Original Article

A physician-staffed ground emergency medical service does not significantly shorten door-to-balloon time in patients with STEMI: an observational study in a single emergency center in Japan

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Aim: Current guidelines recommend a door-to-balloon time (DTBT) of <90 min for reperfusion treatment of patients with ST-segment elevation myocardial infarction (STEMI). A physician-staffed ground emergency medical service (GEMS) using a rapid response car (RRC) system was implemented at our hospital in April 2015. The medical team, including a physician and nurse, is dispatched to assess the patient and expedite the start of treatment by emergency physicians and cardiologists after arrival at the hospital. The study aimed to determine whether the RRC system shortened the DTBT.

Methods: This retrospective observational study was carried out in a tertiary emergency center in Japan. Those STEMI patients with primary percutaneous intervention between January 2016 and December 2018 were evaluated. The DTBTs of patients transported by the RRC system, the emergency medical service (EMS), and transferred from other hospitals after STEMI diagnosis (TRANS group) were compared.

Results: A total of 121 patients were included, 33 in the RCC, 20 in the EMS, and 68 in the TRANS groups. The median DTBT was 51 min (interquartile range [IQR], 43–67) in the RRC, 61 min (IQR, 52–85) in the EMS, and 59 min (IQR, 48–72) in the TRANS groups ($P = 0.13$). The DTBT was not significantly shorter in the RRC than in the other groups.

Conclusion: An RRC physician-staffed GEMS did not significantly shorten the DTBT of patients with STEMI compared with other transport systems.

Key words: doctor car, door-to-balloon time (DTBT), physician-staffed ground emergency medical service (GEMS), rapid response car, STEMI

INTRODUCTION

PROMPT ADMINISTRATION OF reperfusion therapy to patients with ST-segment elevation myocardial infarction (STEMI) is extremely important. A door-to-balloon time (DTBT) of <90 min contributes to improved mortality and is strongly recommended.[1-5] Interventions intended to shorten the DTBT and improve the quality of care for STEMI patients include physician-staffed helicopter medical emergency services (HEMS),[6,7] transmission of a 12-lead electrocardiogram (ECG) to the in-hospital cardiologist,[8] and telemedicine-based intervention by paramedics who use social media to prepare interventional cardiologists.[9,10] Differences in local conditions and the available medical resources make it difficult to generalize the effectiveness of interventions that have been evaluated in other regions and countries.

In April 2015, our center introduced a rapid response car (RRC) system with a physician-staffed ground emergency medical service (GEMS). The team is dispatched to the patient's location, assesses the patient's condition, and contacts in-hospital emergency physicians and cardiologists before arrival at the hospital. The RRC system involves only EMS personnel, field emergency physicians and nurses, and cardiologists, which minimizes the cost and contributes the applicability to other districts. This study evaluated the

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effect of the physician-staffed GEMS and the RRC system on the time to initiate reperfusion therapy in patients with STEMI.

METHODS

THIS RETROSPECTIVE OBSERVATIONAL study was carried out at a tertiary emergency center in Japan. The RRC system was activated by an emergency call for intervention in patients with severe injury or illness including STEMI. The medical team was dispatched simultaneously with an ambulance staffed by an EMS crew from a fire department near the patient. The RRC team was available from 9.00 AM to 7.00 PM on weekdays and from 9.00 AM to 5.00 PM on weekends. The team traveled in a sport-utility vehicle that lacked patient transport capabilities. The distance to most calls was within 15 km. Approximately 200 000 people live in the area covered by the RRC.

Some of the patients who underwent percutaneous coronary intervention (PCI) and were included in the evaluation were transported by EMS, some received an intervention by the RRC team before transport, and some were transferred to our center from other hospitals. In Japan, EMS crews cannot begin i.v. saline infusion in a patient with stable vital signs and cannot administer any medications indicated for treatment of acute coronary syndrome, including morphine, aspirin, or nitrates. The EMS priority for STEMI patients is rapid transport and not intervention. In our district, some EMS vehicles can examine 12-lead ECGs and few EMS vehicles can transmit 12-lead ECGs before arrival at the PCI facility. Most patients transferred to our center from other hospitals received saline infusions and a cardiologist at our hospital had already consulted with a physician at the other hospital. Transferred STEMI patients were managed only by cardiologists. The RRC system physician and nurse started saline infusion and undertook cardiac echography to identify asynergy of left ventricular wall motion and other causes of chest pain. In some cases, the field physician assesses prehospital 12-lead ECGs. The physicians could administer medications such as nitrates or morphine. The assessment and procedures were rapidly carried out. The median time that the ambulance remained at the site was only 4 min. The RRC team intervention could delay arrival at the hospital, but the time to initiation of the physician assessment is shortened. During transportation, the field physician contacted a physician in the emergency department to report the patient's status and facilitate consultation with the cardiologist. The intent of the RRC system is to undertake a prompt initial assessment and reduce the time to treatment following arrival at the hospital. After arrival, patients with suspected STEMI were not directly brought to the catheter laboratory but to an emergency department for a 12-lead ECG and blood work. The need for angioplasty was determined after evaluation by an emergency physician and cardiologist. Patients transferred from other hospitals were evaluated by cardiologists only.

