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Original Article

On-Hours Versus Off-Hours Primary PCI for STEMI: Outcomes in a Real-World Tertiary Hospital Cohort

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Abstract

Background: Primary Percutaneous Coronary Intervention (pPCI) is the preferred reperfusion strategy in ST-elevation myocardial infarction (STEMI). However, concerns remain regarding potential delays and adverse outcomes during off-hours (nights, weekends, and holidays). This study compared clinical outcomes between on-hours and off-hours pPCI, focusing on Door-to-Balloon (D2B) time and Major Adverse Cardiovascular Events (MACE).

Methods: We conducted a single-center retrospective cohort study of consecutive patients with ST-Elevation Myocardial Infarction (STEMI) who underwent pPCI at Harapan Kita National Cardiovascular Center, Jakarta, Indonesia, between January 2023 and April 2024. On-hours were weekdays 08:00–20:00; all other times were off-hours. Only hemodynamically stable STEMI patients were included. The primary outcome was D2B time, and the secondary outcome was 1-year MACE, defined as a composite of urgent revascularization, recurrent myocardial infarction, cardiovascular death, or stroke/Transient Ischemic Attack (TIA). Continuous variables were compared using the Mann–Whitney U test, and categorical variables using the chi-square test. Logistic regression analysis was performed to assess the association between off-hours PCI and clinical outcomes.

Results: Among 287 patients, 98 presented during on-hours and 189 during off-hours. Baseline age was similar (median 55–56 years). Median D2B time was shorter on off-hours: 80 [Interquartile Range (IQR) 70–104] vs 89 [74–121] minutes (p=0.018). The proportion achieving D2B <90 minutes did not differ (63.5% vs 58.2%; p=0.443). At 1 year, MACE rates were comparable (14.8% off-hours vs 17.3% on-hours, p=0.576), with no significant differences across individual components.

Conclusions: In this real-world cohort from a tertiary cardiac hospital in Indonesia, off-hours presentation was associated with faster D2B times and no increase in 1-year MACE, suggesting consistent quality and efficiency of STEMI care across all hours.

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Introduction

ST-Elevation Myocardial Infarction (STEMI) remains one of the leading causes of cardiovascular morbidity and mortality worldwide. Primary Percutaneous Coronary Intervention (pPCI) is the preferred reperfusion strategy. The timing of treatment is crucial for positive outcomes and the minimization of treatment delay, particularly Door-to-Balloon (D2B) time, to improve patient survival and clinical outcomes. While several factors affect treatment timing, delays in the emergency system play a crucial role. Optimizing time-based performance indicators has therefore become a central focus in STEMI management.[1-2]

However, concerns remain regarding potential delays and adverse outcomes during off-hours (nights, weekends, and holidays). Presentations during "off-hours" have been associated with operational challenges, including reduced staffing, delays in catheterization laboratory activation, and longer D2B times compared with "on-hours" (regular weekday hours). These operational discrepancies have raised concerns that off-hours presentation could prolong D2B time and potentially compromise clinical outcomes for STEMI patients.[3-4]

The evidence remains inconsistent; some studies report worse outcomes with off-hours presentations, whereas others do not observe a significant difference in mortality or Major Adverse Cardiovascular Events (MACE). This difference highlights a clear gap in current knowledge, particularly regarding real-world tertiary referral centers that manage high volumes of emergency cardiovascular cases. Few studies have comprehensively evaluated how the timing of PCI (on-hours versus off-hours) influences both reperfusion time performance indicators and associated clinical results in these environments.[5-6]

The primary objective of this study was to evaluate system-level performance, as measured by D2B time, between off-hours and on-hours pPCI. Secondary objectives included the assessment of clinical outcomes to explore the potential clinical implications of differences in D2B time. The study hypothesizes that patients who attend during off-hours may have longer D2B time than those who present during on-hours.

