



Original Article

# Evaluation of Ejection Fraction and Its Determinants at Different Time Intervals After Primary PCI in Elderly Patients: A Descriptive Study

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**Abstract**

**Introduction:** Primary percutaneous coronary intervention (PPCI) is the preferred treatment for patients with ST-elevation myocardial infarction (STEMI). Left ventricular ejection fraction (LVEF) is a key marker of cardiac function. This study aimed to evaluate changes in LVEF during initial hospitalization and at 2- and 6-week follow-up post-PPCI and to identify factors influencing LVEF improvement.

**Methods:** This retrospective descriptive study included 151 patients with STEMI who underwent coronary angiography. Data were collected through patient files, clinical history, echocardiography, and calculation of SYNTAX I and II scores.

**Results:** A significant inverse correlation was observed between SYNTAX scores (I and II) and EF at all three time points (baseline, 2 weeks, and 6 weeks post-PPCI). Mean EF indicated a significant increase two weeks after PPCI ( $P < 0.001$ ). Among 139 patients followed up, 50.4% demonstrated  $\geq 10\%$  improvement in EF at either 2 or 6 weeks. Increasing age was associated with less improvement in EF over the 6 weeks.

**Conclusion:** EF improves significantly within the first 2-6 weeks after PPCI. However, higher SYNTAX scores and older age were associated with less likelihood of EF recovery, highlighting their value as predictors of post-intervention cardiac function.

**Keywords:** Ejection fraction, ST elevation myocardial infarction, Primary percutaneous coronary intervention



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## Introduction

With the development of human lifestyle and modern life habits, Cardiovascular diseases remain among the leading causes of death worldwide. According to the World Health Organization (WHO), coronary artery disease accounts for more than 7.4 million deaths annually worldwide (1). This underscores the need to recognize heart diseases and indicates the importance of timely diagnosis, prevention, and management of their associated complications. Clinically, the diagnosis of myocardial infarction (MI) requires the presence of symptoms suggestive of MI along with evidence of myocardial injury, such as laboratory biomarkers, electrocardiography, or imaging findings (2, 3).

After a clinical history, electrocardiogram (ECG) changes are the most accessible tools for assessing heart damage.

ST-segment changes, specifically ST-elevation, indicate transmural damage of the heart muscle resulting from total occlusion of a coronary artery branch. ST-elevation myocardial infarction (STEMI) and its equivalent conditions demand immediate therapeutic intervention. The primary goal of STEMI treatment is to restore coronary blood flow as quickly as possible after occlusion of the involved vessel. Although fibrinolytic therapy was historically the primary method of reperfusion in these patients, primary percutaneous coronary intervention (PPCI) has become the gold standard of care (4).

Patients who survive after MI experience some degree of heart failure, a clinical syndrome that affects more than 23 million people worldwide (5). Nevertheless, after the occurrence of MI, not all damaged myocardial tissue is



destroyed; a part of this tissue survives despite the damage and can gradually recover its function with the passage of time ranging from a few days to several weeks (6).

Previous studies indicate that when the ejection fraction (EF) falls below 35%, the risk of cardiac arrhythmias increases significantly, often necessitating the implantation of an implantable cardioverter-defibrillator (ICD) for the primary prevention of arrhythmias and their possible death (7, 8). Due to the high cost of these tools, defibrillator installation should be performed only when it is confirmed that the heart function has reached its maximum recovery. Therefore, assessing the improvement of cardiac function after MI is essential for optimizing the timing of such interventions.

Returning to life is a key goal of cardiac therapy. Previous research suggests that the improvement of cardiac function depends on several factors, such as the number and type of vessels involved, the severity of heart failure at the time of referral, cardiac enzyme levels, serum creatinine level during hospitalization, gender, symptom-to-reperfusion time, and Killip class (9-16)

The Syntax score is a factor derived from coronary vessel anatomy during angiography and other clinical characteristics of the patient (13). While this factor helps choose the treatment method between coronary artery bypass grafting (CABG) and PCI in coronary artery involvement, there has been no study on the relationship between Syntax score and the outcome of PPCI as a primary determinant of EF recovery.

