Impact of Doctor Car With Mobile Cloud ECG in Reducing Door-to-Balloon Time of Japanese ST-Elevation Myocardial Infarction Patients

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Summary

Early reperfusion by percutaneous coronary intervention (PCI) is the current standard therapy for ST-elevation myocardial infarction (STEMI). To achieve better prognoses for these patients, reducing the door-to-balloon time is essential. As we reported previously, the Kitasato University Hospital Doctor Car (DC), an ambulance with a physician on board, is equipped with a novel mobile cloud 12-lead ECG system. Between September 2011 and August 2013, there were 260 emergency dispatches of our Doctor Car, of which 55 were for suspected acute myocardial infarction with chest pain and cold sweat. Among these 55 calls, 32 patients received emergent PCI due to STEMI (DC Group). We compared their data with those of 76 STEMI patients who were transported directly to our hospital by ambulance around the same period (Non-DC Group). There were no differences in patient age, gender, underlying diseases, or Killip classification between the two groups. The door-to-balloon time in the DC group was 56.1 ± 13.7 minutes and 74.0 ± 14.1 minutes in the Non-DC Group ($P < 0.0001$). Maximum levels of CPK were 2899 ± 308 and 2876 ± 269 IU/L ($P = 0.703$), and those of CK-MB were 292 ± 360 and 295 ± 284 ng/mL ($P = 0.423$), respectively, in the 2 groups. The Doctor Car system with the Mobile Cloud ECG was useful for reducing the door-to-balloon time. (Int Heart J 2015; 56: 170-173)

Key words: Mobile cloud electrocardiography, STEMI, Prehospital care

Patients with ST-segment elevation myocardial infarction (STEMI) require immediate reperfusion.[1)] The accurate diagnosis of STEMI is critical for quick and efficient treatment[2-4)] and 12-lead electrocardiography (ECG) transmission in the pre-hospital time period could contribute to reducing the door-to-balloon time.[5-12)] However, few Japanese ambulances are currently equipped with an ECG transfer system. In Japan, the medical-related activities of emergency lifesaving technicians in the field is strictly controlled by the law. They cannot administer oral nitroglycerin or heparin injections. Hospitals throughout Japan have been introducing doctor car and doctor helicopter systems.[13,14)] Doctor cars enable a physician and nurse to arrive at the location of the patient as soon as possible where they can immediately stabilize the patient and conduct an accurate diagnostic assessment of the clinical condition, which ensures prompt treatment upon hospital admission.[13)] The Doctor Car of Kitasato University Hospital is dispatched for patients not only with traumatic injury, but also with suspected acute myocardial infarction (AMI).[15)] Shortening the door-to-balloon time as much as possible is very important for achieving a better prognosis in STEMI patients.[16-20)] Guidelines recommend that STEMI patients should receive primary percutaneous coronary intervention (PCI) within 90 minutes.[21,22)] As we have reported previously,[15,23)] our Doctor Car is equipped with a mobile cloud electrocardiography system. The cardiologist who is in charge at the emergency room can read the ECG waveforms simultaneously through a cloud server.[15)] However, the clinical usefulness of doctor cars and doctor helicopters for STEMI patients in Japan has not yet been reported.

Methods

Doctor car system: Kitasato University Hospital established a Doctor Car system equipped with a mobile cloud ECG system in September 2011. The Doctor Car is dispatched to rural areas and cities, including Sagamihara City, Zama City, Yamato City, and Ayase City that are located in the northern middle region of Kanagawa Prefecture, which is adjacent to Tokyo. The pop-

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ulation covered by the service is approximately one million. Suspected AMI patients from regions outside this catchment area were directly transferred to our hospital by conventional ambulance. The dispatch criteria included severe traumatic injury, deteriorating respiratory status, hemorrhagic shock, and suspected AMI with chest pain and cold sweat. The car was in operation from 8:00 am to 4:30 pm on weekdays. The number of dispatches was 10-15 per month. One or two emergency physicians, a nurse, and a driver went out on dispatches in the Doctor Car, which is essentially a conventional ambulance with medical personnel on board.

