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Managing Myocardial Infarction: Challenges Contributing to Delays in DTB Time and Its Components of Timeline Intervals: A Retrospective Chart Review

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Abstract

Background: ST-segment elevation myocardial infarction is the most complicated type of myocardial infarction and often requires aggressive and rapid medical treatment. Door-to-balloon time measures promptness and prognostic outcomes of percutaneous coronary intervention. The DTB time of more than 90 minutes is associated with delays in the other STEMI care components, such as the door-to-ECG, ECG-to-CCL time, and CCL activation to balloon inflation.

Aim: To investigate the delay in DTB time, delay in DTB components of the STEMI care timeline intervals, and the contributing factors in each component in an Oman health care setting.

Method: Retrospective chart review of 281 STEMI patients who registered and underwent primary percutaneous coronary intervention in one of the major hospitals in Oman between 2019 and 2022. The timing of the clinical treatment phases in STEMI management was analysed, measuring the delay in each phase of treatment and the overall door-to-balloon time.

Results: The findings showed average DTB time was 133.40 minutes for female patients (N=48, 17%) and 102.82 minutes for male patients (N=233, 82.6%). It also showed a 38.5% increase in the number of STEMI patients admitted outside working hours (n=174) compared with working hours (n=107) and a significantly higher number of female admissions than males (<.001) and male group (.009) with delays in the treatment timeline interval of patient transfer from ER to CCL (P 0.005). There were significant differences in delays in the timeline intervals during the non-working hours compared to the working hours of the following timeline intervals: 1) Door to time seen by the emergency room doctor (P= 0.026), 2) CCL activation to the time ER was called (P= 0.045).

Conclusion: The study supports the importance of training ER nurses and doctors in STEMI symptoms and the interpretation of STEMI rhythms in ECG tracings to reduce treatment timeline delays. It implies reorganising STEMI patient tasks to avoid delays in PCI during ER peak hours.

Keywords: ST elevation Myocardial Infarction; Cardiac catheterization; Percutaneous coronary intervention; PCI; Door to balloon time

Abbreviations: CCL: Cardiac Catheterisation Laboratory; DTB: Door-to-Balloon time; ECG: Electrocardiogram; ER: Emergency Room; PCI: Percutaneous Coronary Intervention; RMIT: Royal Melbourne Institute of Technology University; STEMI: ST-segment elevation myocardial infarction

Introduction

ST-segment elevation myocardial infarction (STEMI) results from an imbalance in the supply and demand of oxygen caused by insufficient perfusion, leading to progressive and irreversible cardiac muscle necrosis [1]. It is associated with increased mortality and worse cardiac functional outcomes when treatment is delayed by minutes [1]. It accounts for 29.6% of all mortality rates in the world and results in the death of 16 million people each year [2]. By 2030, it is estimated that 23.6 million people will die from Myocardial Infarction (MI) worldwide [3].

Literature Review

STEMI management is referred to as door-to-balloon time (DTB), the period between when patients arrive at the hospital with chest pain and when their first balloon inflation or Percutaneous Coronary Intervention (PCI) is performed [4]. As a quality indicator, DTB time is used to assess PCI promptness and prognosis [5]. According to international guidelines, DTB should not exceed 90 minutes [6]. DTB time involves components of the treatment timeline intervals in STEMI management that may impact the reperfusion time. The first timeline interval is the door to Electrocardiography (ECG), which refers to the time the chest pain patient enters the hospital, and the acquisition of an ECG [7]. According to the National Heart Foundation of Australia, the Cardiac Society of Australia and New Zealand, and the American Heart Association, door-to-ECG time should be no more than ten minutes [8,9].

