Journal of Health Service Administration and Hospital Management (LACERI)
Vol. 02, No. 2, July 2026, Page 21-27
E-ISSN 3123-7185

Improving Door-to-Balloon Time through Operational Efficiency and Patient Safety Culture in STEMI Patients

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Article Information
Received: March 07, 2026
Revised: June 19, 2026
Online: August 04, 2026

Keywords
Door-to-Balloon Time, STEMI, Quality Improvement

ABSTRACT

Background: Timely reperfusion is critical for reducing myocardial damage and mortality in ST-elevation myocardial infarction (STEMI). In many Indian settings, door-to-balloon (DTB) time remains prolonged due to operational and system-level barriers. Objective: To evaluate whether recommended DTB timelines can be achieved in a tertiary care hospital and to identify and address key delay factors. Methods: A prospective study was conducted in a 400-bed tertiary care hospital in South India (Oct 2018–Oct 2019), followed by an intervention phase (Nov 2019–Jan 2020). Phase I (n=282) identified delays using process mapping and Fishbone analysis. Phase II implemented Lean principles and the Plan–Do–Check–Act (PDCA) cycle. Statistical comparison of means was performed, with $p < 0.05$ considered significant. Results: Mean DTB time reduced from 372 minutes to 208 minutes ($p < 0.05$). The proportion achieving DTB <120 minutes increased from 24% to 47%. Shorter DTB times were associated with lower mortality. Conclusion: Structured protocols, early activation systems, and continuous quality improvement can significantly reduce DTB time. However, achieving global benchmarks requires sustained system-level strengthening.

Keywords: *Door-to-Balloon Time, STEMI, Quality Improvement*

INTRODUCTION

Early reperfusion is essential in STEMI management, as myocardial damage progresses rapidly with time. Evidence shows that nearly half of salvageable myocardium is lost within the first hour of coronary occlusion and up to two-thirds within three hours (Reimer et al., 1977).

Over the past three decades, advances in reperfusion therapy have shifted the focus from selecting treatment modalities to ensuring timely delivery of care (Armstrong et al., 2009). International guidelines from the American College of Cardiology/American Heart Association and the European Society of Cardiology strongly recommend organized systems of care to achieve rapid diagnosis and timely primary percutaneous coronary intervention (O'Gara et al., 2013; Steg et al., 2012).

In India and other developing countries, delays in DTB time are influenced by fragmented emergency medical services, transportation challenges, financial constraints, and operational inefficiencies (Alexander et al., 2012; Xavier et al., 2008). As a result, only a small proportion of STEMI patients receive timely PPCI.

Door-to-balloon time is a well-established predictor of mortality, with studies showing that even a one-hour delay significantly increases the risk of adverse outcomes (Terkelsen et al., 2010; McNamara et al., 2006). Despite this evidence, achieving the recommended DTB benchmark of 90 minutes remains challenging in resource-limited settings.

Research Gap: While global literature emphasizes clinical outcomes and system-level frameworks, there is limited evidence on how hospital-level operational and process-based interventions can effectively reduce DTB time in Indian tertiary care settings.

Objective: This study aims to identify delay factors and evaluate the impact of structured quality improvement interventions on DTB time.

METHODS

Prospective observational study conducted in 400 bedded tertiary care hospital for a year (Oct-2018 to Oct-2019).This study was planned in two phases. In Phase I, acute MI cases visited to Emergency Medicine Department (ED), who underwent PPCI analyzed for DTB time with factors causing delay in DTB time.

Fish bone analysis done for root cause and PDCA (Plan, Do, Act, Check) planned in phase II with STEMI team, code, and policy with benchmark of 120 minutes with training on awareness on patient safety and quality of care. Turnaround time taken from- patient arrived to emergency department with myocardial infarction and to balloon inflated time in catheterization laboratory (reinfarction of artery).The study aims at reducing waste of time and cost of poor quality, improvement in process and operational excellence for continuous improvement towards patient care.

1. Inclusion / Exclusion criteria

a. Inclusion criterion

Patients with acute myocardial infarction with ST elevation willing to undergo PPCI.

b. Exclusion criterion

Cardiogenic shock and patients with acute myocardial infarction who underwent thrombolytic & not willing to undergo PPCI

Phase I showed lot of different delay determining factors which were studied further using tools. It was understood that DTB time is achievable by working on factors associated with delaying at various levels using lean thinking towards quality care and safety to achieve better clinical outcomes.

But this includes good quality process management, planning and operation in administration and clinical governess through - Structure Process and Outcome improvements in the hospital with better clinical governess. Consecutive patients who presented with acute MI to hospital and underwent PPCI were studied prospectively. In this study door-to balloon time in phase I was showing huge variations .The delay factors were studied using quality tools –Fish bone analysis (Fig-2). PDCA was planned in the form of interventions. Improvements were identified as the structure – process – outcome improvements which is implemented in Phase II

Figure. Plan–Do–Check–Act (PDCA) Cycle for Standard Operating Procedure (SOP) Implementation and Continuous Quality Improvement

2. Plan, Do, Check, Act (PDCA) Cycle for Interventions & Improvements

Status of Clinical outcome and reduction of TAT time was studied in phase II [Nov-2019 to Jan-2020 data, pilot study]and analyzed to be compared with Phase I .Basic data available was studied to only to understand the delays towards reducing DTB time.

