SUBMITTED 18 JUL 23
REVISIONS REQ. 22 AUG & 2 NOV 23; REVISIONS RECD. 28 SEP & 11 NOV 23
ACCEPTED 14 NOV 23
ONLINE-FIRST: DECEMBER 2023
DOI: https://doi.org/10.18295/squmj.12.2023.089

Influence of Organisational-Level Factors on Delayed Door-to-Balloon Time among Patients with ST-Elevation Myocardial Infarction

Munira A. Al-Rumhi,[1] *Sulaiman D. Al Sabei,[2] Huda S. Al-Noumani,[2] Adil Al-Riyami,[3] Omar Al-Rawajfah[4]

[1]Emergency Department, Sultan Qaboos University Hospital, Muscat, Oman; [2]College of Nursing, Sultan Qaboos University, Muscat, Oman; [3]Department of Medicine, Sultan Qaboos University Hospital, Muscat, Oman; [4]Department of Nursing, Al al-Bayt University, Al-Mafraq, Jordan.
**Corresponding Author's e-mail: alsabei@squ.edu.om*

Abstract

Objective: To estimate the door-to-balloon (DTB) time and determine the organisational-level factors that influence delayed DTB times among patients with ST-elevation myocardial infarction in the Sultanate of Oman. ***Methods:*** A cross-sectional retrospective study was conducted. All patients who presented to the emergency department at two public hospitals and underwent primary percutaneous interventions during the period of two years were included. ***Results:*** The sample included 426 patients. The median door-to-balloon time was 142 minutes. The result of bivariate logistic regression showed that patients who presented to the emergency department with atypical symptoms were three times more likely to have a delayed DTB time compared with patients presenting with typical symptoms (OR = 3.003, 95% CI: 1.409–6.400, *p* = .004). In addition, patients who presented during off-hours were two times more likely to have a delayed DTB time compared with patients who presented during regular working hours (OR = 2.291, 95% CI: 1.284–4.087, *p* = .005). ***Conclusion:*** To meet the door-to-balloon time recommendation, it is important to ensure that there is adequate staffing during both regular and

irregular working hours. Results from this study can be used as a baseline for future studies and inform strategies for improving the quality of care.

Keywords: Acute Myocardial Infarction; Clinical Management; Door-to-balloon Time; Emergency Care Systems; Staffing and Scheduling; Oman.

Advances in Knowledge

- The times of day that patients presented were significantly associated with delayed door-to-balloon times.
- The inability of triage nurses to recognise the symptoms of patients with ST-elevation myocardial infarction was associated with delayed door-to-balloon times.
- Ninety percent of the females who presented with atypical symptoms had a delayed DTB time.

Application to Patient Care

- Training nurses in the emergency triage room to identify patients with ST-elevation myocardial infarction and ensuring the availability of adequate staffing during both regular and irregular working hours are critical factors in performing timely surgical interventions for patients with ST-elevated myocardial infarction.

Introduction

Globally, heart disease is the number one cause of death. According to the latest statistics released by the American Heart Association (AHA), approximately 18.6 million deaths occurred globally from heart disease in 2019.[1] One of the most common heart diseases is ST-segment elevation myocardial infarction (STEMI). It has been associated with negative healthcare outcomes including prolonged length of hospitalisation and increasing in-hospital mortality.[2,3] Therefore, treating STEMI is one of the top priorities of healthcare institutions. Performing timely primary percutaneous interventions (pPCIs) is critical in saving the lives of patients with STEMI.[4] Door-to-balloon time (DTB) is one of the quality indicators for performing timely pPCIs.[5]

The DTB time refers to the time between hospital arrival and the inflation of the first balloon or device.[5] The DTB time should last no more than 90 minutes, according to the most recent guidelines published by AHA and the American College of Cardiology (ACC).[5] Patients who have delayed DTB times have poorer outcomes such as impaired left ventricular ejection fraction, prolonged hospitalisation, and higher crude in-hospital mortality.[3,6]

Investigating the factors contributing to the delayed DTB time is critical in ensuring safe practices. Studies showed that many factors impact DTB times including sex, presenting time, and presenting symptoms.[7–9] The main gap identified in the literature is that most studies assessing the factors responsible for delayed DTB times were conducted in Western countries. Limited studies were conducted in Eastern countries, including Oman. The healthcare system in Western countries is different from that of Eastern countries, which may suggest that different factors can be associated with DTB time depending on the context.

Methods

Study Objectives

The objectives of this study were to estimate the door-to-balloon (DTB) time and determine the organisational-level factors that influence delayed DTB times among patients with ST-elevation myocardial infarction in the Sultanate of Oman.

Study Design and Sample

The current study used a retrospective cross-sectional design. Data were collected for patients who had undergone pPCI over a two-year period (from January 2018 to December 2019) in two public hospitals by reviewing their medical records to gather required information about the DTB time and its associated factors. We included adults above 18 years old who presented with STEMI. Patients who underwent pPCI more than once during the study period were counted as a new case each time. We excluded the referred STEMI patients who were managed from other healthcare facilities, patients who did not choose pPCI as their primary reperfusion therapy, and patients who underwent an elective PCI.