ECGs performed rapidly for STEMI diagnosis are crucial to achieving prompt coronary artery reperfusion or PCI [10]. It has been reported that door-to-ECG within 10 minutes of patient contact with health professional staff is associated with a 50% reduction in mortality [11]. Delays in door-to-ECG were reported to be associated with factors like the presentation to the ER outside working hours, patients with direct arrival by walk-in, and delays in obtaining the ECG [12,13]. A retrospective chart review showed that the door-to-ECG time greater than 10 minutes was more likely in walk-in patients, with atypical chest pain symptoms, and critical STEMI with congestive heart failure that required further investigations besides ECG to confirm STEMI [4]. A prospective chart review revealed that delays in the door-to-ECG time occurred in all patients, with a mean delay of more than 21 minutes. Several factors contributed to delays in door-to-ECG time, such as the failure to recognise patients with chest pain because the patients had atypical ischemic symptoms, the delay in obtaining an ECG, and the delay in activating and transporting patients to the Cardiac Catheterisation Laboratory (CCL) located in another building [14].

Besides the timeline interval of door-to-ECG time, other timeline intervals in STEMI management contributed to the overall DTB time. These timeline intervals vary from institution to institution, depending on the quality measurement indicators of the institution. In a retrospective study, the timeline intervals included ER presentation to first ECG, first ECG to CCL activation, CCL activation to CCL arrival, CCL arrival to vascular access, and vascular access to device deployment [15]. Significant delays were reported in the majority of the timeline intervals ($P < 0.01$), which were associated with the overall delay in DTB time of 124 minutes in 67.4 % of the patients. Factors associated with delays in the timeline intervals included long ER stays, with an average duration of 95 minutes, and a delay from CCL activation to patient arrival in the CCL, averaging 20 minutes. In another study, STEMI treatment timeline intervals involved time from STEMI diagnosis to CCL activation, time of CCL team arrival, time of transport to CCL, time of obtaining consent, and time of arrival to PCI [16].

The study's outcomes showed a delay of 33 minutes in overall DTB time, which was associated with delays in all treatment timeline intervals, particularly in the time of obtaining consent, with an average increase of 20.3 minutes. Another retrospective study showed that the STEMI treatment timeline phases consisted of the door-to-ECG, ECG-to-CCL activation time, CCL activation-to-response time, response to a patient in CCL, and patient-in-CCL-to-attending time [17]. The overall delay in DTB time was an average of 134.4 minutes. It was associated with delays in all timeline intervals but more pronounced in the door-to-ECG interval, with an average delay of 43.1 minutes, and in the ECG-to-activation time interval, with an average delay of 87.1 minutes. Factors related to these delays were reported as long distance between the ECG technician and the patient, and delay in diagnosing STEMI [17].

Background

This study focuses on one of the major government PCI hospitals in Oman. In this hospital, where the current study is conducted, the treatment of STEMI patients involves multiple treatment timeline intervals in the ER and the CCL. The treatment time intervals are measured in minutes according to the hospital policy of DTB time as presented in (Table 1). It includes the time intervals of Door-to-ECG, Door-to-time seen by ER doctor, Time from referral-to-seen by cardiology, Time from seen by cardiology-to-time of CCL activation, Time CCL activation-to-time to ER called, time from patient transfer from ER-to-CCL, and time of patient arrival to CCL-to-PCI performed. This study aims to investigate the delays in DTB time and the delays in DTB components of the STEMI care timeline intervals, as well as the contributing factors in each timeline interval, in an Omani healthcare setting.

Method

Setting

This study was conducted in a tertiary care hospital in Oman. The setting of the study included the ER and CCL as they concerned departments in STEMI management.

Data Collection

The data presented in this study were retrieved from the hospital's electronic medical records of STEMI patient visits in the ER from 2019 to 2022.

Sample

This retrospective chart review included 281 STEMI patients who underwent PCI in a major hospital in Oman from 2019 to 2022. The inclusion criteria included charts of all confirmed STEMI cases that were seen in the ER from 2019 to 2022. The exclusion criteria involved any STEMI chart before 2019 or after 2022, charts of STEMI cases developed in wards, all non-STEMI patients, patients who were not fit for PCI, and those with inadequate documentation of arrival or reperfusion times.

