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Impact of a New Referral System on Time to Treatment in Referred STEMI Patients Compared With Traditional Referral System at Maharat Nakhon Ratchasima Hospital

Pinij Kaewsuwanna

Department of Medicine, Maharat Nakhon Ratchasima Hospital, Nakhon Ratchasima, Thailand

Background: Acute ST-segment elevation myocardial infarction (STEMI) is an emergency condition with a high risk of death if not promptly treated with a reperfusion strategy. Delayed transfer of STEMI patients to the catheterization room is associated with poor outcomes and high mortality. The data recording and transmission system is an important factor that may help shorten the time to access treatment.

Objective: To compare the time to reperfusion between 2 referral systems, the time-oriented transfer system with the traditional referral system.

Methods: The retrospective study of confirmed STEMI patients within 2 distinct timeframes: May 1, 2019, to March 31, 2020, for the traditional referral system; and May 1, 2022, to March 31, 2023, for the time-oriented referral system. Patients between April 1, 2020, and April 30, 2022, were excluded due to the COVID-19 pandemic outbreak.

Results: There were 330 (42.4%) patients referred through the traditional referral system, and 449 (57.6%) patients referred through the time-oriented referral system. Patients in both referral systems had comparable age and sex distributions. The Killip classification was also comparable. Patients in both referral systems were transferred from the community hospitals within comparable distance. The proportion of timely reperfusion was higher, and time to reperfusion were shorter than traditional referral system with statistically significant (median [IQR], 245 [160 - 340] and 203 [129 - 353] minutes, $P < .05$).

Conclusions: The new referral system can reduce total ischemic and reperfusion time.

Keywords: STEMI, Referral system, Time delay to reperfusion

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Corresponding Author:
Pinij Kaewsuwanna
Department of Medicine,
Maharat Nakhon Ratchasima
Hospital, 49 Changphuak Road,
Naimuang, Mueang, Nakhon
Ratchasima 30000, Thailand.
Telephone: +668 1593 5581
E-mail: dr.pinij@gmail.com

Introduction

Acute ST-segment elevation myocardial infarction (STEMI) is an emergency condition with a high risk of death if not promptly treated with a reperfusion strategy.[1] Numerous studies have highlighted the criticality of reducing time to reperfusion in relation with lowering mortality.[2-5] Therefore, organizing the care of these patients is crucial, and timely treatment is necessary. The American College of Cardiology Foundation (ACCF) and the American Heart Association (AHA),[6] and the European Society of Cardiology (ESC) and European Association for Cardio-Thoracic Surgery (EACTS)[7] guidelines recommend a door-to-balloon time of 120 minutes or less for STEMI patients initially arriving at or being transported from a non-percutaneous coronary intervention (PCI) capable hospital, as well as a door-to-needle time of 30 minutes or less for STEMI patients who received fibrinolytic drug. The system of care for STEMI patients in community hospitals, including emergency and network referral systems, plays an important role in providing appropriate and timely treatment.[8] However, despite these systems, the mortality rate remains high, and most patients still experience delayed access to treatment. Delayed transfer of STEMI patients to the catheterization room is associated with poor outcomes and high mortality.[9, 10] Shortening the treatment access time is crucial at every stage of care for these patients.

The data transmission system is one important factor that may help reduce the time delay for treatment.[11] Time delay to reperfusion includes patient and system delay. Patient delay refers to the time from chest pain onset to the first medical contact (FMC) at a local non-PCI capable hospital, while system delay includes the delay to start fibrinolytic drugs or refer the patient to a PCI-capable hospital for primary PCI. To reduce the treatment access time, short and concise time intervals are essential at every stage of care for these patients, including from the first medical contact to electrocardiogram (ECG) diagnosis of STEMI, initiation of fibrinolytic drugs in a pharmaco-invasive strategy, and transfer time in a primary PCI strategy. The method of sending treatment data by writing letters lacks critical time-sensitive information for each stage of treatment, which may lead to a lack of awareness of treatment time and delays in accessing treatment. A time-oriented transfer protocol is a transfer protocol for referring physicians to record the time of STEMI care at every step, from symptom onset until time to reperfusion, ensuring that timing at every step follows the recommendations of standard guidelines before the patient is referred to a receiving PCI center.

