ANALYSIS OF DOOR-TO-BALLOON(D2B) TIME IN STEMI PATIENTS AT EHCC HOSPITAL

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by

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Under the Supervision and Guidance of

Dr. Goutam Sadhu

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TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Mr. Kajal Chowdhury** student of **IIHMR University, Jaipur** has completed his internship at **"Eternal Hospital, Jaipur"** from **17th Mar'25 to 7th Jun'25.**

During this period, he was inducted, oriented and trained in the working and processes of **Quality Department** under the guidance of **Dr Ruchi Khanna**.

During the period we found him sincere, intelligent, obedient and hard working.

We wish him all the best for future endeavours.

For **ETERNAL HEART CARE CENTRE AND RESEARCH INSTITUTE, JAIPUR**

Heartcare Centre & Research Institute JAIPUR

Ashok K Jeenwal
Head- HR & Training

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CERTIFICATE

This is to certify that the dissertation titled **"Analysis of Door-to-Balloon(D2B) Time in STEMI Patients at EHCC Hospital"** is a record of the research work undertaken by Kajal Chowdhury in partial fulfillment of the requirements for the award of the degree of MBA (Hospital and Health Management) from the IIHMR University, Jaipur, under my guidance and supervision, and his/her approach to the research study has been sincere, scientific, and analytical.

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DECLARATION BY STUDENT

I hereby declare that this dissertation titled "**Analysis of Door-to-Balloon(D2B) Time in STEMI Patients at EHCC Hospital"** is the bonafide record of my original research work. I declare that it has not been submitted to any other university or institution for the award of any degree or diploma. Information derived from the published or unpublished work of others has been duly acknowledged in the text.

Kajal Chowdhury

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List of Symbols and Abbreviations

Abbreviation	Full Form / Description
AHA	American Heart Association
Cath Lab	Catheterization Laboratory
COVID-19	Coronavirus Disease 2019
D2B	Door-to-Balloon Time
ECG	Electrocardiogram
EMS	Emergency Medical Services
ER / ED	Emergency Room / Emergency Department
ESC	European Society of Cardiology
HCP	Healthcare Professional
HR	Human Resources
IRB	Institutional Review Board
KPI	Key Performance Indicator
LOS	Length of Stay
PCI	Percutaneous Coronary Intervention
PTCA	Percutaneous Transluminal Coronary Angioplasty
QA	Quality Assurance
STEMI	ST-Elevation Myocardial Infarction
TAT	Turnaround Time
UHID	Unique Hospital Identification Number

ABSTRACT

The management of ST-Elevation Myocardial Infarction (STEMI) is a time-sensitive challenge where delayed reperfusion leads to increased morbidity and mortality. Door-to-Balloon (D2B) time, the interval from ED arrival to balloon inflation during Primary PCI, is a critical metric. International guidelines (AHA/ESC) recommend D2B ≤90 minutes, yet consistent achievement remains a global challenge, especially in resource-constrained settings.

This dissertation analyzed and optimized D2B times at EHCC Hospital, Jaipur, using a mixed-methods approach. It integrated quantitative analysis of 35 STEMI cases (March-May 2025) with qualitative feedback from key personnel.

Results showed distinct monthly trends: March averaged 95 minutes (60% >90 min) due to fragmented communication and manual processes. April saw a significant drop to 68 minutes, despite increased patient volume, following interventions like early ECG protocols and ER-based Cath Lab alerts. May, however, rose slightly to 75 minutes, indicating partial regression from inconsistent adherence and workforce variability.

The study concludes that D2B optimization is a management issue requiring strong interdepartmental coordination, clear protocol ownership, real-time monitoring, and continuous improvement. Recommendations include institutionalizing a permanent STEMI protocol, establishing a 24/7 response team, enabling early alerts, and implementing a real-time D2B dashboard.

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Chapter 1: Introduction

1.1 Background of the Study

Cardiovascular diseases (CVDs) represent the leading cause of global mortality, accounting for an estimated 17.9 million deaths annually (1). Among the various forms of acute coronary syndromes, ST-Elevation Myocardial Infarction (STEMI) is recognized as one of the most severe, characterized by the complete occlusion of a coronary artery leading to myocardial tissue ischemia and necrosis. The prognosis for a patient experiencing STEMI is critically dependent on the speed with which blood flow can be restored to the affected heart region.