Exposure

In this study, the hospital policy of DTB time is considered as primary independent variable.

Table 1: STEMI Treatment Timeline Intervals in Minutes.

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Segments	Treatment Timeline Interval	From	To	Treatment Timeline Interval in Minutes
1	Door to ECG time	The time the chest pain patient enters the hospital	The time at which the first ECG trace is obtained	10
2	Door to time seen by ER doctor	The time the ER doctor is called	The time the patient is seen by the ER doctor	10
3	Time from referral to seen by cardiology	The cardiologist is informed	Time seen by the cardiologist	10
4	Time from seen by cardiology to time of CCL activation	Time STEMI is diagnosed	Time CCL is activated	10
5	Time CCL activation to time to ER called	Time CCL is activated	Time CCL calls ER to transfer the patient	30
6	Time from patient transfer from ER to CCL	Time patient transfer started in the ER	Time patient arrives CCL	5
7	Time of patient arrival to CCL to PCI performed	Time patient arrives CCL	Time PCI performed	15
8	Total DTB time			Total 90 minutes

Predictors & Potential Confounders

The predictors in this study included patient or system-level variables that are likely to influence the DTB time. Patient demographics included variables of age and gender. System-level factors included the statistics of the overall treatment timeline intervals of STEMI patients, the number of STEMI patients arriving at the ER during working hours (WH) from 8 am to 2 pm, and non-working hours (NWH) from 2 pm to 8 am.

Potential Confounders

A confounder is a variable that is independently associated with both the exposure (hospital protocol) and the outcome (DTB time), and if not accounted for, can distort the true relationship between the two. In this retrospective review, patient-level confounders of age and gender were considered as these can influence both the DTB time, e.g., women and older patients may have atypical symptoms leading to diagnostic delays. The system-level confounders of time of arrival were considered as a crucial confounder as it affects both the policy execution and the final DTB time, e.g., off-hours arrivals often result in delays due to lower staffing and cath lab team availability.

Effect Modifiers

An effect modifier is a variable that changes the relationship between the exposure (DTB policy) and the outcome (DTB time). In other words, the effect of the exposure on the outcome is different depending on the level of the third variable. In this study age variable was considered as an effect modifier, as older patients present with more complex and atypical symptoms compared to younger patients. Also, gender was considered a variable as an effect modifier, as the effect of hospital policy on DTB time may be different for men and women, especially since women tend to have longer symptom-to-door times and may present with less typical symptoms.

Comparability of Assessment Method

In this study, the key to ensuring comparability included data on DTB time for STEMI patients across different groups. This involves standardising data extraction, defining time intervals consistently, and controlling for confounding factors that could introduce bias. The most critical aspect is defining the time intervals consistently across all groups. DTB time is a composite of several sub-intervals, and any variation in how these are measured can invalidate the comparison. The DTB sub-intervals are illustrated in Table 1. To ensure comparability between groups of male vs female, or off-hours vs. on-hours patients, standardised data extraction was used to ensure that the data is extracted uniformly by all reviewers.

Statistical Assessment of Comparability

Statistical analysis was performed using SPSS software (version 28) for data analysis. Descriptive statistics test was used to analyse the baseline demographic characteristics of age and gender compared with DTB time. An independent t-test was used to compare the mean score on DTB time and the mean score on each treatment timeline interval for two groups of STEMI patients (male and female groups). An independent t-test was used to compare the mean score on DTB time and the mean score on each treatment timeline interval for two groups of working hours and non–working hours. The Pearson chi-square test was used to determine differences in the mean score of two categorical variables of male and female, with the two categorical variables of WH & NWH.

Potential Source of Bias

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Efforts have been made to avoid potential sources of bias in this retrospective chart review of STEMI patients by focusing on mitigating the inherent limitations of using pre-existing data. These limitations include selection bias and information bias.

