Time-Sensitive Interventions in STEMI: A Retrospective Multistage Performance Review at Ibrahim Bin Hamad Obaidullah Hospital

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Abstract

Background: ST-Elevation Myocardial Infarction (STEMI) is a life-threatening condition that requires immediate intervention to minimize mortality and complications. Timely diagnosis and treatment are critical because delay in intervention increases the one-year mortality risk. While Percutaneous Coronary Intervention (PCI) is the gold standard treatment, its availability is limited to PCI-capable hospitals, making it essential to rapid stabilization and transfer from non-PCI hospitals. Adherence to time-sensitive benchmarks, such as Door-to-ECG, Door-In-Door-Out (DIDO), and transport times, is crucial for achieving optimal outcomes and aligning with international guidelines.

Objective: This study assesses compliance with essential STEMI management benchmarks, such as Door-to-ECG, Door-In-Door-Out (DIDO), and Door-Out to Arrival times at Ibrahim Bin Hamad Obaidallah Hospital over 12 months. It also seeks to identify adherence patterns and reasons for delays in a facility without PCI capabilities.

Methods: A retrospective analysis of hospital records occurred over 12 months(2024) at Ibrahim Bin Hamad Obaidallah Hospital (IBHOH). We included adult patients (aged 18 years and older) who had a Code MI activation due to suspected STEMI while excluding those without Code MI activation or with other diagnoses. Data was categorized by month and verified against various hospital

records for accuracy. Key metrics evaluated included Door-to-ECG time (<10 minutes), Door-In-Door-Out time (30–40 minutes), and Door-Out to Arrival time at Sheikh Khalifa Specialized Hospital(SKSH) (<40 minutes). Findings were summarized using descriptive statistics, covering percentages and averages. The study follows ethical standards to protect patient confidentiality by using aggregated data that lacks personal identifiers.

Results: Over 12 months, 99 Code MI activations occurred. Compliance with the Door-to-ECG benchmark (<10 minutes) exceeded the target of 70% in all months, achieving 100% compliance in six out of twelve months. The lowest compliance rate was observed in May (75%). DIDO compliance was achieved in eight months (100%) but dropped to 50% in May and 85.7% in August due to coordination delays and atypical presentations. Door-out to Arrival times consistently met the hospital target (<40 minutes), with average transport times between 25 and 30 minutes.

Conclusion: This study highlights adherence to Door-to-ECG benchmarks at IBHOH and identifies common delay factors impacting DIDO compliance. Findings underscore the need for contingency protocols to manage delays caused by atypical presentations and PCI center capacity, supporting efforts to improve STEMI care standards in non-PCI hospitals.

Keywords: STEMI, Door-to-ECG, DIDO, PCI transfer, time benchmarks, non-PCI hospital, myocardial infarction, emergency care compliance.

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Introduction

ST-Elevation Myocardial Infarction (STEMI) is one of the most critical forms of acute coronary syndrome, significantly increasing mortality risk and long-term complications if not addressed swiftly[1]. Timely intervention is crucial for minimizing heart muscle damage, reducing complications, and improving survival rates. Every minute of treatment delay for STEMI patients impacts their one-year mortality[2,3]. The primary treatment method for STEMI is Percutaneous Coronary Intervention (PCI), which restores blood flow to the heart. However, this essential treatment is only performed at PCI-capable facilities[4], making rapid access to these centers vital for patient outcomes[2,3]. Ensuring a prompt and coordinated transfer to a PCI-capable facility for patients arriving at non-PCI hospitals is crucial for achieving the therapeutic goal of rapid reperfusion.

The key benchmarks for time-to-treatment in STEMI care at non-PCI-capable hospitals include door-to-ECG time, Door-In-Door-Out (DIDO) time, and the duration from DO-arrival to the PCI-capable hospital. International guidelines from organizations like the American Heart Association (AHA) and the European Society of Cardiology (ESC) outline these benchmarks as evidence-based criteria for effective STEMI management. Specifically, they recommend a Door-to-ECG time of under 10 minutes for prompt diagnosis and a DIDO time of 30-40 minutes in non-PCI facilities to enable quick transfers[6,7]. Furthermore, achieving the first medical contact - balloon within 120 minutes is highlighted as crucial for better patient outcomes. [6,7,8,9]

