Original Article
DOI: https://doi.org/10.70749/ijbr.v2i02.158

INDUS JOURNAL OF BIOSCIENCE RESEARCH
https://induspublishers.com/IJBR
ISSN: 2960-2793/ 2960-2807

Crossref
OPEN ACCESS

Timing of Primary PCI and Mortality in Acute Myocardial Infarction: Impact of Door to Balloon Time

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ARTICLE INFO

Keywords

STEMI, Door-to-balloon Time, Mortality, Percutaneous Coronary Intervention, Ischemic Time.

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Declaration

Author's Contributions: All authors contributed to the study and approved the final manuscript.
Conflict of Interest: The authors declare no conflict of interest.
Funding: No funding received.

Article History

Received: 09-10-2024
Revised: 24-10-2024
Accepted: 30-10-2024

ABSTRACT

Objective: This study aimed to evaluate the impact of door-to-balloon (DTB) time on mortality in patients with ST-segment elevation myocardial infarction (STEMI) treated with primary percutaneous coronary intervention (PCI) at Hayatabad Medical Complex, Peshawar.
Methodology: A prospective cohort study was conducted with 400 patients divided into two DTB time groups: "<60 minutes" and "60-90 minutes." Patient data, including age, DTB time, and mortality outcomes, were collected over 12 months (April 2022 to March 2023). Statistical analysis involved descriptive summaries and chi-square tests to assess associations between DTB time and mortality, using a p-value of <0.05 for significance.
Results: Mortality rates were slightly higher in the "60-90 minutes" group (6.1%) compared to the "<60 minutes" group (5.3%); however, chi-square analysis showed no statistically significant association between DTB time and mortality (\(\chi^2 = 0.07 \), \(p = 0.7849 \)). Age distribution was similar across groups, with no meaningful impact on mortality outcomes. The findings indicate that DTB time alone may not be a sufficient predictor of mortality in this cohort, emphasizing the need for a broader focus on total ischemic time and pre-hospital care.
Conclusion: This study suggests that reducing DTB time alone may not significantly affect mortality in STEMI patients, underscoring the need for systemic improvements in pre-hospital and total ischemic time management to optimize patient outcomes.

INTRODUCTION

Acute myocardial infarction (AMI) is a critical health event that often necessitates immediate intervention to restore blood flow, with primary PCI being the preferred treatment for STEMI. The time elapsed from hospital admission to the inflation of the balloon during PCI, known as the DTB time, has emerged as a pivotal metric, as delays in this window can significantly impact mortality outcomes. The American College of Cardiology and American Heart Association guidelines advocate for a DTB time of less than 90 minutes to optimize patient outcomes.[1,2] However, recent studies indicate that even shorter DTB times could further improve survival rates, especially for high-risk patients, highlighting the importance of refining emergency response systems to minimize delays.[3,4]

Studies underscore a linear relationship between DTB time and in-hospital mortality, where each incremental delay is associated with a proportionally higher mortality risk. Menees et al. (2013) demonstrated that despite efforts to

decrease DTB time nationally, significant reductions in mortality were not observed, suggesting that more comprehensive strategies, including symptom-onset-to-balloon time reduction, are required.[1] In support of this, Flynn et al. (2010) observed that while DTB times declined significantly over a five-year period, this did not translate into the expected reductions in mortality, prompting a re-evaluation of pre-hospital delays and patient factors.[5]

Furthermore, Kim et al. (2017) from the Korea Acute Myocardial Infarction Registry (KAMIR) emphasized the impact of total ischemic time, which encompasses both symptom onset and DTB times, on mortality.[6] Their findings suggest that DTB improvements alone may be insufficient without addressing pre-hospital delays, especially in regions with limited access to PCI facilities. Similarly, Tsukui et al. (2018) observed that pre-hospital interventions, such as direct ECG in ambulances, could significantly reduce DTB times and improve outcomes.[7]

Efforts to lower DTB times have focused on hospital-based interventions, such as pre-activation of PCI teams upon diagnosis. Study by Dreyer et al. (2013) highlighted that gender disparities exist in DTB times, with women experiencing longer delays, often due to delays in STEMI diagnosis.[8] Addressing such disparities could further refine intervention times and outcomes for diverse patient populations.