This study aimed to compare the time to reperfusion between the time-oriented transfer protocol, by sending data via Google Forms, and the traditional method of using written referral letters in STEMI referral systems.

Methods

Study Design

This retrospective cohort study was conducted at Maharat Nakhon Ratchasima Hospital, which is responsible for caring for STEMI patients in Nakhon Ratchasima province. The study utilized data from the hospital's database, including patient registration information, electronic medical records, and catheterization laboratory reports for STEMI patients. The time-oriented referral system was implemented on May 1, 2022. This system involved a protocol where referring hospitals have to input time-sensitive data related to STEMI patient care, including the time of symptom onset, arrival at the FMC, ECG recording time, diagnostic time, decision-making in treatment strategy, fibrinolytic drug administration time in the pharmaco-invasive strategy, and departure time from the referring hospital.

Participants

In these pilot study, there was no sample size calculation. This study identified all confirmed STEMI patients within 2 distinct timeframes: May 1, 2019, to March 31, 2020, for the traditional referral system; and May 1, 2022, to March 31, 2023, for the time-oriented referral system. Patients between April 1, 2020, and

April 30, 2022, were excluded due to the COVID-19 pandemic outbreak, which could potentially interfere with the referral system. Patients were not transferred through the referral system, including those residing in urban areas and those residing outside of Nakhon Ratchasima province, were also excluded. To be eligible for inclusion in the study, patients needed to present themselves at community non-PCI capable hospital after the onset of symptoms and showed evidence of acute STEMI on their 12 leads ECG, with at least 1 mm of elevation in 2 contiguous peripheral or precordial leads.

Ethics

This study was approved by the Institutional Review Board of Maharat Nakhon Ratchasima Hospital, Thailand (No. 065/2023 on June 22, 2023).

Outcomes

The primary efficacy endpoint was the time to reperfusion, which included the time from symptom onset to reperfusion, door-to-balloon time, and door-to-needle time. The secondary endpoint was the clinical outcome, including in-hospital mortality.

Statistical Analysis

Categorical variables were presented as proportions and compared using the chi-square test or Fisher exact test. Normally distributed continuous variables were presented as mean and standard deviation (SD) and compared using the Student *t* test. Critical time intervals were presented as median and interquartile range (IQR) and compared using the Wilcoxon test. A multivariable binary regression analysis was performed to adjust baseline variable to compare the primary outcomes in the 2 groups. The clinical endpoints were analyzed by calculating the event rates for each study group, with a 2-sided *P* value of .05 considered statistically significant.

Results

Among STEMI patients in this study, 330 (42.4%) patients were referred through the traditional referral system (mean [SD] age, 64.7 [12.0] years), and 449 (57.6%) patients were referred through the time-oriented referral system (mean [SD] age, 64.5 [13.0] years). The smoking rates were also similar in both groups, with 44.8% in the traditional referral system group and 42.4% in the time-oriented referral system group. The rates of diabetes and chronic kidney disease were comparable between the 2 groups, but there were fewer cases of hypertension and dyslipidemia in the traditional referral system group. Anterior and inferior wall myocardial infarctions were observed equally in patients from both referral systems. The Killip classification was the same between the 2 groups but those who presenting with survivor post cardiac arrest were more frequent in the traditional referral system group (8.2% vs 2.9%, *P* = .001). The ischemic time delay from symptom onset to FMC was similar in both groups, at 120 minutes. Primary PCI was performed more frequently in the time-oriented referral system group than in the traditional referral system group. Patients in both referral system were transferred from the community hospitals with the comparable distance (mean [SD], 63.0 [24.7] and 65.2 [25.5] km, *P* = .23) (Table 1).