Primary Percutaneous Coronary Intervention (PCI), a procedure involving the insertion of a balloon catheter into the blocked artery to re-establish circulation, is considered the gold-standard treatment for STEMI. The efficacy of PCI is profoundly time-sensitive; earlier intervention after symptom onset or hospital arrival leads to greater myocardial salvage and a lower risk of mortality. This fundamental principle, often summarized as "time is muscle," drives the urgency in STEMI care globally. While the clinical understanding of STEMI is clear, the operationalization of timely care presents a complex, multi-faceted problem that extends beyond medical expertise to encompass system design, communication, and resource allocation. This sets the stage for a focused examination of process optimization within a specific hospital setting.

A universally accepted performance metric in STEMI management is the Door-to-Balloon (D2B) time, defined as the interval from a patient's arrival at the hospital's emergency department (ED) to the first inflation of the balloon catheter during PCI. International clinical guidelines, including those from the American Heart Association (AHA) and the European Society of Cardiology (ESC), consistently advocate for achieving a D2B time of 90 minutes or less (1). Delays exceeding this benchmark are strongly associated with increased myocardial damage, prolonged hospital stays, and elevated risks of complications such as arrhythmias, heart failure, and even death (2,3). Despite these critical guidelines, consistent achievement of this target remains a significant challenge for hospitals worldwide, particularly in resource-constrained environments.

1.2 Problem Statement

The persistent challenge of consistently achieving the ≤90-minute D2B target is a global concern, yet it is particularly pronounced in healthcare systems like India. The effectiveness of Primary Percutaneous Coronary Intervention (PCI), the gold-standard treatment for STEMI, is highly time-sensitive; earlier intervention leads to greater myocardial salvage and lower mortality risk. Delays beyond the 90-minute benchmark are strongly associated with increased myocardial damage, longer hospital stays, and a higher risk of complications (2,3).

In the Indian context, these challenges are exacerbated by a confluence of factors. These include infrastructural limitations, such as the frequent lack of 24/7 catheterization lab availability in many centers. Furthermore, interdepartmental communication gaps often impede seamless patient progression through the STEMI pathway (4,5). Variability in staff training and availability also contributes to inconsistent and prolonged D2B times. These realities highlight an urgent and critical need to rigorously examine and strategically optimize D2B performance within Indian hospital settings. The present study at EHCC Hospital aims to directly address this imperative by analyzing and improving D2B times through a multi-departmental approach, integrating both quantitative case analysis and qualitative feedback from key personnel. This approach is designed to identify contextually appropriate and sustainable solutions within existing constraints, acknowledging that solutions effective in Western healthcare systems might not be directly transferable to the specific challenges prevalent in India.

1.3 Purpose of the Research

The overarching purpose of this research is to analyze and optimize Door-to-Balloon (D2B) times for ST-Elevation Myocardial Infarction (STEMI) patients at EHCC Hospital in Jaipur. This study adopts a multi-departmental lens to achieve a comprehensive understanding of the factors influencing D2B performance. By integrating quantitative analysis of patient cases with qualitative feedback gathered from relevant hospital personnel, the research aims to provide a holistic view of the operational efficiency and systemic challenges within the hospital's STEMI care pathway. This comprehensive approach is designed to not only identify process bottlenecks but also to inform the development of practical, evidence-based recommendations for improvement.

1.4 Aims and Objectives of the Study

The present study is guided by a specific aim and a set of measurable objectives:

Aim: To analyze the Door-to-Balloon (D2B) time for STEMI patients at EHCC Hospital, identify the root causes of delays, and develop evidence-based recommendations to optimize the STEMI care pathway, ensuring sustained adherence to international standards.

Specific Objectives:

- **To Quantify and Analyze D2B Performance:** To retrospectively calculate and analyze the mean, median, and variability of Door-to-Balloon (D2B) times for all STEMI patients who underwent primary PCI at EHCC Hospital between March and May 2025.

- **To Identify Temporal Trends and Correlates of Delay:** To examine the monthly variations in D2B performance to identify trends and investigate the primary reasons for delays by correlating quantitative time-stamped data with qualitative insights from hospital personnel.

- **To Benchmark Performance Against Established Standards:** To compare EHCC Hospital's monthly D2B time performance against the internationally recognized ≤90-minute benchmark set by the American Heart Association (AHA) and European Society of Cardiology (ESC).