The study included patients with STEMI and PCI between January 2016 and December 2018 and intervention on weekdays between 9.00 AM and 7.00 PM. Patients treated during daytime on weekdays were eligible because the RRC system was operational then and hospital cardiologists and the catheter laboratory were available. Eligible patients were identified from their hospital medical records and the PCI database. The outcomes of those who received prehospital care from the RRC, the EMS care, or were transferred from other hospitals (TRANS group) were compared. Patient age, sex, and clinical risk factors of ischemic coronary disease, vital signs on arrival, body mass index, the implementation rate of prehospital 12-lead ECG, the PCI target lesion, Killip class, and the time from symptom onset to the hospital arrival (OTHsp) were included in the analysis. The primary outcome was the DTBT. The secondary outcome was all-cause in-hospital mortality. The study was approved by the hospital ethics committee.

Statistical analysis was undertaken with RStudio version 1.2.5033, running R 3.6.1 (https://rstudio.com). Continuous variables were reported as medians and interquartile range (IQR) or means and standard deviation. Between-group comparisons for non-parametric data were made by the Kruskal–Wallis rank sum test. Comparisons of categorical variables were undertaken using Fisher's exact test. *P*-values < 0.05 were considered statistically significant.

RESULTS

DURING THE STUDY period, 442 patients with STEMI received PCI. Of those, 321 patients were excluded because these patients received PCI when the RRC system was not operational. One hundred twenty-one patients were diagnosed with STEMI and received PCI at our institute during the weekday–daytime hours of RRC operation. Thirty-three received RRC intervention, 20 received routine EMS intervention, and 68 patients were TRANS patients. (Fig. 1). The patient characteristics are shown in Table 1. Patient age, OTHsp time, current smoking, and a history of coronary artery bypass grafts in the three groups were significantly different. Vital signs, Killip class, body mass index, and the lesions causing the STEMI were not significantly different. The implementation rate of prehospital 12-lead ECG was 12.1 % in the RRC group and 10.0 % in the EMS group. There was a tendency toward shorter OTHsp times in the EMS patients and a tendency for

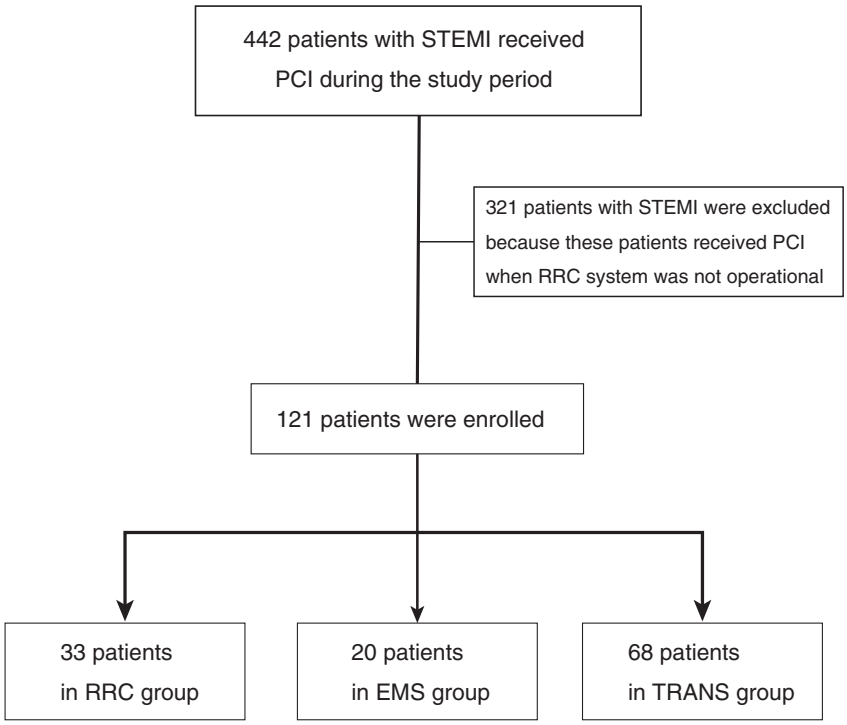

Fig. 1. Flowchart of selection of patients with ST-segment elevation myocardial infarction (STEMI). EMS, emergency medical service; PCI, percutaneous coronary intervention; RRC, rapid response car group; TRANS, transported group.

