minutes, respectively. LVEF showed improvement in more than half of the patients (57.7%) at 3 months' follow-up. The binomial regression analysis of various variables, predicting LVEF improvement at 3 months, showed that the most significant predictor of LVEF improvement was a shorter total ischemic time ($P$<0.001; OR, 1.01; 95% CI, 1.00 to 1.01), followed by LVEF of 40% or higher at presentation ($P$<0.02; OR,1.01; 95% CI, 0.95 to 1.01).

***Conclusions:*** In patients with STEMI, the total ischemic time and LV systolic function at presentation can help predict EF recovery after successful primary PCI. Patients at risk can be treated with aggressive medical management. ***(Iranian Heart Journal 2022; 23(4): 69-79)***

**KEYWORDS:** Latent cardiac disease, Pharmacological stress, Echocardiography, Contractile reserve, Liver transplantation, Coronary angiogram

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Cardiovascular disease is the leading cause of death in India, and among the patients who present with acute coronary syndrome (ACS), the majority (>60%) tend to have ST-elevation myocardial infarction (STEMI).[1] Of particular concern is the incidence of STEMI in a relatively younger population and the high fatality rate associated with it.[2,3] Most guidelines recommend primary percutaneous coronary intervention (PCI) as the treatment of choice over fibrinolysis, with sufficient evidence demonstrating superior outcomes with primary PCI.[4] While there is a vast disparity between the availability of treatment for STEMI in rural and urban India, most corporate hospitals in the metropolises of India made primary PCI available 24/7 with state-of-the-art technology and competent cardiology teams in the hope to limit the loss of life and subsequent morbidity as a consequence of STEMI. Though a few registries have recorded a decreasing trend of mortality in STEMI,[3] much is yet needed to achieve viable and effective care pathways for optimal results in this area.

Although the advances in the emergency care for STEMI have resulted in improvement in early survival, there is a growing population of survivors with impaired left ventricular (LV) function, who are at risk of significant morbidity due to heart failure. These patients are also at risk for mortality in the longer term, but that is seldom attributed to STEMI. Hence, a successful primary PCI should restore myocardial reperfusion at the cellular level, resulting in improved LV function. However, this task is hindered by heavy thrombus burden, longer ischemic times, and high incidence rates of comorbidities.[2] With such a significant impact of LV function on outcomes and quality of life, further data are required to optimize treatment. Accordingly, the present study was conducted to assess the factors that impact the improvement of LV function in STEMI patients following primary PCI.

## METHODS

This is a prospective, observational, single-center study in a 600-bed super-specialty hospital with 24/7 primary PCI capability, in a cosmopolitan city in southern India. All patients presenting to the emergency department within 12 hours of the onset of STEMI requiring primary PCI between June 2014 and June 2016 were enrolled in the study. No patients were thrombolyzed during the study period. Patients presenting with stent thrombosis or with a history of previous bypass surgery and those who did not achieve thrombolysis in myocardial infarction (TIMI) flow grade III after primary PCI were excluded from the study. The aim of the study was to assess the predictors of improvement in left ventricular ejection fraction (LVEF) after primary PCI among those presenting within 12 hours of symptom onset. The objectives of the study were also to assess the clinical and procedural profile of patients presenting with STEMI within 12 hours of symptom onset stratified by LVEF at presentation and evaluate the clinical outcomes in-hospital and at a 3-month follow-up. A total of 246 patients were included in the study. Two patients were lost to follow-up, 5 patients did not achieve TIMI flow grade III after PCI, and the rest of the patients were included in the study.

STEMI was diagnosed if there was evidence of acute myocardial ischemia along with the detection of a rise and/or fall of cardiac troponin values with at least 1 value above the 99th percentile upper reference limit with either symptoms of myocardial ischemia or new ischemic electrocardiographic (ECG) changes, or development of pathological Q waves, or imaging evidence of new loss of viable myocardium or new regional wall motion abnormalities in a pattern consistent with an ischemic etiology or identification of a coronary thrombus by angiography or autopsy.[5] The patients' demographic, clinical, laboratory, and procedural details were documented in detail. ECG and

