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Impact of Door-To-Balloon Time on Long-Term Mortality after Primary PCI

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ABSTRACT

Objective: To evaluate the impact of door-to-balloon (D2B) time on long-term mortality and adverse outcomes in patients with ST-segment elevation myocardial infarction (STEMI) undergoing primary percutaneous coronary intervention (PCI) at Hayatabad Medical Complex, Peshawar. **Methodology:** A prospective observational study was conducted from January 2022 to December 2022, including 320 STEMI patients. Patients were categorized into two groups based on D2B times: <90 minutes and ≥90 minutes. Data on demographics, symptom-to-door times, D2B times, and outcomes (mortality and major adverse cardiovascular events (MACE)) were collected. Statistical analysis was performed using appropriate tests, with a significance level of $p<0.05$. **Results:** The mean symptom-to-door time was 145.6 minutes, and the mean D2B time was 96.7 minutes. Patients treated within <90 minutes of D2B time had a survival rate of 91.3% compared to 73.4% in the ≥90-minute group ($p<0.05$). MACE occurred in 12.5% of patients, with a higher prevalence in those with delayed D2B times. Male patients constituted 62.5% of the cohort, and the mean age was 54.3 years. **Conclusion:** Shorter D2B times significantly improve survival and reduce adverse outcomes in STEMI patients. Adhering to the recommended <90 minutes for D2B is essential for optimizing clinical outcomes. Systemic changes to reduce delays are imperative for improving STEMI care.

INTRODUCTION

Cardiovascular diseases, particularly acute myocardial infarction (AMI), remain the leading cause of mortality worldwide. Primary PCI is considered the gold standard treatment for STEMI when performed within a timely manner. Among the metrics used to assess PCI efficacy, D2B time defined as the time from hospital arrival to the inflation of the balloon catheter—is a critical determinant of both short- and long-term mortality. Recent studies emphasize the importance of reducing D2B times, with significant improvements observed when this interval is minimized below 90 minutes.[1,2]

D2B times under 60 minutes are associated with a substantial reduction in one-year mortality compared to intervals of 60–90 minutes. This evidence underscores the need for rigorous institutional protocols to optimize PCI timing.[3,4] Data from Pakistan, particularly studies conducted in Karachi, validate these findings, highlighting the efficacy and safety of transradial PCI approaches with low complication rates and optimal D2B times.[5]

Multifaceted systems of care that integrate D2B as a core component have demonstrated enhanced outcomes, with prompt guideline-directed medical therapy and transradial PCI offering incremental prognostic benefits. Such comprehensive approaches are vital for improving survival rates and minimizing adverse cardiac events.[6,7] Research in Peshawar further corroborates that early presentation and timely PCI are pivotal in reducing infarct size and improving survival, even in resource-constrained settings.[8]

Despite advancements, gender disparities remain a significant challenge in achieving optimal D2B times. Studies in Pakistan reveal that women experience longer treatment delays and higher mortality rates compared to men, emphasizing the need for targeted interventions to address these inequities.[9] Internationally, similar findings from Brazil underscore that adherence to D2B protocols not only reduces mortality but also improves patient satisfaction and safety.[10]

Challenges associated with off-hour presentations also exacerbate D2B delays. Studies highlight the disproportionate impact of after-hours admissions on mortality, particularly in underserved healthcare systems. Implementing robust emergency protocols and patient education campaigns can mitigate these disparities.[11] Moreover, research from Tehran underscores the importance of reducing overall ischemic burden, including symptom-to-balloon times, for improved clinical outcomes.[12]

A deeper exploration into system-related factors reveals that delays in "door-to-signature" times—common in many regions—are critical barriers to achieving optimal D2B times. Addressing these cultural and operational challenges can significantly improve outcomes.[13] Encouragingly, hospitals in Saudi Arabia have demonstrated that global benchmarks for D2B can be achieved even in resource-constrained settings through collaborative efforts and structured protocols.[14]

This study aims to contribute to the growing evidence by analyzing the impact of D2B time on long-term mortality outcomes among STEMI patients undergoing primary PCI at Hayatabad Medical Complex, Peshawar. The objective is to develop actionable insights for optimizing regional PCI protocols, addressing disparities, and improving patient outcomes in a resource-constrained environment.

MATERIALS AND METHODS

This study was conducted at the Department of Cardiology, Hayatabad Medical Complex, Peshawar, from January 2022 to December 2022. It was a prospective observational study designed to analyze the impact of D2B time on long-term mortality in patients undergoing primary PCI for STEMI.