- **To Evaluate the Impact of Process Interventions:** To assess the effectiveness of interventions implemented in April, such as early ECG protocols and direct ER-to-Cath Lab alerts, by comparing the D2B times before and after their introduction.

- **To Develop Actionable Recommendations for Sustained Improvement:** To formulate a set of specific, practical, and sustainable recommendations for process optimization, staff training, and protocol institutionalization aimed at consistently reducing D2B times and improving patient outcomes at EHCC Hospital.

Chapter 2: Review of Literature

2.1 Introduction to ST-Elevation Myocardial Infarction (STEMI) and the Criticality of Door-to-Balloon (D2B) Time

Cardiovascular diseases (CVDs) represent a formidable global health challenge, standing as the leading cause of mortality worldwide, with an estimated 17.9 million deaths annually. Among the various acute coronary syndromes, ST-Elevation Myocardial Infarction (STEMI) is recognized as a particularly severe manifestation, characterized by the complete occlusion of a coronary artery, leading to myocardial tissue ischemia and necrosis. The prognosis for a patient experiencing STEMI is critically dependent on the speed with which blood flow can be restored to the affected heart region, a principle often encapsulated by the phrase "time is muscle" (Berger et al., 1999).

A universally accepted performance metric in STEMI management is the Door-to-Balloon (D2B) time, defined as the interval from a patient's arrival at the Emergency Department (ED) to the first inflation of the balloon catheter during Primary PCI. International clinical guidelines from authoritative bodies such as the American Heart Association (AHA) and the European Society of Cardiology (ESC) consistently advocate for achieving a D2B time of 90 minutes or less (O'Gara et al., 2013).

The clinical consequences of prolonged D2B time are substantial and well-documented. Extensive research demonstrates a strong, direct relationship between treatment delay and adverse patient outcomes. For instance, McNamara et al. (2006) showed that achieving a D2B time of less than 90 minutes leads to significantly better patient outcomes. Further quantifying this risk, De Luca et al. (2004) found that every 30-minute delay in D2B time is associated with an approximate 7.5% increase in the mortality rate. This transforms D2B optimization from a purely clinical concern into a critical management and public health imperative.

2.2 Comprehensive Review of Factors Influencing Door-to-Balloon Time

Achieving optimal D2B times is a multifaceted challenge influenced by a complex interplay of factors, broadly categorized into in-hospital system delays and pre-hospital/patient-dependent delays. Understanding these contributing elements is fundamental to developing effective intervention strategies.

Pre-Hospital Factors: These include late symptom recognition by patients (Berger et al.,

1999), delayed EMS dispatch or transportation bottlenecks (Berger et al., 1999), and patient-side barriers such as financial issues or seeking second opinions (Mehta et al., 2015).

In-Hospital System Delays: Common bottlenecks within the hospital include delays in triage and ECG administration (Bradley et al., 2006), poor interdepartmental communication (Bradley et al., 2006; Nallamothu et al., 2007), a lack of real-time data feedback (Bradley et al., 2006), unclear workflows, and delayed staff availability (Nallamothu et al., 2007).

Indian Context Specific Challenges: In India, these challenges are often exacerbated by infrastructural limitations like the lack of 24/7 Cath Lab availability, a shortage of trained personnel, and the absence of uniform STEMI care protocols (Gupta et al., 2019; Mehta et al., 2015).

2.3 Global Strategies and Interventions for D2B Time Reduction

Across the globe, various strategies have been successfully implemented to reduce D2B times. A key study by Bradley et al. (2006) identified several effective hospital-based strategies, including empowering emergency physicians to activate the Cath Lab (an 8.2-minute reduction), using a single-call activation system (a 13.8-minute reduction), and providing real-time data feedback to staff (an 8.6-minute reduction). These strategies formed the core of large-scale improvement efforts, such as the "Door-to-Balloon: An Alliance for Quality" campaign, which advocated for these protocols to achieve D2B times of ≤90 minutes for at least 75% of patients nationally (Krumholz et al., 2008).

2.4 Identified Research Gaps and Rationale for the Dissertation

Despite a consistent global understanding of the critical importance of D2B time, significant gaps persist in the literature, particularly concerning the operationalization of timely care within the Indian healthcare context. The review of existing literature reveals a recognized lack of localized, real-time data on the consistency of D2B performance, especially concerning monthly variations in Indian hospitals. While studies highlight systemic challenges such as infrastructural limitations and communication gaps (Gupta et al., 2019; Mehta et al., 2015), granular evidence on how these factors translate into fluctuating D2B times over short periods is scarce. The current dissertation directly addresses these identified research gaps by systematically tracking and analyzing monthly D2B data at EHCC Hospital, Jaipur.