Table 1. Patient Characteristics

Variable	No. (%)		*P* Value*
	Time-Oriented Refer (n = 449)	Traditional Refer (n = 330)	
Age, mean (SD), y	64.5 (13.0)	64.7 (12.0)	.83
Male	339 (75.5)	237 (71.8)	.25
Smoking	201 (44.8)	140 (42.4)	.52

Table 1. Patient Characteristics (Continued)

Variable	No. (%)		*P* Value*
	Time-Oriented Refer (n = 449)	Traditional Refer (n = 330)	
Comorbidity			
Diabetes mellitus	113 (25.2)	75 (22.7)	.43
Hypertension	200 (44.5)	118 (35.8)	.01
Dyslipidemia	90 (20.0)	43 (13.0)	.01
Chronic kidney disease	22 (4.9)	19 (5.8)	.60
Location of myocardial infarction			
Anterior wall	201 (44.8)	153 (46.4)	.66
Inferior wall	219 (48.8)	167 (50.6)	.61
Killip classification			
I	267 (59.5)	187 (56.7)	.43
II	81 (18.0)	49 (14.8)	.24
III	33 (7.4)	24 (7.3)	.97
IV	71 (15.8)	70 (21.2)	.05
Post cardiac arrest survivor	13 (2.9)	27 (8.2)	.001
Left ventricular ejection fraction, mean (SD), %	48.4 (13.9)	51.3 (13.8)	.03
Time delay to FMC, median (IQR), min	120 (60 - 240)	120 (60 - 223)	.64
Distance from referred hospital, mean (SD), km	63.0 (24.7)	65.2 (25.5)	.23
Patients referred > 60 km	201 (44.8)	154 (46.7)	.60
Length of stay, median (IQR), d	2 (2 - 4)	2 (2 - 4)	1.00
Primary PCI	296 (65.9)	168 (50.9)	< .001

Abbreviations: FMC, first medical contact; IQR, interquartile range; PCI, percutaneous coronary intervention; SD, standard deviation.

* The statistical significance was determined at $P < .05$.

The angiographic outcomes, including the culprit vessel and thrombolysis in myocardial infarction (TIMI) flow were comparable between the 2 groups of the referral system, but there were more cases of triple vessel disease (TVD) in the time-oriented referral system group than in the traditional referral system group (Table 2).

The rates of the primary outcome, time to reperfusion, including the total ischemic time from onset to reperfusion, door-to-needle time, and door-to-balloon time (Table 3).

The total ischemic time was longer in the traditional referral system group than in the time-oriented referral system group (median [IQR], 245 [160 - 340] and 203 [129 - 353] minutes, $P < .05$). Both the median door-to-balloon time and door-to-needle time were shorter in the time-oriented referral system group than in the traditional referral system group, with statistically significant. The time to reperfusion, door-to-balloon time, and door-to-needle time were determined (Figure 1).

The clinical outcome, in-hospital mortality was 9.1% equally in both the traditional referral system group and the time-oriented referral system group. After adjusted baseline variables included age, sex, comorbidity, smoking, location of myocardial infarction, number of coronary vessel diseases, culprit vessel, and Killip classification by multivariable binary regression model, there was no statistically significant (Table 4).

Table 2. Result of Coronary Angiography

Variable	No. (%)		*P* Value*
	Time-Oriented Refer (n = 449)	Traditional Refer (n = 330)	
Number of vessels			
Single vessel disease	198 (44.3)	168 (51.1)	.02
Double vessel disease	120 (26.8)	95 (28.8)	
Triple vessel disease	129 (28.9)	66 (20.1)	
Left main	39 (8.7)	21 (6.4)	.23
Culprit vessel			
Left anterior descending	193 (43.0)	140 (42.4)	.95
Right coronary artery	200 (44.5)	146 (44.2)	
Left coronary circumflex	37 (8.2)	31 (9.4)	
Left main	19 (4.2)	13 (3.9)	
TIMI 0 - 1 at 1st angiography	242 (53.9)	159 (48.2)	.24
Fail PCI	8 (1.8)	7 (2.1)	.48

Abbreviations: TIMI, thrombolysis in myocardial infarction; PCI, percutaneous coronary intervention.