echocardiography (the VIVID-E9 [GE] machine) were done for all the patients at admission and at the 3-month follow-up as a part of routine investigation, and the Simpson method was used to assess LV function in all the patients. Patients presenting with cardiogenic shock or pulmonary edema requiring assisted ventilation and high-grade atrioventricular (AV) blocks requiring temporary pacing were recruited in the study after they were stabilized, as per the protocol. Significant arrhythmia was defined as any ventricular or supraventricular arrhythmia causing hemodynamic instability or high-degree AV blocks. Hypotension was defined as a systolic blood pressure below 80 mm Hg requiring inotropic support. Significant bleeding was defined as any TIMI major bleeding.[6] The total ischemic time was calculated as the time from the onset of symptoms to the introduction of the first intracoronary device in minutes, and the door-to-balloon time was calculated as the time from the arrival of the patient at the emergency room to the introduction of the first intracoronary device time in minutes. In this study, coronary angiography and primary PCI were done with the PHILIPS FD10 machine at the core angiography laboratory of the study site. Epicardial coronary arteries having more than 70% luminal stenosis and the left main artery having more than 50% stenosis were considered significant. Primary PCI was done using standard techniques. The decision to perform thrombosuction, do predilation, use stents (type, size, and number), utilize adjunctive medications such as GPIIb/IIIa inhibitors were left to the operator's discretion. Angiographic criteria of less than 30% residual stenosis and or TIMI flow grade III were used to determine the success of primary PCI. All the patients were treated with dual antiplatelets and statins following the recent guidelines. Other necessary cardiac medications were given in accordance with the recent guidelines in the absence of contraindications. All the patients were followed up after 3 months. LVEF was considered to have improved if there was a 10% increase or more from the baseline, and a 10% increase or less or no change in EF was considered no improvement. If LVEF showed a reduction by 10% or more, it was considered to denote deterioration. Informed consent was obtained from all the study participants, and the patients who did not provide informed consent were excluded from the study. The institutional ethics committee approved the study protocol.

### Statistical Analysis

Continuous and normally distributed baseline characteristics were presented as the mean ± the standard deviation. Non-normally distributed data were presented as the median with the interquartile range. Categorical data of the baseline characteristics and primary and secondary outcomes were presented as frequencies and percentages. Categorical variables were compared using the $\chi^2$ or Fisher exact test. Comparisons between 3 mean values were tested using 2-tailed unpaired *t* tests for normal distribution and the Mann–Whitney *U* test for non-normal distribution. Logistic regression analysis was used to study the independent association of variables with post-PCI LV improvement at the 3-month follow-up. Patient survival was analyzed using the Kaplan–Meier curve. For the comparison of survival between the patients based on LVEF, the Cox regression analysis was done. The statistical analyses were performed using the SPSS statistical package, version 25.0 (IBM Corp, Armonk, NY, USA), and the statistical significance was set at 0.05.

## RESULTS

Data from 239 patients were analyzed for the study. Table 1 shows the baseline clinical and laboratory characteristics of the study population. The mean age of the patients was 54.2±11.3 years, and 90% of the patients were

male. Diabetes and hypertension were prevalent at 44.8% and 38.9%. Additionally, 34.7% of the patients were smokers. Eight patients required cardiopulmonary resuscitation at admission, 12.5% of the patients presented in the Killip class III or IV, but only 7.5% received an intra-aortic balloon pump (IABP) insertion. Nearly half of the patients (41%) had hypotension periprocedurally, mandating inotrope infusions, and 11.7% required a temporary pacemaker insertion. Moreover, 94.5% of the study population had evidence of regional wall motion abnormalities at presentation on echocardiography. The average total ischemic and door-to-balloon times were 260 and 60 minutes, respectively. Table 2 shows the baseline angiographic and procedural characteristics. The majority of the studied patients had single-vessel disease (46.4%), and the left anterior descending artery (LAD) was the culprit in most patients (54.8%). Most patients received drug-eluting stents, and 78.2% had optimal ST-segment resolution immediately after the procedure. Table 3 and Figure 1 demonstrate the increased mortality both in-hospital and at 3 months for patients with LVEF of 40 or less. The cumulative survival using Cox regression analysis showed that survival distribution between the groups (LVEF≤40 and ≥40) was statistically significant ($\chi^2$=11.1, *P*=0.001).