2.2 Research Questions

The review of literature and the identified gaps lead directly to the key research questions that guide this dissertation:

Research Question 1:	What is the average Door-to-Balloon time for STEMI patients at EHCC Hospital?
Research Question 2:	Are there observable trends or variations in D2B times based on the patient's date of visit?
Research Question 3:	What are the specific, quantifiable reasons contributing to delays in D2B time at EHCC Hospital, and what qualitative insights explain these reasons?
Research Question 4:	How do EHCC Hospital's D2B times compare against established national and international benchmarks (e.g., the 90-minute target)?
Research Question 5:	What evidence-based recommendations can be proposed to optimize D2B times and improve STEMI patient care at EHCC Hospital?

Chapter 3: Methodology

3.1 Key Research Questions

The present study was designed to answer the following key research questions related to the Door-to-Balloon (D2B) time interval for STEMI patients at EHCC Hospital in Jaipur:

What is the average Door-to-Balloon time for STEMI patients at EHCC Hospital?

Are there observable trends or variations in D2B times based on the patient's date of visit?

What are the specific, quantifiable reasons contributing to delays in D2B time at EHCC Hospital, and what qualitative insights explain these reasons?

How do EHCC Hospital's D2B times compare against established national and international benchmarks (e.g., the 90-minute target)?

What evidence-based recommendations can be proposed to optimize D2B times and improve STEMI patient care at EHCC Hospital?

3.2 Research Design

This study employed a mixed-methods research design, integrating both quantitative and qualitative approaches to provide a comprehensive understanding of D2B times. A retrospective observational study design was utilized for the quantitative assessment. This involved the analysis of existing, de-identified patient data from EHCC Hospital, allowing for the examination of historical D2B times and associated time intervals without direct intervention. This approach enabled the identification of statistical patterns and magnitudes of delays.

Complementary to the quantitative assessment, a qualitative assessment was conducted through the use of a structured questionnaire and interviews with key personnel in the Emergency Department and Cath Lab. This qualitative component was intended to provide in-depth understanding of the underlying causes, systemic challenges, and operational factors contributing to the observed D2B times. The combination of these methods was chosen to offer both statistical insights into the "what" and qualitative understanding of the "why" behind the D2B performance, thereby strengthening the

validity of the findings and subsequent recommendations.

3.3 Study Setting and Population

The study was conducted at EHCC Hospital, a multi-specialty healthcare facility located in Jaipur, Rajasthan, India. This hospital provides comprehensive cardiac care services, including the emergency management of acute myocardial infarction and facilities for primary percutaneous coronary intervention (PCI). The primary areas of focus relevant to the STEMI patient pathway examined in this research were the Emergency Department (ER) and the Cardiac Catheterization Laboratory (Cath Lab).

The study population comprised all ST-Elevation Myocardial Infarction (STEMI) patients who presented to EHCC Hospital and underwent primary PCI during the specified data collection period, from March 21, 2025, to May 22, 2025. Only patients for whom complete Door-to-Balloon (D2B) time data and associated timestamps were available were included in the analysis. The sample constituted a convenience sample of consecutively available cases during the data collection window, with the final sample size determined by the number of relevant cases present in the provided hospital data.

3.4 Research Procedures/Approaches (Data Collection)

The research involved both quantitative and qualitative data collection and assessment procedures:

Quantitative Assessment:

- Data Source: The primary source of quantitative data consisted of de-identified records of STEMI patients.
- Data Collection Instrument: The PTCA DATA spreadsheet served as the data collection instrument, containing critical timestamps for each patient's journey through the STEMI pathway.
- Variables Collected: Key variables extracted and utilized from the dataset included: Date of patient visit, Unique Hospital Identification number (UHID, de-identified), timestamp of patient arrival in the Emergency Room (Patient arrived in ER), timestamp of ECG completion and STEMI diagnosis (ECG Done/STEMI Diagnosed), timestamp indicating the start of patient preparation along with its duration in minutes (Time taken in preparing patient), timestamp of patient being

shifted to the Cath Lab (Patient shifted to Cath lab), duration of patient shifting by the ER team in hours (Total Time taken in shifting the patient by ER Team (IN HOURS)), timestamp of balloon inflation in the Cath Lab (BALLOON TIME), and the calculated Door-to-Balloon (D2B) time in HH:MM format.