* The statistical significance was determined at $P < .05$.

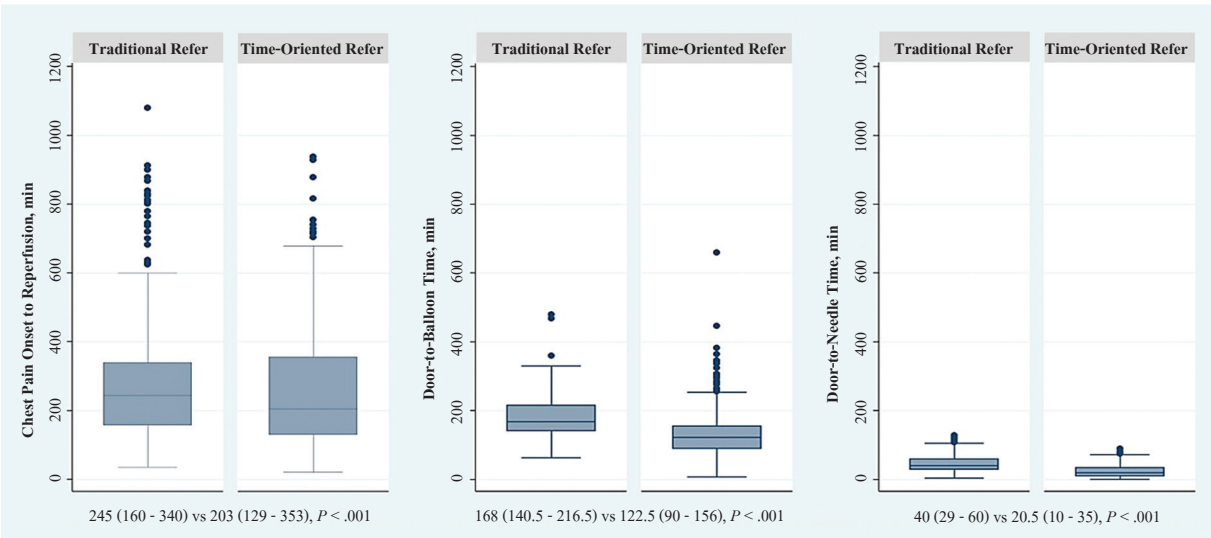
Table 3. Time to Revascularization

Variable	Time-Oriented Refer (n = 449)	Traditional Refer (n = 330)	*P* Value*
Total ischemic time, median (IQR), min	203 (129 - 353)	245 (160 - 340)	< .001
Time to revascularization			
Door-to-needle time, median (IQR), min	20.5 (10 - 35)	40 (29 - 60)	< .001
Door-to-balloon time, median (IQR), min	122.5 (90 - 156)	168 (140.5 - 216.5)	< .001
Proportion of timely reperfusion			
Door-to-needle time, No. of events/No. of patients (%)	110/153 (71.9)	51/162 (31.5)	< .001
Door-to-balloon time, No. of events/No. of patients (%)	144/296 (48.6)	19/168 (11.3)	< .001
Combine, No. (%)	254 (56.6)	70 (21.2)	< .001

Abbreviation: IQR, interquartile range.

* The statistical significance was determined at $P < .05$.