Mobile cloud ECG system: As we have previously reported,[15,23] our Doctor Car was equipped with a mobile cloud ECG system (Cloud Cardiology®, Labtech Co., Debrecen, Hungary) and 12-lead ECGs obtained in the field were transmitted anonymously to a secure cloud server with commercially available Android tablets via a mobile telephone network. The 12-lead ECG in the cloud server could be browsed simultaneously from a limited number of personal computers in the Kitasato University Hospital Emergency Center after password authentication (Figure 1). Since a password was used, this system rendered correct transmission of ECG data and was fairly reliable. In addition, because an already-existing telephone network was used, transmission was available from anywhere in the service area and the set-up and maintenance costs of the system were low. While using this system, cardiologists in the hospital are able to read the ECG waveforms transmitted to the cloud server from the field and decide whether emergency catheterization is necessary. In most typical cases successfully diagnosed as STEMI in the center, the cardiologist in charge contacted and activated the catheter lab as well as other staff in advance of arrival of the patient.

Study patients: The study patients were those who were brought to the hospital by the Doctor Car due to suspected AMI between September 2011 (after the DC was equipped with the mobile cloud ECG system) and August 2013. The control group consisted of STEMI patients who were transported by conventional ambulance during the same time period. Midnight cases and holiday cases were excluded from the control group because at the time of admission a cardiologist who would perform the emergent PCI was not on duty in the hospital.

Statistical analysis: The data are presented as the mean ± SD or counts (%). Categorical data were compared with the chi-square test. Continuous variables were compared using the Wilcoxon test.

Data were statistically analyzed using JMP version 10.0 (SAS Institute Inc., NC, USA). $P \leqq 0.05$ was considered to be statistically significant.

Ethics: Written consent to collect the data from medical records was obtained from each patient or his family. The study was approved by the Kitasato University Medical Ethics Organization (KMEO B12-64).

Results

From September 2011 to August 2013, there were 260 emergency dispatches and the number of suspected AMI cases was 55. Transmission success was achieved in all cases (100%). Among these 260 patients, 3 were transferred to other hospitals and 1 died of recurrent ventricular fibrillation (VF) so they were excluded from this study. Four patients were not diagnosed as AMI but as aortic dissection. Four patients had no coronary stenosis and were diagnosed as having coronary spastic angina. Three had supraventricular tachycardia such as paroxysmal supraventricular tachycardia (PSVT) and paroxysmal atrial fibrillation (PAF), 7 had heart failure and did not undergo emergent catheterization, and one underwent an emergency coronary artery bypass grafting operation. Thirty-two patients received emergency PCI (DC-group) (Figure 2).

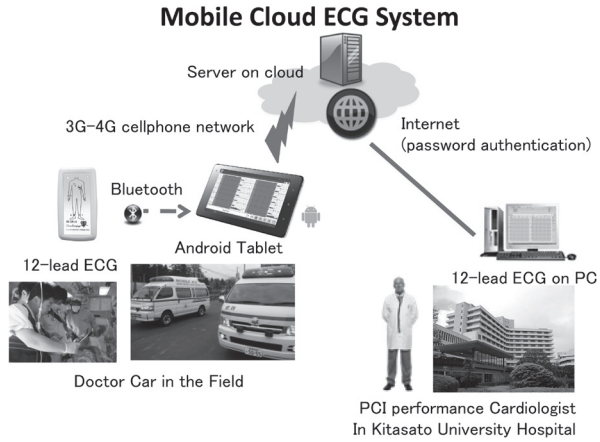

Figure 1. 12-lead ECG is sent to a tablet PC via a Bluetooth connection in the field. The ECG data are transmitted to a secure cloud server via an existing mobile telephone network. The data in the cloud server can be browsed from a personal computer in Kitasato University Hospital Emergency Center after password authentication. Thus, the cardiologist who is in charge of emergent PCI can read the 12-lead ECG waveforms and prepare for the catheterization.