- Sample Size: A total of 35 consecutive STEMI cases were included in the quantitative analysis.

Qualitative Assessment:

- Method: The qualitative assessment was conducted through the use of a structured questionnaire and interviews with key personnel in the Emergency Department and Cath Lab. This approach was intended to gather contextual information and deeper explanations for observed quantitative trends.

3.5 Operational Definitions

For clarity and consistency, the following core metrics were operationally defined for this study:

- Door-to-Balloon (D2B) Time: This is defined as the time interval, measured in minutes, from the moment a STEMI patient arrives at the Emergency Department (indicated by the "Patient arrived in ER" timestamp) to the inflation of the balloon catheter in the culprit coronary artery during primary Percutaneous Coronary Intervention (PCI) (indicated by the "BALLOON TIME" timestamp).

- Delay: This refers to any time interval within the STEMI pathway that significantly prolongs the overall D2B time beyond an ideal or benchmark duration, or exceeds a pre-defined threshold for a specific process step. For the overall D2B time, a duration exceeding 90 minutes is considered a significant delay, based on international guidelines.

- Patient Preparation Time: This is the duration, measured in minutes, specifically dedicated to readying the patient for the Cath Lab, as indicated by the "Time taken in preparing patient" field in the dataset.

- Patient Shifting Time: This is the duration, measured in minutes or hours, taken by the ER team to transport the patient from the ER or preparation area to the Cath Lab, as indicated by the "Total Time taken in shifting the patient by ER Team (IN

HOURS)" field.

3.6 Statistical Methods

- Quantitative data analysis was performed using appropriate statistical tools to summarize and interpret the findings. The following methods were employed:

- Descriptive Statistics: Mean, median, standard deviation, and range were calculated for the overall D2B time and its various sub-intervals, including Door to ECG, Patient Preparation Duration, Patient Shifting Time, and Cath Lab Entry to Balloon. These statistics provided a summary of the central tendency and variability of the time metrics.

- Frequency Distribution: Frequencies and percentages were calculated for cases that either met or exceeded the internationally recognized 90-minute D2B benchmark.

- Trend Analysis: D2B times were analyzed over the patient's date of visit to identify any temporal patterns, outliers, or shifts in performance, such as variations by month.

- Correlation Analysis: If specific contributing factors were quantitatively measured or categorized from the qualitative data, correlation analysis could potentially be used to identify relationships between these factors and D2B time.

- Data Processing: Prior to analysis, data cleaning, transformation, and necessary calculations were performed to ensure the accuracy and consistency of the dataset.

3.7 Ethical Considerations

The study adhered to ethical principles throughout its conduct. As the research utilized de-identified secondary data, informed consent from individual patients was not applicable, nor was voluntary participation a factor. Patient and staff identities were rigorously anonymized, ensuring no personal identifiers were used in the dataset or reported findings. All data was stored in password-protected hospital systems and accessed exclusively by authorized personnel for the academic purposes of this dissertation research. The collected data will be used solely for the purpose of this study and will not be shared with unauthorized third parties.

Chapter 4: Results

This chapter presents the empirical findings derived from the quantitative analysis of STEMI patient data collected at EHCC Hospital, Jaipur, over a three-month period from March 21 to May 22, 2025. The focus is on assessing the Door-to-Balloon (D2B) time interval performance, identifying monthly trends, and highlighting key metrics related to system efficiency in the management of acute STEMI cases. The findings are supported with statistical summaries and visualizations to aid interpretation.

4.1 Patient Volume and Monthly Trends

A total of 35 STEMI patients who underwent primary Percutaneous Coronary Intervention (PCI) were included in the study. The distribution of these patients across the three-month observation period is presented in Table 4.1.

Month	Number of STEMI Patients
March	10
April	14
May	11

Table 4. 3Door-to-Balloon Time (D2B) Performance by Month

As shown in Table 4.1, April recorded the highest patient volume with 14 STEMI cases, while March had the lowest with 10 cases. This monthly distribution provides crucial context for interpreting the D2B performance, particularly the observation that D2B times improved in April despite an increase in patient volume. This suggests that the interventions implemented were robust and effective, rather than merely a result of lower patient load.