Selection Bias: The researchers used a consecutive patient sampling method to include all eligible patients from a defined period, minimising the chances of leaving out specific groups. The researchers clearly defined and reported the inclusion and exclusion criteria to ensure transparency and allow for critical evaluation of the study's representativeness.

Information Bias: The authors avoided Information bias by ensuring the absence of inaccuracies or inconsistencies in data collection from patient charts. Key variables like the exact time of intervals within the DTB pathway (e.g., time of ECG completion) were checked for not being missing, leading to inaccurate time interval calculations.

Results

The retrospective chart review included 281 STEMI patients registered in the ER of a major hospital in Oman from 2019 to 2022. The chart review shows the majority of the patients were male (n=233,82.6%), while female patients were 17% of STEMI presentations (n=48), with an average age for all patients of 56.52 (± 12.58), as shown in Table 2.

Treatment timeline intervals for male and female STEMI patients are presented in Table 3, 4. Although segments 1,2,3,4,5, & 7 of the two gender groups were almost the same with no statistical significance, the timeline interval in segment 6 was (t -2.126, df 278, P=0.005) significantly higher in males than females, as shown in Table 4. Similarly, the female groups had a higher time in segments 2, 3,4, & 5 than their male counterparts, but no statistical difference was found. The DTB time in this patient group was over 20 minutes higher than the benchmarks.

Table 2: Demographic Characteristics.

Age (Mean/SD)	56.52 (12.58)
Gender	
Male (No. (%))	233 (82.6%)
Female (No. (%))	48 (17%)

Table 3: Difference of DTB Time Between Male and Female Patients.

Gender	No. (%)	DTB time Mean (minutes) (SD)	P value	df
Female	48 (17%)	113.40 (44.17)	0.180	279
Male	233 (82.6%)	102.82 (50.61)		

Table 4: Descriptive Statistics of The Treatment Timeline Intervals Between Male and Female Patients.

Segments	Treatment Timeline intervals	Gender	Mean (+-SD) in minutes	t	df	P value
1	Door to ECG time	Female	5.58 (8.47)	-0.105	279	0.916
		Male	5.76 (11.26)			
2	Door to time seen by ER Dr	Female	7.38 (8.86)	-0.795	279	0.427
		Male	9.11 (14.58)			
3	Time from referral to seen by cardi-ology	Female	11.00 (12.72)	0.567	279	0.571
		Male	9.52 (17.14)			
4	Time from seen by cardiology to time CCL activation	Female	16.56 (15.29)	1.246	277	0.214
		Male	13.53 (15.36)			
5	Time CCL activation to time to ER called	Female	27.98 (18.31)	0.759	279	0.448
		Male	25.61 (19.95)			
6	Patient transfer from ER to CCL	Female	7 (4.1)	2.126	278	0.005
		Male	9.12 (6.65)			
7	Door-to-Balloon time	Female	113.40 (44.169)	1.346	279	0.145
		Male	102.82 (50.614)			

Table 5: Number of STEMI Patients in Working Hours VS Non-Working Hours.

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Time of STEMI patient arrival to ER	Number (%)	DTB time Mean (SD)	P-value.
Working Hours	107 (38%)	99.29 (50.3)	0.282
Non-Working Hours	174 (62%)	107.91 (49.14)	

Table 6: Gender vs Working Hours and Non-Working Hours.

	Male	Female	Total	Pearson Chi-Square value	df
Working hours	87 (81.3%)	20 (18.7%)	107(100%)	0.316[a]	1
Non-working hours	146 (83.9%)	28 (16.1%)	174(100%)		
Total	233 (83%)	48 (17.0%)	281 (100%)		

Table 7: Descriptive Statistics of the Treatment Timeline Interval of STEMI Patients during WH and NWH.