Methods

Study Design and Population

We conducted a single-center retrospective cohort of 287 consecutive STEMI patients undergoing pPCI at National Cardiovascular Center Harapan Kita (Jakarta, Indonesia) between January 2023 and April 2024. On-hours were weekdays 08:00–20:00; all other times were off-hours. Primary outcomes were D2B time, and secondary outcomes were 1-year MACE (urgent revascularization, recurrent myocardial infarction, cardiovascular death, or stroke/Transient Ischemic Attack [TIA]).

A total of 870 STEMI patients were screened during the study period. Patients who did not undergo primary PCI (n = 240) were excluded. Additional exclusions included cardiogenic shock at presentation (n = 71), in-hospital mortality (n = 56), and incomplete or missing data (n = 343). The final study population consisted of 287 STEMI patients who underwent primary PCI and had complete clinical and procedural data.

Inclusion and Exclusion Criteria

Inclusion criteria were patients ≥18 years old and those diagnosed with ST-segment elevation myocardial infarction (STEMI) who underwent pPCI (primary PCI). Patients who experienced cardiogenic shock during the same hospitalization as the index procedure were excluded. We also excluded patients who died during the same hospitalization as the index procedure, as well as patients with incomplete MACE data.

Data Collection

Baseline characteristics, clinical presentations (onset of symptoms, Killip class, and Thrombolysis In Myocardial Infarction [TIMI] Risk score), and D2B time data were obtained from the Electronic Medical Record (EMR) and the cath lab registry. MACE data were retrieved from the EMR; if any information was incomplete, additional data were obtained via telephone follow-up. At least two attempts were made to contact by telephone. Patients who could not be reached by telephone and had no available EMR follow-up data were considered lost to follow-up and were excluded from the 1-year MACE analysis.

Statistical Analysis

Statistical analysis was performed using SPSS Version 26.0, with descriptive statistics and inferential tests to analyze the data, with $p < 0.05$ considered statistically significant. Continuous variables were compared using the Mann–Whitney test, and categorical variables using χ^2 tests. Logistic regression analysis was performed to explore factors associated with the composite and individual components of 1-year MACE and to assess the association between off-hours presentation and clinical outcomes.

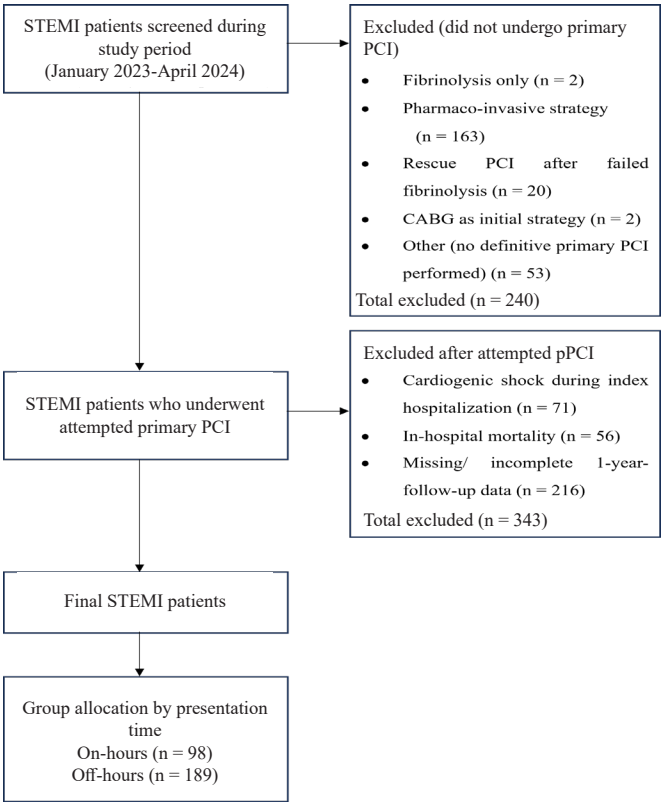


Figure 1. Study Flow Diagram
Each patient was counted once only, based on the primary reason for exclusion.

Results

This study primarily evaluated system-level performance using D2B time as the primary outcome. The median D2B time was slightly shorter in the off-hours group compared with the on-hours group. Clinical outcomes were assessed as secondary outcomes, and the rates of 1-year MACE were comparable between the two groups.