much longer OTHsp times in the TRANS patients compared with other groups. The primary outcome, median DTBT, was 51 (IQR, 43–67) min in RRC patients, 61 (IQR 52–80) min in EMS patients, and 60 (IQR 48–72) min in TRANS patients (P = 0.130; Table 2). There was a tendency toward a shorter DTBT in the RRC patients compared with the other groups but the difference did not reach significance. Differences in mortality among the three groups were not significantly different.

DISCUSSION

IMMEDIATE REPERFUSION THERAPY is central to the treatment of STEMI. This study investigated whether the RRC intervention practiced at our hospital shortened the DTBT of STEMI patients. The DTBT for the RRC patients was shorter than that of the EMS and TRANS patients but the difference was not statistically significant. The DTBT at our institution is already short, and has been less than 90 min for a long time. Difficulty in achieving further improvement might have contributed to the lack of significant differences among the three study groups. Further shortening of the DTBT might be accomplished by sending a suspected STEMI patient from the ambulance directly to a catheter laboratory. If that practice is initiated, then cardiologists should be prepared to accept a false carry-in of patients. As many interventions are planned every day, especially during daytime hours, it would be difficult to manage additional, urgent procedures at those times. A study by Parikh *et al*. found that referral of patients by emergency physicians directly to a catheter laboratory significantly shortened the DTBT, with 9% false carry-in.[11] It should be considered that the false carry-in rate might be higher for emergency physicians working in the field than it is for emergency department staff physicians. Our RRC system is not a 24-h service. To achieve further DTBT benefits to STEMI patients, the operational time would need to be extended.

Numerous medical professionals support our RRC system. Emergency call center personnel dispatch the RRC team, basing the decision on keywords, such as chest pain and chest zonesthesia. The ambulance crew and the RRC are dispatched simultaneously and the EMS crew works on-site with the RRC physician and nurse. In Japan, the EMS paramedics cannot administer any STEMI medications, such as nitrates, morphine, or antiplatelet drugs. The paramedics can only start oxygen inhalation therapy if the suspected STEMI patient exhibits hypoxemia and can administer saline only if the patient is in a shock status. The primary aim

Table 1. Demographics and clinical data of patients with ST-segment elevation myocardial infarction

	RRC (n = 33)	EMS (n = 20)	TRANS (n = 68)	P-value
Demographic data				
Age, years	67.5 (14)	65.3 (11)	72.3 (13)	0.049
Male sex (%)	25 (75.8)	18 (90.0)	48 (70.6)	0.209
BMI, kg/m^2	24.7 (3.6)	24.4 (3.3)	24.0 (3.4)	0.633
Clinical data				
SBP, mmHg	127 (34)	121 (29)	127 (30)	0.728
DBP, mmHg	78 (22)	79 (23)	77 (20)	0.899
HR, b.p.m.	76 (23)	77 (15)	81 (22)	0.525
Comorbidities				
Hypertension (%)	20 (60.6)	11 (55.0)	49 (73.1)	0.220
Diabetes mellitus (%)	11 (33.3)	7 (35.0)	20 (29.4)	0.860
Hyperlipidemia (%)	5 (15.2)	7 (35.0)	18 (26.9)	0.235
CKD (%)	3 (9.1)	0 (0.0)	6 (8.8)	0.381
On HD (%)	0 (0.0)	0 (0.0)	1 (1.5)	0.675
Smoker (%)	24 (72.7)	16 (80.0)	33 (49.3)	0.012
PCI history (%)	7 (21.2)	3 (15.0)	4 (6.0)	0.073
CABG history (%)	1 (3.0)	3 (15.0)	0 (0.0)	0.005
OMI (%)	4 (12.1)	4 (20.0)	5 (7.4)	0.263
Prehospital 12-lead ECG (%)	4 (12.1)	2 (10.0)	NA	NA
Killip class (%)				
I	26 (78.8)	13 (65.0)	54 (79.4)	0.538
II	4 (12.1)	4 (20.0)	8 (11.8)	
III	1 (3.0)	0 (0.0)	0 (0.0)	
IV	2 (6.1)	3 (15.0)	6 (8.8)	
Lesion of PCI (%)				
LAD	15 (45.5)	9 (45.0)	36 (52.9)	0.631
LCX	4 (12.1)	4 (20.0)	4 (5.9)	
LMT	1 (3.0)	0 (0.0)	2 (2.9)	
RCA	13 (39.4)	7 (35.0)	26 (38.2)	
Onset-to-hospital time (%)				
<60 min	7 (21.9)	9 (45.0)	2 (3.3)	<0.001
60–120 min	8 (25.0)	7 (35.0)	6 (9.8)	
120–180 min	2 (6.2)	2 (10.0)	12 (19.7)	
180 min<	15 (46.9)	2 (10.0)	41 (67.2)	