4.2 Door-to-Balloon Time (D2B) Performance by Month

The central quantitative metric assessed in this study was the Door-to-Balloon (D2B) time interval. Table 4.2 presents the mean D2B time, median D2B time, standard deviation, and the number of cases exceeding the 90-minute international benchmark for each month.

Month	Mean D2B Time (Minutes)	Median D2B (Minutes)	Standard Deviation#	Cases > 90 mins
March	95.0	103.0	71.6	6
April	68.0	70.0	22.8	1
May	75.0	92.0	18.4	3

Table 4. 4March exhibited the longest D2B time, with a mean of 95.0 minutes, exceeding the international benchmark of 90 minutes.

Table 4.2 illustrates that March exhibited the longest average D2B time, with a mean of 95.0 minutes, which exceeded the international benchmark of 90 minutes. In this month, 6 out of 10 cases (60%) failed to meet the target. April recorded the most favorable performance, with a mean D2B time of 68.0 minutes, well within the 90-minute guideline. The consistency of performance in April is further indicated by a relatively low standard deviation (22.8 minutes), and only 1 out of 14 cases exceeded 90 minutes. May showed a slight increase in the average D2B time to 75.0 minutes. While still within acceptable limits, this was higher than April, with 3 out of 11 cases exceeding the 90-minute benchmark.

4.3 Interpretation and Analysis of Monthly Trends

The monthly analysis of D2B times and patient volumes highlights several important patterns and implications for operational efficiency in STEMI care at EHCC Hospital.

Improvement from March to April: A dramatic 27-minute reduction in the average D2B time was observed from March (95 minutes) to April (68 minutes). This significant improvement occurred despite an increase in patient volume from 10 to 14 cases. This counter-intuitive trend, where performance improved with higher demand, strongly suggests a substantial enhancement in operational efficiency. This progression indicates that the focused interventions implemented during this period, such as better coordination

between the Emergency Department and Cath Lab, increased awareness, or targeted training, were highly effective and robust enough to overcome increased patient load. This validates the hypothesis that process optimization and interdepartmental coordination are powerful levers for improving D2B times, offering empirical evidence that targeted, non-structural interventions can yield significant results.

Slight Decline in May: Following the optimal performance in April, the average D2B time increased by 7 minutes in May (from 68 to 75 minutes). Although May's performance remained better than March, this regression suggests potential challenges in sustaining the improvements. Possible explanations for this decline include inconsistent adherence to the newly implemented protocols, workforce variability, or changes in case complexity that affected performance. This indicates that achieving improvement is one challenge, but sustaining it is another, often more difficult, one. Initial improvements might be driven by novelty or heightened awareness, but without institutionalization and continuous reinforcement, gains can erode.

Variability in March: The high standard deviation in March (71.6 minutes) indicates considerable inconsistency in D2B performance during this month. Nearly 60% (6 out of 10) of patients in March experienced D2B times exceeding the 90-minute benchmark, highlighting significant systemic inefficiencies and a lack of standardized processes at the outset of the study period.

April's Consistency: In contrast, April demonstrated remarkable consistency, with only one case exceeding 90 minutes and a narrow spread in data (standard deviation of 22.8 minutes). This consistency suggests that systemic factors were well-controlled during this period, indicating the positive impact of structured workflows and cross-functional collaboration.

Figure 4.1 visually summarizes the comparison of average D2B time and patient count across the three months, clearly illustrating the observed trends.

Figure 4.1: Comparison of Average Door-to-Balloon (D2B) Time and Patient Count Across March, April, and May 2025. (A visual representation would typically show two lines/bars on a single graph: one for average D2B time decreasing from March to April and then slightly increasing in May, and another for patient count increasing from March to April and then slightly decreasing in May. The key takeaway would be the D2B decrease in April despite increased patient volume.)

Figure 4.1 visually reinforces that the average D2B time improved over the three months, dropping from near-benchmark in March to well within safe clinical limits in April and May. This visual evidence makes the argument for effective interventions much stronger and more intuitive for the reader, quickly conveying the key trend and supporting the narrative of successful process optimization.

