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Original Article

One-Year Outcomes of Major Adverse Cardiac Events in Patients with ST-Segment Elevation Myocardial Infarction Who Received Delayed PCI in a Type-B Hospital

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Abstract

Background: Delayed Percutaneous Coronary Intervention (PCI) remains common in resource-limited hospitals due to system-related delays, often resulting in prolonged ischemic time. Although early reperfusion is the standard of care for ST-segment Elevation Myocardial Infarction (STEMI), delayed PCI may still be performed in selected, clinically stable patients. This study aimed to evaluate the one-year incidence of Major Adverse Cardiac Events (MACE) among STEMI patients undergoing PCI in a Type-B hospital, where delayed PCI was the predominant treatment pattern.

Methods: This retrospective cohort study included adult STEMI patients who underwent PCI at PKU Muhammadiyah Gamping Hospital, Yogyakarta, Indonesia, between September 2018 and December 2020. Patients with incomplete medical records or loss to follow-up were excluded. Baseline clinical characteristics, comorbidities, infarct location, and door-to-wire-crossing time were collected. MACE included all-cause mortality, acute pulmonary edema, non-ST-segment elevation myocardial infarction, stroke, and rehospitalization due to reinfarction or acute heart failure within one year after PCI. Kaplan-Meier survival analysis and Mann-Whitney testing were applied.

Results: Among 130 STEMI patients who underwent PCI, 123 (94.6%) received delayed PCI, with a median door-to-wire-crossing time of 10 hours 34 minutes. During one-year follow-up, MACE occurred in 10 patients (7.7%), corresponding to a 92.3% event-free survival rate. No significant association was observed between door-to-wire-crossing time and one-year MACE ($p = 0.927$).

Conclusions: In this single-center study conducted at a Type-B hospital, one-year MACE occurred in 7.7% of STEMI patients undergoing PCI, most of whom received delayed PCI. No significant association was observed between door-to-wire-crossing time and MACE occurrence. Given the observational design and the limited number of events, these findings should be interpreted with caution. Delayed PCI appears feasible in selected patients, but should not be considered equivalent to guideline-recommended early PCI.

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Keywords: Delayed PCI, MACE, STEMI, Type-B hospital

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Introduction

Comparative studies between thrombolytic therapy and primary Percutaneous Coronary Intervention (PCI) for ST-segment Elevation Myocardial Infarction (STEMI) have been extensively reported in developed healthcare systems.[1–3] These studies consistently demonstrate that timely primary PCI is associated with improved clinical outcomes and form the basis of contemporary guideline recommendations. However, implementation of these evidence-based standards remains challenging in developing countries, particularly in regional hospitals, where infrastructural limitations and system-level delays frequently hinder timely reperfusion.

STEMI is characterized by acute myocardial ischemia with persistent ST-segment elevation on electrocardiography and elevated myocardial necrosis biomarkers. STEMI accounts for approximately 38% of acute coronary syndrome cases in hospital-based settings.[4] Previous studies have reported that the management of acute coronary syndrome in developing countries, including Indonesia, often deviates from guideline-directed therapy, primarily due to delayed patient presentation and prolonged total ischemic time.[5] Such delays may adversely affect myocardial salvage and long-term clinical outcomes.

Primary PCI remains the preferred reperfusion strategy for STEMI because irreversible myocardial necrosis progresses rapidly following coronary artery occlusion, and the therapeutic benefit of reperfusion is strongly time-dependent.[6] Major Adverse Cardiac Events (MACE), encompassing cardiac death, recurrent myocardial infarction, and repeat revascularization, are widely used as composite clinical endpoints to evaluate the safety and effectiveness of reperfusion strategies.[7] Recent evidence suggests that, in selected and clinically stable patients, delayed PCI combined with Optimal Medical Therapy (OMT) may still be associated with acceptable clinical outcomes; however, data supporting this approach in regional hospitals within developing countries remain limited.[8-9]

In 2018, the cardiac catheterization laboratory at PKU Muhammadiyah Gamping Hospital began providing PCI services for STEMI patients, representing an expansion of cardiovascular care capacity in a regional hospital setting. Given the frequent occurrence of delayed reperfusion in this context, evaluating long-term clinical outcomes after delayed PCI is clinically relevant. This study was therefore conducted to assess one-year MACE among STEMI patients undergoing delayed PCI at PKU Muhammadiyah Gamping Hospital, with the aim of contributing real-world evidence from a resource-limited clinical setting.