Data collection to monitor the Door-to-balloon time was divided into 10 stages-[table 3]

1) Door to ECG(Electrocardiogram) time
2) Time taken for STEMI team to be activated
3) STEMI activation To Coronary Care Unit (CCU)
4) Time taken in CCU for Echocardiogram & preparation
5) CCU To Blood Investigation Receiving time
6) Time taken from CCU to Catheterization laboratory (Cathlab)
7) Time taken from entry Cathlab To First shot
8) Time taken for the consent for PPCI
9) Time taken for financial process
10) Time taken from first shot to balloon/stent (first passage of any intracoronary device)

RESULTS

A door-to-balloon (DTB) audit was conducted to assess whether a target of ≤120 minutes could be achieved, compared to the AHA recommendation of ≤90 minutes. DTB time was calculated from arrival at the Emergency Department to reperfusion in the catheterization laboratory.

1. Phase I

Among 282 patients undergoing PPCI, the median DTB time was 216 minutes and the mean was 372 minutes. Only 24% (67 patients) achieved DTB <120 minutes, while 76% (215 patients) exceeded 120 minutes. Mortality was lower in patients with DTB <2 hours (1.5%) compared to those with DTB >2 hours (2.8%). Patient flow was higher during daytime (58%) than nighttime (42%). Daytime patients had shorter turnaround time (TAT) (342 minutes) compared to nighttime patients (406 minutes, $p < 0.05$). In terms of payment, 46% were under government schemes, 42% were cash-paying, and 12% had private insurance. Patients with private insurance had significantly lower TAT (5 hours 47 minutes) than others ($t(280) = 14.14$, $p = 0.0026$), likely due to quicker approvals.

Journal of Health Service Administration and Hospital Management (LACERI)
Vol. 02, No. 2, July 2026

2. Phase II

In the post-intervention phase, 47 STEMI patients were analyzed. Of these, 47% (22 patients) achieved DTB <120 minutes, while 53% (25 patients) exceeded it. Mortality was 0% in the <120-minute group and 4% in the >120-minute group. Most patients presented during daytime (74%) compared to nighttime (26%). Daytime admissions had lower TAT (174 minutes), though the difference was not statistically significant ($p > 0.05$). Regarding payment type, 19% were under government schemes, 48% had private insurance, and 33% were cash-paying. Private insurance patients had lower TAT (244 minutes), though this was not statistically significant ($t(35) = 13.28$, $p = 0.19$). Mean TAT reduced from 372 minutes in Phase I to 208 minutes in Phase II, a decrease of 164 minutes. This reduction was statistically significant ($t(327) = 5.237$, $p < 0.05$) [Table 2]. However, some delays remained, particularly in echocardiography (ECHO), which requires further improvement.

3. Figures and Tables

Fig 1 Recommended maximal time delays to reperfusion strategies. IRA, infarct-related coronary artery; FMC, first medical contact; PPCI, primary percutaneous coronary intervention; STEMI, ST-elevation myocardial infarction; XPCI, transfer from non PCI centre.