Data Collection Procedure

The study was approved by the Medical Research and Ethics Committee and the Ministry of Health. The data was collected by including all patients who underwent primary and elective PCIs from January 2018 to December 2019 at Royal and Sultan Qaboos University Hospitals. The PCI registry is a prospective registry designed to collect and record PCI types and their timings. The pPCIs were extracted and the list was generated. The principal investigator reviewed and scanned the medical records of the listed patients. This task involved reviewing nursing notes, physician notes, and laboratory results. The catheterization (balloon) times were extracted from the catheterization laboratory registry, which is available in both study hospitals.

Because this is a retrospective study, there was no direct contact with the study participants, and no informed consent was required. Patient confidentiality was maintained throughout the study period by removing all identification data from all study documents. A total of 3,281 PCIs were conducted at the participating hospitals during the study period. A total of 2855 cases were excluded because they were elective (n = 2768) or referral cases (n = 87) from other hospitals that were not admitted through the emergency department (ED). The final sample consisted of 426 patients (300 patients from the Royal hospital and 126 patients from Sultan Qaboos University Hospital) who met the inclusion criteria (see Figure 1).

Study Variables

Dependent variable: DTB time was measured from the time of registration in the ED to the time of intervention as recorded in the patients' health record system. A DTB time of more than 90 minutes was considered a delayed time.

Independent variables: The independent variables were age; sex; troponin level; history of comorbidities including diabetes, hypertension, and dyslipidemia; previous MI, previous coronary artery bypass graft (CABG); smoking status; presenting time (off-hours versus regular working hours); triage level (low versus severe); presenting symptoms (atypical versus typical); and presenting status (stable versus non-stable). Data were retrieved from the patient's electronic medical records. Patients with STEMI who presented to the ED without congestive heart failure, hypotension, or cardiac arrhythmia were considered hemodynamically stable.[10] Patients who

presented with chest, arm, jaw, and radiating symptoms such as nausea, vomiting, sweating, dyspnea, and palpitation were classified as typical.[11] Patients who presented to the emergency department with indigestion-like symptoms from the triage chief complaint episode as indicated in the medical record were classified as atypical.[11] Accordingly, a variable called "presenting symptoms" was created in the SPSS. The variable was dichotomous, and responses were either typical or atypical.

Patient presenting time is defined as the comparison of off-hours versus regular hours as weekend and night versus weekday regular hours, weekend versus weekday, or night versus daytime.[12] Operationally, patients who presented to the ED between 7 AM and 3 PM from Sunday to Thursday were recorded as patients presented during regular working hours, while patients who presented to the ED from 3 PM to 7 AM were classified as off-working hours. Also, patients who presented during weekend and public holidays were considered as presented during off-working hours.

Statistical Analysis

Data were analysed by using SPSS program version 23. Statistical significance was considered at a *p*-value less than 0.05. We estimated DTB times among patients with STEMI at selected hospitals in Oman by using median and interquartile statistics. Then we examined the possible factors associated with delayed DTB times among the same patients by using bivariate logistic regression. No sensitivity analyses were conducted.

Patient and Public Involvement

Neither patients nor the public were involved in the design, conduct, reporting or dissemination plans of our research.

Results

Sample Characteristics

The sample consisted of predominantly male (81.7%) and Omani (76.1%) patients. The mean age of study participants was 56.76 years old (*SD* = 12.38). More than half the patients (60.6%) did not have a family history of cardiac diseases. Fifty-five percent (*n* = 234) of patients were

triaged at either level 1 (5.4%) or level 2 (49.5 %). More than three-quarters (89.9%) of the patients had positive troponin results at presentation (see Table 1).

Many patients had a history of hypertension (47.7%) or diabetes (45.5%). Furthermore, 14.1% of the patients had a previous diagnosis of MI and had been treated with PCI whereas 2.6% had undergone a CABG. Approximately 4% of the patients had a history of chronic kidney disease (CKD). In addition, 27.9% of the patients were smokers. Among the patients presenting to the ED, more than three-quarters (89.7%) were considered stable according to their vital signs. Approximately two-thirds (70.9%) presented with complaints of typical MI symptoms. The majority of study patients (76.8%) presented to the ED after official hospital hours (see Table 1).

The relationship between patients' characteristics and door-to-balloon time was assessed using chi square test of independence for dichotomous variables, such as gender, and fisher exact test for categorical variable, such as presenting status (see Table 1). Findings revealed that patients presenting time and symptoms were the only variables that were significantly door to balloon time (p = .005).

Door-to-Balloon Time

The median DTB time was 142 (*IQR* = 110 - 190) minutes. The majority (n = 357, 83.8%) were classified as delayed DTB times (> 90 minutes), whereas only 69 cases (6.2%) had non-delayed times. Patients in the delayed DTB group spent 150 minutes (*IQR* = 128 – 150), while patients in the non-delayed group spent 75 minutes (*IQR* = 67 – 83) from the time they reached the ED until the balloon procedure was implemented (see Table 2).

