ORIGINAL ARTICLE

Impact of Off-Hour Versus Work-Hour Presentation on Clinical Outcomes in Acute STEMI Patients Treated With Primary PCI: A Retrospective Analysis

Primer PCI ile Tedavi Edilen Akut STEMI Hastalarında Mesai Saatleri Dışında Başvurunun Klinik Sonuçlara Etkisi: Retrospektif Bir Analiz

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Abstract: For patients with ST-segment elevation myocardial infarction (STEMI), optimal reperfusion timing is crucial for positive outcomes. The existence of treatment delays or disparities in outcomes for off-hours presentations is still debated. This study examined how the timing of hospital presentation (working hours vs. off-hours) affects procedural efficiency and early clinical outcomes in patients with ST-segment elevation myocardial infarction (STEMI) undergoing primary percutaneous coronary intervention (PCI). This retrospective, single-center study examined 186 consecutive adult STEMI patients who were treated with primary PCI between January and December 2023. Patients were divided into two groups based on their time of admission: working hours (8:00 a.m.–5:00 p.m. on weekdays; n = 54) and off-hours (5:00 p.m.–8:00 a.m. on weekends and holidays; n = 132). Door-to-balloon time (DTB), PCI duration, left ventricular ejection fraction (EF), length of stay (LOS) and in-hospital mortality were compared. DTB ≤ 60 minutes was achieved in 86.1% of all patients, with no difference between the two groups (working vs. off-hours: 87.0% vs. 85.6%; p=0.909). However, the duration of PCI was significantly longer during off-hours (43.00 ± 24.87 minutes vs. 32.13 ± 17.05 minutes; p = 0.001). There were no statistically significant differences in in-hospital mortality (6.82% vs. 7.41%; p = 1.000), ejection fraction (EF), or length of stay (LOS). Despite the longer PCI times during off-hours, the early clinical outcomes were equivalent to those during working hours. This underscores the importance of dedicated 24/7 STEMI protocols with robust PCI infrastructure in providing consistent, high-quality care regardless of admission time. Streamlining off-hours workflows could further optimize procedural efficiency within emergency cardiovascular systems.

Keywords: ST-segment elevation myocardial infarction, primary PCI, door-to-balloon time, off-hours, emergency cardiology, reperfusion therapy

Özet: ST segment yükselmesi olan miyokard enfarktüsü (STEMI) hastalarında, olumlu sonuçlar için optimal reperfüzyon zamanlaması çok önemlidir. Mesai saatleri dışında başvurularda tedavi gecikmeleri veya sonuçlarda farklılıklar olup olmadığı hala tartışılmaktadır. Bu çalışma, hastaneye başvuru zamanının (çalışma saatleri ve çalışma dışı saatlerde) ST segment yükselmeli miyokard enfarktüsü (STYMI) geçiren ve primer perkütan koroner girişim (PKG) uygulanan hastalarda prosedür verimliliğini ve erken klinik sonuçları nasıl etkilediğini incelemiştir. Bu retrospektif, tek merkezli çalışmada, Ocak ve Aralık 2023 tarihleri arasında birincil PKG ile tedavi edilen 186 ardışık yetişkin STYMI hastası incelenmiştir. Hastalar, kabul saatlerine göre iki gruba ayrıldı: çalışma saatleri (hafta içi 08:00-17:00; n = 54) ve çalışma dışı saatler (hafta sonu ve tatil günleri 17:00-08:00; n = 132). Kapı-balon süresi (KBS), PCI süresi, sol ventrikül ejeksiyon fraksiyonu (EF), yatış süresi (LOS) ve hastane içi mortalite karşılaştırıldı. Tüm hastaların %86,1'inde DTB ≤ 60 dakika elde edildi ve iki grup arasında fark yoktu (çalışma saatleri içinde ve dışında: %87,0 ve %85,6; p=0,909). Ancak, PKG süresi mesai saatleri dışında önemli ölçüde daha uzundu (43,00 ± 24,87 dakika karşı 32,13 ± 17,05 dakika; p = 0,001). Hastane içi mortalite (6,82% vs. 7,41%; p = 1,000), ejeksiyon fraksiyonu (EF) veya yatış süresi (LOS) açısından istatistiksel olarak anlamlı bir fark yoktu. Mesai dışı saatlerde PCI sürelerinin daha uzun olmasına rağmen, erken klinik sonuçlar mesai saatlerindeki sonuçlarla eşdeğerdi. Bu durum, yatış saatinden bağımsız olarak tutarlı ve yüksek kaliteli bakım sağlamak için sağlam PCI altyapısına sahip 7/24 STEMI protokollerinin önemini vurgulamaktadır. Mesai dışı saatlerdeki iş akışlarının düzene sokulması, acil kardiyovasküler sistemlerdeki prosedür verimliliğini daha da optimize edebilir.