Methods

This study employed a retrospective cohort design using observational data. It was conducted at PKU Muhammadiyah Gamping Hospital, Yogyakarta, Indonesia, a Type-B hospital equipped with a cardiac catheterization laboratory capable of performing PCI for STEMI. During the study period, institutional referral protocols required clinically unstable or high-risk STEMI patients to be transferred to tertiary centers. Consequently, PCI at this institution was primarily performed in clinically stable patients who remained hospitalized. The study protocol was reviewed and approved by the Ethics Committee of PKU Muhammadiyah Gamping Hospital. The requirement for informed consent was waived due to the retrospective nature of the study.

All consecutive adult patients (≥18 years) admitted with confirmed STEMI who underwent reperfusion therapy at PKU Muhammadiyah Gamping Hospital between September 2018 and December 2020 were screened. STEMI was diagnosed based on persistent ST-segment elevation on electrocardiography and elevated cardiac biomarkers. A total of 130 patients met the inclusion criteria and were included in the final analysis. Of these, 123 (94.6%) received delayed PCI, whereas the remainder underwent primary PCI. Patients were excluded if they had incomplete medical records, were lost to follow-up, had alternative diagnoses that could confound STEMI (such as myocarditis or Takotsubo cardiomyopathy), or had documented refusal of invasive management. Patients who died before undergoing PCI were not included, as the study population consisted only of individuals who survived to receive PCI.

Total sampling was applied. Data collected from medical records included age, sex, smoking status, STEMI location (anterior or inferior), comorbidities (hypertension, diabetes mellitus, dyslipidemia, obesity, and prior stroke), length of hospitalization, and clinical outcomes during follow-up. Anterior STEMI was defined as myocardial infarction involving the Left Anterior Descending (LAD) artery, whereas inferior STEMI was defined as myocardial infarction involving the Right Coronary Artery (RCA). Delayed PCI was defined as PCI performed more than 12 hours after the onset of chest pain symptoms. In this cohort, delayed PCI

was the predominant treatment pattern. Time to reperfusion was defined as door-to-wire-crossing time, calculated from the patient's arrival at the emergency department to successful guidewire passage across the culprit coronary lesion during PCI.

The primary outcome was the occurrence of MACE within one year following PCI. MACE was defined as a composite of all-cause mortality, acute pulmonary edema, non-STEMI, stroke, and rehospitalization due to reinfarction or acute heart failure within one year after PCI. Follow-up data were obtained from hospital medical records and structured telephone interviews. Mortality was confirmed through hospital documentation or communication with family members when death occurred outside the hospital.

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 20.0 (SPSS Inc., Chicago, IL, USA). Categorical variables were summarized as absolute numbers and percentages. Continuous variables were presented as mean ± standard deviation or median with minimum and maximum values, as appropriate. The association between door-to-wire-crossing time and one-year MACE was analyzed using the Mann–Whitney U test. A two-sided p-value <0.05 was considered statistically significant.

Results

A total of 130 patients with confirmed STEMI who underwent PCI were included in the final analysis. Among them, 123 (94.6%) received delayed PCI. Baseline demographic and clinical characteristics are summarized in Table 1. The majority of patients were male (107 patients, 82.3%), with a mean age of 59.3 ± 11.6 years. Anterior STEMI was the most frequent infarct location (77 patients, 59.2%), while 53 patients (40.8%) presented with inferior STEMI. Common

Table 1. Baseline patient characteristics.

Variables	N	%	Mean ± SD Or Median (min-max)
Age (years ± SD)			59.31 ± 11.63
STEMI Location			
Anterior	77	59.2%	
Inferior	53	40.8%	
Smoking History			
Yes	109	83.8%	
No	21	16.2%	
Sex			
Male	107	82.3%	
Female	23	17.7%	
Comorbidity			
Stroke	11	8.5%	
Hypertension	68	52.3%	
Dyslipidemia	17	13.1%	
Diabetes Mellitus	46	35.4%	
LM disease	18	13.8%	
Weight status			
Underweight	6	4.6%	
Normal	53	40.8	
Overweight	42	32.3%	
Obese 1	25	19.2%	
Obese 2	4	3.1%	
Length of hospital stay, days			3 (0 – 20)
TIMI Flow			3 (1 – 3)
Weight (Kg)			60 (40 – 87)
Height (cm)			165 (145 – 180)
BMI			23.44 (17.58 – 33.20)

Duration of IGD-wire crossing (hours- minutes)	10:34 (1:02 – 23:52)

STEMI: ST-Segment Elevation Myocardial Infarction; TIMI: Thrombolysis in Myocardial Infarction; BMI: Body Mass Index

cardiovascular risk factors included smoking (109 patients, 83.8%), hypertension (68 patients, 52.3%), and diabetes mellitus (46 patients, 35.4%).