According to the latest available guidelines, the minimum time required to make a decision regarding ICD implantation in patients with STEMI is six weeks (17). This time was established based on studies performed before the availability of PPCI. However, it seems that PPCI has reduced the time required to reach peak EF, and it is expected to reach the maximum heart function faster after PPCI than with other methods.

Since most studies in this field were conducted before PPCI became widely available, and considering the importance of improving cardiac function for patients after a heart attack, the present study aimed to investigate EF and the factors affecting its improvement during the initial hospitalization at 2- and 6-week intervals after PPCI.

## Methods

This retrospective descriptive study involved 151 patients referred to the angiography department due to ECG changes compatible with STEMI who subsequently underwent PPCI from September 1, 2017 to September 1, 2018. A census sampling method was used. Patients who underwent PPCI during this period were included in the study, and patients under 18 years of age, those with a history of heart failure, and people who had previously undergone CABG surgery were excluded from the study. Data collection tools included demographic information forms, patient medical records, clinical history, and echocardiographic reports. The SYNTAX score was calculated online for the patients.

Informed consent was obtained from all patients, and

the necessary explanations were provided in detail. In order to conduct this study, upon hospital admission and diagnosis, basic laboratory and non-laboratory data were collected. The SYNTAX score was calculated based on the angiographic images. Following the PPCI procedure, patients underwent echocardiography as soon as possible, and factors such as EF were evaluated using the Simpson's method, and valvular disorders were assessed.

Follow-up echocardiography was performed at 2 and 6 weeks post-PPCI, and patients who completed echocardiographic evaluations at all specified time points were included in the study; those lacking baseline or follow-up echocardiograms at these desired intervals were excluded. Patients' clinical status during hospitalization was monitored through a review of their medical records. Data were extracted from medical records at the first visit, post-PPC, and at the 2- and 6-week follow-up visits. Information regarding the treatment course was recorded in a data collection form completed by the researcher. Then patients were categorized based on their initial EF levels.

All data were analyzed using SPSS software version 16. Descriptive statistics were used to summarize baseline clinical characteristics and patient demographics. The normality of the data was checked by measuring skewness and kurtosis. The Chi-square test or Fisher's exact test was used to evaluate the relationship between categorical variables. An independent samples t-test was used to investigate the relationship between qualitative and quantitative variables in two groups of patients with normal distribution, whereas the Mann-Whitney U test was used in two groups of patients for non-normally distributed variables. The paired t-test was used for normally distributed data to evaluate differences in continuous variables within the same group before and after the procedure, and the Wilcoxon signed-rank test was used for non-normally distributed data. Analysis of variance (ANOVA) was used to evaluate differences in continuous variables across three or more independent groups. To investigate the relationship between two continuous variables with normal distribution, Pearson correlation or linear regression was used for non-normally distributed data. Kruskal-Wallis test was used to compare non-normally distributed continuous variables across three or more independent groups. A *P*-value < 0.05 was considered statistically significant for all statistical tests.

## Results

In this study, data from 151 patients were analyzed, of whom 84.1% were men and 15.9% were women. The age of the patients varied between 31 and 94 years, with a mean age of 61.69 years. More than half of the patients were smokers. In terms of disease history, more than half of the patients (52.3%) had chronic obstructive pulmonary disease (COPD), about one-third had hypertension, and one-quarter had a history of diabetes mellitus (Table 1).

There was a significant inverse correlation between SYNTAX I and II scores and left ventricular EF (LVEF) at all 3 time points (on admission, 2 weeks, and 6 weeks after

PPCI). The highest correlation coefficient was observed between the SYNTAX II score and EF at 6 weeks post-PPCI ( $r = -0.58$ ,  $P < 0.001$ ), indicating that patients with lower SYNTAX II scores had significantly higher EF values (Table 2).