Figure 1

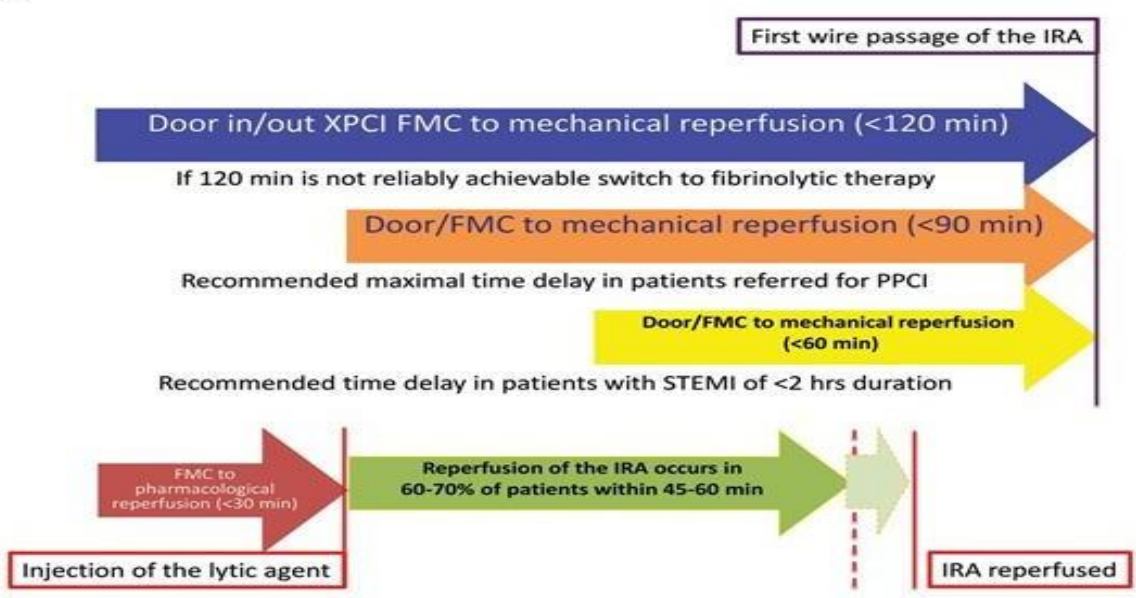

Figure 1. Recommended maximal time delays to reperfusion strategies

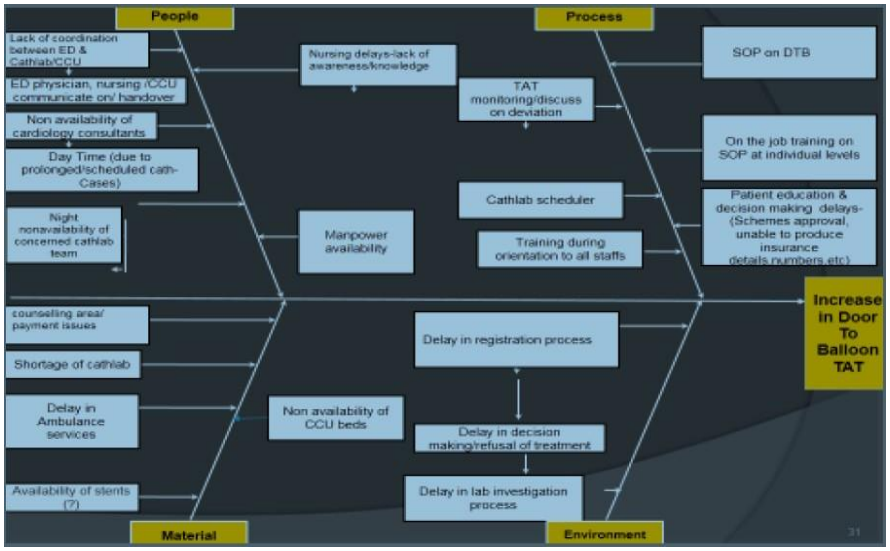

Figure 2. Fishbone analysis of delay factors

Table 1. Lean management process using DMAIC (Define, Measure, Analyze, Control, Improve)

Define	Measure	Analysis	Control	Improve
· Project discussion with stake holders- cardiologists, catheterization laboratory team Emergency Physicians, insurance desk staffs and admission staff · Review the · process in phase I and plan the process · Process mapping done · Project plan identified	Data collection plan [FORMAT] Cost of poor quality Continuous quality improvement Turnaround time(TAT)	· Sampling · Cause and effect · Process mapping · Data capturing process review · PDCA · Process analysis	· Pilot study in phase 2 · Preparation of Standard Operating Procedures(SO P)and policy · Training · Set target · Cost benefit analysis · Clinical improvements	· Identify opportunities and plan · Operational excellence · Develop future plans · Participate in better community services · Patient education and awareness

Table 2. Group statistics and comparison between Phase I and Phase II

	N	%	Mean	Std div'n	OUTCOME
Phase-I, Year Oct. 2018 to Oct. 2019	282	86%	372	362	Mortality rate was 1.5% in D2B of < 2 Hours [24cases] and mortality rate was 2.8% in D2B > 2 hours [76 cases].
Phase-II, [Pilot study] Nov. 2019 to Jan. 2020	47	14%	208	148	Morality rate was 0% in <120 min (22 cases) and 4 % in >120 min in 25 cases.

t-Value	D.OF	sig(2 Tailed)
5.237	327	1

Table 3. Step-wise breakdown of DTB turnaround time

	Set Std (in min)Phase II	Average (in min)	SD(in min)
Door to ECG time	**5**	4	3
Time taken for STEMI team to be activated	**2**	5	4
STEMI activation To CCU	**10**	28	12
Time taken in CCU for Echo & preparation	**5**	16	25
CCU To Blood Investigation Receiving time	**25**	36	47
Time taken from CCU to Cathlab	**10**	56	118
Time taken from entry Cathlab To First shot	**40**	40	31
Time taken for the consent for PCI	**8**	8	7
Time taken for financial process.	**10**	10	2
Time taken from first shot to balloon/stent (first passage of any intracoronary device)	**5**	5	5
Overall TAT (Door to Balloon/stent)	**120**	208	167

DISCUSSION

This study shows that structured operational interventions can significantly reduce DTB time. The use of Lean tools and PDCA cycles helped identify and address inefficiencies across the care pathway.

Similar findings have been reported in other studies, where early activation systems and coordinated teams improved treatment timelines. However, in our setting, administrative and financial processes also played a major role in delays, highlighting a context-specific challenge.

Despite improvements, DTB time remains above recommended benchmarks. This indicates the need for stronger integration of pre-hospital care, faster diagnostics, and streamlined financial approvals.

CONCLUSIONS

Operational efficiency and patient safety culture play a critical role in reducing DTB time. While significant improvements are achievable, sustained efforts and broader system-level changes are required to meet global standards.

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