Non-PCI hospitals encounter distinct challenges in meeting these benchmarks, primarily due to their limited capacity for on-site revascularization. Delays in patient transfers, arising from the need for coordination between hospitals and the availability of PCI centers, significantly affect DIDO compliance[2]. In the U.S., non-PCI hospitals exhibit variability in DIDO times, often failing to meet the AHA-established benchmarks. In their 2011 study, Wang et al. examined data from 14,821 patients diagnosed with STEMI who were transferred to 298 centers equipped to handle PCI across the United States from January 2007 to March 2010. They discovered that only 11% of these patients achieved a DIDO time of 30 minutes or less; the median DIDO time was 68 minutes. In this study, Factors linked to longer DIDO times included older age, female gender, transfer during off-hours, atypical presentation, and non-emergency medical services transportation to the initial hospital[2]. Similarly, data from European facilities indicate considerable variation in DIDO compliance, with rural or understaffed hospitals requiring more resources to meet these benchmarks. Oliveira et al. 2023 in their retrospective study, found that among the 523 patients with STEMI transferred for primary PCI, the median DIDO time was 82 min. Only seven patients (1.3%) were transferred in 30 min or less, thus achieving the recommended time. By contrast, 75.3% were transferred in more than 60 minutes and 42.1% in more than 90 minutes[10.] The European Society of Cardiology's treatment guidelines for STEMI recommend that a primary percutaneous coronary intervention (PCI) be performed within 120 minutes of electrocardiographic diagnosis in the prehospital or non-PCI capable hospital setting and within 60 minutes if diagnosed in the hospital.[11]

Current Setting and Study Rationale

Ibrahim Bin Hamad Obaidallah Hospital (IBHOH) in Ras Al Khaimah, a specialized public hospital that covers the Emirate of Ras Al Khaimah and the surrounding areas, is a 200-bed hospital serving as a vital initial care facility for STEMI patients. Although it lacks PCI capabilities, STEMI patients require quick stabilization and urgent transfer to a PCI-capable hospital. Without PCI services on-site, IBHOH relies on transferring patients to Sheikh Khalifa Specialized Hospital (SKSH), which is located about 31.7 kilometers away. Following strict, time-sensitive protocols during these transfers is crucial for achieving patient outcomes. IBHOH encounters no transportation issues due to its advanced ambulance service, which is staffed by highly qualified hospital doctors and nurses available around the clock. However, while serving a diverse community, IBHOH faces typical global healthcare challenges, particularly the need to transfer STEMI patients to external PCI-capable facilities, which can impact timely treatment.

This study evaluates the hospital's adherence to STEMI management benchmarks, focusing on Door-to-ECG, DIDO, and DO times to SKSH arrival. It identifies compliance patterns and areas for improvement. By

analyzing time metrics and identifying the causes of delays, the research aims to provide valuable insights into the operational dynamics of non-PCI centers handling STEMI cases. Comparing with international standards will contextualize IBHOH's performance and suggest strategies to enhance STEMI care, ensuring optimal patient outcomes even in non-PCI settings.

Methodology

2.1. Study Design and Setting

This retrospective observational study was conducted at Ibrahim Bin Hamad Obaidallah Hospital in Ras Al Khaimah. The study assessed STEMI management practices over 1 year (2024), focusing on adherence to vital time-sensitive benchmarks, including Door-to-ECG time, Door-In-Door-Out (DIDO) time, and Door-Out Arrival at the PCI-capable center, Sheikh Khalifa Specialized Hospital (SKSH).

2.2. Inclusion Criteria:

- Adult patients aged 18 years and older with typical chest pain.
- Patients who presented to the Emergency Room (ER) with typical chest pain are eligible for Code MI.
- Cases where Code MI was activated in alignment with institutional STEMI protocols.
- Cases sent directly from the ER for PCI are included.

2.3. Exclusion Criteria:

- Patients younger than 18 years old.
- Patients presenting with chest pain but without Code MI activation due to any reason.
- Cases with confirmed alternate diagnoses, such as non-STEMI or non-cardiac causes of chest pain.
- Late presentation STEMI.
- Cases are sent from the ward to the PCI center after a delay or on the next day.
- Patients often refuse to sign the consent form for PCI or have incomplete records when key time metrics or patient details are unavailable.

2.4. Data Collection

Patient records were retrospectively reviewed and cross-referenced with hospital records to confirm the accuracy of time metrics and patient data. The following information was extracted:

Demographics: Age, sex, and mode of arrival.

Time Metrics:

Door-to-ECG time (Time from ER arrival to first ECG).

DIDO time (Time from ER arrival to transfer for PCI).

Door-Out to Arrival at SKSH (Transport time to PCI-capable center).