The overall DTB time was further divided into three intervals: (a) the average time interval spent from door to ECG, (b) ECG to transfer to the catheterization laboratory, and (c) arrival at the catheterization laboratory to the balloon procedure (see Table 2). Findings showed that the longest time was spent between conducting the ECG and transferring the patient to the catheterization laboratory (ECG to Cath Lab; (Median = 78 minutes, *IQR* = 53 - 98.25), followed by the time spent between the catheterization laboratory and the balloon (Median = 70 minutes, *IQR* = 44 – 90.25). Mann-Whitney U test was used to compare the DTB time intervals between

delayed and non-delayed DTB patients. The time difference between the two groups was statistically significant in all DTB time-interval categories, as indicated in Table 2.

The DTB time intervals were also compared across the two study settings, namely Hospital 1 and Hospital 2, showing significant difference in all door-to-balloon time intervals between the two hospitals, see Table 3.

Factors Associated with Delayed DTB Times

Bivariate logistic regression was performed to identify factors influencing the likelihood of a delayed DTB time (Table 4). The model was tested against the constant only model and was found to be statistically significant ($\chi 2 = 17.13$, $p = 0.04$). The total Nagelkerke R^2 for the model was 0.086 whereas the Cox–Snell R^2 was 0.050.

'Presenting symptom' and 'presenting time' were the only significant factors that were associated with the likelihood of delayed DTB times (OR = 3.003, 95% CI: 1.409–6.400, p = 0.004) and (OR = 2.291, 95% CI: 1.284–4.087, $p = 0.005$) respectively. The overall successful prediction rate of the model was 83.8% to classify patients in delayed and non-delayed categories. A post-estimation Hosmer-Lemeshow test was conducted to assess the goodness of fit for the logistic regression model, ($\chi 2 = 10.254$, $p = 0.248$).

Discussion

The current study findings showed that 83.8% of the study patients had a delayed DTB time. The median DTB time was 142 minutes, which is longer than the time recommended by AHA and ACC for managing patients with STEMI.

At the regional level, the current study showed that DTB times in Oman were higher than the times reported in studies conducted in Iran,[8] Qatar,[13] Saudi Arabia,[14] Kuwait, Bahrain, and the United Arab Emirates.[15] At the international level, the DTB time in Oman was also higher than in other countries including Thailand,[16] Singapore,[17] Japan,[18] Nepal,[19] Canada,[20] Australia,[21] and the United States.[22]

The differences in the DTB times among patients treated in Oman compared to the findings of other studies can be attributed to the differences in study design, sample size, study setting, and the implementation of quality improvement projects. One of the factors that could have contributed to the variation in the reported DTB times across studies was the use of different study designs. For example, the study that was conducted in Nepal[19] utilised a prospective design. The use of a prospective design can ensure the accuracy of data and the ability to examine many variables, results that are not possible in a retrospective approach. Moreover, sample size is another factor that could affect reported DTB times. Some studies reported a small sample size ranging from 79 to 150 participants.[16,19] In addition, some of the studies were conducted at a single centre such as studies conducted in Qatar,[13] Iran,[8] Saudi Arabia,[14] Thailand,[16] Singapore,[17] and Canada.[20] The generalisability of such study findings is limited, which might be another factor that contributed to their lower DTB times compared with the current study, which collected data from two settings.

The current study found that the average time expended from the ECG to the catheterization laboratory was 85.15 minutes (SD = 56.45 minutes). According to the literature, the recommended ECG-to-catheterization-laboratory time should be less than 45 minutes.[22] The ECG-to-catheterization-laboratory time in the current study was shorter than the time reported by Tungsubutra and Ngoenjan among patients in Thailand, which was 93 minutes.[16]

There are many potential explanations for the delayed ECG-to-catheterization-laboratory time in the current study. The first explanation is that delays in management decisions resulted in delayed activation.[8] The emergency physicians, in the two selected hospitals, do not have the privilege of activating the catheterization laboratory, instead they are required to wait for the senior cardiologist to confirm the STEMI diagnosis. The second explanation is a delay in obtaining informed consent. The patient could take a long time to provide informed consent. Swaminathan et al. reported that Asian people take a long time to sign the informed consent.[23] The Omani cultural practice of obtaining the informed pPCI consent is quite different because of cultural considerations. For example, the doctors must wait for a male relative to sign the informed consent for female patients. Moreover, language barriers also play a significant role in

delaying informed consent. Future studies are needed to explore the impact of cultural delays in obtaining informed consent on the DTB time.