Figure 1. Time from Chest Pain Onset to Reperfusion, Door-to-Balloon Time, and Door-to-Needle Time Between 2 Referral Systems



A) Chest Pain Onset to Reperfusion B) Door-to-Balloon Time C) Door-to-Needle Time

Table 4. In-Hospital Mortality

Variable	No. (%)		Crude RR (95% CI)	*P* Value*	Adjusted RR (95% CI)**	*P* Value*
	Time-Oriented Refer (n = 449)	Traditional Refer (n = 330)				
In-hospital mortality	41 (9.1)	30 (9.1)	1.00 (0.86 - 1.16)	.99	0.96 (0.70 - 1.32)	.81
Cardiovascular death	32 (7.1)	26 (7.9)	0.90 (0.55 - 1.49)	.69	1.00 (0.37 - 2.67)	.99

Abbreviations: CI, confidence interval; RR, relative risk.

* The statistical significance was determined at $P < .05$.

**Adjusted age group, sex, comorbidity, smoking, location of infarction, Killip classification, survival post cardiac arrest, left ventricular ejection fraction, culprit lesion, number of vessel disease, left main involvement, time to first medical contact and total ischemic time.

Discussion

The implementation of a time-oriented referral system significantly reduced the total ischemic time and time to reperfusion for STEMI patients transferred from local network hospitals. This reduction was mainly attributed to the shorter system delay within the hospital, specifically the door-to-balloon time and door-to-needle time. The key to this success may lie in with well-established data recording and sending system with a time-oriented protocol that ensures a shorter time to reperfusion and transfer time to the referral hospital while also facilitating early activation of the catheterization laboratory.

Studies such as the Danish Trial in Acute Myocardial Infarction-2 (DANAMI-2) have reported that shorter system delays are associated with reduced absolute mortality.[12] Although there was a significant reduction in total ischemic time and time to reperfusion, this study did not find a significant difference in the rate of in-hospital mortality between the 2 groups that may be a small number of populations. However, a recent study on

in-hospital mortality reported that death rates have remained constant despite significant improvements in door-to-balloon time for patients receiving primary PCI for STEMI. This suggests that additional strategies are needed to reduce in-hospital mortality in this patient population.[13] Increased focus on the total healthcare system delay may optimize the management of patients with STEMI and be the key to further improving survival rates. A network system approach to transfer STEMI patients can achieve sustained over years.[14] Implementing a time-oriented referral system for STEMI patients may help improve overall care and outcomes. However, further studies are needed to explore the potential benefits of improving patient outcomes, cost-effectiveness, and the feasibility of implementing such a system on a larger scale.[15]

When comparing our result of door-to-balloon time with those in South Korea, median door-to-balloon time of patients in time-oriented referral system was longer (122.5 vs 60 minutes).[16]

For future improvements in the time-oriented referral system, online source of patient transport information endeavors to create a mobile application. This application will include data of patient identity, current vital signs, timing of care in each step, laboratory data, and imaging data (such as ECG, x-ray, and echocardiogram [ECHO] examination) from the local hospital. Combined with a telemedicine via a mobile phone, this will facilitate real-time communication among physicians and include an online feedback tracking system for transport time and patient outcomes at the transferred hospital.

Patient delay from symptom onset to the first medical contact still appears to hinder the timely delivery of STEMI care. This may be due to a lack of population awareness regarding the signs and symptoms of STEMI. A public campaign program should be incorporated into the STEMI network program to educate people about rapidly contacting the nearest hospital or activating local emergency medical services (EMS) system by calling 1669 if they suspected a heart attack, as this approach has been associated with shorter patient delay time.

This study had limitations. In this retrospective study, confounding variables could have influenced the results, and variables were not prespecified. This study was from a single hospital with a relatively small number of patients may not feasible for difference area. Additionally, comparing the 2 referral systems between different time frames may impact the analyses and interpretation of the findings.

Conclusions

This study compared the traditional referral system in STEMI patient by the written referral letter, with the time-oriented referral system through Google Forms. The implementation of the time-oriented referral system showed advantage in a reduction in total ischemic time and faster reperfusion times.