During the same period, 132 STEMI cases were transported to our emergency center directly by a conventional ambulance. Among these 132 cases, 56 were excluded from this study because a cardiologist who performs emergent PCI was not present in the hospital since they were admitted at night or on a statutory holiday. Thus, a total of 76 cases (Non-DC group) were compared with the DC-group (Figure 3).

There were no significant differences in age, gender, hypertension, hyperlipidemia, diabetes mellitus, current smoke or Killip classification between the two groups (Table I). In the DC group, two cases were intubated and no case had antithrombotic therapy in the field. The door-to-balloon time was within 90 minutes in 87.5% (28/32) of the DC group patients and in 81.6% (62/76) of the non-DC group patients. The door-to-balloon time in the DC group was significantly reduced (56.1 ± 13.7 minutes versus 74.0 ± 14.1 minutes, $P < 0.0001$). Maximum levels of creatine phosphokinase (CPK) were 2899 ± 308 IU/L and 2876 ± 269 IU/L ($P = 0.703$) and those of creatine kinase MB fraction (CK-MB) 292 ± 360 ng/mL and 295 ± 284 ng/mL in the DC and non-DC groups, respectively ($P = 0.423$) (Table II).

Discussion

Immediate reperfusion is important for improving the prognosis of STEMI patients.[6] We have made various attempts

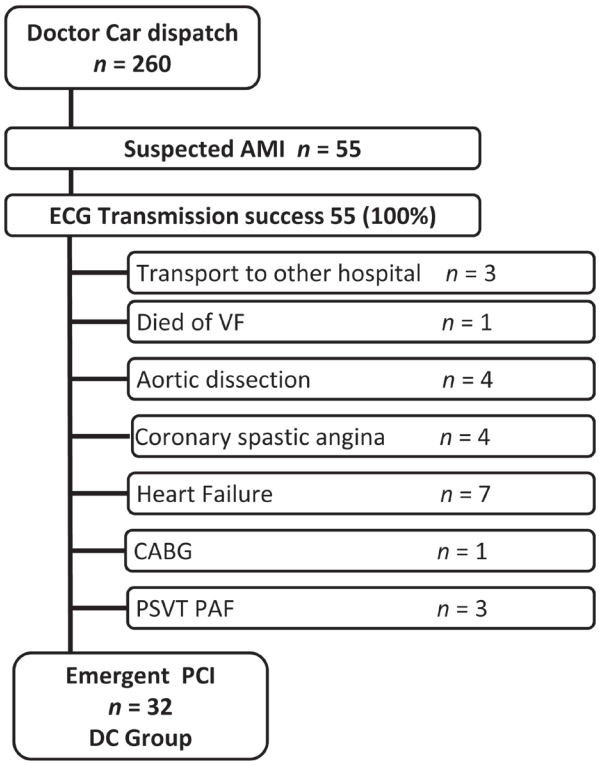

Figure 2. There were 55 cases of suspected AMI for which our Doctor Car was required. However, some were diagnosed as having cardiac arrhythmia and aortic dissection by a physician in the field and some patients were transported to other hospitals. Consequently, 32 patients actually received emergent catheterization at our hospital.