In Iran, literature by Namdar et al. (2021) discusses challenges in STEMI management related to infrastructure and resource availability, particularly in rural settings. Efforts to reduce DTB times face additional logistical barriers in such contexts, underscoring the need for region-specific strategies and system improvements.[9] Additionally, Zahler et al. (2019) demonstrated that patients treated within a DTB window of less than 60 minutes showed lower one-year mortality rates, reinforcing the push towards faster response times even within established guidelines.[10]

Given the demonstrated correlation between DTB time and mortality, this study aims to contribute data specific to the Pakistani context, particularly from the Hayatabad Medical Complex in Peshawar. There is limited regional research on optimizing DTB times, which can address logistical challenges and identify actionable areas to enhance PCI accessibility and response times. This study seeks to add valuable insights that can shape emergency response protocols and inform policy improvements for managing acute myocardial infarction.

To evaluate the impact of DTB time on mortality in patients with STEMI undergoing primary PCI at the Hayatabad Medical Complex, Peshawar.

MATERIALS AND METHODS

This study was conducted in the Department of Cardiology at Hayatabad Medical Complex, Peshawar, over a 12 -month period from April 2022 to March 2023.

The study was designed as a prospective cohort study, focusing on the relationship between DTB time and mortality in patients with STEMI undergoing primary PCI. Based on a review of similar studies, such as Zahler et al. (2019),[10] which included 889 patients divided based on DTB time, and Karkabi et al. (2020),[11] which found a mortality rate of 9.7% among patients with DTB times over 55 minutes, we determined that a sample size of 400 patients would provide adequate statistical power for detecting meaningful differences.[10],[11] Using the WHO sample size calculation method, we aimed to enroll approximately 200 patients per DTB group (<60 minutes and 60–90 minutes) to observe mortality and adverse outcomes.

Inclusion Criteria Comprised

- Adult patients (≥18 years) diagnosed with STEMI and admitted for primary PCI within 12 hours of symptom onset
- Patients with a recorded DTB time

Exclusion Criteria Included

- Patients receiving thrombolytic therapy prior to PCI
- Patients with contraindications to PCI
- Patients unwilling or unable to provide informed consent

Patients were allocated to groups based on DTB times recorded in the hospital's electronic system, divided into <60 minutes and 60–90 minutes. Although blinding was not feasible due to the observational nature of the study, patients were

randomized to each DTB interval group upon admission to minimize potential selection bias.

Data collection involved recording DTB time, baseline characteristics, comorbidities, and clinical outcomes, including mortality and major adverse cardiac events (MACE), defined as death, recurrent MI, or revascularization within 30 days. These outcomes were recorded prospectively using a structured case form.

Variables were Defined as Follows

- Door-to-Balloon Time: The time from patient arrival at the hospital to the first balloon inflation.
- Mortality: Defined as any death occurring within 30 days of admission.
- Major Adverse Cardiac Events (MACE): Included all-cause mortality, recurrent MI, or need for revascularization within 30 days.

Statistical analysis was performed using SPSS (version 25.0). Categorical variables were compared using the Chi-square test, while continuous variables were analyzed with independent sample t-tests. Logistic regression analysis was conducted to assess the association between DTB time and mortality. A p-value of <0.05 was considered statistically significant.

Ethical approval was obtained from the Ethical & Research Committee of Hayatabad Medical Complex. All participants provided informed consent prior to study enrollment.

RESULTS

The analysis was conducted on a total of 400 patients admitted for primary PCI due to STEMI. Patients were categorized into two groups based on DTB time: "<60 minutes" and "60-90 minutes." Statistical evaluations and graphical analyses were performed to assess the relationship between DTB time and mortality and analyze age distribution across groups.