**Table 1:** Baseline clinical and laboratory characteristics of the patients

| Characteristics | Mean/% | SD/IQ |
|---|---|---|
| Age | 54.2 | 11.3 |
| Male | 90% | n =215 |
| Female | 10% | n =24 |
| BMI | 26.7 | 4.1 |
| Diabetes mellitus | 44.8% | n =107 |
| Hypertension | 38.9% | n =93 |
| PVD | 1.6% | n =4 |
| CVA | 0.4% | n =1 |
| CAD | 5% | n =12 |
| Smoking | 34.7% | n =83 |
| Alcohol | 19.6% | n =47 |
| CPR | 3.3% | n =8 |
| Pulmonary edema | 12.5% | n =30 |
| IABP | 7.5% | n =18 |
| RWMA at presentation | 94.5% | n =226 |
| Significant arrhythmia | 26.7% | n =64 |
| TPI | 11.7% | n =28 |
| RBS (mg/dL) | 191.2 | 82.3 |
| Hemoglobin(mg/dL) | 12.2 | 2.8 |
| Serum creatinine(mg/dL) | 0.5 | 0.4 |
| Total cholesterol(mg/dL) | 175.3 | 45.8 |
| LDL(mg/dL) | 121.7 | 39.4 |
| HDL(mg/dL) | 37.2 | 9.5 |
| Triglycerides(mg/dL) | 147.4 | |
| Total ischemic time (median; min) | 260 | 175-440 |
| Door-to-balloon time (median; min) | 60 | 40-65 |

SD, Standard deviation; IQ, Interquartile range; BMI, Body mass index; PVD, Peripheral vascular disease; CVA, Cerebral vascular accident; CAD, Coronary artery disease; CPR, Cardiopulmonary resuscitation; IABP, Intra-aortic balloon pump; TPI, Temporary pacemaker; RBS, Random blood sugar; LDL, Low-density lipoprotein; HDL, High-density lipoprotein

**Table 2:** Baseline angiographic and procedural characteristics

| Characteristics | Mean/% | SD/IQ |
|---|---|---|
| Single-vessel disease | 46.4% | n=111 |
| Double-vessel disease | 31.4% | n=75 |
| Triple-vessel disease | 22.2% | n=53 |
| Left anterior descending artery (LAD) | 54.8% | n=131 |
| Left circumflex artery (LCX) | 12.6% | n=30 |
| Right coronary artery (RCA) | 30.5% | n=73 |
| Left main disease | 2.1% | n=5 |
| LAD + LCX | 1.3% | n=3 |
| LAD + RCA | 0.4% | n=1 |
| RCA + LCX | 0.4% | n=1 |
| Plain old balloon angioplasty | 1.7% | n=4 |
| Thrombus aspiration | 7.1% | n=17 |
| GP IIb/IIIa inhibitors | 59.8% | n=143 |
| Bare-metal stent | 0.8% | n=2 |
| Bioresorbable vascular stent | 2 0.8%) | n=2 |
| Drug-eluting stent | 96.2% | n=230 |
| Covered stent | 0.4% | n=1 |
| ST-segment resolution | 78.2% | n=187 |

SD, Standard deviation; IQ, Interquartile range

LVEF exhibited improvement in more than half of the patients (57.7%) at the 3-month

follow-up. None of the patients had deterioration in LVEF. Patients presenting with Killip class III or IV (18.8% vs 8%; *P*=0.01), those who had periprocedural hypotension (49.5% vs 34.8%), and patients with longer total ischemic times (400 min vs 215 min; *P*<0.001) had no improvement in their LVEF. No angiographic variables impacted LVEF at the 3-month follow-up (Table 5). The binomial regression analysis of various variables predicting LVEF improvement (Table 6) showed that the most significant predictor of LVEF improvement was a shorter total ischemic time (*P*<0.001; OR, 1.01; 95% CI, 1.00 to 1.01), followed by LVEF of 40% or higher at presentation (*P*<0,02; OR, 1.01; 95% CI, 0.95 to 1.01).

**Table 3:** In-hospital clinical outcomes stratified by LVEF

| Characteristics | EF≤40, (n=75) (%) | EF≥40 (n=164) (%) | *P* value |
|---|---|---|---|
| In-hospital death | 8 (10.7%) | 3 (1.8%) | 0.005 |
| Death at 3 months | 10 (13.3%) | 4 (2.4%) | 0.002 |
| Stroke | 0 | 0 | - |
| Significant bleeding | 1 | 2 | 1 |
| Urgent CABG | 0 | 0 | - |
| Stent thrombosis | 1 (1.4%) | 1 (0.6%) | 0.5 |
| Post-PCI EF improvement | 43 (57.3%) | 95 (57.9%) | 1 |

LVEF, Left ventricular ejection fraction; CABG, Coronary artery bypass graft; PCI, Percutaneous coronary intervention; EF, Ejection fraction

