Factors associated with the failure to achieve door to balloon time $\leq 90$ minutes in patients with ST-segment elevation myocardial infarction in an electrocardiogram triage system: a retrospective observational study

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Research Article

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Abstract

Background

Door to balloon time is a crucial factor of mortality in patients with ST-segment elevation myocardial infarction. However, the factors that contribute to failure of achieving door to balloon time ≤90 minutes in an electrocardiogram triage system remain unknown.

Methods

This single-center retrospective observational study collected data from consecutive patients with ST-segment elevation myocardial infarction from April 2016 to March 2021. The primary outcome was the failure to achieve door to balloon time ≤90 minutes. A multivariate logistic regression model was performed to predict factors associated with failure to achieve door to balloon time ≤90 minutes.

Results

In total, 190 eligible patients were included. Of these, the 139 (73.2%) patients with door to balloon time ≤90 minutes were significantly younger compared to those with door to balloon time >90 minutes (p=0.02). However, there was no significant difference in sex and timing of hospital arrival between the door to balloon time ≤90 and >90 minutes groups. Presence of chest pain and ambulance usage were significantly more frequent in patients with door to balloon time ≤90 minutes (p≤0.01, p=0.02, respectively). Multivariate analysis showed that absence of chest pain (adjusted odds ratio 4.76; 95% confidence interval, 2.04-11.1; p<0.01) and non-ambulance usage (adjusted odds ratio 3.53; 95% confidence interval, 1.57-7.94; p<0.01) are predictive factors of failure to achieve door to balloon time ≤90 minutes.

Conclusion

Patients without chest pain as the chief complaint or non-ambulance usage were significantly associated with the failure to achieve door to balloon time ≤90 minutes.

Introduction

Acute coronary syndrome (ACS) is a common disease that is annually diagnosed in more than 7 million people worldwide and has a high mortality rate.\(^1\) ACS is classified into two categories: ST-segment elevation myocardial infarction (STEMI) and non-ST-segment elevation ACS (NSTE-ACS), which consists of non-ST-segment elevation myocardial infarction (NSTEMI) and unstable angina.\(^2,3\) STEMI accounts for 30–40% of ACS and has higher mortality than NSTE-ACS.\(^4,5\)

Especially for STEMI, early intervention, including primary percutaneous coronary intervention (PCI), is crucial.\(^1\) Many guidelines for ACS recommend a short time interval from the patient’s arrival at the hospital to balloon dilatation of the coronary artery (door to balloon time; DTBT) for patients with
STEMI. Some studies showed that achievement of DTBT ≤ 90 minutes in patient with STEMI was associated with lower in-hospital mortality than a non-achievement, and the American Heart Association advocates DTBT ≤ 90 minutes as a quality measure in patients with STEMI.

To achieve DTBT ≤ 90 minutes, early diagnosis is essential. Therefore, some clinical guidelines recommend that the time from the patient’s arrival at the hospital to performing an electrocardiogram (ECG) (Door to ECG Time; DTET) should be ≤ 10 minutes if ACS is suspected.

Some triage systems, called ECG triage systems, have proposed that ECG should be performed at the time of triage to achieve shorter DTET and DTBT and to prevent oversights. These ECG triage systems have shown high sensitivity for ACS or STEMI and improved the achievement of DTBT ≤ 90 minutes.

However, there are limited studies regarding the factors of failure to achieve DTBT ≤ 90 minutes among the patients with STEMI, with the ECG triage system. Therefore, we conducted a retrospective observational study to predict the factors of failure to achieve DTBT ≤ 90 minutes among the patients with STEMI with the ECG triage system.

Methods

Study design and setting

This was a single-center retrospective observational study, which was conducted at the Emergency department (ED) of a 344-bed urban acute care community hospital in Japan. This hospital is a 24-hour stroke/cardiovascular center with the capability of PCI. The ECG triage system at this ED requires that ECG is performed within 5 minutes for all patients with chest pain or palpitations and patients over 45 years of age with epicardial pain, epigastric pain, or nausea without diarrhea and the ECG is reviewed immediately by the attending physician.

This study was approved by the ethics committee of the hospital and was conducted according to the ethical guidelines of the Declaration of Helsinki. The ethics committee also approved the waiver of informed consent because of retrospective nature of this study.

Study participants and population

Myocardial infarction (MI) was defined according to the Fourth Universal Definition of Myocardial Infarction. Diagnostic ST-segment elevation was defined as ST-segment elevation at least two contiguous leads (2.5 mm in men < 40 years, 2mm in men 40 years, or 1.5 mm in women in leads V 2–V 3 and 1mm in the other leads). The patients with MI with ST-segment elevation were diagnosed as STEMI. Patients who were diagnosed as STEMI after visiting ED and underwent PCI at this hospital from April 2016 to March 2021 are included. We excluded the following patients: patients who were referred for STEMI by their previous physician, patients who were not initially treated by ER physicians,
patients who did not undergo PCI, patients with cardiopulmonary arrest (CPA), and patients who were transferred to other hospitals after diagnosis of STEMI.