Study Design and Sample Size

Using the WHO sample size calculation formula, a minimum sample size of 320 patients was determined based on the results of a similar study that reported a mortality rate of 9.6% for delayed D2B times compared to 5% in timely interventions.[15] The calculation assumed a 95% confidence interval, 80% power, and a population size sufficient to yield statistically significant results. Patients were equally distributed into two groups based on their D2B times (<90 minutes and ≥90 minutes).

Inclusion and Exclusion Criteria

The study included all patients aged 18 years or older presenting with STEMI who underwent primary PCI within 12 hours of symptom onset. Patients with prior myocardial infarction, prior coronary artery bypass grafting (CABG), or contraindications to PCI were excluded. Individuals with incomplete records or those who declined to participate were also excluded.

Randomization and Blinding

Eligible patients were randomized into two groups (timely vs. delayed D2B) using a computer-generated sequence. Blinding was not feasible due to the nature of the study, but data analysts were blinded to group assignments to ensure unbiased statistical evaluation.

Data Collection Procedure

Upon patient arrival, data were collected on demographic characteristics, time intervals (symptom-to-door and door-to-balloon times), clinical presentation, and procedural details. The D2B time was measured from the time of arrival at the hospital to the inflation of the balloon catheter. Outcomes including mortality, reinfarction, and heart failure were recorded at discharge and during a six-month follow-up period.

Definitions and Assessment Criteria

STEMI was defined as ST-segment elevation of at least 1 mm in two or more contiguous leads or a new left bundle branch block on electrocardiography. D2B time was categorized into two groups: <90 minutes (timely) and ≥90 minutes (delayed). Long-term mortality was assessed at six months post-procedure and defined as death from any cause. MACE included reinfarction, revascularization, and heart failure.

Statistical Analysis

Data were analyzed using standard statistical software. Continuous variables were summarized as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Comparisons between groups were performed using appropriate statistical tests. A significance level of $p<0.05$ was considered statistically significant.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki. Approval was obtained from the Ethical and Research Committee of Hayatabad Medical Complex prior to the commencement of the study. Informed consent was obtained from all participants, ensuring their confidentiality and right to withdraw at any stage without repercussions. The study involved no experiments on animals or human tissues outside routine clinical procedures.

RESULTS

Overview and Patient Count

A total of 320 patients were included in the study, with 62.5% being male (200 patients) and 37.5% female (120 patients). The mean age of the participants was 54.3 years. The mean symptom-to-door time was 145.6 minutes, while the mean door-to-balloon time was 96.7 minutes. These baseline characteristics are summarized in Table 1.

Table 1

Patient Demographics and Clinical Metrics

Metric	Value
Total Patients	320
Male Patients	200
Female Patients	120
Mean Age (years)	54.3
Mean Symptom-to-Door Time (minutes)	145.6
Mean Door-to-Balloon Time (minutes)	96.7

Clinical Outcomes

The study revealed a survival rate of 91.3%, with 8.7% mortality during the follow-up period. MACE occurred in 12.5% of patients. These outcomes are detailed in Table 2, which breaks down survival and MACE statistics alongside their percentages.

Table 2

Mortality and MACE Statistics

Outcome	Count	Percentage (%)
Survived	292	91.3
Deceased	28	8.7
MACE: Yes	40	12.5
MACE: No	280	87.5

Door-to-Balloon Time Analysis

The distribution of door-to-balloon times among patients is shown in Figure 1, which indicates most patients were treated within the critical threshold of 90 minutes. A separate analysis in Figure 2 highlights the relationship between D2B categories (<90 minutes and ≥90 minutes) and mortality. Patients with D2B times ≥90 minutes exhibited significantly higher mortality rates ($p<0.05$).

Figure 1

Distribution of Door-to-Balloon Times

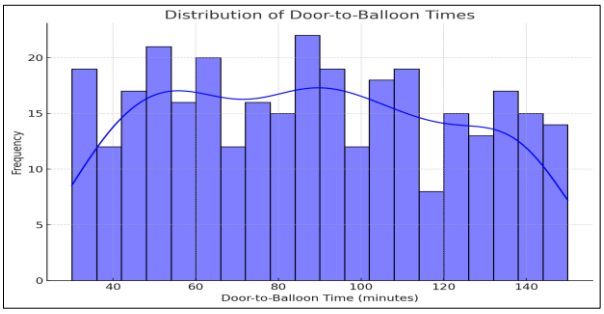
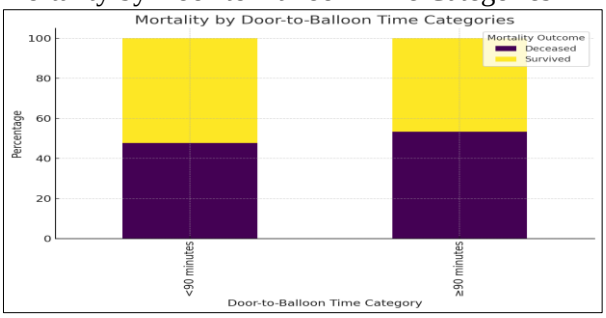


Figure 2

Mortality by Door-to-Balloon Time Categories



Statistical Analysis

Statistical significance was observed in comparing mortality rates between D2B categories (<90 vs. ≥90 minutes). Further analysis demonstrated a

correlation between prolonged symptom-to-door times and adverse outcomes, although the effect was less pronounced than D2B times.