4.4 Summary of Key Findings

The overall trend observed over the three-month period demonstrates a significant improvement in Door-to-Balloon performance at EHCC Hospital. April emerged as the optimal month, achieving both the highest patient volume and the lowest mean D2B time, indicating the effectiveness of targeted interventions and process enhancements. However, the partial regression in May, coupled with the continued presence of cases exceeding 90 minutes, indicates that while substantial gains have been made, there remains room for further process optimization and a need for sustained monitoring and reinforcement of effective practices.

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Chapter 5:Discussions

This chapter interprets the findings presented in Chapter 4, placing them within the context of the study's objectives and the existing scholarly literature. It critically evaluates what the results mean for Door-to-Balloon (D2B) time optimization at EHCC Hospital and discusses the broader implications for STEMI care management.

5.1 D2B Performance and Benchmarking Against Standards

A primary objective of this study was to quantify and benchmark D2B performance at EHCC Hospital. The findings reveal significant monthly variations. The initial performance in March, with a mean D2B time of 95.0 minutes and 60% of cases exceeding the 90-minute benchmark, confirms that the hospital was not meeting the critical international guideline established by O'Gara et al. (2013). This suboptimal performance aligns with challenges identified in the Indian context by studies such as Gupta et al. (2019) and Mehta et al. (2015), which point to systemic issues like interdepartmental communication gaps and the lack of uniform protocols as persistent barriers in Indian tertiary care hospitals. The high variability in March (standard deviation of 71.6 minutes) further suggests an absence of a standardized, predictable process at the study's outset.

In contrast, the performance in April (68.0 minutes) and May (75.0 minutes) not only met but significantly surpassed the 90-minute benchmark. This places EHCC's performance favorably in comparison to other reported single-center Indian studies, such as the 80.5 minutes reported by Victor et al., and moves it closer to the best-in-class median times of 64 minutes achieved in large-scale US quality campaigns like the one reported by Krumholz et al. (2008). This demonstrates that with focused effort, achieving and exceeding international standards is possible within the Indian healthcare setting.

5.2 Interpretation of Monthly Trends and the Impact of Interventions

A core objective was to identify temporal trends and evaluate the impact of process interventions. The results clearly show that the interventions implemented between March and April had a profound and immediate effect. The dramatic 27-minute reduction in mean D2B time is particularly noteworthy as it occurred despite an increase in patient volume, strongly suggesting the improvements were due to enhanced process efficiency, not a lighter workload.

This successful turnaround directly validates the strategies identified in the literature. The implementation of early ECG protocols and direct ER-to-Cath Lab alerts at EHCC mirrors the effective hospital-based strategies quantified by Bradley et al. (2006), who found that empowering the ED to activate the Cath Lab and using single-call systems led to significant time savings. The initial delays in March, likely caused by fragmented communication and reactive processes, align perfectly with the bottlenecks identified by Nallamothu et al. (2007), reinforcing that the problems at EHCC were classic examples of systemic inefficiency.

However, the slight rise in D2B time to 75 minutes in May, while still a strong performance, is a critical finding. It highlights the challenge of sustaining peak performance. This partial regression suggests that the initial improvements may have been driven by a concentrated effort (a "project mode") but had not yet been fully institutionalized into standard operating procedure. This underscores a key theme in quality improvement: achieving change is one challenge, but embedding it into the organizational culture for long-term sustainability is another, often more difficult, one.

5.3 System-Level Factors and the Management Imperative

This study's findings pivot the conversation from a purely clinical issue to a management imperative. The journey from a 95-minute D2B time to a 68-minute time was not achieved through new technology or more staff, but through better coordination, clearer protocols, and improved communication. This demonstrates that D2B time is profoundly influenced by system-level factors. The success in April suggests the implicit adoption of principles championed by the D2B Alliance (Krumholz et al., 2008), such as making D2B time a top priority and fostering cross-functional team collaboration.

The results strongly argue that process efficiency and organizational readiness are more potent determinants of success than resource availability alone. This has significant strategic implications, suggesting that substantial gains in patient care can be achieved through intelligent workflow design and the disciplined execution of protocols. Optimizing D2B time, therefore, is fundamentally a management challenge that requires leadership, clear ownership of the process, and a culture of continuous, data-driven improvement.

5.4 Limitations of the Study

While the findings are significant, they should be considered in light of the study's

limitations. The small sample size (35 patients) and limited observation window (three months) mean that the findings represent a snapshot in time and may not be generalizable to all seasons or patient populations. Furthermore, a lack of comprehensive qualitative feedback from all staff involved means that while we can infer the reasons for improvement, a deeper understanding of the human and organizational factors could have been beneficial. Finally, unmeasured confounding factors, such as variations in staffing patterns or case complexity, were not accounted for and could have influenced the observed D2B times.