The third explanation is the limited number of catheterization laboratories. In SQUH, there is only one catheterization laboratory, and in Royal Hospital, there are five catheterization laboratories in the cardiac center and one catheterization laboratory in the main hospital building. As a result, if the catheterization laboratory were occupied with an elective case, significant delays would arise. When this occurs, the ED staff is told to keep the patient who was diagnosed with STEMI in the ED until the catheterization laboratory is ready to receive them. Time spent within the ED and transferring to the catheterization laboratory is considered to be the largest component of DTB time. The in-house nursing staff can reduce DTB time by shifting the patient immediately to the catheterization laboratory.[24]

The present study showed that the mean time of catheterization laboratory to balloon was 72.89 minutes (SD = 42.63 minutes) longer than the recommended time which is 15 minutes.[22] The catheterization-laboratory-to-balloon time in our study was longer compared to the study done by Zamani et al.[8] They found that the catheterization-laboratory-to-balloon time was 15 minutes in both the delayed and non-delayed DTB groups. In the catheterization laboratory, the delay could occur in the patient handover between the ED and catheterization laboratory nursing staff especially for complicated and unstable patients.[17,18] Other possible factors are the patient's presenting status, comorbidities, procedure characteristics and the number of involved blood vessels.[23] Future observational study is needed to explore the factors contributing to the delayed catheterization to balloon time.

The study's findings demonstrate that patients who presented in the ED with atypical symptoms of STEMI were three times more likely to have delayed DTB times compared with patients presenting with typical symptoms. This is in line with the findings of other studies.[17,23,24]This indicates that the absence of typical chest pain, which is the typical presenting symptom in patients with STEMI, makes the recognition and identification of the case more challenging. Therefore, when patients present with atypical symptoms, this causes a delay in the overall DTB time because of a delay in obtaining the ECG,[23] which slows the diagnosis.[20]

Identifying patients who are more likely to present with atypical symptoms is critical to time and management. The current study showed that the main characteristics of patients who presented with atypical symptoms were that they were elderly or had diabetes. This finding is consistent with other studies.[17,18] Female sex was also another factor significantly associated with atypical presenting symptoms. In the current study, just over half (53%) of the female patients presented with atypical symptoms. Ninety percent of the females who presented with atypical symptoms had a delayed DTB time. This resembles the findings of previous studies, which found that females had long DTB times due to atypical symptoms.[21,25,26] It is imperative that ED physicians or triage personnel maintain a high level of suspicion to prevent delays in door-to-ECG times caused by gender and age disparities.

The current study findings also demonstrated that when patients present with atypical symptoms, nurses tend to assign them to low severity triage levels. Looking deeply at the current study data shows that, out of the total study sample, 192 patients (45%) were triaged in the low severity group (levels 3, 4 or 5); more specifically, there were four STEMI patients who were assigned to triage level 4 (less urgent) and two to triage level 5, the non-urgent category. Seventy-seven (40%) of the patients who were triaged in the low severity category presented with atypical symptoms. Sixty-nine (42.6%) patients who presented with atypical symptoms and who were triaged in the low severity group had a delayed DTB time. This indicates that triage nurses were unable to identify the STEMI cases because of the atypical presenting symptoms, so they assigned the patients to less severe triaging levels. Similar findings were reported by Zamani et al.[8] Assigning qualified nurses to triage and providing them with appropriate training to recognise the symptoms of STEMI are recommended strategies to improve quality of care.

The current study found that patients presenting after working hours were two times more likely to have a delayed DTB time compared with patients presenting to the ED during working hours. In the current study, more than half the study sample (n = 327, 76.8%) presented to the hospital after working hours. The DTB time was 16 minutes longer among patients presenting after working hours compared with patients who presented during regular working hours. This is consistent with the findings of Sorita et al.[12] who found that DTB times were longer in patients

who presented during off-hours by 14.8 minutes compared to the patients who presented during working hours.

The current study finding was consistent with other studies showing that patients with STEMI who presented to the ED during weekends, public holidays and off-hours had longer DTB times compared to those presenting during the weekday and regular working hours.[18,27] Several researchers explained that the delayed DTB time during off-hours was a result of having an insufficient number of in-call cardiologists and support staff for the cardiac catheterization laboratory during off-hours.[12,27] This could be explained by the long response time for the cardiac catheterization laboratory.

Reflecting on the clinical practice at the current study sites, the number of ER staff was equal in both regular and off-hours; however, there were fewer catheterization laboratory technicians during off-hours. More specifically, during off-hours, both hospitals followed the in-home on-call system. More time could be wasted when the cardiology on-call doctor in the hospital must call members of the on-call catheterization laboratory team, such as the cardiology consultant and catheterization laboratory technician, to come from the home to prepare the catheterization laboratory for receiving patients. A patient would be shifted from the ED only after the catheterization laboratory team was ready. In some cases, the residences' commuting distance from the hospitals may affect the laboratory team's reaction time to prepare the lab. The international standard is for staff to arrive within the recommended 20- to 30-minute time frame.[28] Several researchers recommended that the patient be ready in the laboratory when the staff arrives at the hospital to minimise delays caused by long travel times during off-hours cases.[29]

Hospital policies must implement effective strategies to reduce DTB time and address factors responsible for the delay. The clinical indications in the triage policy for taking the ECG must be expanded, especially for suspected MI cases and for patients who are elderly, female or diabetic and who present with atypical STEMI symptoms. In addition, starting in-house on-call system for catheterization lab staff during off-hours can ensure rapid reaction time and timely

treatment.[30] These steps will help to identify and manage patients with STEMI who present to the ED with atypical symptoms and patients who present during off-hours.