Two weeks post-PPCI, the mean EF showed a significant increase ( $P < 0.001$ ) by 18.03% (SD = 14.51). Furthermore, among patients with EF measured at all three time points, 95 patients showed a significant increase ( $P < 0.001$ ). Although both groups of people with intermediate SYNTAX II score (scores 17–24) and the high SYNTAX II score (scores  $> 24$ ) experienced significant EF increase across the three follow-up intervals, the difference in EF between the two groups was statistically significant ( $P = 0.016$ ). Specifically, in the

intermediate SYNTAX II group, the mean EF increased from 45.33% to 49.33%, while in the high SYNTAX II group, it increased from 36.0% to 44.78% (Figure 1). Changes in EF at 2 weeks and 6 weeks after PPCI were statistically significant ( $P < 0.001$ ). Compared with baseline EF, EF improvement was observed in 39.1% of patients at 2 weeks, and in 50.0% of patients at 6 weeks post-PPCI (Table 3). In general, among the patients followed up after PPCI, 50.4% (70 of 139) had an absolute increase of at least 10% in LVEF at either the 2- or 6-week follow-up.

The rate of LVEF improvement over the 6 weeks post-PPCI was higher in men than in women (52.1% vs. 40.9%), but this difference was not statistically significant ( $P = 0.334$ ). Additionally, the mean age of patients who showed LVEF improvement was approximately two years younger than that of patients without improvement or with clinical deterioration (60.97% vs. 62.52%), which was not statistically significant ( $P = 0.386$ ). LVEF recovery was also higher in patients with right coronary artery-dominant circulation than in those with left-dominant circulation (51.2% vs. 40.0%), although this difference was not statistically significant ( $P = 0.532$ ). Furthermore, the rate of LVEF improvement across different SYNTAX II classes was almost similar, with no statistically significant differences observed ( $P = 0.530$ ) (Table 4). In the multivariate logistic regression model including all variables listed in Table 4, age was the only significant variable for improving EF

**Table 1.** Distribution of Demographic and Basic Variables in Research Units

|                                       | Number of Valid Data | Frequency (%) | Percentage/SD |
|---------------------------------------|----------------------|---------------|---------------|
| Gender, n (%)                         | 151                  |               |               |
| Female                                |                      | 24            | 15.9          |
| Male                                  |                      | 127           | 84.1          |
| Age, Mean (SD)                        | 151                  | 61.69         | 10.60         |
| Smokers, n (%)                        | 151                  | 85            | 56.3          |
| Dominancy                             | 151                  |               |               |
| Left                                  |                      | 10            | 6.6           |
| Right                                 |                      | 141           | 93.4          |
| Positive Disease Records, n (%)       |                      |               |               |
| Chronic Obstructive Pulmonary Disease | 107                  | 56            | 52.3          |
| Thrombosis                            | 151                  | 123           | 81.5          |
| Diabetes Mellitus                     | 149                  | 36            | 24.2          |
| High Blood Pressure                   | 149                  | 54            | 36.2          |
| Chronic Kidney Disease                | 149                  | 4             | 2.7           |
| Stroke                                | 149                  | 3             | 2.0           |

Note. SD: Standard deviation; n: Number.

**Table 2.** Correlation Coefficients of SYNTAX Score With Left Ventricular Blood Output Fraction at Three Follow-up Times

|                 | Left Ventricular Ejection Fraction |                    |                    |
|-----------------|------------------------------------|--------------------|--------------------|
|                 | Admission                          | 2 Weeks After PPCI | 6 Weeks After PPCI |
| SYNTAX I Score  | -0.401                             | -0.410             | -0.444             |
| SYNTAX II Score | -0.545                             | -0.424             | -0.587             |

Note. SYNTAX: Synergy between PCI with taxus and cardiac surgery; PPCI: Primary percutaneous coronary intervention. \*All correlation coefficients were significant at  $P < 0.001$ .