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การศึกษาระยะเวลาในการเข้าถึงการรักษาของผู้ป่วยกล้ามเนื้อหัวใจตายเฉียบพลันชนิด ST ยกสูง เปรียบเทียบระหว่างระบบใหม่ในการส่งต่อผู้ป่วยกับระบบการเขียนใบส่งต่อแบบเดิม ณ โรงพยาบาลมหาราชนครราชสีมา

พินิจ แก้วสุวรรณะ

ภาควิชาอายุรศาสตร์ โรงพยาบาลมหาราชนครราชสีมา นครราชสีมา ประเทศไทย

บทนำ: กล้ามเนื้อหัวใจตายเฉียบพลันชนิด ST ยกสูงมีโอกาสในการเสียชีวิตสูง หากไม่ได้รับการรักษาอย่างทันท่วงที รวมถึงความล่าช้าในการเข้าถึงการรักษา ระบบส่งต่อที่ดีอาจช่วยลดความล่าช้าในการเข้าถึงการรักษาได้

วัตถุประสงค์: เพื่อเปรียบเทียบระยะเวลาการเข้าถึงการรักษาระหว่างผู้ป่วยในระบบส่งต่อแบบเดิมกับระบบส่งต่อที่มีการกำหนดเวลา

วิธีการศึกษา: การศึกษาย้อนหลังในผู้ป่วยที่ได้รับการวินิจฉัยกล้ามเนื้อหัวใจตายเฉียบพลันชนิด ST ยกสูง ที่ถูกส่งตัวมารับการรักษาใน 2 ช่วงเวลา คือ ช่วงระบบส่งต่อแบบเดิม ตั้งแต่วันที่ 1 พฤษภาคม พ.ศ. 2562 ถึงวันที่ 31 มีนาคม พ.ศ. 2563 และช่วงระบบส่งต่อใหม่ที่มีการกำหนดให้ลงเวลา ตั้งแต่วันที่ 1 พฤษภาคม พ.ศ. 2565 ถึงวันที่ 31 มีนาคม พ.ศ. 2566 โดยเว้นช่วงที่มีการระบาดของโรคโควิด 19 ตั้งแต่วันที่ 1 เมษายน พ.ศ. 2563 ถึงวันที่ 30 เมษายน พ.ศ. 2565 เนื่องจากอาจส่งผลต่อเวลาในการส่งต่อผู้ป่วย

ผลการศึกษา: ผู้ป่วยถูกส่งตัวมาในระบบส่งต่อเดิม จำนวน 330 คน คิดเป็นร้อยละ 42.4 และถูกส่งมาในระบบที่มีการกำหนดให้ลงเวลาในการตรวจรักษา จำนวน 449 คน คิดเป็นร้อยละ 57.6 โดยผู้ป่วยทั้ง 2 กลุ่ม มีอายุ เพศ ความรุนแรงของโรค และระยะทางที่ถูกส่งต่อมาไม่แตกต่างกัน ผลการศึกษาพบว่า ผู้ป่วยที่ถูกส่งมาในระบบใหม่มีระยะเวลาในการเข้าถึงการรักษาได้ดีกว่าในระบบเก่าอย่างมีนัยสำคัญ (median [IQR], 245 [160 - 340] และ 203 [129 - 353] นาที, $P < .05$)

สรุป: ระบบการส่งต่อผู้ป่วยแบบใหม่ช่วยลดระยะเวลาในการเข้าถึงการรักษา

คำสำคัญ: กล้ามเนื้อหัวใจตายเฉียบพลันชนิด ST ยกสูง ระบบการส่งต่อผู้ป่วย ความล่าช้าในการเข้าถึงการรักษา

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Corresponding Author:
พินิจ แก้วสุวรรณะ
ภาควิชาอายุรศาสตร์
โรงพยาบาลมหาราชนครราชสีมา
49 ถนนช้างเผือก
ตำบลในเมือง อำเภอเมือง
นครราชสีมา 30000 ประเทศไทย
โทรศัพท์ +668 1593 5581
อีเมล dr.pinij@gmail.com