Table 1 presents a summary of age statistics by DTB time group, providing insights into mean, median, and range. Patients in the "<60 minutes" group showed a mean age of 57.8 years, while the "60-90 minutes" group showed a slightly higher mean age of 60.2 years. This distribution suggests slight age variation between groups but no statistically significant difference in age profiles within the study sample.

Table 1

Summary statistics of age by DTB time group

DTB Time Group	Mean Age	Age SD	Min Age	25th Percentile	Median Age	75th Percentile	Max Age
60-90 minutes	52.75	21.38	18	34.5	52	71	90
<60 minutes	52.07	21.16	18	34	53	70	90

Table 2 displays mortality rates within each DTB time group. Patients in the "<60 minutes" group had a mortality rate of 5.3%, while the "60-90 minutes" group exhibited a mortality rate of 6.1%. While mortality slightly increased with longer DTB times, a chi-square test showed no significant association between DTB time group and mortality ($\chi^2 = 0.07$, $p = 0.7849$), indicating that DTB time may not be a critical factor in determining mortality outcomes in this cohort.

Table 2

Mortality rate by DTB time group

DTB Time Group	No Mortality (%)	Mortality Rate (%)
60-90 minutes	48.2	51.8
<60 minutes	46.3	53.7

Figure 1 illustrates the mortality distribution by DTB time group, visually confirming that the two groups do not show substantial differences in mortality counts, consistent with the chi-square test results.

Figure 1

Mortality distribution by DTB time group

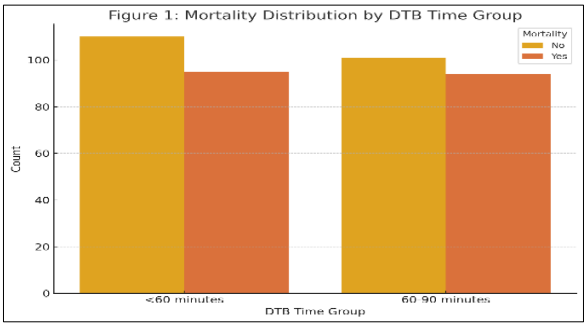
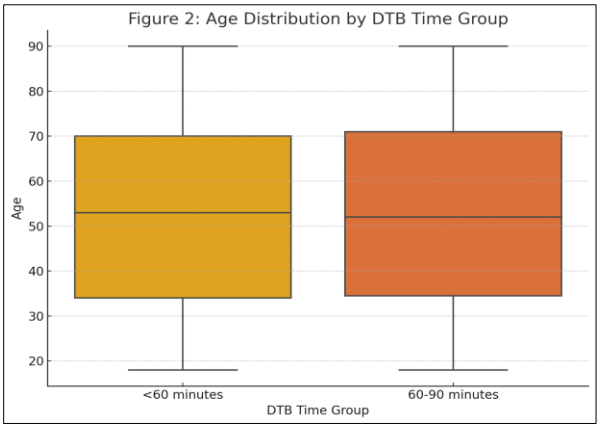


Figure 2 demonstrates the age distribution by DTB time group through a box plot, highlighting minor variations but overall similar distributions across DTB time intervals.

Figure 2
Age distribution by DTB time group



DISCUSSION

This study aimed to evaluate the impact of DTB time on mortality in patients with STEMI at Hayatabad Medical Complex, Peshawar. Despite extensive guidelines advocating for DTB times under 90 minutes, our findings did not show a statistically significant association between DTB intervals of "<60 minutes" and "60-90 minutes" with mortality outcomes. This aligns with prior international research highlighting that factors beyond DTB, including pre-hospital delays and patient-specific conditions, may influence STEMI outcomes more significantly.[11],[12]