**Table 4:** Baseline clinical characteristics of patients with improvement or no improvement in left ventricular ejection fraction at a 3-month follow-up

| Characteristics | Left Ventricular Function | | |
|---|---|---|---|
| | Improvement (n=138) | No Improvement (n=101) | *P* value |
| Age | 53.2±10.6 | 55.6±12 | 0.09 |
| Male | 128 (92.8%) | 87 (86.1%) | 0.1 |
| Female | 10 (7.2%) | 14 (13.9%) | |
| BMI | 26.7±4.2 | 26.5±3.9 | 0.6 |
| Diabetes mellitus | 63 (45.7%) | 44 (43.6%) | 0.8 |
| Hypertension | 48 (34.8%) | 45 (44.6%) | 0.1 |
| PVD | 3 (2.2%) | 1 (1%) | 0.6 |
| Smoking | 47 (34.1%) | 36 (35.6%) | 0.9 |
| Ischemic time, median (min) | 215 (150,300) | 400 (258,577) | <0.001 |
| Door-to-balloon time, median (min) | 55 (40,66.3) | 60 (40,67.5) | 0.8 |
| CPR | 5 (3.6%) | 3 (3%) | 1 |
| Hypotension | 48 (34.8%) | 50 (49.5%) | 0.02 |
| IABP | 6 (4.3%) | 12 (11.9%) | 0.04 |
| Significant arrhythmia | 34 (24.6%) | 30 (29.7%) | 0.4 |
| TPI | 16 (11.6%) | 12 (11.9%) | 1 |
| Killip class III-IV | 11 (8%) | 19 (18.8%) | 0.01 |
| **LV DYSFUNCTION** | | | |
| LVEF ≤40 | 23(30.6%) | 52(69.3%) | 0.001 |
| LVEF ≥40 | 115 (70.1%) | 49(29.9%) | |

BMI, Body mass index; PVD, Peripheral vascular disease; CPR, Cardiopulmonary resuscitation; IABP, Intra-aortic balloon pump; TPI, Temporary pacemaker; LVEF, Left ventricular ejection fraction

**Table 5:** Baseline angiographic and procedural characteristics of patients with improvement or no improvement in LVEF at a 3-month follow-up

| Characteristics | Left Ventricular Function | | |
|---|---|---|---|
| | Improvement (n=138) | No Improvement (n=101) | *P* value |
| SVD | 67 (48.6%) | 44 (43.6%) | 0.5 |
| DVD | 43 (31.2%) | 32 (31.7%) | |
| TVD | 28 (20.2%) | 25 (24.7) | |
| LAD | 79 (57.2%) | 51 (51.5%) | 0.6 |
| LCX | 16 (11.6%) | 14 (13.9%) | |
| RCA | 41 (29.7%) | 32 (31.6%) | |
| LAD + LCX | 1 (0.7%) | 2 (2%) | |
| LAD + RCA | 0 | 1 (1%) | |
| RCA + LCX | 1 (0.7%) | 0 | |
| POBA | 1 (0.7%) | 3 (3%) | 0.3 |
| Thrombus aspiration | 8 (5.8%) | 9 (8.9%) | 0.4 |
| GP IIb/IIIa | 80 (58%) | 63 (62.4%) | 0.6 |
| BMS | 1 (0.7%) | 1 (1%) | 0.5 |
| BVS | 2 (1.5%) | - | |
| DES | 134 (97.8%) | 96 (95%) | |

VSD, Single-vessel disease; DVD, Double-vessel disease; TVD, Triple-vessel disease; LAD, Left anterior descending artery; LCX, Left circumflex artery; RCA, Right coronary artery; POBA, Plain old balloon angioplasty; BMS, Bare-metal stent; BVS, Bioresorbable vascular stent; DES, Drug-eluting stent

**Table 6:** Binary logistic regression analysis for the predictors of post-PCI LV improvement in echocardiography at a 3-month follow-up

| Characteristics | *P* value | Odds ratio (OR) | 95% CI |
|---|---|---|---|
| Age | 0.6 | 1.01 | 0.98-1.04 |
| Sex | 0.2 | 1.99 | 0.70-5.63 |
| Diabetes Mellitus | 0.6 | 1.14 | 0.63-2.07 |
| Hypertension | 0.07 | 0.07 | 0.31-1.05 |
| Smoking | 0.1 | 0.14 | 0.32-1.17 |
| IABP | 0.4 | 0.42 | 0.12-2.41 |
| Killip class III-IV | 0.6 | 0.63 | 0.21-2.57 |
| Total ischemic time (min) | <0.001 | 1.01 | 1.00-1.01 |
| Door-to-balloon time (min) | 0.2 | 0.99 | 0.98-1.05 |
| Hypotension | 0.06 | 0.53 | 0.27-1.02 |