Anahtar Kelimeler: ST-segment elevasyonlu miyokard enfarktüsü, primer PKG, kapı-balona süre, mesai dışı saatler, acil kardiyoloji, reperfüzyon tedavisi

1. Introduction

ST-segment elevation myocardial infarction (STEMI) represents the most severe manifestation of acute coronary syndrome (ACS) and is associated with the highest rates of morbidity and mortality among acute cardiac events (1). Without prompt intervention, this ischemic event can rapidly progress to irreversible myocardial necrosis. Delays in treatment can result in serious complications or even death. Therefore, time is a critical factor in the effective management of STEMI: an early diagnosis and the rapid initiation of appropriate therapy are key to improving patient prognosis (2).

STEMI is primarily diagnosed based on the presence of characteristic ST-segment elevation on a 12-lead electrocardiogram (ECG). This diagnosis is supported by clinical findings and the evaluation of cardiac biomarkers. Cardiac troponins, particularly troponin T and troponin I, are highly specific indicators of myocardial injury. This biomarkers enhance diagnostic accuracy and provide prognostic information regarding disease severity and the risk of adverse outcomes (3).

The primary goal of STEMI treatment is to promptly restore myocardial perfusion by reperfusion of the occluded coronary artery. Two main reperfusion strategies are employed for this purpose: primary percutaneous coronary intervention (PCI) and thrombolytic therapy. Primary PCI involves mechanically reopening the blocked artery, typically with stent implantation, while thrombolytic therapy aims to dissolve the clot pharmacologically. However, mortality and morbidity rates among STEMI patients remain high even with timely reperfusion, emphasizing the importance of rapid and effective management in emergency care settings (2).

In recent years, numerous studies have investigated whether treatment outcomes and process times differ between in-hours and off-hours presentations (4,5). Some reports suggest that patients presenting during off-hours may experience longer door-to-balloon times and higher short-term mortality due to reduced staff availability and slower activation of catheterization laboratory teams (6).

Evaluating process efficiency and early outcomes during off-hours is critical, as potential variations in workflow and resources could impact the delivery of time-sensitive interventions like primary PCI. Assessing these metrics help ensure consistent, high-quality care is maintained 24/7, which is a fundamental aspect of STEMI management systems.

2. Materials and Method

Study Design and Setting

This retrospective study aimed to evaluate the impact of healthcare services delivered during working hours versus off-working hours on the early prognosis of patients presenting to the Emergency Department of Eskişehir Osmangazi University Hospital with a diagnosis of STEMI, who then underwent primary PCI, between January 1 and December 31, 2023. Ethical approval for the study was obtained from the Clinical Research Ethics Committee of Eskişehir Osmangazi University Faculty of Medicine dated January 16, 2024(Approval No: 03).

Eskişehir Osmangazi University Hospital is a tertiary care center with 1,200 beds and 24/7 availability of all vascular interventional services. All patients suspected of having STEMI were triaged to a monitored resuscitation area within the Emergency Department (ED). During working hours, emergency medicine specialists and senior residents assessed patients, initiated diagnostic procedures and contacted the cardiology team. The on-call cardiology team, available 24/7, consisted of a cardiologist, an interventional cardiologist, an emergency physician, a nurse, and radiology staff. During off-hours, emergency medicine residents initiated initial patient management and informed the on-call emergency medicine specialist and interventional cardiologist, thereby activating the cardiology team immediately.

Patients diagnosed with STEMI who were eligible for primary PCI were treated according to contemporary international guidelines (7). The hospital was equipped to perform PCI procedures around the clock, both during and outside regular working hours. After the procedure, patients were admitted to the Coronary Care Unit, where they received continuous monitoring and advanced care. During follow-up, transthoracic echocardiography and additional imaging were performed as needed.

