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 RRC, 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
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
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. 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...
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%, \( P = 0.002 \)).

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/m²             | 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 (%)** | 7 (21.9) | 9 (45.0) | 2 (3.3) | <0.001 |
| <60 min                | 8 (25.0)    | 7 (35.0)    | 6 (9.8)       |         |
| 60–120 min             | 2 (6.2)     | 2 (10.0)    | 12 (19.7)     |         |
| 120–180 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.
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 patient. Because prehospital activity had the limitation on time, detailed examination over time for asynchrony was thought to be impossible. It could be considered that the dedicated emergency 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.

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

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