PCI, Percutaneous coronary intervention; LV, Left ventricle

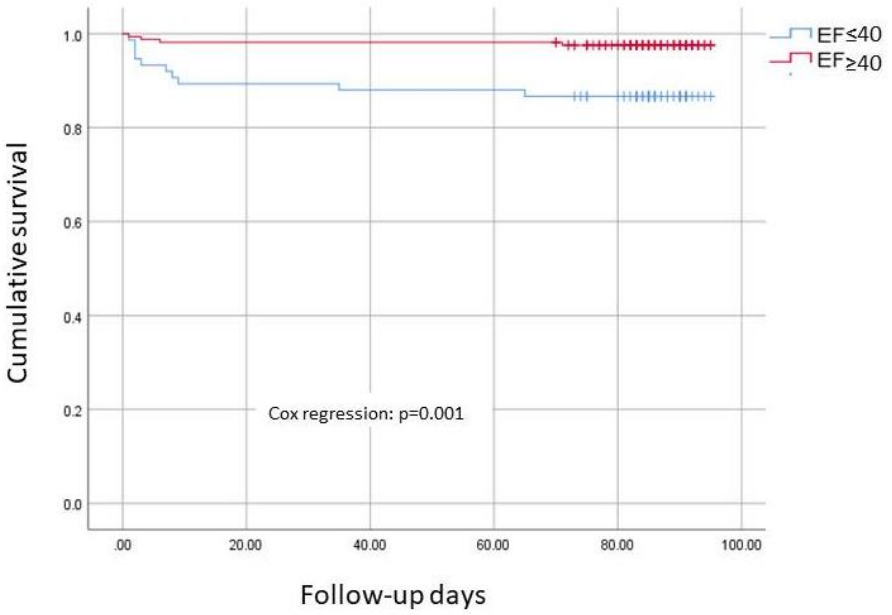


**Figure 1:** The image depicts the cumulative survival among patients with left ventricular (LV) function ≤40 compared with those with LVEF ≥40 using the Cox regression analysis.

A log-rank test was run to determine the differences in survival distribution between patients with LVEF <40 and >40. The survival distribution between the groups was statistically significant ($\chi^2$=11.1, *P*=0.001).

## DISCUSSION

The preferred treatment for patients with STEMI is primary PCI, especially in developing countries, where there are extensive delays in presentation, limiting the efficacy of thrombolysis. Primary PCI can limit myocardial damage and preserve LV systolic function.[7] However, LV function does not improve homogeneously in all patients after primary PCI. LV dysfunction, as a consequence of STEMI, often results in heart failure, contributing to substantial morbidity and eventual mortality. Myocardial stunning due to ischemia may also contribute to LV dysfunction, but the time course of recovery remains uncertain. It is estimated that heart failure occurs in an estimated 25% of patients hospitalized with STEMI and is strongly associated with early all-cause mortality and sudden cardiac death.[8] Therefore, it is essential to study the factors that impact LV function since they may be the ideal targets for therapeutic interventions. The results of the current study established that LVEF of 40% or higher at index STEMI and shorter total ischemic times (<215 mins) were associated with improvement in LV function at follow-up echocardiography (Table 6). LV function at presentation is a proxy marker of LV muscle damage in patients with STEMI and can be used to prognosticate outcomes. In the PREDICTS study, the subsequent recovery of LVEF after STEMI was best predicted by EF at presentation, along with peak troponin levels, a history of prior myocardial infarction (MI), and presentation with cardiac arrest.[9] Another large study including 4044 patients who underwent primary PCI showed that LV dysfunction (≤40%) at index STEMI was one of the important predictors of LV dysfunction at follow-up.[10] In the HORIZONS-AMI trial, LVEF below 40% at the time of primary PCI was associated with markedly increased

adverse events predominantly seen in the first 30 days after the index presentation.[11] In our study too, most deaths occurred within the first month among patients with EF of 40% or less (Fig. 1).

The ideal time period to assess improvement in LV function after STEMI is still debated. With the availability of new devices and pharmacological agents that preserve microcirculatory perfusion and decrease adverse LV remodeling, some former studies assessed LV function within days of the index event,[12,13] while others studied the same from months to years.[14,15] We preferred a time period of 3 months to assess the LV as most guidelines recommend implantable cardioverter defibrillators (ICDs) only after 90 days of primary PCI, permitting myocardial dysfunction and dyssynchrony to fully recover.[16] The best method to assess LV function is debatable too. Cardiovascular magnetic resonance imaging,[15] the radionuclide left ventricular ejection fraction,[17] the wall motion score index, the average peak systolic mitral annular velocity, the B-type natriuretic peptide plasma concentration,[14] and echocardiograms[9,18] all have been used to assess LV function following STEMI.