Study population selection

All patients were evaluated by the ED team upon presentation and received prompt initial treatment. Patients with suspected STEMI underwent an immediate ECG along with concurrent measurement

of cardiac biomarkers (Troponin I/T and CK-MB). Those exhibiting ST-segment elevation on ECG and receiving a clinical diagnosis of STEMI were assessed for eligibility to undergo primary PCI. Upon confirmation of STEMI, the cardiology team was activated to determine an individualized treatment strategy.

The inclusion criteria for the study were as follows: age 18 years or older; a confirmed diagnosis of STEMI; and having undergone primary PCI at the hospital's catheterization laboratory.

Patients were excluded from the study if they met any of the following criteria: death prior to or during the initial ED evaluation; pregnancy; transfer to another medical facility; refusal to undergo coronary angiography; or achieving return of spontaneous circulation (ROSC) after cardiac arrest..

Data collection

The following data were recorded for each patient included in the study: demographic characteristics, comorbid conditions, blood glucose levels at presentation, and key intervention times. Left ventricular ejection fraction was assessed using transthoracic echocardiography during the index hospitalization, prior to patient discharge. This measurement was used to evaluate the early impact of revascularization on myocardial function. Retrospective data analysis was conducted using data from the hospital's prospectively maintained cardiology database.

Study Endpoints

The primary outcome of this study was defined as in-hospital all-cause mortality. Time-related parameters were also analyzed, including symptom-to-intervention time, door-to-catheterization laboratory time, and door-to-balloon time. These variables were compared between two groups according to the time of hospital presentation: Group 1 (working hours: 08:00–17:00) and Group 2 (off-hours: 17:00–08:00, which included weekends and public holidays).

Statistical Analysis

The normality of the data distribution was assessed using the Shapiro-Wilk test. Categorical variables were expressed as frequencies and percentages (%). Comparisons of categorical data were performed using Pearson's chi-square test or Fisher's exact test, depending on the sample size; continuity correction was applied when necessary. For group comparisons of continuous variables, Welch's t-test was used when assumptions were met; otherwise, the Mann-Whitney U test was applied.

A p-value of less than 0.05 was considered statistically significant. Effect sizes were reported with 95% confidence intervals (CI); Cohen's d was calculated for continuous variables, while Cramer's V coefficient was used for categorical variables. All statistical analyses were conducted using IBM SPSS Statistics software (version 26; Chicago, IL, USA).

3. Results

A total of 89,393 patients presented to the ED during the study period, of whom 198 were diagnosed with STEMI. Twelve patients were excluded based on the predefined criteria: eight due to achieving ROSC after cardiac arrest and four due to transfer to another facility. Thus, the final analytical cohort comprised 186 patients. Of these, 54 (29.0%) presented during working hours and 132 (71.0%) presented during off-hours.

The median age of the included patients was 63.5 years (IQR: 56–72). Table 1 summarizes the demographic data, comorbidities, vital signs at admission, laboratory parameters, and echocardiographic findings.

ST-segment elevation was observed in the anterior leads in 40.3% of patients, in the inferior leads in 47.7%, in the lateral leads in 14.2%, in the posterior leads in 8.7%, in the right ventricular leads in 2.1%, and in lead aVR in 2.7%. No statistically significant differences were found in the distribution of ST elevation across these lead groups between the working hours and off-hours groups (p > 0.05).

Table 1. Comparison of Demographic Characteristics, Vital Signs, Risk Scores, Laboratory and Echocardiographic Findings

	Work hours n=54 (%)	Off hours n=132 (%)	p*
Gender. *Male*	46 (%85.18)	102 (%77.27)	0.310
Comorbidities			
History of Previous MI	14 (%25.93)	20 (%15.15)	0.129
HT	25 (%46.3)	66 (%50.38)	0.731
DM	16 (%29.63)	44 (33.33)	0.751
CAD	18 (%33.33)	34 (%25.76)	0.387
CHF	4 (%7.4)	9 (%6.82)	1.000
CRF	3 (%5.56)	3 (%2.27)	0.488
COPD	0 (%0)	6 (%4.54)	0.256
History of Stent Implantation	22 (%40.74)	39 (%29.54)	0.192
Vital Signs. *Median (IQR)*			
SBP (mmHg)	130 (120-130)	127 (120-130)	0.641
DBP (mmHg)	80 (72-80)	80 (75.75-80)	0.477
Heart Rate. beats/min)	78 (75-80)	80 (75-80)	0.967
Oxygen Saturation (SpO₂) (%)	97 (95-97)	97 (95-97)	0.699
Risk Scores. *Median (IQR)*			
TIMI Score	3 (1-4)	2.5 (1-4)	0.884
HEART Score	8 (6.25-8)	8 (7-9)	0.147
Laboratory Results. *Median (IQR)*			
Tropnonin I(ng/ml)	0.028 (0.014-0.081)	0.042 (0.019-0.157)	0.100
Pro-BNP (pg/ml)	746 (271.5-1792.5)	873 (330-3379.25)	0.412
Echocardiographic Findings *Median (IQR)*			
EKO-EF	50 (38.5-52)	46 (34-52.25)	0.228