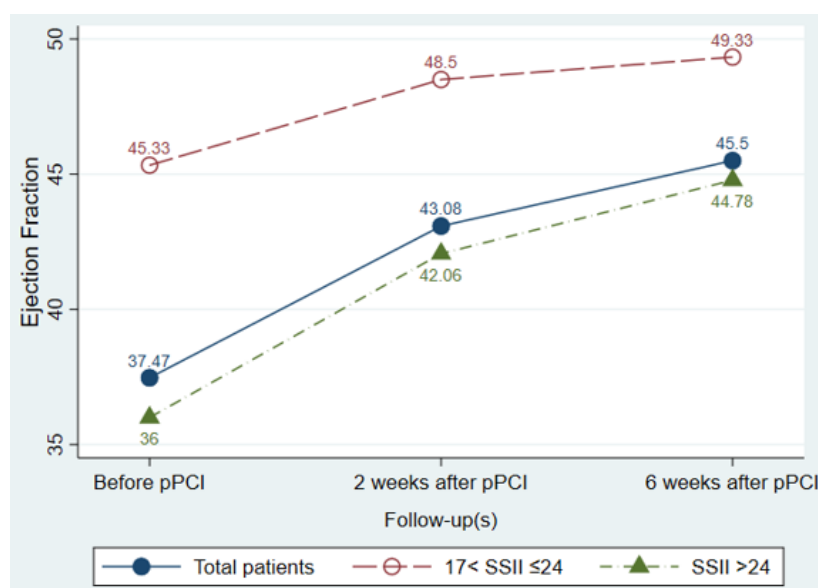


**Figure 1.** Mean Changes in Ejection Fraction Before and After PPCI in All Patients According to SYNTAX II Score. Note. SYNTAX: Synergy between PCI with taxus and cardiac surgery; PPCI: Primary percutaneous coronary intervention

**Table 3.** Changes in LVEF at 2- and 6-Weeks After PPCI

|                            | LVEF in Baseline |           |           |             | P-value |
|----------------------------|------------------|-----------|-----------|-------------|---------|
|                            | ≤40              | 41-49     | ≥50       | Total       |         |
| LVEF at 2 Weeks After PPCI |                  |           |           |             | <0.001  |
| ≤40                        | 37 (26.8)        | 5 (3.6)   | 1 (0.7)   | 43 (31.2)   |         |
| 41-49                      | 12 (8.7)         | 2 (1.4)   | 3 (2.2)   | 17 (12.3)   |         |
| ≥50                        | 17 (12.3)        | 25 (18.1) | 36 (26.1) | 78 (56.5)   |         |
| Total                      | 66 (47.8)        | 32 (23.2) | 40 (29.0) | 138 (100.0) |         |
| LVEF at 6 Weeks After PPCI |                  |           |           |             | <0.001  |
| ≤40                        | 27 (28.1)        | 2 (2.1)   | 1 (1.0)   | 30 (31.3)   |         |
| 41-49                      | 12 (12.5)        | 1 (1.0)   | 0 (0.0)   | 13 (13.5)   |         |
| ≥50                        | 13 (13.5)        | 23 (24.0) | 17 (17.7) | 53 (55.2)   |         |
| Total                      | 52 (54.2)        | 26 (27.1) | 18 (18.8) | 96 (100.0)  |         |

LVEF > 50: HFpEF, 41-49: HFmrEF, and <40: HFrEF. Note. LVEF: Left ventricular ejection fraction; PPCI: Primary percutaneous coronary intervention; HFpEF: Heart failure with preserved ejection fraction; HFmrEF: Heart failure with mildly reduced ejection fraction; HFrEF: Heart failure with reduced ejection fraction.

( $P=0.038$ ), with an odds ratio (OR) of 0.941 (95% confidence interval: 0.889-0.997). In other words, every additional year of age increases the odds of non-recovery by 1.06 after removing the effect of other variables.