Outcomes: Compliance with Door-to-ECG, DIDO, and transport benchmarks as defined by international guidelines, as well as the two hospitals' agreement and protocol.

2.5. Benchmarks and Standards

The study utilized benchmarks defined by the American Heart Association (AHA) and the European Society of Cardiology (ESC):

Door-to-ECG: Less than 10 minutes, DIDO: 30–40 minutes, DO to SKSH: Less than 40 minutes, and First Medical Contact to Balloon: Less than 120 minutes.

2.6. Data Analysis

The collected data were analyzed to:

1. Assess compliance with defined benchmarks for Door-to-ECG, DIDO, and transport times.
2. Identify patterns or trends in compliance rates over the 12-month study period.
3. Investigate the causes of delays in cases that do not meet benchmarks, including hospital-level and system-level factors.
4. Line graphs and summary tables were generated using Python to effectively present compliance rates and key findings.

2.7. Ethical Considerations

Patient confidentiality was maintained by anonymizing data and adhering to EHS ethical standards and international research guidelines. Ethical approval was obtained, ensuring compliance with all protocols to protect patient privacy and rights.

Results

*Note: All tables mentioned in this section are provided at the end of the article.

Over a period of twelve months, this study examined adherence to essential STEMI care benchmarks at IBHOH. Metrics evaluated include Door-to-ECG, Door-In-Door-Out (DIDO), and Door-Out Arrival at SKSH, measured against international standards. The analysis highlights patterns of compliance, timing metrics, and reasons for delays, offering insights into the hospital's performance in handling STEMI cases.

3.1. Door-to-ECG Compliance

The review of adherence to Door-to-ECG times for STEMI patients at IBHOH shows a strong performance over the year, consistently exceeding the 70% compliance target. February, April, August, October, November, and December achieved a perfect compliance rate of 100%. May recorded the lowest compliance at 77.7%. In comparison, January had 86%, March 91.6%, June 90%, July 85%, and September 86%. It is important to note that some Code MI activations were excluded due to alternate diagnoses or other circumstances; nonetheless, Door-to-ECG times were recorded for these instances, demonstrating a reliable system for capturing and monitoring this vital metric.

3.2. DIDO Compliance

DIDO compliance rates consistently demonstrated strong performance in most months, achieving 100% compliance in eight out of twelve months. However, compliance dropped to 50% in May and reached 85.7% in August, primarily due to external factors and individual patient conditions. The hospital met its target of 80% in all months except May, while the benchmark of 88% was achieved in ten out of twelve months.

3.3. Door-Out to Arrival at SKSH

During the study period, the Door-Out to Arrival times at SKSH consistently met the target of less than 40 minutes. The average transport times ranged from 25 to 30 minutes, demonstrating reliable and efficient patient transfers. These results show that all documented transport times fell comfortably within the set target, highlighting the effectiveness of the hospital's transportation protocols.

3.4. Reasons for DIDO Exclusions

Three categories of patients excluded from the DIDO compliance analysis were identified. First, cases with alternate diagnoses accounted for exclusions where the initial STEMI diagnosis was ruled out, such as non-cardiac chest pain. Second, exclusions due to patient instability involved cases where patients required immediate stabilization before transfer, including instances of cardiogenic shock. Third, external factors, such as the unavailability of the PCI center, were responsible for a subset of cases not meeting the target. These categories summarize the reasons for exclusion from the analysis, ensuring an accurate representation of compliance outcomes.

Discussion

This research assesses the effectiveness of IBHOH in handling STEMI cases over 12 months. It emphasizes conformity to essential international standards: Door-to-ECG time, DIDO time, and the time from Door-Out to arrival at a facility capable of performing percutaneous coronary intervention (PCI).

4.1. Door-to-ECG Compliance

IBHOH consistently exceeded the 70% compliance target for Door-to-ECG times, achieving 100% compliance in six out of twelve months. The lowest compliance rate, 77.7% in May, remained above the recommended threshold, aligning with guidelines from the American Heart Association and the European Society of Cardiology, which advocate a Door-to-ECG time under 10 minutes for prompt diagnosis[12].

This performance reflects the hospital's effective triage protocols, well-trained staff, and the availability of dedicated ECG machines in the triage area, collectively minimizing delays. While occasional challenges such as high patient volumes and atypical presentations caused minor delays, the results demonstrate a robust system capable of consistently delivering timely care within international standards[13].