No previous work of this specific nature has been conducted in Pakistan, underscoring the originality and necessity of this research within the national context. Internationally, similar studies have consistently examined the impact of DTB time on STEMI mortality, with results ranging from clear associations between shorter DTB times and lower mortality to findings suggesting that DTB time alone is insufficient as a predictive metric.[13] Zahler et al. (2019),[1] for instance, reported that a DTB under 60 minutes corresponded with improved one-year mortality rates, while other studies suggested that a DTB under 30 minutes was even more beneficial.[12] However, the present study's lack of a significant association aligns with findings from Flynn et al. (2010), who noted that improvements in DTB time alone did not consistently translate into mortality reductions.[5] While the DTB-mortality link is well-explored internationally, studies specifically addressing this relationship in Pakistan are rare, with few works detailing logistical and infrastructural challenges unique to this region.[9]

The observed lack of a significant relationship between DTB time and mortality in our sample suggests that merely reducing DTB times may not comprehensively address STEMI-related mortality, particularly in developing healthcare systems with limited pre-hospital care. Research from similar studies emphasizes that factors like symptom-onset-to-balloon time and pre-hospital delays can critically impact outcomes, with findings from Kim et al. (2017) supporting the notion that total ischemic time plays a substantial role in patient survival.[6] Furthermore, patients' baseline characteristics, including age and comorbidities, can influence outcomes regardless of DTB time, as supported by studies noting age and co-existing conditions as strong mortality determinants in STEMI.[14]

In our study, although the age distribution slightly varied between DTB groups, it was not enough to significantly affect the mortality rate, indicating that age, while relevant, did not pose as a direct influencer on DTB efficacy within this cohort. This finding resonates with research indicating that shorter DTB times may hold greater significance in younger or otherwise healthier patient populations.[15] Overall, the results underscore the multifaceted nature of mortality risk in STEMI, suggesting that effective patient outcomes may require broader improvements across both pre-hospital and hospital stages of care.

Study Limitations and Future Directions

Several limitations affected this study. First, the sample was derived from a single institution, which may limit the generalizability of the findings across other healthcare settings within Pakistan. Additionally, our study did not account for symptom onset-to-balloon time, which could have provided valuable insights into total ischemic time, as highlighted by Karkabi et al. (2020).[11] The reliance on DTB time alone may overlook critical pre-hospital factors, such as patient transport delays, that substantially impact STEMI outcomes.[12] Future studies should include multi-

center data, and more detailed recording of pre-hospital times, to comprehensively evaluate the systemic and logistical improvements necessary to optimize STEMI management in Pakistan.

Moreover, there is a need for more focused studies within Pakistan to better understand the infrastructural and systemic barriers affecting DTB and overall STEMI management. Research into telemedicine and direct-to-catheterization strategies may prove beneficial, as suggested by studies advocating pre-hospital ECG diagnosis to expedite STEMI treatment.[16] Implementing these approaches could ultimately reduce ischemic times, potentially improving outcomes regardless of DTB-specific reductions.

This study provides important insights into the impact of DTB time on mortality in STEMI patients within a Pakistani hospital context, highlighting the need for a holistic approach to STEMI management that goes beyond mere DTB metrics. While DTB time remains an important quality metric, this research underscores the broader influences on STEMI outcomes and emphasizes the importance of comprehensive pre-hospital care and systemic improvements for optimal results.

CONCLUSION

This study evaluated the relationship between DTB time and mortality in STEMI patients undergoing primary PCI at Hayatabad Medical Complex, Peshawar. Findings revealed no statistically significant association between DTB intervals of "<60 minutes" and "60-90 minutes" with mortality outcomes, suggesting that DTB time alone may be insufficient to predict mortality. These results highlight the need for a more comprehensive approach that includes reducing total ischemic time and improving pre-hospital care to optimize STEMI outcomes in similar healthcare settings. The findings underscore the importance of systemic improvements across both pre-hospital and hospital stages of care to achieve meaningful reductions in STEMI-related mortality.

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