## Discussion

The present study was conducted to investigate EF and the factors affecting its improvement during the first hospitalization and at intervals of 2 and 6 weeks after PPCI. The present study showed a significant inverse correlation between SYNTAX I and II scores and LVEF at all three evaluated time points: admission, 2 weeks, and 6 weeks post-PPCI. It indicates that a lower SYNTAX score is associated with a higher EF. A study conducted on Egyptian patients diagnosed with STEMI undergoing PPCI similarly showed that a higher SYNTAX score correlates with a lower EF, and also demonstrated a significant relationship with poor short-term outcomes in these patients (18). Another study indicated that a high SYNTAX score after PPCI in STEMI patients with chronic total coronary occlusions is associated with lower EF and increased mortality (19). Meanwhile, the results of the present study revealed a significant difference in the magnitude of EF improvement between the intermediate and high SYNTAX II score groups, with the high-score group experiencing a higher increase in EF. In contrast, Wollmuth et al reported that a high SYNTAX score is related to a weak improvement in EF (20).

Previous studies have demonstrated that percutaneous coronary intervention can significantly improve left ventricular function in patients with coronary artery disease, even when their EF is preserved (4). The results of the present study showed that the mean EF increased significantly at 2 and 6 weeks after PPCI. The study in 2022 showed that even in high-risk PCI patients, the EF rate improved from 35% to 45% at the 90-day follow-up (20). Similarly, Balouch et al reported a significant improvement in LVEF in young patients with STEMI at 40 and 90 days

**Table 4.** Factors Affecting Changes in LVEF during 6 weeks After PPCI

|                                       | Changes in EF at 6 Weeks After PPCI |                        |         |
|---------------------------------------|-------------------------------------|------------------------|---------|
|                                       | At Least One Improvement Floor      | Unchanged or Worsening | P-value |
| Gender, n (%)                         |                                     |                        |         |
| Female                                | 9 (40.9%)                           | 13 (59.1%)             | 0.334   |
| Male                                  | 61 (52.1%)                          | 56 (47.9%)             |         |
| Age, Mean (SD)                        | 60.97 (11.43)                       | 62.52 (9.49)           | 0.386   |
| Smokers, n (%)                        |                                     |                        |         |
| No                                    | 29 (46.8%)                          | 33 (53.2%)             | 0.448   |
| Yes                                   | 41(53.2%)                           | 36 (46.8%)             |         |
| Dominancy, n (%)                      |                                     |                        |         |
| Left                                  | 4 (40.0%)                           | 6 (60.0%)              | 0.532   |
| Right                                 | 66 (51.2%)                          | 63 (48.8%)             |         |
| Rote                                  |                                     |                        |         |
| Femoral                               | 36 (48.6%)                          | 38 (51.4%)             | 0.667   |
| Radial                                | 34 (52.3%)                          | 31 (47.7%)             |         |
| SYNTAX II Score, n (%)                |                                     |                        |         |
| Less than 17                          | 0 (0.0%)                            | 2 (100%)               | 0.530   |
| 17-24                                 | 15 (51.7%)                          | 14 (48.3%)             |         |
| More than 24                          | 55 (50.9%)                          | 53 (49.1%)             |         |
| Disease Records, n (%)                |                                     |                        |         |
| Chronic Obstructive Pulmonary Disease |                                     |                        |         |
| No                                    | 19 (40.4%)                          | 28 (59.6%)             | 0.101   |
| Yes                                   | 28 (57.1%)                          | 21 (42.9%)             |         |
| Thrombosis                            |                                     |                        |         |
| No                                    | 9 (36.0%)                           | 16 (64.0%)             | 0.113   |
| Yes                                   | 61 (53.5%)                          | 53 (46.5%)             |         |
| Diabetes Mellitus                     |                                     |                        |         |
| No                                    | 55 (52.4%)                          | 50 (47.6%)             | 0.585   |
| Yes                                   | 15 (46.9%)                          | 17 (53.1%)             |         |
| High Blood Pressure                   |                                     |                        |         |
| No                                    | 45 (51.7%)                          | 42 (48.3%)             | 0.846   |
| Yes                                   | 25 (50.0%)                          | 25 (50.0%)             |         |
| Chronic Kidney Disease                |                                     |                        |         |
| No                                    | 69 (51.5%)                          | 65 (48.5%)             | 0.614   |
| Yes                                   | 1 (33.3%)                           | 2 (66.7%)              |         |
| Stroke                                |                                     |                        |         |
| No                                    | 68 (50.4%)                          | 67 (49.6%)             | 0.497   |
| Yes                                   | 2 (100%)                            | 0 (0.0%)               |         |