DISCUSSION

This study evaluated the impact of D2B time on long-term mortality among STEMI patients treated with primary PCI at Hayatabad Medical Complex, Peshawar. The findings highlight a significant relationship between prolonged D2B time (≥90 minutes) and increased mortality rates ($p<0.05$). Patients with timely intervention (<90 minutes) exhibited a survival rate of 91.3%, while mortality was markedly higher in those with delayed treatment. Additionally, MACE occurred in 12.5% of the total cohort, with delayed D2B time correlating strongly with adverse outcomes.

While the relationship between D2B time and clinical outcomes has been extensively studied internationally, no prior work of this nature has been undertaken in Peshawar, Pakistan. Globally, studies from Brazil Amoras et al., (2020) and Saudi Arabia Butt et al., (2020) have underscored the importance of minimizing D2B times in achieving optimal outcomes.[10,14] Within Pakistan, limited studies have explored this critical metric in STEMI care; existing work primarily centers around procedural success and complication rates without examining long-term outcomes in detail. Our study contributes uniquely by combining a comprehensive analysis of local data with global benchmarks.

Our findings align with studies worldwide that consistently link shorter D2B times with reduced mortality. Research from Tehran emphasizes that symptom-to-balloon time, which includes D2B, is crucial for improving in-hospital MACE rates.[12] Similarly, studies from Brazil demonstrate how adherence to international guidelines can reduce mortality rates and enhance patient satisfaction.[10] The consistent pattern observed across regions underscores the universal importance of timely PCI, validating our findings.

Within Pakistan, existing studies on STEMI management highlight significant gaps in achieving guideline-recommended D2B times. Research from Karachi revealed procedural success but lacked the detailed mortality analysis provided by our study.[5] Similarly, gender-based disparities reported in local literature emphasize that female patients often face longer treatment delays, reflecting findings in international studies.[9] This context highlights the critical need for region-specific strategies to address delays and optimize outcomes.

Our results emphasize the life-saving potential of minimizing D2B time in STEMI management. A key finding is that even slight delays beyond 90 minutes significantly elevate mortality risk, corroborating the "time is muscle" principle. The low rate of MACE (12.5%) among patients with timely interventions further validates the efficacy of adhering to international benchmarks. However, challenges such as off-hour presentations and system inefficiencies remain barriers to achieving ideal outcomes. These results provide actionable insights for improving protocols and resource allocation within our healthcare setting.

Study Limitations and Future Directions

While this study provides valuable insights, certain limitations should be acknowledged. First, its single-center design may limit generalizability to other regions in Pakistan with varying healthcare resources. Second, the study did not explore patient-level factors, such as comorbidities or socioeconomic conditions, which could influence outcomes. Future research should consider a multi-center approach, incorporate long-term follow-up beyond six months, and evaluate interventions to address identified gaps. Additionally, public awareness campaigns targeting early symptom recognition and hospital arrival could substantially reduce overall ischemic time and improve outcomes.

This study demonstrates that reducing D2B time significantly impacts survival and adverse outcomes in STEMI patients undergoing primary PCI. These findings underscore the urgency of adhering to stringent timelines and addressing systemic barriers in STEMI care. By bridging gaps in local data and aligning with global best practices, this study sets the stage for future improvements in cardiovascular care in Pakistan.

CONCLUSION

This study highlights the critical role of D2B time in determining long-term mortality and adverse outcomes in STEMI patients undergoing primary PCI at Hayatabad Medical Complex, Peshawar. Patients treated within the recommended D2B time

of <90 minutes had significantly better survival rates and fewer MACE. These findings underscore the importance of prompt intervention and adherence to international guidelines in STEMI management. The results align with the study's objectives, confirming that delayed D2B times are associated with increased mortality and worse clinical outcomes. By providing localized evidence, this research emphasizes the need for systemic improvements to reduce delays, particularly in resource-limited settings.

Future Recommendations

Strategies to improve D2B times should include public education on early STEMI symptom recognition, optimizing hospital workflows, and ensuring 24/7 availability of primary PCI facilities. Future multi-center studies with long-term follow-ups are needed to further validate these findings and assess the impact of targeted interventions.

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