In addition, the care manager can conduct a regular auditing system that will help ensure adherence to the recommended guidelines in the ED and cardiology units. The evidence showed that care managers play a vital role in communicating the conditions of patients with heart failure to the interdisciplinary team.[27,31] The care manager can communicate the audit results to all involved stakeholders to reduce the delay and find effective practical solutions.

Limitations

The study has some limitations that should be acknowledged. First, most of the data were taken from nursing and medical notes, which may have been subject to human entry error. Second, this was a cross-sectional retrospective study. Hence, assessing the causes of factors leading to delayed DTB times was not possible. Third, because the study utilised a retrospective design, several key variables were not assessed because they were not available. For example, no data were recorded regarding the patient load in the ED and the time of the cardiologist's arrival at the ED.

Conclusion

Performing timely DTB is critical to ensuring safe practices. To meet the DTB time recommendation, it is important to have an effective on-call system that can ensure timely lab activations and transfer of patients. Moreover, there is a need to expand the triage protocol, especially the chief complaints about STEMI symptoms, by including atypical presenting symptoms. Conducting regular training sessions for ED staff is recommended to enhance their awareness of atypical STEMI symptoms and reduce potential DTB delays. The current study results could serve as a baseline for future studies and inform strategies for improving quality of care.

Acknowledgements

The authors would like to thank the participating hospitals for facilitating data collection.

Authors' Contribution

MA-R contributed to the manuscript writing and data collection. SAS was involved in project supervision, data analysis and critical review of the manuscript. HA-N, AA-R and OA-R did the critical review of the manuscript. All authors approved the final version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interests.

Funding

No funding was received for this study.

References

1. Virani SS, Alonso A, Aparicio HJ, et al. Heart Disease and Stroke Statistics - 2021 Update: A Report From the American Heart Association. *Circulation*. 2021;143(8):E254-E743. doi:10.1161/CIR.0000000000000950/FORMAT/EPUB
2. Li M, Li S, Du X, et al. Factors attributed to the higher in-hospital mortality of ST elevation myocardial infarction patients admitted during off-hour in comparison with those during regular hour. *PLoS One*. 2017;12(4). doi:10.1371/JOURNAL.PONE.0175485
3. Park J, Choi KH, Lee JM, et al. Prognostic Implications of Door-to-Balloon Time and Onset-to-Door Time on Mortality in Patients With ST-Segment–Elevation Myocardial Infarction Treated With Primary Percutaneous Coronary Intervention. *J Am Heart Assoc*. 2019;8(9). doi:10.1161/JAHA.119.012188/FORMAT/EPUB
4. Kathryn L. McCance SEH. *Pathophysiology-E-Book: The Biologic Basis for Disease in Adults and Children*. Elsevier Health Sciences; 2018.
5. Jneid H, Addison D, Bhatt DL, et al. 2017 AHA/ACC Clinical Performance and Quality Measures for Adults with ST-Elevation and Non-ST-Elevation Myocardial Infarction: A Report of the American College of Cardiology/American Heart Association Task Force on Performance Measures. *Circ Cardiovasc Qual Outcomes*. 2017;10(10). doi:10.1161/HCQ.0000000000000032

6. Karkabi B, Meir G, Zafrir B, et al. Door-to-balloon time and mortality in patients with ST-elevation myocardial infarction undergoing primary angioplasty. *Eur Heart J Qual Care Clin Outcomes*. 2021;7(4):422-426. doi:10.1093/EHJQCCO/QCAA037
7. Berga Congost G, Brugaletta S, Valverde Bernal J, et al. The importance of organizational variables in treatment time for patients with ST-elevation acute myocardial infarction improve delays in STEMI. *Australas Emerg Care*. 2021;24(2):141-146. doi:10.1016/J.AUEC.2020.10.001
8. Zamani B, Ghadimi S, Moradoghli F, et al. Associated Factors with Delayed Door to Balloon Time in STEMI Patients. *International Journal of Cardiovascular Practice*. 2021;6(1):131479. doi:10.5812/intjcardiovascpract-131479
9. Namdar P, YekeFallah L, Jalalian F, Barikani A, Razaghpoor A. Improving Door-to-Balloon Time for Patients With Acute ST-Elevation Myocardial Infarction: A Controlled Clinical Trial. *Curr Probl Cardiol*. 2021;46(3):100674. doi:10.1016/J.CPCARDIOL.2020.100674
10. Otaal PS, Shah A, Batta A, Sood A, Pal A. Clinical and Angiographic Prophesy of Hemodynamic Status in Patients with Acute Anterior Wall ST-Segment-Elevation Myocardial Infarction and Totally Occluded Left Anterior Descending Artery. *Integr Blood Press Control*. 2021;14:89. doi:10.2147/IBPC.S315050
11. Prasad A, Raphael C. Acute coronary syndrome: STEMI and NSTEMI. In: Kaski J, Kjeldsen K er, eds. *The European Society of Cardiology Handbook on Cardiovascular Pharmacotherapy*. Vol 71. 2nd ed. ; 2019.
12. Sorita A, Ahmed A, Starr SR, et al. Off-hour presentation and outcomes in patients with acute myocardial infarction: systematic review and meta-analysis. *The BMJ*. 2014;348. doi:10.1136/BMJ.F7393
13. Arabi A, Alqahtani A, Arafa S, et al. The Impact of SARS-CoV-2 on ST-Elevation Myocardial Infarction Volume, Time to Presentation, and Door-to-Balloon Time: A Report from a High-Volume Statewide Primary Percutaneous Intervention Program. *Heart Views*. 2020;21(3):161. doi:10.4103/HEARTVIEWS.HEARTVIEWS_159_20
14. Butt TS, Bashtawi E, Bououn B, et al. Door-to-balloon time in the treatment of st segment elevation myocardial infarction in a tertiary care center in Saudi Arabia. *Ann Saudi Med*. 2020;40(4):281-289. doi:10.5144/0256-4947.2020.281