Note. SD: Standard deviation; n: Number; LVEF: Left ventricular ejection fraction; PPCI: Primary percutaneous coronary intervention.

after PPCI (21). Blake et al also found that 69% of patients with STEMI who initially had low EF showed improvement two weeks after PPCI, which is compatible with the results of the present study (22). Likewise, Altman et al showed that in people with EF less than 35% after STEMI, PPCI could lead to improvement in EF within 6 to 8 weeks afterwards (23). In general, in the present study, 50.4% of the patients followed up after PPCI exhibited at least 10% improvement in EF either at week 2 or week 6 after PPCI.

In the present study, no significant difference was observed between EF recovery and gender, coronary dominance, or history of underlying disease; however, the likelihood of non-recovery of EF increased with age at 6 weeks after PPCI. Previous studies have shown inconsistent results regarding gender differences in LVEF improvement after PPCI among patients with STEMI. Guo et al reported that women experienced less improvement in LVEF compared to men (24). In contrast, another study identified female gender as an independent predictor of LVEF improvement (25). Weissler et al found no significant gender-related difference in the improvement of left ventricular function or EF, which is consistent with the results of the present study (26). Differences among these studies can be attributed to differences in sample size, design, and sampling methods.

Veltman et al found that patients with left coronary system dominance had a lower EF at the time of STEMI diagnosis; however, no significant difference in EF was observed 12 months after PPCI (27). In another study conducted by Mikaeilvand et al, patients with dominant right coronary artery had higher EF after PPCI than those with left coronary dominance (28), a finding that differed from the results of the present study.

Hamdy et al identified several factors related to the improvement in left ventricular function after PCI: male gender, diabetes, chronic kidney disease, normal ECG findings, absence of hyperuricemia, lower heart rate, the presence of chest pain and shortness of breath, absence of chronic total obstruction, single-vessel disease, and the use of ACE inhibitors and clopidogrel (29). However, in the present study, no significant relationship was observed between previous disease records, laboratory indicators, and EF recovery. This difference can be attributed to the difference in sample size and the mean age of the participants.

The findings of the present study showed that older age was significantly associated with reduced EF recovery at 6 weeks after PPCI. In contrast, Serrao et al reported that age was not a predictor of EF improvement after PPCI (25). However, the results of the study by Gharacholou et al indicated that increasing age was associated with increased mortality and adverse outcomes after PPCI in patients with STEMI (30).

One limitation of this study was the lack of data regarding the exact door-to-balloon time and precise time of chest-pain onset. These time intervals may have influenced post-PPCI left ventricular function and may partially explain variations in EF recovery among patients.

## Conclusion

The results of the present study showed that mean EF increases significantly within 2 and 6 weeks post-PPCI, and there was a negative relationship between the SYNTAX score and EF. Therefore, an increase in the SYNTAX score was associated with a reduced improvement in EF. Additionally, advanced age may also be associated with a lack of improvement in cardiac EF during the initial 6-week

post-PPCI period. Evaluation of EF after PPCI is important to assess patient recovery, predict long-term outcomes, and optimize patient care. Understanding the factors that affect EF recovery, including age and medical history, is crucial for effective patient management and achieving positive long-term outcomes. Further research in this field can improve our understanding of EF recovery and enable personalized and more effective treatment strategies.

## Authors' Contribution

Conceptualization: Abdollah Amirfarhangi  
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## Competing Interests

None declared.

## Ethical Approval

This article was derived from a thesis that received ethical approval from the Iranian National Committee for Ethics in Biomedical Research (Approval Code: IR.IUMS.FMD.REC.1400.261).

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