During one year of follow-up, 10 patients (7.7%) experienced MACE, whereas 120 patients (92.3%) remained free from MACE. The overall proportion of patients with and without MACE during follow-up is illustrated in Figure 1.

The distribution of individual MACE components is presented in Figure 2. All-cause mortality was the most frequent event, occurring in 4 patients (3.1%). This was followed by acute pulmonary edema in 3 patients (2.3%), non–STEMI in 2 patients (1.5%), and stroke in 1 patient (0.8%). No rehospitalization due to recurrent STEMI was observed during the one-year follow-up period.

Time to reperfusion was assessed using door-to-wire-crossing time, defined as the interval from patient arrival at the emergency department to successful guidewire passage across the culprit coronary lesion during PCI. The median door-to-wire-crossing time was 10 hours 34 minutes (range: 1:02–23:52). Comparison between patients who experienced MACE and those who did not showed no statistically significant difference in door-to-wire-crossing time. Median times were 10:12 hours (3:11–23:30) in the MACE group and 10:47 hours (1:02–23:52) in the non-MACE group (p = 0.927, Mann–Whitney U test). Detailed results of this analysis are presented in Table 2.

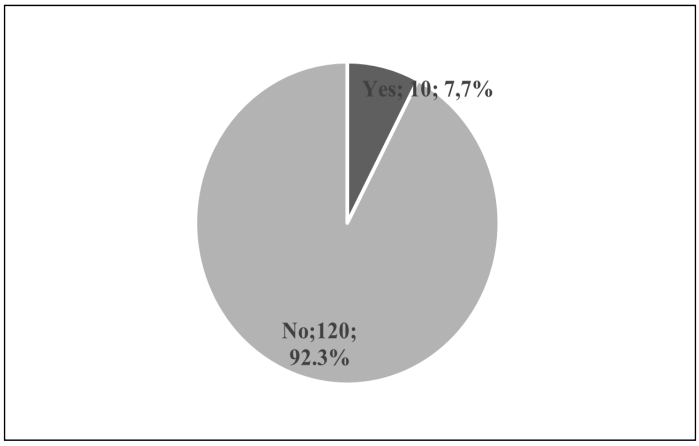

Figure 1. One-year incidence of MACE after delayed PCI.

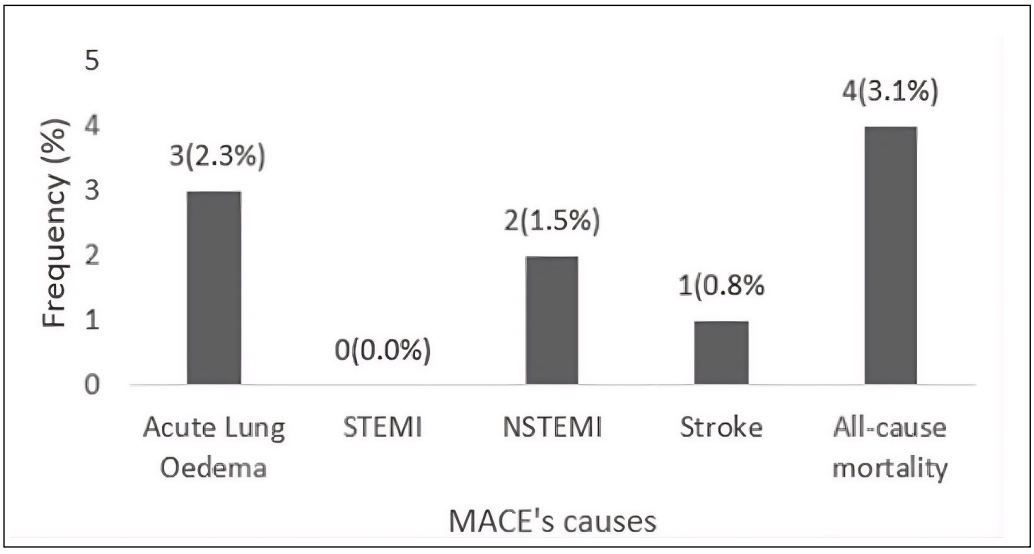

Figure 2. Distribution of MACE components.

Table 2. Association between door-to-wire-crossing time and one-year MACE occurrence.