*MI: Myocardial Infarction, DM: Diabete s Mellitus, CAD: Coronary Artery Disease, CHF: Congestive Heasr Failure, CRF: Chronic Renal Failure, COPD: Chronic Obstructive Pulmonary Disease, *Mann Whitney-U Testi was used*

Table 2. Comparison of Primary PCI Time Intervals Between Working Hours and Off-Hours

	Work Hours n=54 (%)	Off Hours n=132 (%)	
Length of Stay, days, median (IQR)	4 (3-5)	4 (3-5)	0.312
In-Hospital Mortality, n (%)	4 (%7.41)	9 (%6.82)	1.000

Presentations

The mean duration of primary PCI was 37.9 ± 22.9 minutes for the entire cohort. The procedure duration was significantly shorter during working hours compared to off-hours (30 versus 35 minutes, $p = 0.001$).

The median length of hospital stay was 4.0 days (IQR: 3.0–5.0) for patients with a DTB time of ≤60 minutes and 4.0 days (IQR: 3.0–6.0) for those with a DTB time of > 60 minutes, with no significant difference ($p = 0.293$). Similarly, the in-hospital mortality rates were 6.8% and 8.0% in these respective DTB groups, showing no statistically significant difference ($p = 1.000$). The overall mean length of stay was 4.8 ± 3.9 days. When analyzed by presentation time, the mean length of stay was 4.6 ± 2.6 days (median: 4) for the working hours group and 4.9 ± 4.7 days (median: 4) for the off-hours group, which was not a statistically significant difference ($p = 0.312$).

A total of 13 patients (7.06%) died during the in-hospital follow-up period. The in-hospital mortality rate was 7.41% for the working hours group and 6.82% for the off-hours group, with no statistically significant difference ($p = 1.000$) (Table 3).

Table 3. Comparison of Hospitalization Duration and In-Hospital Mortality Between Working-Hours and Off-Hours

		Work hours n=54 (%)	Off hours n=132 (%)	
Door-to-Balloon Time	≤60 min.	46 (%85.18)	115 (%87.12)	0,909
	>60 min.	8 (%14.82)	17 (%12.88)	
		Median (IQR)	Median (IQR)	
Primary PCI Duration. minutes		30 (20-40)	35 (30-50)	0.001

Presentations

4. Discussion

This study evaluated the impact of presentation time (during working hours versus off-hours) on key process metrics and early clinical outcomes among STEMI patients undergoing primary PCI at our institution. While no significant differences were observed in door-to-balloon (DTB) times or in-hospital mortality, the duration of primary PCI procedures was significantly longer during off-hours. This specific finding indicates a temporal disparity in procedural duration. Crucially, however, this delay did not translate into a detectable difference in early clinical outcomes, which were preserved under the existing institutional care model.

STEMI is characterized by acute transmural myocardial ischemia leading to myocardial injury or necrosis. According to the 2018 universal definition, the diagnosis is based on elevated cardiac biomarkers with concomitant ECG or clinical evidence of ischemia (8). Timely diagnosis and intervention are critical in ACS. The provision of consistent, high-quality STEMI care around the clock is increasingly achievable with structured protocols and 24/7 PCI capabilities.

Previous studies have reported conflicting findings regarding the impact of off-hours presentation in patients undergoing PCI. Some have associated off-hours care with delays in treatment and worse outcomes (9–12). A meta-analysis also confirmed that off-hours presentation was associated with longer door-to-balloon times and increased mortality. In contrast, other large-scale studies have demonstrated no significant difference in mortality or clinical outcomes (13–19). In our study, the comparable EF and mortality rates between groups suggest that robust institutional protocols effectively mitigated the potential impact of longer procedure times.