Segments	Treatment Time	WH or NWH	Mean (SD) mins	t	df	Sig.
1	Door to ECG time	WH	6.31 (11.21)	0.698	279	0.473
		NWH	5.38(10.68)			
2	Door to time seen by ER doctor	WH	9.94(15.68)	1.078	279	0.026
		NWH	8.12(12.47)			
3	Time from referral to seen by cardiology	WH	8.80(13.21)	-0.773	279	0.315
		NWH	10.37(18.25)			
4	Time from seen by cardiology to time CCL activation	WH	14.77(17.18)	0.615	277	0.170
		NWH	13.61(14.37)			
5	Time CCL activation to time ER is called.	WH	19.29(21.67)	-4.657	279	0.045
		NWH	30.15(17.21)			
6	Patient transfer from ER to CCL	WH	8.97(6.87)	0.442	278	0.436
		NWH	8.63(6.15)			
7	Door-to-Balloon time	WH	99.29(50.37	1.415	279	0.282
		NWH	107.91(49.14)			

Table 5 presents a delay in DTB time if the patient started the STEMI pathway during the NWH, with an average of 107.91, ± 49.14 minutes, compared with those who entered the path during the WH, 99.29, ±50.3. A Pearson Chi-Square Test for Independence indicates a significant association between gender and the time the pathway was initiated (either during WH or NWH). X2 (1, n =281) p <.001 as shown in Table 6. Table 7 presents the treatment timeline intervals during WH and NWH for the STEMI patients. The segments 1,3,4,6, & 7 were almost the same with no statistical significance; however, the timeline interval in segment 2 of the door to the time seen by the ER doctor was (t 1.078, df 279, P=0.026) significantly higher in WH (9.94 ± 15.68) than NWH (8.12 ± 12.47). Similarly, segment 5 of CCL activation and the time ER was called was (t-4.657, df 279, P=0.045) significantly higher in NWH (30.15 ± 17.21) than in WH (19.29 ±21.67). The DTB time in this patient group was over 8 minutes higher than the benchmarks.

Discussion

This study examined all possible segments of reperfusion delays in STEMI patients admitted to one of the largest tertiary care hospitals in Oman from door to balloon by analysing different timeline intervals of care of STEMI patients. The study compared gender impact on the timeline intervals for transferring patients from ER to CCL, which had an impact on the overall DTB time. Gender impact on DTB time was reported by [18], as female STEMI patients delay reporting to the ER from the time of symptoms onset due to non-chest pain or atypical symptoms. Compared to male patients with STEMI, females were significantly more likely to experience epigastric symptoms and jaw, neck, arm, and shoulder pain [18]. The role of gender in the perception of STEMI symptoms was assessed and found that nearly 70% of the females reported non-chest pain symptoms [19]. Similar outcomes were reported in another study, which found that females were almost one hour late in ER presentation compared to male patients [20].

Gender impact on the ECG tracing characteristics was evaluated in one of the studies, which suggested a relationship

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between atypical symptoms and disease comorbidities like diabetes, with its impact on the ECG tracing characteristics [19]. The study found that the ECG tracing in men was more likely to have left anterior descending artery ischaemic-related characteristics that are commonly found in the STEMI tracing, whereas women were more likely to have right coronary artery ischaemic-related characteristics, which may have resulted in more subtle changes to the ECG in women [19].

Gender variability in STEMI care was evaluated using a comprehensive STEMI protocol [21]. This protocol included 4 steps in activating the CCL by an Emergency Room (ER) physician, along with a safe handoff checklist detailing the roles of emergency department nurses and cardiologists to facilitate simultaneous high acuity assessments, immediate transfer to the CCL, and first radial PCI.