BMI, body mass index; CABG, coronary artery bypass grafting; CKD, chronic kidney disease; DBP, diastolic blood pressure; ECG, electrocardiogram; EMS, emergency medical service group; HD, hemodialysis; HR, heart rate; LAD, left anterior descending artery; LCX, left circumflex artery; LMT, left main coronary trunk; NA, not applicable; OMI, old myocardial infarction; PCI, percutaneous coronary intervention; RCA, right coronary artery; RRC, rapid response car group; SBP, systolic blood pressure; TRANS, transported group.

of the RRC system medical staff is not therapeutic intervention. They do not routinely administer medications such as morphine, aspirin, or nitrates. Their contribution is an assessment of suspected STEMI patients to speed the examination time and ultimately reduce the time before starting treatment following hospital arrival. A study by Gunnarsson *et al*. found that the benefits of a physician-staffed HEMS for suspected STEMI patients included fewer in-hospital adverse outcomes, including cardiac arrest, cardiogenic shock, and serious arrhythmias, compared with a HEMS that was not physician-staffed (11.3% versus 25.4%, P = 0.002).[7] Our study utilized ground rather than air transport, but both systems were physician-staffed. In Gunnarsson *et al*., the presence of physicians might have reduced adverse hospital outcomes. In that study, more medications, such as nitrates, morphine, and antiplatelet drugs, were given more frequently than in the HEMS without physicians. Administration of these medications on a case-

Table 2. Comparison of door-to-balloon time (DTBT) and survival rate among patients with ST-segment elevation myocardial infarction, grouped by prehospital intervention

	RRC (n = 33)	EMS (n = 20)	TRANS (n = 68)	P-value
DTBT (min)	51.0 (43–57)	61.0 (52–68)	59.5 (48–72)	0.130
Survival rate (%)	31 (93.9)	19 (95.0)	66 (97.1)	0.746

EMS, emergency medical service group; RRC, rapid response car group; TRANS, transported group.

by-case basis as judged necessary by the physician could have led to the reduction in adverse events.

Not all ambulances in our district are equipped with a 12-lead ECG and there is no capability to transmit an ECG to the PCI center. In this study, only 10.0 % of patients in the EMS group received prehospital 12-lead ECG. Paramedics cannot directly contact an in-hospital cardiologist before the patient arrives at the PCI center. They can only contact emergency physicians or general physicians in charge of the emergency department during off-hours. Under those conditions, the presence of physicians in the RRC GEMS has a meaningful benefit. Before arriving at the hospital, emergency physicians on the RRC staff assess the suspected STEMI patient and carry out cardiac ultrasonography with a hand-held device. Not all patients in the RRC group received prehospital 12-lead ECG. Thus, STEMI was diagnosed by comprehensively judging the present medical history, symptoms, risk factors of STEMI, and findings of cardiac ultrasonography. If there is a high probability of STEMI, the field physician can order an in-hospital physician to consult an interventional cardiologist and activate the catheter laboratory staff.

The call center personnel did not activate the RRC in response to every call that involved patients in this study, despite its availability. That might reflect the skill of the call center personnel or have resulted from atypical symptoms of the patients. As the symptoms and chief complaints were not included in the study analysis, patient heterogeneity might be a confounder that influenced the DTBT. Although the TRANS patients had already been diagnosed with STEMI at another hospital, they had a longer DTBT than the RRC patients (60 min versus 51 min, respectively). The OTHsp time was shorter in the RRC than in the TRANS patients, which was considered to be one of the reasons for longer DTBT in TRANS patients. The collaboration of emergency physicians and cardiologists in the RRC system was also important in shortening the DTBT of the RRC compared with the TRANS patients.