Our center achieved a DTB time of ≤60 minutes in 86.1% of patients, demonstrating adherence to international recommendations (20,21) . Despite longer PCI procedure times during off-hours, early outcomes such as EF and in-hospital mortality were comparable, indicating that robust systemic protocols can mitigate the impact of procedural delays.

The longer primary PCI durations observed during off-hours highlight a potential area for workflow optimization. Implementing strategies focused on improving team coordination, standardizing activation protocols, and optimizing off-hours staffing models could help mitigate these procedural delays.

Although procedural delays are known to negatively affect myocardial preservation (7) our study found no significant difference in EF between groups. This may be attributed to a well-organized healthcare infrastructure that mitigates time-related disadvantages. Our findings underscore the importance of systemic efficiency in minimizing the impact of procedural variability on clinical outcomes.

The observed ejection fraction values in our cohort, ranging between 40% and 50%, were consistent with those reported for STEMI patients following PCI (22), indicating preserved myocardial function and supporting the representativeness of our population.

That EF did not significantly differ between work-hour and off-hour groups suggests similar levels of myocardial salvage. This is consistent with previous literature showing that timely PCI helps preserve EF (7). Our findings further support the importance of effective revascularisation, regardless of timing. In line with previous studies, our results support the beneficial effects of prompt and effective revascularisation on myocardial recovery (23).

Door-to-balloon time is a well-recognized quality metric in STEMI care, strongly associated with improved myocardial preservation and clinical outcomes (20,24). In our cohort, however, no significant difference in ejection fraction or other clinical outcomes was observed between patients with a DTB time of ≤60 minutes and those with a DTB time of >60 minutes. The lack of a discernible association may be attributed to the overall high adherence to the target DTB time (86.1% of patients), which likely attenuated the potential impact of delays and resulted in a generally favorable outcome profile across both groups.

Contrary to the common trend observed in some studies, our data showed no significant difference in DTB time between the working-hours and off-hours groups. This indicates that emergency care standards and protocol adherence were commendably maintained throughout the 24-hour cycle, effectively mitigating potential resource limitations during off-hours.

Other studies have reported prolonged door-to-balloon times during off-hour presentations, which have been associated with increased mortality rates. This highlights the critical role of hospital

organisation in providing 24-hour services in influencing clinical outcomes (25).

While the emergency department effectively maintained DTB times, the significantly longer PCI durations during off-hours identified in our study highlight a specific opportunity for improvement. Future efforts should therefore focus on optimizing the off-hours PCI workflow, including team dynamics and resource mobilization, to further enhance the efficiency of myocardial revascularization and ensure consistent, high-quality care.

In conclusion, this single-center study found no significant difference in mortality between patients presenting during working hours and off-hours, a key outcome metric that was maintained despite longer primary PCI procedure times during off-hours. This finding suggests that, within the context of our institution with dedicated 24/7 primary PCI services, the implemented STEMI protocol was effective in standardizing core aspects of care to preserve patient outcomes across different time periods. While our results are encouraging for similar tertiary centers, they underscore the complexity of measuring "system resilience" and highlight the need for future comparative studies between centers with and without 24/7 PCI capabilities to definitively assess the impact of round-the-clock service availability on STEMI outcomes.

Limitations

This study has several limitations. Its retrospective design may have limited the scope of data collection. The modest sample size reduces the statistical power to detect differences in rare outcomes, such as specific complications. Furthermore, the lack of granular data on periprocedural complications and nuanced clinical details may constrain a comprehensive interpretation of the findings. As a single-center study, the generalizability of our results may be limited to institutions with similar resources and protocols. Future prospective, multi-center studies with larger cohorts are needed to validate these findings. Moreover, qualitative and quantitative investigations into the impact of team dynamics and specific clinical protocols on procedural efficiency during off-hours present a crucial avenue for further research.

5. Conclusion

In summary, our findings demonstrate that standardized protocols and effective teamwork in the ED can facilitate successful STEMI management and preserve clinical outcomes regardless of the time of presentation. This work reaffirms the vital importance of early, organized intervention and underscores how a robust systemic approach can mitigate temporal variations in care. Ultimately, these results provide a benchmark for 24/7 STEMI care and lay the groundwork for future multi-center studies to validate strategies that optimize off-hours procedural efficiency.

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