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Original Contribution

The first-door-to-balloon time delay in STEMI patients undergoing interhospital transfer☆

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ABSTRACT

Background: Interhospital transfer delays for ST-elevation myocardial infarction (STEMI) patients requiring primary percutaneous coronary intervention (PCI) may be shortened by improved regional care systems. We evaluated the transfer process and first door-to-balloon (D1toB) time in STEMI patients who underwent interhospital transfer for primary PCI.

Methods and Results: We evaluated the D1toB time in 1837 patients who underwent interhospital transfer for primary PCI from the Cardiovascular Disease Surveillance program in Korea. Only 29.3% of patients had a D1toB time less than 120 minutes, as recommended by the American College of Cardiology Foundation/American Heart Association guidelines for the management of STEMI. After adjusting for potential confounders, chest pain at presentation (adjusted odds ratio [AOR], 2.06; 95% confidence interval [CI], 1.18-3.83), transfer to a PCI center with an annual PCI volume greater than 200 (AOR, 1.35; 95% CI, 1.04-1.74), and higher urbanization level (AOR, 2.01 [95% CI, 1.40-2.91], for urban areas; AOR, 3.70 [95% CI, 2.59-3.83], for metropolitan areas) showed beneficial effects on reducing the D1toB time. The median length of stay in the referring hospital (D1LOS) and interhospital transport time were 50 (interquartile range [IQR], 30-100) minutes and 32 (IQR, 20-51) minutes, respectively. The median time interval from the door of the receiving hospital to balloon insertion was 55 (IQR, 40-79) minutes.

Conclusions: Patients with STEMI undergoing interhospital transfer did not receive definite care within the recommended therapeutic time window. Delays in the transfer process (length of stay in the referring hospital and interhospital transport time) were major contributors to the delay in the D1toB time.

1. Introduction

1.1. Background

Several randomized trials have reported that in patients with ST-elevation myocardial infarction (STEMI) presenting to non–percutaneous coronary intervention (PCI)–capable hospitals, rapid transfer to a PCI-capable center improves outcomes [1–3]. The 2013 American College of Cardiology Foundation/American Heart Association (ACC/AHA) guidelines for the management of STEMI recommend immediate transfer of patients to a PCI-capable hospital, with a first medical contact-to-device time system goal of 120 minutes or less [4]. The development and utilization of regional networks for STEMI in the US and Europe have resulted in a reduction in the delays of interhospital transfers [5]. On the other hand, in many other regions, interhospital transfer is still one of the major factors that delays the door-to-balloon time, especially in areas with underdeveloped or developing stages of regionalization [6–8].

1.2. Goal of this study

The objective of this study was to understand the factors affecting the transfer process and total door-to-balloon time delay in STEMI patients undergoing interhospital transfer for primary PCI.

2. Materials and methods

2.1. Study design and setting

This study was a secondary analysis of the registry data of the Cardiovascular Disease Surveillance (CAVAS) program conducted by 23 tertiary academic emergency departments, sponsored by the Korean

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Centers for Disease Control and Prevention, during a period of approximately 5 years (from November 1, 2007, to December 31, 2012). More detailed information about the CAVAS program has been described in previously published articles [9,10]. The study protocol was approved by the institutional review board of Seoul National University hospitals. The need for informed consent was waived by the board (institutional review board no. 1012-134-346).

2.2. Selection of participants

The CAVAS registry includes patients with acute myocardial infarction (AMI) who presented for management at the participating hospitals' emergency departments. All consecutive patients with a diagnosis of AMI based on the *International Classification of Disease, 10th Revision* discharge diagnosis (I21.0-I21.1, I21.2, I21.3, I21.4, and I21.9) were considered eligible and screened for inclusion into the study. *ST-elevation myocardial infarction* was defined as associated ST-segment elevation in 2 or more leads or left bundle-branch block upon electrocardiography at the receiving hospital. Among these patients, we limited our analysis to a final study population of patients with a STEMI symptom onset of less than 12 hours after presentation. Our analysis included patients who transferred from other hospitals and who underwent primary PCI in the participating hospitals. Patients who received any fibrinolytic therapy at the referring hospital or who did not undergo primary PCI in the receiving hospital were excluded.