The study has some limitations. First, it was a retrospective observational study undertaken in a single tertiary emergency center in Japan. Not many institutions in Japan have begun using an RRC system, probably because of a lack of evidence supporting the benefits of physician-staffed GEMS and a shortage of emergency physicians. Second, EMS and emergency medical systems vary widely among countries. The results in Japan might not apply to other countries, but the study did find that prehospital assessment by a field physician and nurse could reduce the DTBT for suspected STEMI patients. In each country, emergency physicians and cardiologists can consider how the available medical resources can be used to further improve the prehospital care of STEMI patients. Third, the exact factor that promoted the field physicians to activate the PCI team was unknown and not evaluated. That might be 12-lead ECG, cardiac echography, and patients' medical history and symptoms. The point of care ultrasonography for chest pain was instrumental in ruling out other causes of chest pain, including pneumothorax, acute aortic dissection, and pulmonary embolism. Because prehospital activity had the limitation on time, the detailed examination over time for asynergy was thought to be impossible. It could be considered that the dedicated physicians and nurses could comprehensively assess the suspected STEMI patients from several findings. Finally, the study sample size was small. The RRC system did not significantly shorten the DTBT, but the DTBT was already less than 60 min and there was a tendency to shorten DTBT compared with other groups. The accumulation of more cases is ongoing, as is evaluation of the effectiveness of our RRC system. For same reason, it was difficult to examine the effect on the outcome of mortality.

CONCLUSION

IN THIS OBSERVATIONAL study, the RRC system, which comprised a physician-staffed GEMS, tended to shorten the DTBT of STEMI patients, but the difference was not statistically significant. The prehospital activity of a dedicated emergency physician and nurse has the potential to contribute to shortening the DTBT. Further study to examine the effect of the physician-staffed GEMS on STEMI patients is desired.

DISCLOSURE

Approval of the protocol: The study was approved by the hospital ethics committee.
Informed consent: N/A.

Registry and the registration no. of the study/trial: N/A.
Animal studies: N/A.
Conflict of interest: None.

REFERENCES

1 Shiomi H, Nakagawa Y, Morimoto T *et al*. Association of onset to balloon and door to balloon time with long term clinical outcome in patients with ST elevation acute myocardial infarction having primary percutaneous coronary intervention: observational study. BMJ 2012; 23: e3257.

2 O'Gara PT, Kushner FG, Ascheim DD *et al*. 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction: executive summary: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. J. Am. Coll. Cardiol. 2013; 61: 485–510.

3 Foo CY, Bonsu KO, Nallamothu BK *et al*. Coronary intervention door-to-balloon time and outcomes in ST-elevation myocardial infarction: a meta-analysis. Heart 2018; 104: 1362–9.

4 Scholz KH, Maier SKG, Maier LS *et al*. Impact of treatment delay on mortality in ST-segment elevation myocardial infarction (STEMI) patients presenting with and without haemodynamic instability: results from the German prospective, multicentre FITT-STEMI trial. Eur. Heart J. 2018; 39: 1065–74.

5 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: e012188.

6 Pathan SA, Soulek J, Qureshi I *et al*. Helicopter EMS and rapid transport for ST-elevation myocardial infarction: The HEARTS study. J. Emerg. Med. Trauma Acute Care 2017; 2017: 8.

7 Gunnarsson SI, Mitchell J, Busch MS *et al*. Outcomes of physician-staffed versus non-physician-staffed helicopter transport for ST-elevation myocardial infarction. J. Am. Heart Assoc. 2017; 6: e004936.

8 Adams GL, Campbell PT, Adams JM *et al*. Effectiveness of prehospital wireless transmission of electrocardiograms to a cardiologist via hand-held device for patients with acute myocardial infarction (from the Timely Intervention in Myocardial Emergency, NorthEast Experience [TIME-NE]). Am. J. Cardiol. 2006; 98: 1160–4.

9 Rasmussen MB, Frost L, Stengaard C *et al*. Diagnostic performance and system delay using telemedicine for prehospital diagnosis in triaging and treatment of STEMI. Heart 2014; 100: 711–5.

10 Brokmann JC, Conrad C, Rossaint R *et al*. Treatment of acute coronary syndrome by telemedically supported paramedics compared with physician-based treatment: a prospective, interventional, multicenter trial. J. Med. Internet Res. 2016; 18: e314.

11 Parikh R, Faillace R, Hamdan A *et al*. An emergency physician activated protocol, "Code STEMI" reduces door-to-balloon time and length of stay of patients presenting with ST-segment elevation myocardial infarction. Int. J. Clin. Pract. 2009; 63: 398–406.