15. Zubaid M, Rashed W, Alsheikh-Ali AA, et al. Disparity in ST-segment Elevation Myocardial Infarction Practices and Outcomes in Arabian Gulf Countries (Gulf COAST Registry). *Heart Views*. 2017;18(2):41. doi:10.4103/HEARTVIEWS.HEARTVIEWS_113_16
16. Tungsubutra W, Ngoenjan D. Door-to-balloon time and factors associated with delayed door-to-balloon time in ST-segment elevation myocardial infarction at Thailand's largest tertiary referral centre. *J Eval Clin Pract*. 2019;25(3):434-440. doi:10.1111/JEP.13061
17. Sim WJ, Ang AS, Tan MC, et al. Causes of delay in door-to-balloon time in south-east Asian patients undergoing primary percutaneous coronary intervention. *PLoS One*. 2017;12(9). doi:10.1371/JOURNAL.PONE.0185186
18. Ikemura N, Sawano M, Shiraishi Y, et al. Barriers Associated With Door-to-Balloon Delay in Contemporary Japanese Practice. *Circulation Journal*. 2017;81:815-822. doi:10.1253/circj.CJ-16-0905
19. Dhungel S, Malla R, Adhikari C, et al. Door-to-balloon time and the determining factors in a tertiary cardiac center in Nepal. *Indian Heart J*. 2018;70 Suppl 3(Suppl 3):S309-S312. doi:10.1016/J.IHJ.2018.07.011
20. Nosworthy SE. *Improving Triage to ECG Time in the Emergency Department*. University of Calgary; 2018. doi:10.11575/PRISM/31406
21. Murphy AC, Yudi MB, Farouque O, et al. Impact of Gender and Door-to-Balloon Times on Long-Term Mortality in Patients Presenting With ST-Elevation Myocardial Infarction. *American Journal of Cardiology*. 2019;124(6):833-841. doi:10.1016/j.amjcard.2019.06.008
22. Bloos SM, Kaur K, Lang K, et al. Comparing the Timeliness of Treatment in Younger vs. Older Patients with ST-Segment Elevation Myocardial Infarction: A Multi-Center Cohort Study. *J Emerg Med*. 2021;60(6):716-728. doi:10.1016/J.JEMERMED.2021.01.031
23. Borden WB, Fennessy MM, O'Connor AM, et al. Quality improvement in the door-to-balloon times for ST-elevation myocardial infarction patients presenting without chest pain. *Catheterization and Cardiovascular Interventions*. 2012;79(6):851-858. doi:10.1002/CCD.23221
24. Lawesson SS, Isaksson RM, Ericsson M, Ängerud K, Thylén I. Gender disparities in first medical contact and delay in ST-elevation myocardial infarction: a prospective

multicentre Swedish survey study. *BMJ Open*. 2018;8(5):20211. doi:10.1136/BMJOPEN-2017-020211

25. Keats A, Moran D, Rothwell S, Woodcock T, Williams T, Rawat N. A quality improvement project to reduce door-to-electrocardiogram time: A multicenter study Production and hosting by Elsevier. *J Saudi Heart Assoc*. 2018;30:180-187. doi:10.1016/j.jsha.2017.11.005

26. Freimuth VS, Hilyard KM, Barge JK, Sokler LA. Hours of a Pandemic. 2008;9(4):35-44. doi:10.1177/1524839908322111

27. Shahin M, Obeid S, Hamed L, et al. Occurrence and Impact of Time Delay to Primary Percutaneous Coronary Intervention in Patients With ST-Segment Elevation Myocardial Infarction. *Cardiol Res*. 2017;8(5):190. doi:10.14740/CR612W

28. Parikh S V., Treichler DB, Depaola S, et al. Systems-based improvement in door-to-balloon times at a large urban teaching hospital a follow-up study from parkland health and hospital system. *Circ Cardiovasc Qual Outcomes*. 2009;2(2):116-122. doi:10.1161/CIRCOUTCOMES.108.820134