To achieve 100% compliance in all months, it is recommended that staff training be enhanced to improve

the identification of atypical presentations and that additional ECG machines be allocated during peak hours to manage high patient volumes efficiently. Regular review and adjustment of triage protocols can further optimize response times[13,14].

4.2. DIDO Compliance

DIDO compliance for IBHOH, located 37.1 km from SKSH, was assessed against a target of 80%. The hospital achieved 100% compliance in eight months, consistently surpassing the target. In May, compliance dropped to 50%. In August, it was 85.7%; in November, it was 90%; and in December, it was 89%, still meeting the target.

In May, compliance challenges were primarily due to external factors. Two of eight patients experienced delays caused by the unavailability of SKSH's Cath lab, a situation beyond the hospital's control. The remaining two delays were linked to atypical presentations, including back pain and a referral miscommunication from a private clinic. In August, delays resulted from one case where the PCI center was busy. In November, the patient was in an unstable bradycardia. SKSH asked to stabilize the patient before sending, and in December, the patient refused the procedure and signed high-risk LAMA. These findings demonstrate strong performance, with occasional challenges due to external constraints and atypical presentations. Enhanced coordination with PCI centers and improved recognition of non-classical STEMI presentations are recommended to sustain high compliance rates[15,16].

4.3. Door-Out to Arrival at PCI-Capable Facility

Transport durations, recorded from Door-Out to arrival at the PCI-capable hospital, consistently met the target of under 40 minutes, with average times ranging from 25 to 30 minutes throughout all months. These durations are entirely influenced by the efficiency of the non-PCI hospital, which manages and operates its own ambulances and trained medical personnel, thereby maintaining complete control over this phase of care[16,17].

The sustained success of IBHOH underscores the efficiency of its specialized transport system, manned by proficient medical professionals equipped to manage critical STEMI cases in transit. With ambulances available around the clock and strict compliance with established protocols, patient transfers are carried out quickly and smoothly, even during busy periods[18,19].

This efficient transport system is crucial in minimizing ischemic time, a key determinant of patient outcomes in STEMI care. Regular training, scenario-based simulations, and periodic reviews of transport protocols further strengthen the hospital's ability to sustain compliance with these benchmarks and maintain high standards of care for its patients[19].

Timely transfers are crucial for achieving the target of under 120 minutes for the first medical contact-to-balloon time, which is vital for optimal STEMI outcomes. Achieving these goals aligns with international guidelines and significantly enhances patient survival and recovery by reducing ischemic damage[19,20]. The hospital’s steady commitment to transport benchmarks highlights the necessity of continuous training programs and regular assessments to maintain high performance in patient transfers. Future initiatives may involve scenario-based drills to tackle potential challenges during transport, ensuring ongoing compliance without interruptions.

Strengths and Limitations

A strength of this study is the comprehensive validation of data through cross-referencing multiple sources, which ensures accuracy and reliability. The detailed analysis of adherence to key, time-sensitive benchmarks provides valuable insights into STEMI management practices. However, the retrospective design may have limitations, including missing data and reliance on existing documentation. Additionally, focusing on a single institution may limit the generalizability of the findings. Furthermore, the study did not include detailed analyses of balloon times or patient outcomes post-PCI, which are critical indicators of the overall quality and effectiveness of care, providing additional insights into the quality of care. The exclusion of these factors limits the ability to fully evaluate the impact of timely interventions on clinical outcomes. Incorporating these factors into future studies, alongside a multicenter approach, would strengthen the assessment of STEMI management practices and outcomes.

Conclusion

This study highlights IBHOH's firm adherence to international standards for STEMI management, particularly concerning Door-to-ECG and Door-Out to Arrival times. The high compliance rates demonstrate the effectiveness of the hospital's triage systems, diagnostic processes, and ambulance services. To achieve 100% compliance for Door-to-ECG in all months, it is recommended that staff training be enhanced to improve the identification of atypical presentations and that additional ECG machines be allocated during peak hours to manage high patient volumes efficiently. Regular review and adjustment of triage protocols can further optimize response times. Nonetheless, the variation in DIDO compliance highlights areas that need improvement, particularly in managing delays caused by atypical cases, coordination issues, and the availability of PCI centers.

To fill these gaps, the hospital needs to enhance coordination between hospitals by improving communication protocols and considering other ways to manage PCI center workload during busy periods. While the hospital's checklist for quick preparation is efficient, conducting regular audits and updates in line with clinical advancements will boost its effectiveness.