	MACE at 1 Year		
	Yes	**No**	**p**
Door-to-wire-crossing time, (hours:minutes); median (min-max)	10:12 (3:11-23:30)	10:47 (1:02-23:52)	0.927

Chi-Square, Fisher exact, Mean ± SD: Independent T test; Median (min-max): Mann Whitney. MACE: Major Adverse Cardiac Events.

To further characterize the temporal pattern of MACE occurrence, Kaplan–Meier survival analysis was performed. The Kaplan–Meier curve demonstrated a high cumulative event-free survival during the one-year follow-up period, with only a modest decline observed in the early months after PCI. At one year, 92.3% of patients remained free from MACE (Figure 3). Censored observations represent patients without events at the last follow-up.

Discussion

This study evaluated one-year clinical outcomes among patients with STEMI who underwent PCI at PKU Muhammadiyah Gamping Hospital, most of whom received delayed PCI. MACE occurred in 10 patients (7.7%), while 120 patients (92.3%) remained event-free during follow-up. These findings reflect outcomes in a selected population of clinically stable patients who survived to undergo delayed PCI.

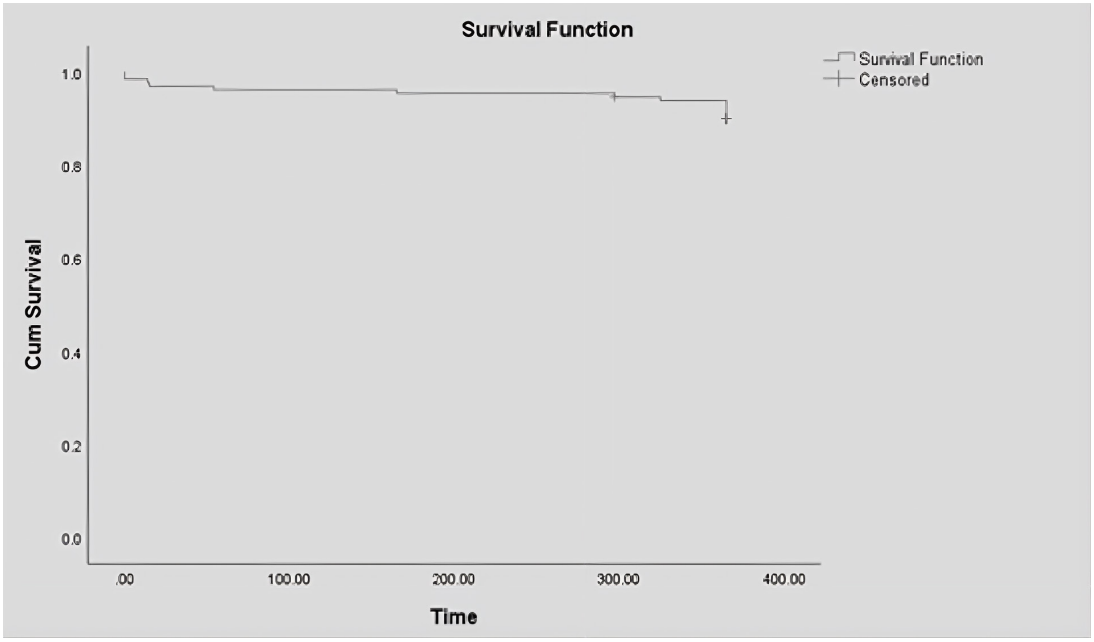

Figure 3. Kaplan-Meier curve of MACE-free survival during one-year follow-up.

The observed MACE rate in this cohort is comparable to previously reported one-year incidences among selected delayed-PCI or late-presenting STEMI populations.[10-11] Similar outcomes have also been reported in low-risk STEMI cohorts, in which delayed and early invasive strategies yielded comparable short-term and mid-term clinical results.[6] The consistent application of guideline-directed medical therapy may have contributed to favorable outcomes, as prior studies demonstrated that high adherence to optimal medical therapy significantly reduces post-PCI MACE risk.[12] In addition, preserved coronary collateral flow has been associated with smaller infarct size and improved ventricular recovery, potentially mitigating adverse outcomes despite delayed reperfusion.[13]

The Mann–Whitney analysis demonstrated no statistically significant association between door-to-wire-crossing time and one-year MACE occurrence ($p = 0.927$; Table 2). However, this finding should be

interpreted cautiously. The small number of MACE events (n = 10) limits statistical power and increases the risk of type II error. Therefore, the absence of statistical significance does not imply equivalence between delayed and guideline-recommended early PCI strategies.[1]

Kaplan–Meier analysis further showed that 92.3% of patients remained free from MACE at one year (Figure 3). This pattern suggests sustained clinical stability among patients who underwent PCI in this cohort, most of whom received delayed PCI. Previous studies have reported that rehospitalization after PCI is often driven by recurrent symptoms and baseline disease severity.[14] Early discharge strategies have also been shown to be safe in carefully selected low-risk STEMI patients, emphasizing the importance of patient selection in determining outcomes.[14] These studies underscore the importance of early and effective intervention in STEMI patients to reduce the incidence of rehospitalization due to MACE.