29. Hsiao YT, Hung JF, Zhang SQ, Yeh YN, Tsai MJ. The Impact of Emergency Department Arrival Time on Door-to-Balloon Time in Patients with ST-Segment Elevation Myocardial Infarction Receiving Primary Percutaneous Coronary Intervention. *J Clin Med*. 2023;12(6). doi:10.3390/jcm12062392

30. Khot UN, Johnson-Wood ML, VanLeeuwen R, Ramsey C, Khot MB. A hospital-wide system to ensure rapid treatment time across the entire spectrum of emergency percutaneous intervention. *Catheter Cardiovasc Interv*. 2016;88(5):678. doi:10.1002/CCD.26372

31. Al Sabei SD, Ross AM. The Relationship between Nursing Leadership and Patient Readmission Rate: A Systematic Review. *Can J Nurs Res*. 2023;55(3):267-278. doi:10.1177/08445621231152959

Table 1: Sample characteristic (N = 126)

	Total population	**Non-delayed**	**Delayed**		
Variable	**Frequency (%)**	**Frequency (%)**	**Frequency (%)**	**$\chi 2$**	**p-value**
Age					
55 or less	199 (46.7%)	37 (53.6%)	162 (45.4%)	1.579	.209

More than 55	227 (53.3%)	32 (46.4%)	195 (54.6%)		
Nationality					
Omani	324 (76.1%)	50 (72.5%)	274 (76.8%)	0.584	.445
Non-Omani	102 (23.9%)	19 (27.5%)	83 (23.2%)		
Gender					
Male	348 (81.7%)	57 (82.6%)	291 (81.5%)	0.046	.829
Female	78 (18.3%)	12 (17.4%)	66 (18.5%)		
Family history of cardiac disease					
No	258 (60.6%)	40 (58 %)	218 (61.1%)	.630	.362
Yes	168 (39.4%)	29 (42 %)	139 (38.9%)		
Triage level					
More severe (Level 1 & 2)	234 (54.9%)	39 (56.5%)	195 (54.6%)	0.084	.772
Less severe (Level 3,4 & 5)	192 (45.1%)	30 (43.5%)	162 (45.4%)		
Initial troponin level					
Positive	384 (89.9%)	61 (88.4%)	322 (90.2%)	0.204	.651
Negative	43 (10.1%)	8 (11.6%)	35 (9.8%)		
History of diabetes					
No	232 (54.5%)	40 (58.0%)	192 (53.8%)	0.409	.522
Yes	194 (45.5%)	29 (42.0%)	165 (46.2%)		
History of hypertension					
No	223 (52.3%)	41 (59.4%)	182 (51.0%)	1.651	.199
Yes	203 (47.7%)	28 (40.6%)	175 (49.0%)		
History of dyslipidemia					
No	364 (85.4%)	62 (89.9%)	302 (84.6%)	1.287	.257
Yes	62 (14.6%)	7 (10.1%)	55 (15.4%)		
History of heart failure					
No	419 (98.4%)	69 (100%)	350 (98.0%)	.241	.287
Yes	7 (1.6%)	0 (0%)	7 (2.0%)		
History of previous MI					
No	366 (85.9%)	60 (88.4%)	305 (85.4%)	0.422	.516
Yes	60 (14.1%)	8 (11.6%)	52 (14.6%)		
History of previous PCI					
No	366 (85.9%)	61 (88.4%)	305 (85.4%)	0.705	.332
Yes	60 (14.1%)	8 (11.6%)	52 (14.6%)		
History of previous CABG					

No	415 (97.4%)	67 (97.1%)	348 (97.5%)	0.033	.856
Yes	11 (2.6%)	2 (2.9%)	9 (2.5%)		
Smoking status					
No	307 (72.1%)	53 (76.8%)	254 (71.1%)	0.921	.337
Yes	119 (27.9%)	16 (23.2%)	103 (28.9%)		
Presenting status					
Stable	386 (89.7%)	60 (87%)	322 (90.2%)		
Cardiogenic shock	19 (4.5%)	4 (5.8%)	15 (4.2%)	.664*	.717
Cardiac arrest	25 (5.9%)	5 (7.2%)	20 (5.6%)		
Presenting symptoms					
Typical symptoms	302 (70.9%)	59 (85.5%)	243 (68.1%)	8.523	.005
Atypical symptoms	124 (29.1%)	10 (14.5%)	114 (31.9%)		
Presenting time					
Regular	99 (23.82%)	25 (36.2%)	74 (20.7%)	7.791	.005
Off-hours	327 (76.8%)	44 (63.8%)	283 (79.3%)		

**Fisher exact test*

Table 2: Distribution of Cases with Delayed and Non-Delayed DTB Time across Time Interval in Minutes.