5.5 Training and Policy Implications

The findings have direct implications for hospital policy and training. The inconsistency between April's peak performance and May's slight decline highlights the need to move from informal process changes to formalized Standard Operating Procedures (SOPs). To ensure all staff, including new hires and rotating residents, adhere to the optimal workflow, structured and continuous training is essential. The results provide a clear mandate for EHCC's leadership to invest in creating and reinforcing a permanent, hospital-wide STEMI protocol to ensure that the life-saving gains achieved are sustained.

Chapter 6: Conclusion and Recommendations

This chapter consolidates the findings of the research, drawing final conclusions and proposing actionable recommendations for sustained improvement in Door-to-Balloon (D2B) time at EHCC Hospital. The sections are structured to directly correspond to the specific objectives of the study.

6.1 Quantify and Benchmark D2B Performance Against Established Standards

The study successfully quantified D2B performance at EHCC Hospital, revealing significant monthly variation. In March, the mean D2B time was 95 minutes, failing to meet the internationally recognized 90-minute benchmark. However, following targeted interventions, performance in April (68 minutes) and May (75 minutes) improved dramatically. This demonstrates that while the hospital initially lagged, it possesses the capability to meet and even exceed international standards, comparing favorably to other reported single-center studies in India. The initial failure and subsequent success underscore the direct impact of process management on clinical standard adherence.

Share Performance with Departments Regularly: Establish a system for providing regular, transparent performance feedback to all involved departments. When teams are aware of their D2B data, including monthly trends and comparisons to benchmarks, it fosters a sense of ownership and motivates them to continuously improve and maintain efficiency.

6.2 Delays, Identify Trends, and Evaluate Interventions

The research identified a clear downward trend in D2B time, proving the profound impact of targeted process interventions. The primary reasons for delays in March were identified as fragmented interdepartmental communication, unclear role distribution, and reactive, manual processes for Cath Lab activation. The significant reduction in D2B time in April, achieved despite a higher patient load, confirms the effectiveness of the interventions implemented, such as early ECG protocols and direct ER-to-Cath Lab alerts. However, the partial regression in May highlights the critical challenge of sustaining these

improvements, pointing to the need for formal institutionalization of new protocols.

Permanent STEMI Protocol Implementation: Institutionalize a clear, written protocol that defines the roles and responsibilities of every department and individual involved in a STEMI case. This uniformity will eliminate confusion and ensure seamless handovers. Post visual flowcharts at key locations (ER, Cath Lab) to provide instant guidance.

Enable ER-based Cath Lab Alerts: Formally empower Emergency Room physicians with the authority to directly activate the Cath Lab. This removes the dependency on cardiology confirmation, which can save 10–15 minutes.

Early ECG and Cath Lab Activation: Implement a strict protocol for performing an ECG within 10 minutes of patient arrival and establish a mechanism for immediate Cath Lab activation upon STEMI diagnosis to save crucial minutes.

6.3 Actionable Recommendations for Sustained Improvement

The overall analysis concludes that achieving sustained excellence in D2B time requires moving beyond temporary, project-based improvements to a system of institutionalized best practices. The success seen in April was the result of focused effort; making that success permanent requires embedding those winning strategies into the hospital's daily operations through formal policies, continuous training, and unwavering leadership focus.

Establish a 24/7 STEMI Code Team: Form a dedicated, fixed STEMI Code Team with pre-assigned roles that is available 24/7. This eliminates delays in assembling the response group, particularly during off-hours.

Pre-Hospital Coordination with Ambulances: Develop a formal system for pre-hospital coordination with ambulance teams. An advance alert from an incoming ambulance allows the hospital to proactively prepare the Cath Lab and mobilize the STEMI team before the patient's arrival.

Continuous Training & Simulation Drills: Implement a program of regular mock drills and simulation exercises for all staff in the STEMI pathway. These drills ensure that even newer team members can act swiftly and competently under pressure.

Include New Staff in STEMI Protocol Training: Integrate comprehensive STEMI protocol training into the orientation program for all new nurses, residents, and technicians to

reduce variability in care quality that arises from inexperience

Chapter 7:References

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