2.3. Data collection

The patient records included data on demographics, route of visit, emergency medical service (EMS) use, clinical characteristics, and therapies administered for STEMI. Based on the time of arrival at the referring hospital, we categorized the time of visit into office time (weekday arrival between 8 AM and 6 PM) and non–office time (weekday arrival between 6 PM and 8 AM or weekend arrival). The annual PCI volume was assessed by the receiving hospital's capacity for rapid PCI; these were categorized as high and low volumes according to the annual case number (more and less than 200 cases, respectively) [11]. We categorized the urbanization levels as metropolitan, urban, and rural according to the population sizes, and the patients were classified based on their address/zip code. A total of 248 counties are contained within the boundaries of Korea, defined by the statute for geographical administrative purposes (metropolitan, 95; urban, 67; rural, 86 counties in 2010) [12]. The metropolitan counties are segmented administrative areas of metropolitan cities (eg, Seoul) with populations of more than 500 000, whereas the urban and rural counties are classified as those located in areas with populations of more and less than 100 000 inhabitants, respectively.

2.4. Outcome measures

Our primary end point was the first door-to-balloon (D1toB) time, measured from the time of arrival at the referring hospital to the time of the first balloon inflation at the receiving hospital. The patients were divided into 2 groups according to the D1toB (D1toB <120 vs ≥120 minutes).

The "process of care" was categorized according to the following time intervals: length of stay at the referring hospital (D1LOS), transport time from the referring to the receiving hospital (D1toD2), and the time interval from arrival to balloon inflation during primary PCI at the receiving hospital (D2toB).

2.5. Statistical analysis

Descriptive statistics were calculated and are reported as counts and percentages or medians and interquartile ranges (IQRs), as appropriate. Differences in the patient demographics, visit characteristics, and clinical characteristics were compared between the D1toB <120 and D1toB ≥120 groups using the χ^2 test. In order to identify the significant characteristics affecting the D1toB, a multivariable logistic regression model was constructed. The adjusted odds ratios (AORs) and 95% confidence intervals (CIs) were calculated after adjusting for potential risk factors, including age, sex, presenting symptom, time of visit, and the annual total PCI volume of the receiving hospital. For all analyses, a 2-sided *P* value less than .05 was considered statistically significant. Data management and analyses were performed using R software, version 3.02 (available at http://www.r-project.org).

3. Results

3.1. Demographic findings and comparison of D1toB

A total of 9989 STEMI patients were eligible for this study, of whom 1837 patients met all inclusion criteria and were included in the final analysis. Percutaneous coronary intervention was recommended for STEMI patients (n = 6418) with a symptom onset of less than 12 hours. Interhospital transport occurred in 2614 patients (40.7%). Among them, the following patients were excluded: (1) those who underwent revascularization, including thrombolysis, PCI, and coronary artery bypass grafting before interhospital transfer (n = 150; 1.5%); (2) those who did not undergo primary PCI at the receiving hospital (n = 503; 5.0%); and (3) those with a D1toB of more than 24 hours (n = 124; 1.2%) (Fig. 1).

Of the 1837 enrolled patients, 1299 (70.7%) patients were included in the D1toB ≥120 group, whereas 538 (29.3%) patients comprised the D1toB <120 group. Compared with the D1toB <120 group, the D1toB ≥120 group comprised a higher proportion of women and patients living in rural areas (Table 1). In rural areas, only 16.0% of patients were included in the D1toB <120 group, whereas the corresponding proportions in the urban and metropolitan areas were 28.3% and 41.4%, respectively ($P < .01$). Patients in the D1toB ≥120 group were less likely to have chest pain on presentation. Notably, patients who experienced prehospital cardiac arrest or cardiogenic shock tended to have similar D1toB to patients who did not (Table 1). The time intervals of the "process of care" according to the D1toB groups are demonstrated in Fig. 2.

3.2. Multivariable analysis for D1toB

The urbanization level of the patients' area of residence, presence of chest pain on presentation, and transfer to high-volume PCI hospitals were found to be significant independent factors associated with D1toB delays in the multivariable logistic regression analysis (Table 2). Especially even after adjusting for potential confounders, rural areas were significantly associated with D1toB delays (AOR, 2.01 [95% CI, 1.40-2.19] vs urban areas; AOR, 3.70 [95% CI, 2.59-5.38] vs metropolitan areas).

3.3. Process of transfer

The median D1LOS and interhospital transport time were 50 (IQR, 30-100) minutes and 32 (IQR, 20-51) minutes, respectively. The median time interval from the door of the receiving hospital to balloon insertion was 55 (IQR, 40-79) minutes. The median D1toB time was 160 (IQR, 115-240) minutes. The mean proportion of D1LOS out of the total D1toB was 36.0%.

Fig. 3 shows the proportions of D1toB and the other 4 time intervals of the "process of care," namely, symptom-to-first door time (S2D1), D1LOS, D1toD2, and D2toB according to the urbanization level. The S2D1 and D2toB did not differ according to the urbanization level ($P = .9$ and $P = .08$, respectively). However, the D1LOS and D1toD2 time intervals in the rural areas were longer than those of the urban and metropolitan areas ($P = .02$ and $P < .01$, respectively).