Time interval	Total population	Non-Delayed	Delayed	*p*-value
	Median (IQR)	Median (IQR)	Median (IQR)	
Door to ECG	12.00 (5 - 37)	6.00 (4.50 – 18)	15.00 (5 - 45)	.001
ECG to Cath Lab	78.00 (53 - 98.25)	40.00 (74.50 – 20)	82.00 (85 – 122.50)	< .001
Cath Lab to Balloon	70.00 (44 - 90.25)	55.00 (25 – 78)	75.00 (54 – 94)	.020
Door to Balloon	142.00 (110 - 190)	75.00 (67 – 83)	150.00 (128 – 150)	< .001

Note. Cath Lab: Catheterization laboratory, IQR: Interquartile from 25 to 75 percentiles.

Table 3: Distribution of DTB Time Interval in Minutes across Study Settings.

Time interval	Hospital (A)	Hospital (B)	*p*-value
	Median (IQR)	Median (IQR)	
Door to ECG	10.00 (3 – 22.50)	25.50 (10 - 62.25)	< .001
ECG to Cath Lab	81.00 (60 – 123.75)	74.00 (35.50 - 88.25)	.004
Cath Lab to Balloon	75.00 (50 – 92.75)	65.00 (35 - 87.25)	.028
Door to Balloon	145.50 (110 – 193)	136.50 (87.25 - 108)	.044

Note. IQR: Interquartile from 25 to 75 percentiles.

Table 4: Factors Associated with Delayed DTB Time (n = 426).

Variable	B	S.E.	Wald	*p*	Adjusted OR	95% CI	
						Lower	Upper
Age (reference: 25– 49 years old)	.176	.290	.369	.544	1.193	.675	2.105
Female relative to Male	-.226	.391	.335	.563	.797	.731	1.715
Negative vs. positive troponin level	-.096	.439	.048	.826	.908	.385	2.145
H/O diabetes	.082	.305	.073	.787	1.086	.597	1.973
H/O hypertension	-.261	.312	.698	.403	.770	.418	1.421
H/O dyslipidemia	-.359	.457	.615	.433	.698	.285	1.712
H/O previous MI	-.233	.468	.226	.634	.800	.320	2.003
H/O previous CABG	.425	.903	.221	.638	1.529	.260	8.979
Smokers	-.204	.332	.377	.539	.816	.425	1.564
Presenting time (Off-hours relative to regular working hours)	.829	.295	7.877	.005	2.291	1.284	4.087
Presenting symptoms (Atypical relative to typical)	1.100	.386	8.113	.004	3.003	1.409	6.400
Presenting status (non-stable relative to stable)	-.278	.422	.435	.509	.757	.331	1.731
Triage level (Less to more severe triage)	-.164	.284	.333	.564	.849	.487	1.481

Note. H/O: History of

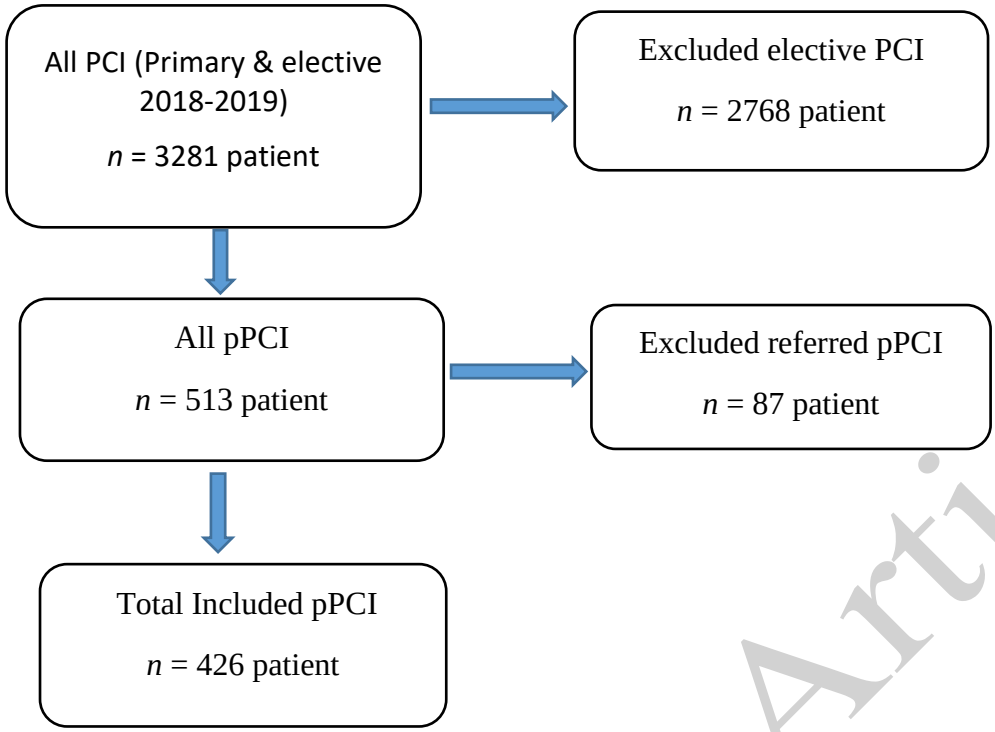

Figure 1: Filtration phases of patients' medical records.