The total ischemic time is another vital prognosticator of LV function after primary PCI as myocardial necrosis is a time-dependent process, and the duration of ischemia is a significant determinant of the infarct size in STEMI.[12] A small pilot study by Ray et al[19] concluded that an increase in the total ischemic time by 60 minutes reduced LVEF by 0.63%. In experimental studies, other than the total ischemic time, the extent of ischemia, the presence of collateral circulation, and myocardial oxygen demand were also key factors to predict LV function.[20,21] Still, it is extremely challenging to quantify the contribution of all these factors in an emergency clinical setting such as STEMI. Reimer et al[22] conducted an experiment on dogs. Their results showed that the duration of the ligation of the left circumflex coronary artery was directly associated with the degree of transmural myocardial necrosis, with the percentage of necrosis increasing from 38% at 40 minutes to 85% at 24 hours duration. Hasche et al[12] studied the determinants of infarct size by using continuous ST-segment monitoring and showed that the degree of myocardial salvage was inversely related to the duration of ischemia. Chiming in with our study, Hasche and colleagues also showed that patients with less than 6 hours of ischemia displayed substantial functional recovery within 7 days compared with those with a prolonged ischemic time.

Large therapeutic trials in STEMI populations utilizing either thrombolysis or primary PCI have also discovered the ischemic time to be a significant predictor of worse clinical outcomes.[23,24] A prolonged ischemic time was associated with higher in-hospital mortality even when the optimal door-to-balloon time was achieved in a prior investigation.[25]

The time from symptom onset to reperfusion is the most decisive factor amenable to intervention in the successful treatment of STEMI. Several patient- or system-related factors can influence the total ischemic time, especially in developing countries. Delays in the recognition of symptoms by the patient (150 min) were the most common deterrent to a shorter ischemic time in a study by Doddipalli et al.[26] In the Kerala ACS Registry, STEMI patients presented to the hospital 6 hours after symptom onset, predominantly because the symptoms of ischemia were ignored.[27] Poor accessibility to emergency transport or medical services and limited health care infrastructure for PCI all can be major contributors to a longer ischemic time. Because this study was conducted in an urban, tertiary cardiac center, all post-first-medical-contact delays were successfully limited by

achieving guideline-recommended door-to-balloon times (<60 min). However, since we were evaluating the effects of timely primary PCI on LV systolic function, we had to exclude all patients presenting more than 12 hours of symptom onset and, therefore, did not assess the causes for the delay. Eugene Braunwald[28] coined the most appropriate adage for the treatment of MI almost 50 years ago: "Time is muscle." Hence, the importance of total ischemic time holds true regardless of the type of reperfusion.

### Limitations

The present study has a few limitations. It is an observational study and is not randomized. It may, therefore, be subject to bias. The measurement of ejection fraction by echocardiography may overestimate it due to the sympathetic stimulation usually associated with STEMI. Be that as it may, we performed LV angiography to calculate a more precise estimation of EF.

## CONCLUSIONS

In patients presenting within 12 hours of STEMI symptom onset, more than half will have an eventual recovery in their LVEF if primary PCI is performed within the recommended timelines. Shorter ischemic times (≤215 min) and LVEF of 40% or higher at index presentation were independently associated with improved LV systolic function at a 3-month follow-up in our study population. Higher mortality rates were documented in patients with moderate or severe LV dysfunction.

**Conflicts of Interest**: None

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## REFERENCES

1. National Commission on Macroeconomics and Health Burden of Disease in India. Ministry of Health and Family Welfare, Government of India, Delhi, India (2005) http://www.who.int/macrohealth/action/NCMH_Burden%20of%20disease (2%20Sep%202005). pdf. Accessed 20.01.2022. Google Scholar

2. Xavier D, Pais P, Devereaux PJ, Xie C, Prabhakaran D, Reddy KS, et al; CREATE registry investigators. Treatment and outcomes of acute coronary syndromes in India (CREATE): a prospective analysis of registry data. Lancet. 2008; 371:1435–1442. doi: 10.1016/S0140-6736(08)60623-6.

3. Prabhakaran D, Yusuf S, Mehta S, Pogue J, Avezum A, Budaj A, et al. Twoyear outcomes in patients admitted with non-ST elevation acute coronary syndrome: results of the OASIS registry 1 and 2. Indian Heart J. 2005; 57:217–225.