**Data collection**

We obtained data including age, sex, mode of hospital arrival (ambulance usage or not), the timing of hospital arrival (on-hours or off-hours), symptoms (chief complaint), DTBT, and DTET. On-hours was defined as 9 a.m.-5 p.m. on weekdays. Chief complaint consists of chest pain, palpitations, epicardial pain, epigastric pain, nausea without diarrhea and others. In this study, door time (i.e., the patient's arrival time) was defined as the time of arrival at reception for walk-in patients or the time of ambulance arrival.

**Outcome measure**

The primary outcome was the failure to achieve DTBT ≤ 90 minutes. The secondary outcome was the failure to achieve DTET ≤ 10 minutes. Both outcomes are defined as clinical indicator in several clinical guidelines.6–8

**Statistical analysis**

Continuous variables were expressed as median values with interquartile range (IQR), based on their distributions. Categorical variables were expressed as numbers and percentages. Age, sex, mode of hospital arrival, timing of hospital arrival, chief complaint were compared between the DTBT ≤ 90 minutes and DTBT > 90 minutes groups and between the DTET ≤ 10 minutes and DTET > 10 minutes group, using the Mann-Whitney U test for continuous variables based on the distributions and the Chi-square test for categorical variables when appropriate. To predict factors associated with failure to achieve DTBT ≤ 90 minutes and DTET ≤ 10 minutes, multivariate logistic regression models were constructed, adjusting for the following factors: age, sex, mode of hospital arrival, timing of hospital arrival, and chief complaint.

The statistical analyses were performed using R software (R Core Team, Vienna, Austria). Two-sided p-values of < 0.05 were considered statistically significant.

**Results**

Five hundred patients had ST-segment elevation on initial ECG and we excluded 310 patients; 146 were transported after diagnosis of STEMI, 71 did not undergo emergency PCI, 64 were not initially treated by ER physicians, 23 had CPA (including OHCA) in ER, and 6 were transferred to other hospitals. The remaining 190 patients were eligible for this study (Figure 1). Patients with DTBT ≤ 90 minutes were 73.2% (139/190).

The baseline characteristics of each group are shown in Table 1. Patients in DTBT ≤ 90 minutes group were significantly younger than those in DTBT > 90 minutes group (the median [IQR] 65 years. [52-74] vs. 72 years [57-82]; p=0.02). Chest pain and ambulance usage were significantly frequent in DTBT ≤ 90 minutes group than in DTBT >90 minutes group (87% vs. 58%; p<0.01, 82% vs. 65%; p=0.02, respectively).
There was no significant difference in sex and the timing of hospital arrival between the DTBT ≤ 90 minutes and DTBT >90 minutes groups.

The multivariate regression analysis showed absence of chest pain and non-ambulance usage were predictive factors of failure to achieve DTBT ≤ 90 minutes (adjusted OR 4.76; 95%CI, 2.04-11.1; p<0.01, adjusted OR 3.53; 95%CI, 1.57-7.94; p<0.01, Table 2).

As secondary outcomes, patients with DTET ≤ 10 minutes were 72.6% (138/190, Appendix Table 1). Multivariate regression analysis showed absence of chest pain and non-ambulance usage were predictive factors of failure to achieve DTET ≤ 10 minutes (adjusted OR 4.76; 95%CI, 1.92-12.5; p<0.01, adjusted OR 14.5; 95%CI, 5.88-35.8; p<0.01, Table 3).

**Discussion**

This study showed that absence of chest pain and non-ambulance usage were predictive factors for the failure to achieve DTBT ≤ 90 minutes. On the other hand, off-hours presentation was not a predictive factor.

The absence of chest pain as the chief complaint was associated with a significantly higher rate of failure to achieve DTBT ≤ 90 minutes and DTET ≤ 10 minutes. Consistent with our results, previous studies have reported that the absence of chest pain was an independent risk factor for delayed DTBT.\(^{18,19}\) Our results suggested that the absence of chest pain could delay the diagnosis and intervention of STEMI because absence of chest pain makes it harder for healthcare providers to suspect STEMI. Triage providers need to triage high-risk patients even in the absence of chest pain.

Non-ambulance usage was associated with a significantly higher rate of failure to achieve DTBT ≤ 90 minutes. Previous studies reported that arrival by walk-in was an independent factor for the failure to achieve DTBT ≤ 90 minutes similarly.\(^{20,21}\) In addition, our study also showed an association of non-ambulance usage with a significantly higher rate of failure to achieve DTET ≤ 10 minutes. Therefore, we believe that establishing a rapid ECG implementation system after arrival at the hospital by walk-in is necessary.