Several methodological considerations should be taken into account when interpreting these findings. PKU Muhammadiyah Gamping Hospital operates as a Type-B facility with PCI capability, and institutional referral pathways during the study period prioritized early transfer of clinically unstable or high-risk STEMI patients to tertiary centres. Consequently, patients who underwent PCI at this institution predominantly represented a clinically stable cohort, which may partly explain the relatively low observed one-year MACE rate and may limit generalizability to broader STEMI populations or true Type-C hospital settings.

In addition, the retrospective design introduces inherent survivorship bias. The study population was restricted to patients who survived long enough to receive PCI, thereby excluding early mortality occurring during prolonged ischemia. As a result, the present findings primarily reflect outcomes among patients who reached PCI alive and clinically stable, and the overall risk associated with delayed PCI in unselected STEMI populations may be underestimated.

The limited number of MACE events in this study reduces the statistical power to detect potential associations between reperfusion delay and clinical outcomes. Therefore, the absence of a statistically significant association should be interpreted with caution and does not exclude the possibility of a clinically meaningful effect.

Current guidelines consistently emphasize the importance of minimizing total ischemic time in STEMI management.[15–18] Prolonged ischemia has been associated with increased mortality and higher MACE rates in both short- and long-term follow-up.[19–21] Nevertheless, delayed PCI remains common in resource-limited settings due to patient-related and system-level barriers.[5,17] Emerging evidence suggests that delayed PCI may still offer clinical benefit compared with OMT alone in selected late presenter.[11,20] The present study adds context-specific data to this evolving evidence base.

Overall, these findings indicate that delayed PCI, which predominated in this cohort, may be feasible in carefully selected, clinically stable STEMI patients treated in a resource-limited hospital setting when timely reperfusion cannot be achieved. However, the present results do not support non-inferiority or equivalence to guideline-recommended early PCI strategies. Further prospective studies with larger sample sizes and comparative designs are warranted to better define the optimal management of late-presenting STEMI in resource-limited settings.

Conclusion

In this cohort of clinically stable STEMI patients who underwent PCI at a Type-B hospital, most of whom received delayed PCI, the one-year incidence of MACE was 7.7%. No statistically significant association was found between door-to-wire-crossing time and MACE; however, this result should be interpreted cautiously due to the limited number of events. These findings suggest that delayed PCI, which was the predominant treatment pattern in this cohort, may be feasible in selected patients when timely reperfusion is not achievable, but they do not support equivalence to guideline-recommended early PCI. Further studies with larger sample sizes and comparative designs are needed to clarify the long-term outcomes of delayed PCI in resource-limited settings.

List of Abbreviations

MACEs Major Adverse Cardiac Events
PCI Percutaneous Coronary Intervention
OMT Optimal Medical Therapy
STEMI ST-Elevation Myocardial Infarction

Ethical Clearance

The design and conduct of the study were approved by the Local Ethics Committee of PKU Muhammadiyah Gamping Hospital (094/KEP-PKU/III/2022). The requirement for informed

consent was waived due to the retrospective nature of the study.

Publication Approval

All authors have critically reviewed, approved the final version, and agreed the publication of this manuscript.

Authors Contributions

GBP and NM conceived the study and designed the methodology. GBP and NM were responsible for project development and data collection. GBP conducted the statistical analysis and prepared the initial manuscript draft. NM contributed to data interpretation and manuscript preparation. FM and MKA contributed to project development and assisted in manuscript writing and revision. All authors reviewed and approved the final version of the manuscript.

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Conflict of Interest

The authors declare that they have no competing interests.

Availability of Data and Materials

The datasets generated and/or analyzed during the current study are not publicly available due to patient privacy and institutional data protection restrictions at a single participating center. Data are available from the corresponding author upon reasonable request.

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Generative AI and AI-Assisted Technologies in the Writing Process

Artificial intelligence–based tools, including large language models, were used during the writing and revision process to support language enhancement, proofreading, and structural clarity. All AI-assisted content was carefully reviewed and edited by the authors. The scientific content, data analysis, and conclusions remain entirely the work of the authors, who take full responsibility for the final manuscript.

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