A total of 287 patients with STEMI who underwent pPCI were included in the analysis, of whom 189 (65.8%) presented during off-hours and 98 (34.1%) during on-hours.

Baseline Characteristics

The median age of the study population was 56 years (Table 1), with similar median ages between the two groups: 55 years in the off-hours group versus 56 years in the on-hours group, with no significant differences observed (Table 2). In terms of sex, the majority of patients were male (87.5%), with 90.5% in the off-hours group and 81.6 % in the on-hours group. Male sex and smoking history were more prevalent in the off-hours group, while other baseline clinical characteristics were similar between the two groups.

Regarding cardiovascular risk factors, hypertension was the most prevalent condition (65.2%), followed by hyperlipidemia (47.7%) and type 2 diabetes mellitus (33.9%). A family history of coronary artery disease was present in 31 patients (11.1%), while chronic kidney disease was identified in 10 patients (3.5%). However, smoking history was significantly more prevalent in the off-hours group (69.7% vs. 57.1%, p = 0.034).

Clinical Presentations

This cohort had a median onset of symptoms of 6 hours, with more than 80% patients presenting with Killip I class and a median TIMI Risk score of 3. No significant differences in clinical presentations were found between the off-hours and on-hours groups.

Primary PCI & Clinical Outcomes

Median D2B time was shorter on off-hours: 80 [IQR 70–104] vs 89 [74–121] minutes (p=0.018). The proportion achieving D2B ≤90 minutes did not differ (63.5% vs 58.2%; p=0.443). In terms of clinical outcomes within one year, no statistically significant differences were observed between off-hours and

Table 1. Baseline characteristics.

Characteristics	Total (n=287)
Age, y, median (Q1-Q3)	56 (49–62)
Male, n (%)	215 (87.5)
Risk factors, n (%)	
Family History	31 (11.1)
Hypertension	187 (65.2)
Hyperlipidemia	137 (47.7)
Type 2 DM	87 (33.9)
Chronic Kidney Disease	10 (3.5)
Cigarette smoking	187 (65.2)
Clinical presentations	
Onset of symptoms, hours, median (Q1-Q3)	6.0 (4.0–9.0)
Killip class, n (%)	
I	240 (83.9)
II	43 (15.0)
III	3 (1.0)
TIMI Risk score, median (Q1-Q3)	3 (2–5)
Primary PCI	
D2B, min, median (Q1-Q3)	83 (71–109)
D2B <90 mins	177 (61.7)

*DM: Diabetes Mellitus; PCI: Percutaneous Coronary Intervention; D2B: Door-to-Balloon Time; CKD: Chronic Kidney Disease; TIMI: Thrombolysis In Myocardial Infarction.

Table 2. Comparison of baseline characteristics, door-to-balloon time, and clinical outcomes between off-hours and on-hours PCI.

Characteristics	Off-Hours (n=189)	On-Hours (n=98)	P-Value
Age, y, median (Q1-Q3)	55 (49–62)	56 (50–63)	0.342
Male, n (%)	171 (90.5%)	80 (81.6%)	0.032
Risk factors, n (%)			
Family History	23 (12.2)	9 (9.2)	0.437
Hypertension	118 (62.8)	69 (70.4)	0.197
Hyperlipidemia	91 (48.4)	46 (46.9)	0.814
Type 2 DM	68 (36.2)	29 (29.6)	0.265
CKD	6 (3.2)	4 (4.1)	0.697
Smoking history	131 (69.7)	56 (57.1)	0.034
Clinical presentations			
Onset of symptoms, hours, median (Q1-Q3)	6.5 (4.0–9.0)	6.0 (4.0–8.5)	0.767
Killip class, n (%)			0.488
I	159 (84.6)	81 (82.7)	
II	28 (14.9)	15 (15.3)	
III	1 (0.5)	2 (2.0)	
TIMI Risk score, median (Q1-Q3)	3 (2–5)	4 (3–5)	0.484
Primary PCI			
D2B time, min, median (Q1-Q3)	80 (70–104)	89 (74–121)	0.018