The study reported that pre-protocol DTB time for males vs females was 104 vs 112 minutes, and post-protocol had a significant reduction (89 vs 91 minutes) indicating the impact of early and efficient triage on both genders' DTB time [21]. This implicates the public awareness of STEMI symptoms and early reporting to PCI centres. As well, it implicates the importance of training ER nurses and doctors on atypical symptoms of STEMI and the interpretation of different STEMI rhythms in ECG tracings. This study also compared patient arrival during NWH to STEMI patients' arrival during WH. The WH patients had longer wait times before being seen by the ER physician when they arrived at the emergency room. ER physicians' delay in attending to critical cases was associated with the peak number of patients arriving during WH, as opposed to during NWH [22] or due to the demands of managing other critical cases [23]. A study suggested strategies to improve patient waiting time during the peak of patients' census by the multitasking technique, in which a multitasker can reduce the amount of time spent waiting between tasks by completing numerous tasks at once switching from a pending task to a new one, rather than waiting on a pending one [24].

Another strategy for managing multitasking is the early task initiation strategy, in which, if the system is congested, tasks that normally occur late in the process can be initiated at an earlier stage to reduce the patient's waiting time [25]. The potential benefit is that tasks are taken out of congested resources and handled concurrently or during wait times [25]. It implies proposing improvements to the management of STEMI cases in emergency rooms by introducing all required tests to the triage room immediately after a STEMI has been confirmed by an ECG and completing patient preparation, including shaving and consent prior to the arrival of the cardiologist. Although this might affect the cost and the effort if the STEMI case is a false positive, it would nonetheless save patients precious minutes if the STEMI case were a true positive.

The current study outcomes also showed time delays during the NWH in the treatment timeline interval from the time CCL activation to the time ER is called. Similar outcomes were found in another study [26], which found a significant delay during the NWH between CCL activation to the time of PCI, with a longer delay of 72 minutes during the NWH compared to 55 minutes during the WH. Another study revealed that the delay in CCL activation was related to the unavailability of the CCL team and the cardiologist at the PCI centre during NWH, which caused a delay of 34.59 minutes in reaching the hospital after activation of the CCL [27]. To improve CCL activation time, the study suggested modifying the on-call team protocol on CCL arrival time by reducing the expected arrival time from 30 minutes to 20 minutes, considering traffic congestion and the effects of distance on arrival times [27].

Limitation

The outcomes of this study might not be generalised to other settings as it was conducted in a single centre. Since the authors of this study were unable to retrieve any data before 2019, the retrospective chart review presented here is limited to the data collected from 2019 to 2022, from the time data was recorded. Moreover, the presented data lacked treatment history and treatment outcomes due to the manual entry of the patient data in an Excel sheet and then transferred to the system, which imposed the possibility of missing data.

Conclusion

In conclusion, this study has revealed delays in several timeline intervals of STEMI care. Delays due to the patient's gender were significant in female STEMI patients which resulted from atypical symptoms and delay in presenting to the ER from the time of the onset of chest pain. This implies initiatives such as public education campaigns aimed at raising public awareness of how to recognise and distinguish STEMI pain, as well as encouraging early reporting to PCI centres, may be beneficial. Furthermore, the study reported delays associated with the time of day, such as delays in the ER physician's first contact with STEMI patients during the WH. Methods for improving the efficiency of healthcare workers in utilising patient time throughout the peak hours of the ER were suggested in this study. Additionally, there were delays during the NWH, which were associated with the factors contributing to the delays in the CCL team's arrival until the ER was called to transfer the patient for PCI. The impact of the traffic and the distance travelled by staff on call should be taken into consideration to assess the CCL team's arrival time. Finally, studies with a focus on gender and the time of day are recommended to further investigate the effects of these factors on DTB.

Ethics

This study was approved by the Human Research Ethics Committee at RMIT University (approval number 25548) and the Research and Study Centre at the Ministry of Health, Oman.

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Conflict of Interest

This research-based manuscript or a substantially similar version is not under consideration by another journal, nor has it been accepted or published elsewhere. The research was unfunded. This manuscript contributes to knowledge development in nursing education. No commercial interests or financial conflicts of interest are disclosed for either of the authors.

Each author contributed to the work as follows.

Author Contributions:

Study design: BA, KL, ZL

Data collection: BA

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Study supervision: KL, ZL

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