4. Keeley EC, Boura JA, Grines CL. Primary angioplasty versus intravenous thrombolytic therapy for acute myocardial infarction: a quantitative review of 23 randomised trials.Lancet. 2003; 361:13–20. doi:10.1016/S0140-6736(03)12113-7

5. Thygesen K, Alpert JS, White HD; Joint ESC/ACC/AHA/WHF Task Force for the Redefinition of Myocardial Infarction. Universal definition of myocardial infarction. Eur Heart J. 2007; 28:2525–2538; Circulation. 2007; 116:2634–2653; J Am Coll Cardiol. 2007; 50:2173–2195.

6. Mehran R, Rao SV, Bhatt DL, Gibson CM, Caixeta A, Eikelboom J; et al. (2011). "Standardized bleeding definitions for cardiovascular clinical trials: a consensus report from the bleeding academic research consortium". Circulation. 123 (23): 2736–47. doi:10.1161/CIRCULATIONAHA.110.009449. PMID 21670242.

7. Yeh RW, Sidney S, Chandra M, Sorel M, Selby JV, Go AS. Population trends in the incidence and outcomes of acute myocardial infarction. N Eng J Med. 2010; 362:2155–2165. doi: 10.1056/NEJMoa0908610.

8. Sutton NR, Li S, Thomas L, Wang TY, de Lemos JA, Enriquez JR, Shah RU, Fonarow GC. The association of left ventricular

ejection fraction with clinical outcomes after myocardial infarction: findings from the Acute Coronary Treatment and Intervention Outcomes Network (ACTION) Registry-Get With the Guidelines (GWTG) Medicare-linked database. Am Heart J. 2016; 178:65–73. DOI: 10.1016/j.ahj.2016.05.003

**9.** Brooks, G. C., Lee, B. K., Rao, R., Lin, F., Morin, D. P., Zweibel, S. L., Buxton, A. E., Pletcher, M. J., Vittinghoff, E., Olgin, J. E., & PREDICTS Investigators (2016). Predicting Persistent Left Ventricular Dysfunction Following Myocardial Infarction: The PREDICTS Study. Journal of the American College of Cardiology, 67(10), 1186–1196. https://doi.org/10.1016/j.jacc.2015.12.042.

**10.** Kim DH, Park CB, Jin ES, Hwang HJ, Sohn IS, Cho JM, Kim CJ. Predictors of decreased left ventricular function subsequent to follow-up echocardiography after percutaneous coronary intervention following acute ST-elevation myocardial infarction. Exp Ther Med. 2018 May; 15(5):4089-4096. doi: 10.3892/etm.2018.5962. Epub 2018 Mar 19. PMID: 29725361; PMCID: PMC5920495.

**11.** Ng, V. G., Lansky, A. J., Meller, S., Witzenbichler, B., Guagliumi, G., Peruga, J. Z., Brodie, B., Shah, R., Mehran, R., & Stone, G. W. (2014). The prognostic importance of left ventricular function in patients with ST-segment elevation myocardial infarction: the HORIZONS-AMI trial. European heart journal. Acute cardiovascular care, 3(1), 67–77. https://doi.org/10.1177/2048872613507149

**12.** Hasche ET, Fernandes C, Freedman SB, Jeremy RW. Relation between ischemia time, infarct size, and left ventricular function in humans. Circulation. 1995 Aug 15; 92(4):710-9. doi: 10.1161/01.cir.92.4.710. PMID: 7641348.

**13.** Møller JE, Egstrup K, Køber L, Poulsen SH, Nyvad O, Torp-Pedersen C. Prognostic importance of systolic and diastolic function after acute myocardial infarction. Am Heart J. 2003 Jan; 145(1):147-53. doi: 10.1067/mhj.2003.46. PMID: 12514667.

**14.** Świątkiewicz I, Magielski P, Woźnicki M, Gierach J, Jabłoński M, Fabiszak T et al. Occurrence and predictors of left ventricular systolic dysfunction at hospital discharge and in long-term follow-up after acute myocardial infarction treated with primary percutaneous coronary intervention. Kardiol Pol. 2012. PMID: 22528703

**15.** Reinstadler SJ, Klug G, Feistritzer HJ, Kofler M, Pernter B, Göbel G, etal. Prognostic value of left ventricular global function index in patients after ST-segment elevation myocardial infarction, European Heart Journal - Cardiovascular Imaging, Volume 17, Issue 2, February 2016, Pages 169–176, https://doi.org/10.1093/ehjci/jev129

**16.** Steinbeck G, Andresen D, Seidl K, et al. Defibrillator implantation early after myocardial infarction. N Engl J Med. 2009; 361:1427–1436.