D2B time ≤90 mins, n (%)	120 (63.5)	57 (58.2)	0.443
Clinical outcomes, n (%)			
Composite of MACE	28 (14.8)	17 (17.3)	0.576
Urgent revascularization	14 (7.4)	7 (7.1)	0.935
Cardiovascular death	4 (2.1)	2 (2.0)	0.966
Acute MI	20 (10.6)	13 (13.3)	0.499
Stroke or TIA	5 (2.6)	2 (2.0)	0.753

*DM: Diabetes mellitus; PCI: Percutaneous Coronary Intervention; D2B: Door To Balloon Time; CKD: Chronic Kidney Disease; MACE: Major Adverse Cardiovascular Events; MI: Myocardial Infarction; TIA: Transient Ischemic Attack.

Table 3. Risk factors for the composite of major adverse cardiovascular events.

Characteristics	OR (95% CI)	P-Value
Age	1.02 (0.99–1.06)	0.206
Male	0.29 (0.07–1.23)	0.092
Family History	0.33 (0.08–1.42)	0.136
Hypertension	0.95 (0.49–1.86)	0.885
Hyperlipidemia	0.94 (0.50–1.78)	0.857
Type 2 DM	0.97 (0.49–1.90)	0.928
CKD	2.39 (0.59–9.60)	0.220
Smoking history	1.55 (0.76–3.16)	0.225
Clinical presentations		
Onset of symptoms	1.05 (0.99–1.10)	0.054
Killip class (ref. class I)		
II	1.07 (0.44–2.58)	0.886
III	2.74 (0.24–31.03)	0.415
TIMI Risk score	1.09 (0.92–1.30)	0.330

*OR: odds ratio; CI: confidence interval; DM: diabetes mellitus; CKD: chronic kidney disease.

Table 4. Logistic regression analysis of off-hours PCI on major adverse cardiovascular events.

Characteristics	OR (95% CI)	P-Value
Composite of MACE	1.21 (0.62–2.33)	0.576
Urgent revascularization	0.96 (0.38–2.47)	0.935
Cardiovascular death	0.96 (0.17–5.36)	0.966
Acute MI	1.29 (0.62–2.72)	0.500
Stroke or TIA	0.77 (1.47–4.03)	0.753

*OR: odds ratio; CI: confidence interval; MACE: major adverse cardiovascular event; MI: myocardial infarction; TIA: transient ischemic attack.

on-hours groups in composite MACE (14.8% vs. 17.3%, p = 0.576), urgent revascularization (7.4% vs. 7.1%, p = 0.935), cardiovascular death (2.1% vs. 2.0%, p = 0.966), acute myocardial infarction (10.6% vs. 13.3%, p = 0.499), or stroke/TIA (2.6% vs. 2.0%, p = 0.753). In logistic regression analysis evaluating predictors of the composite of 1-year MACE, no individual baseline clinical or presentation variable demonstrated a statistically significant association with the outcome (Table 3). In a separate regression analysis examining the association between timing of presentation and clinical outcomes, off-hours pPCI was not associated with an increased risk of composite MACE compared with on-hours presentation (OR 1.21, 95% CI 0.62–2.33; p = 0.576) (Table 4). No significant associations were observed between off-hours presentation and individual MACE components.

Discussion

This study aimed to evaluate whether there were differences in D2B time between the off-hours and on-hours groups, and to assess whether there were differences in MACE between the two groups in the National Cardiovascular Center Harapan Kita, Jakarta, Indonesia. Our analysis of 287 patients revealed several key findings. The predominance of STEMI patients presenting during off-hours (66% of the cohort) is inconsistent with a previous study, of which STEMI onset frequently occurred between morning and noon.[7-8]

An especially important result of this study is that the median D2B time was significantly shorter during off-hours (80 minutes) than during on-hours (89 minutes) (p=0.018). Our study was inconsistent with several studies from other countries, which reported that D2B time during off-hours was longer than during on-hours.[9-10] During off-hours, no elective procedures are scheduled, and the catheterization laboratory team is on standby for emergency activation, allowing immediate cath-lab availability. In contrast, during on-hours, high elective procedure volume and emergency department crowding may contribute to workflow delays before primary PCI initiation.