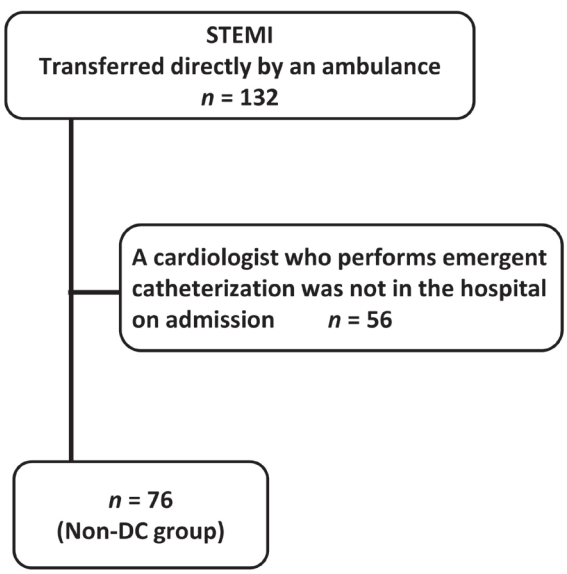

Figure 3. There were 76 STEMI patients who were directly transported by ambulance around the same period.

to reduce the door-to-balloon time within our institutes. Although ECG transmission is recommended,[8] there are no ambulances with ECG transmission systems in our hospital catchment area. We have already reported the usefulness and security of the mobile cloud ECG system in our Doctor Car.[15] Our system is low cost and reliable from a security standpoint because it does not produce erroneous transmissions of ECG data, unlike other systems.[24] To reduce the door-to-balloon time, an accurate diagnosis and preparation of an emergency catheter are essential. The advantage of this cloud system is that cardiologists in the hospital can simultaneously read the ECG waveforms and decide whether emergent PCI is necessary with robust transmission capability and low cost. Therefore, preparation for emergent catheterization can be completed before the Doctor Car returns to the hospital, and the patient can be brought immediately into the emergent catheterization room. Consequently, our Doctor Car with the mobile cloud ECG system has reduced the door-to-balloon time by 18 minutes. Based on these favourable results, we are planning to equip fire department ambulances with the mobile cloud ECG as well.

Another advantage of this system is the stratification of the patients based on their risks. Some patients were diagnosed with PAF or PSVT by a physician in the pre-hospital field even if their chief complaints were chest pain and cold sweat. The patients who had no ST change were transferred to other hospitals without PCI capability.[25] They may have needed a gastroscopy exam later on. This Doctor Car with a mobile cloud ECG system contributed to the effective and economical use of regional medical resources.

There were no significant differences in the maximum levels of CPK and CK-MB between the DC and Non-DC groups. This might be because severe and mild STEMI patients were present in both groups. Since CPK levels depend on the stenosis sites, the results may have been different if we had a larger number of subjects and compared the data only among the patients having the same stenosis sites. The reduction in door-to-balloon time may have a prognostic implication.[17]

Recently, it has been reported that reducing the door-to-balloon time is not sufficient for in-hospital mortality.[26,27] We may pay more attention to pre-hospital activity such as first medical contact (FMC) to balloon time.

Table I. Patient Background

	DC group $n = 32$	Non-DC group $n = 76$	P
Age	64.9 ± 12.9	66.6 ± 11.4	0.644
Male (%)	75.8	79.7	0.644
Hypertension (%)	64.1	71.8	0.467
Hyprelipidemia (%)	57.1	68.5	0.306
Diabetes melitus (%)	25.1	19.4	0.524
Smokers (current) (%)	46.2	49.8	0.567
Killip ≧ 2 (%)	3.1	5.2	0.629

Table II. Clinical Parameters

	DC group $n = 32$	Non-DC group $n = 76$	P
Door-to-balloon time (minutes)	56.1 ± 13.7	74.0 ± 14.1	< 0.0001
CPK (IU/L)	2899 ± 308	2876 ± 269	0.703
CK-MB (ng/mL)	292 ± 360	295 ± 284	0.423

Study limitations: This study was a case control study based on medical records and was not a randomized study. Therefore, the cases in which the Doctor Car was and was not required might be biased. In addition, our data were obtained from a limited area that included only 4 cities in the vicinity of Kitasato University Hospital. Since our results were favorable, we hope to expand our study to include more areas in the future.

Conclusion: Our Doctor Car that is equipped with a Mobile Cloud ECG system could reduce the door-to-balloon time in STEMI patients.

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