**17.** Aret BL, Wackers FJ, Terrin ML, Forman SA, Williams DO, Knatterud GL, Braunwald E. Value of radionuclide rest and exercise left ventricular ejection fraction in assessing survival of patients after thrombolytic therapy for acute myocardial infarction: results of Thrombolysis in Myocardial Infarction (TIMI) phase II study. The TIMI Study Group. J Am Coll Cardiol. 1995 Jul; 26(1):73-9. doi: 10.1016/0735-1097(95)00146-q. PMID: 7797778.

**18.** Wong EC, Fordyce CB, Wong G, Lee T, Perry-Arnesen M, Mackay M, Singer J, Cairns JA, Turgeon RD. Predictors of the Use of Mineralocorticoid Receptor Antagonists in Patients With Left Ventricular Dysfunction Post-ST-Segment-Elevation Myocardial Infarction. J Am Heart Assoc. 2021 Jul 20; 10(14):e019167. doi: 10.1161/JAHA.120.019167. Epub 2021 Jul 6. PMID: 34227405; PMCID: PMC8483484.

**19.** Ray S, Chattopadhyay BP, Ghosh AK, Ray S, Kundu S, Deb P, Bannerjee A. Importance of ischaemic time as a predictor of LV systolic function in Indians. Indian Heart J. 2010 Jan-Feb; 62(1):39-42. PMID: 21180033.

**20.** Reimer KA, Jennings RB, Cobb FR, Murdock RH, Greenfield JC Jr, Becker LC, Bulkley BH, Hutchins GM, Schwartz RP Jr, Bailey KR, Passamani ER. Animal models for protecting the ischemic myocardium: results of the NHLBI cooperative study: comparison of unconscious and conscious dog models. Circ Res.1985; 56:651-665.

**21.** Reimer KA, Lowe JE, Rasmussen MM, Jennings RB. The wavefront phenomenon of myocardial ischemic cell death, I: myocardial infarct size vs duration of coronary occlusion in dogs. Circulation.1977; 56:786-794.

**22.** Reimer KA, Lowe JE, Rasmussen MM, Jennings RB. The wave front phenomenon of ischemic cell death: 1. Myocardial infarct size vs. duration of coronary occlusion in dogs. Circulation 1977; 56:786-94. 10.1161/01.CIR.56.5.786

**23.** The GUSTO Angiographic Investigators. The effects of tissue plasminogen activator, streptokinase, or both on coronary artery patency, ventricular function, and survival after acute myocardial infarction. N Engl J Med.1993; 329:1615-1622.

**24.** Grines CL, Browne KF, Marco J, Rothbaum D, Stone GW, O'Keefe J, Overlie P, Donohue B, Chelliah N, Timmis GC, Vlietstra RE, Strzelecki M, Puchrowicz-Ochocki S, O'Neill WW. A comparison of immediate angioplasty with thrombolytic therapy for acute myocardial infarction. N Engl J Med.1993; 328:673-679.

**25.** Khowaja S, Ahmed S, Kumar R, Shah J A, Khan K A, Khan N U et al. Time to think beyond door to balloon time: signifcance of total ischemic time in STEMI. Egypt Heart J (2021) 73:95 https://doi.org/10.1186/s43044-021-00221-1.

**26.** Doddipalli S.R, Rajasekhar D, Vanajakshamma V, Naik KS. Determinants of total ischemic time in primary percutaneous coronary interventions: A prospective analysis. Indian Heart J., 70 (Suppl 3) (2018 Dec), pp. S275-S279, 10.1016/j.ihj.2018.05.005

**27.** Mohanan PP, Mathew R, Harikrishnan S, Krishnan MN, Zachariah G, Joseph J, Eapen K, Abraham M, Menon J, Thomas M, Jacob S, Huffman MD, Prabhakaran D; Kerala ACS Registry Investigators. Presentation, management, and outcomes of 25 748 acute coronary syndrome admissions in Kerala, India: results from the Kerala ACS Registry. Eur Heart J. 2013 Jan; 34(2):121-9. doi: 10.1093/eurheartj/ehs219. Epub 2012 Sep 7. PMID: 22961945; PMCID: PMC3538274.

**28.** Abreu LM. Time is Muscle. Arq Bras Cardiol. 2019; 112(4):408-409. doi:10.5935/abc.20190059