Improving transport efficiency is vital, and IBHOH must prioritize ambulance service preparedness by conducting scenario-based drills and frequent evaluations. Establishing structured feedback systems for delayed cases will help pinpoint systemic issues and guide corrective measures. Enhancing collaborations with PCI-capable facilities, like SKSH, and utilizing data-driven insights will facilitate smooth patient transfers and promote ongoing advancements in STEMI care pathways. Expanding research to include multicenter studies and examining patient demographics, transportation methods, and symptoms will enhance our understanding of compliance trends. These efforts support the hospital's goal of enhancing STEMI management, enabling timely interventions and better patient outcomes in facilities lacking PCI capabilities.

Enhancing patient education on identifying STEMI symptoms and pursuing prompt medical care could significantly improve outcomes. Additionally, utilizing telemedicine for early coordination with PCI centers during patient transport may help mitigate delays caused by external factors. By incorporating these strategies into current protocols, IBHOH can further bolster its STEMI management practices, ensuring even more substantial compliance and better patient outcomes in the future.

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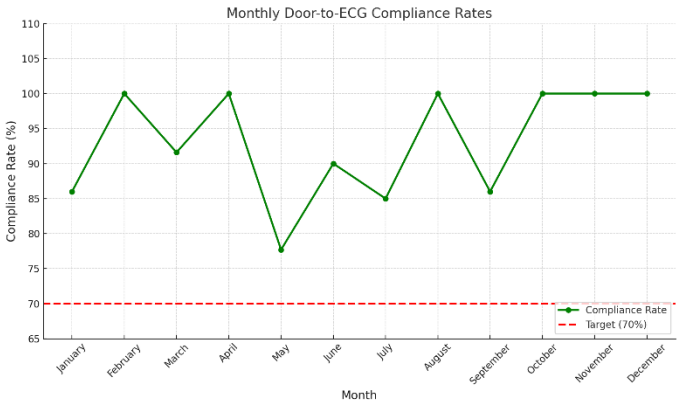

Figure 1: door-in to ECG time.

Table 1: door-in to ECG time.

Month	STEMI Patients (Door-in to ECG <10 mins)	Total STEMI Codes	Compliance (%)
January	6	7	86%
February	4	4	100%
March	11	12	91.6%
April	6	6	100%
May	7	9	77.7%
June	9	10	90%
July	6	7	85%
August	9	9	100%
September	6	7	86%
October	8	8	100%
November	10	10	100%
December	10	10	100%

Table 2: DIDO compliance.

Month	Code MI Activations	Eligible for DIDO Compliance	Met DIDO Target	Compliance (%)
January	7	5	5	100%
February	4	3	3	100%
March	12	9	9	100%
April	6	6	6	100%
May	9	8	4	50%
June	10	9	9	100%
July	7	7	7	100%
August	9	7	6	85.7%
September	7	6	6	100%
October	8	8	8	100%
November	10	10	9	90%
December	10	9	8	89%

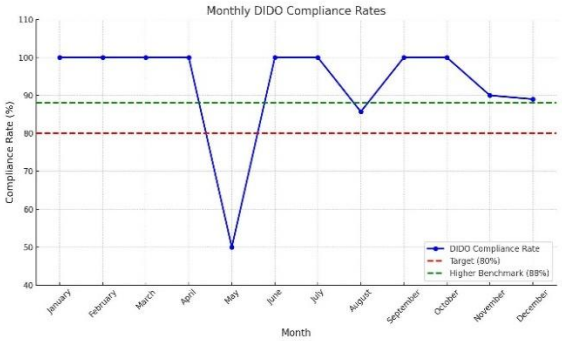

Figure 2 shows DIDO

Table 3: the Door-Out to arrival at a PCI-capable hospital.

Month	Average Transport Time (Minutes)	Benchmark (Minutes)
January	25	40
February	28	40
March	30	40
April	26	40
May	29	40
June	27	40
July	25	40
August	30	40
September	26	40
October	28	40
November	23	40
December	24	40

Figure 3 Door-Out to Arrival at SKSH

Table 4: reasons for the excluded case

Month	Total Exclusions	Reason for Exclusion
January	0	NA
February	0	NA
March	3	Late presentation (1), alternate diagnosis (DKA) (1), unstable patient managed on-site (1)
April	0	None
May	1	Pulmonary edema
June	1	Diagnoses other than STEMI
July	0	None
August	2	Alternate diagnosis (NSTEMI) (1), heart failure managed on-site (1)
September	1	Heart failure admitted to the medical ward
October	0	NA
November	0	NA
December	1	Signed LAMA