In this study, off-hours presentation was not associated with the failure to achieve DTBT ≤ 90 minutes. This was contrary to previous studies, which reported that off-hours presentation was significantly associated with a higher rate of failure to achieve DTBT ≤ 90 minutes and of in-hospital mortality.\(^{22}\) Holmes et al. reported the usefulness of STEMI protocol during off hours and emphasized the introduction of STEMI protocols.\(^{23}\) Since no off-hours delays were observed in this study, the introduction of the ECG triage system could have contribution to reducing off-hours DTBT.

This study revealed that the factors for delayed diagnosis and treatment of STEMI patients is absence of chest pain or non-ambulance usage. The advance triage system that performs ECGs, even if patients have no chest pain or did not arrive by ambulance, could potentially prevent delays in diagnosis and
treatment of STEMI. However, comprehensive testing could increase medical costs. Therefore, further research is warranted to verify the cost-effectiveness of such a system. As this research, exploratory research after the introduction of triage systems can lead to the development of a standardized Triage ECG System. The standardized triage system will be validated in a multicenter and prospective study.

Our study had several potential limitations. First, our study was a retrospective observational study conducted at a single facility with urban ER-based emergencies. Generalizability may not be applicable. Second, potentially unmeasured confounders that affected DTBT or DTET. Third, the accuracy of the medical records may have been hampered by vague symptom descriptions by the physicians in charge.

**Conclusion**

Patients without chest pain as the chief complaint or non-ambulance usage were significantly associated with the failure to achieve DTBT $\leq$ 90 minutes and DTET $\leq$ 10 minutes.

**Declarations**

**Ethics approval and consent to participate:** The registry was approved by the Ethics Committee of Tokyobay Urayasu Ichikawa Medical Center (Reference number is 664). The research was conducted according to the ethical guidelines of the Declaration of Helsinki. The patients' information was anonymized and deidentified before the analysis, and thus informed consent of the patients was waived.

**Consent for publication:** Not applicable

**Availability of data and materials:** Due to the nature of this research, participants of this study did not agree with the sharing of their data publicly; supporting data are unavailable.

**Competing interests:** The authors declare that they have no competing interests.

**Funding:** None

**Authors' contributions:** AI and MM researched literature and conceived the study. AI, MM, HF, JT was involved in protocol development, gaining ethical approval, patient recruitment and data analysis. AI wrote the first draft of the manuscript. All authors reviewed and approved the final manuscript.

**Acknowledgements:** None

**References**


Tables

Table 1. Patient characteristics according to door to balloon time

<table>
<thead>
<tr>
<th>Variables</th>
<th>Overall (n=190)</th>
<th>Door to Balloon Time ≤ 90minutes (n=139)</th>
<th>Door to Balloon Time &gt; 90minutes (n=51)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, median (IQR), year</td>
<td>67 (52-77)</td>
<td>65 (52-74)</td>
<td>72 (57-82)</td>
<td>0.02</td>
</tr>
<tr>
<td>Male sex</td>
<td>147 (77)</td>
<td>111 (80)</td>
<td>36 (69)</td>
<td>0.18</td>
</tr>
<tr>
<td>Non-ambulance usage</td>
<td>44 (23)</td>
<td>26 (18)</td>
<td>18 (35)</td>
<td>0.02</td>
</tr>
<tr>
<td>Off-hour presentation*</td>
<td>143 (75)</td>
<td>107 (77)</td>
<td>36 (71)</td>
<td>0.45</td>
</tr>
<tr>
<td>Absence of chest pain</td>
<td>39 (21)</td>
<td>18 (13)</td>
<td>21 (42)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
Abbreviation: IQR, interquartile range.

Data were presented as n (%) of patients unless otherwise indicated.

Percentages may not equal 100 due to rounding.

*Off-hour were defined as all other hours.

Table 2. Factors associated with failure to achieve Door to Balloon Time ≤90 minutes.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Adjusted odds ratio (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.98 (0.95-1.01)</td>
<td>0.16</td>
</tr>
<tr>
<td>Male sex</td>
<td>0.92 (0.38-2.21)</td>
<td>0.86</td>
</tr>
<tr>
<td>Non-ambulance usage</td>
<td>3.53 (1.57-7.94)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Off-hour presentation</td>
<td>0.98 (0.44-2.17)</td>
<td>0.97</td>
</tr>
<tr>
<td>Absence of chest pain</td>
<td>4.76 (2.04-11.1)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Abbreviation: CI, confidence interval

Table 3. Factors associated with failure to achieve Door to ECG Time ≤10 minutes.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Adjusted odds ratio (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.97 (0.94-1.00)</td>
<td>0.053</td>
</tr>
<tr>
<td>Male</td>
<td>1.12 (0.43-2.92)</td>
<td>0.81</td>
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<tr>
<td>Non-ambulance usage</td>
<td>14.5 (5.88-35.8)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Off-hour presentation</td>
<td>1.06 (0.45-2.50)</td>
<td>0.89</td>
</tr>
<tr>
<td>Absence of chest pain</td>
<td>4.76 (1.92-12.5)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

Abbreviation: CI, confidence interval

Figures
Figure 1

Study flow diagram.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- AppendixTable1.docx