While the median D2B time difference was statistically significant, it is important to emphasize that the proportion of patients achieving the recommended guideline target of D2B time ≤90 minutes was comparable between the two groups (63.5% in the Off-Hours group vs. 58.2% in the On-Hours group, p = 0.443). This suggests that, although off-hours showed a slight institutional advantage in median D2B time, both time periods were equally effective at achieving this important reperfusion target for most patients.

In this study, we observed no significant differences in 1-year clinical outcomes between patients undergoing pPCI during off-hours compared with those treated during on-hours. Rates of composite MACE, urgent revascularization, cardiovascular death, recurrent myocardial infarction, and stroke/TIA were comparable between the two groups, suggesting that off-hours presentation did not adversely affect long-term outcomes. This finding is consistent with several previous studies, which also reported no significant differences in MACE outcomes and mortality between off-hours and on-hours pPCI.[11-13] These findings indicate that off-hours presentation does not negatively impact long-term clinical outcomes for STEMI patients undergoing pPCI.

The findings of this study primarily reflect system-level performance and clinical outcomes among stable STEMI patients undergoing pPCI. Patients with cardiogenic shock or severe hemodynamic instability were excluded; therefore, the results should be interpreted in this context.

Study Limitations

This study has several limitations. First, it is a single-center retrospective study, which may limit generalizability and introduce selection or information bias. Second, only hemodynamically stable STEMI patients were included in the analysis, which may further limit the applicability of our findings to higher-risk populations, such as those presenting with cardiogenic shock.

Third, a substantial proportion of patients were lost to follow-up because they had difficulty answering phone calls from unknown numbers despite prior contact via text messages, which may introduce attrition bias and limit the interpretation of long-term clinical outcomes. Further limitations include the fact that the definition of off-hours was based on our local cath lab operations and may not reflect practices at other centers.

Additionally, overall mortality may also be underestimated, as patients who died before or during transfer from non-PCI hospitals were not included. Additionally, the study focused only on management up to pPCI and did not evaluate post-procedural guideline-directed therapies that may influence outcomes. Finally, the relatively small sample size may limit the statistical power to detect differences in infrequent outcomes such as MACE.

Conclusion

In this real-world cohort from a tertiary cardiac hospital in Indonesia, off-hours presentation was associated with faster D2B times and no increase in 1-year MACE, suggesting consistent quality and efficiency of STEMI care across all hours. Further multicenter studies are warranted to validate these results and to explore system-level factors that contribute to workflow performance across different healthcare settings.

List of Abbreviations

D2B	Door-to-Balloon
EMR	Electronic Medical Record
IQR	Interquartile Range
MACE	Major Adverse Cardiovascular Events
pPCI	Primary Percutaneous Coronary Intervention

STEMI ST-Elevation Myocardial Infarction
TIA Transient Ischemic Attack
TIMI Thrombolysis In Myocardial Infarction

Ethical Clearance

The study was approved by the Committee on Institutional Review Board/Health Research Ethics of National Cardiovascular Center Harapan Kita Hospital, under approval number DP.04.03/KEP191/EC128/2026.

Publication Approval

All authors have reviewed and approved the final version of the manuscript and agree with its submission.

Authors' Contributions

RS contributed to the study conceptualization, methodology, data collection, and manuscript drafting. DF contributed to study supervision, methodology, and critical revision of the manuscript. DVC contributed to data curation, data analysis, and manuscript review. CR contributed to data collection, data curation, and manuscript review. All authors critically reviewed and approved the final version of the manuscript.

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Conflict of Interest

We declare no conflicts of interest.

Availability of Data and Materials

Not applicable.

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Copyright/Permissions for Figures

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Generative AI and AI-Assisted Technologies in the Writing Process

ChatGPT (OpenAI) was used solely for language editing, grammar correction, and improving the clarity and readability of the manuscript. All scientific content, data analysis, interpretation, and conclusions were performed and verified by the authors.

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