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Original Article

Smartphone transmission of electrocardiography images to reduce time of cardiac catheterization laboratory activation

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Abstract

Background: This retrospective study evaluated the use of a smartphone application to facilitate communication between the emergency physician (EP) and the interventional cardiologist in order to minimize the time to cardiac catheterization laboratory (CCL) activation and time to percutaneous coronary intervention (PCI).
Methods: We retrospectively collected pertinent time-points in the management of patients diagnosed with STEMI in the emergency department and their outcome. The primary outcome was the reduction in the time from ECG interpretation to CCL activation after the implementation of a smartphone application. A total of 84 patients were enrolled. Patients' electrocardiography (ECG) were described by traditional verbal communication via telephone (group 1, $n = 40$) and by additional smartphone transmission of ECG images to an interventional cardiologist (group 2, $n = 44$). Relevant time-points were recorded for analysis.
Results: The time from ECG interpretation to CCL activation was reduced from 28.3 ± 4.1 in group 1 to 17.6 ± 2.3 min in group 2 ($p = 0.03$). Similarly, the time from ECG interpretation to balloon inflation time (D2B) decreased from 93.1 to 73.4 min ($p = 0.025$). Comparing group 2 with group 1, the door to balloon (D2B) time improved to 90.4 ± 9.8 from 119.3 ± 16.3 min ($p = 0.23$), the proportion of patients with a D2B time less than 90 min increased to 70.5% from 52.5% ($p = 0.09$), and the mortality rate decreased to 2.2% from 12.5% ($p = 0.07$).
Conclusion: The additional use of a smartphone application to transmit ECG information to interventional cardiologists by EPs facilitated communication and reduced the decision time to CCL activation and percutaneous intervention.

Keywords: Cardiac catheterization laboratory; Electrocardiography; Percutaneous coronary intervention

1. Introduction

The term ‘time is muscle’ is frequently used to emphasize the treatment for patients presenting with ST-segment elevation myocardial infarction (STEMI). Guidelines in adult advanced cardiac life support recommend that the door-to-balloon (D2B) time between initial presentation to the hospital and restoration of coronary flow to the ischemic myocardium should be within 90 min.[1] Evidence has indicated that primary percutaneous coronary intervention (PCI) exhibits a

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greater benefit than fibrin-lytic therapy for treating patients with STEMI to restore myocardial reperfusion if performed less than 90 min after the initial presentation. Also, the guidelines state that electrocardiography (ECG) should be performed for patients presenting with chest pain and suspected acute coronary syndrome within 10 min upon arrival to the emergency department (ED). When STEMI is diagnosed, the emergency physician (EP) contacts the interventional cardiologist, and the most frequently used method of communication is verbal report by telephone. Telephone communication is rapid and convenient, but miscommunications may occur. Nowadays, images photographed on a smartphone can be transmitted to another smartphone easily, and there are many smartphone applications that can be used to transmit images.

Many types of smartphone applications have recently been developed recently that have this function. The Line application (Line Corporation), which is an increasingly popular mobile messaging application, is available on all smartphone platforms. Like WhatsAPP, Line is a smartphone application used by more than 211 million people worldwide, and it allows users to send text messages and other types of media (such as images, voice messages, and videos) to their contacts. It is also easy to set up a group conference call that allows multiple users to participate in a conversation. For example, EPs have been using Line to transmit ECG images to interventional cardiologists when STEMIs are diagnosed in the ED (known as tele-ECG). After evaluating the patient's history and ECG, the cardiologist decides whether to activate the cardiac catheterization laboratory (CCL). This study evaluated the use of Line to facilitate communication between the EP and the interventional cardiologist in order to minimize the time from presentation to CCL activation.

2. Methods

Fifty-thousand patients visit the ED of this hospital annually, and patients can undergo emergent PCI. The hospital has six interventional cardiologists on call for consultation and emergent PCI (24/7). The decision to activate CCL was delegated to the interventional cardiologists after evaluation of the patient history and the ECG. For patients presenting with chest pain or angina-equivalent symptoms such as shortness of breath, ECGs were performed immediately upon the patient's arrival, and the EP was responsible for interpreting the findings immediately after it was completed. Mobile devices with a 12 megapixel camera were encrypted and provided by the hospital for the transmission of ECG images. Only personnel that participated in the program had access to the image transferred. Once STEMI had been diagnosed, the EP immediately consulted the interventional cardiologist by telephone. In the traditional group (group 1), the EP described the ECG pattern to the interventional cardiologist. In the tele-ECG group (group 2), the EP also transmitted the images of ECG to the interventional cardiologist through a smartphone application and as well as discussing the ECG images.

We retrospectively evaluated patients diagnosed with STEMI who underwent PCI from January 1, 2014 to December 31, 2015. Patients were excluded if they were transferred from another hospital and if our hospital was informed of their arrival in advance. Group 1 included patient from the period January 1, 2014 to December 31, 2014 when traditional verbal (non-smartphone) communication was used. During this time period, hospital policy mandated adherence to the STEMI guidelines. In the ED, more technicians were hired to perform the initial ECG in the ED and steps in this process of care were enhanced to improve D2B time. In group 2, we included the use of Line for transmitting ECG that started on January 1, 2015, and we reviewed the charts of patients with STEMI through this method until December 31, 2015. To prepare for the use of smartphones to transmit ECGs, the smartphones of EPs and interventional cardiologists were encrypted. The images of ECG did not show any patient identifiers.

We recorded chief complaints on arrival, and whether the patient's arrival was during regular hours or off-hours. Regular hours were defined as the time from 8:00 am to 5:00 pm Monday to Friday except for holidays, and off-hours represented all times other than regular hours. As demonstrated in Fig. 1, we recorded further time-points: (1) the time the ECG was performed from the initial time of ED arrival, (2) the time of ECG interpretation by the EP from the initial time of ED arrival, (3) the time of interventional cardiologist consultation from the initial time of ED arrival, (4) the CCL activation time by the interventional cardiologist from the initial time of ED arrival, and (5) D2B (time of balloon inflation after the initial time of ED arrival). We defined: (1) Time to ECG interpretation by EP = time from ED arrival to ECG interpretation by an EP; (2) Time to ECG interpretation by an EP = from initial time of ED arrival to ECG interpretation by an EP; (3) Activated CCL time = time from ED arrival to CCL activation; (4) Time of CCL activation = from initial time of ED arrival to CCL activation by the cardiologist.

Our primary outcome was the time from ECG interpretation to CCL activation. Secondary outcomes included D2B time $\leq$ 90 min, the proportion of patients reaching D2B time $\leq$ 90 min, and the 28-day mortality rate. Mortality is defined as death within 28 days after ED presentation.

2.1. Statistical analysis

Continuous variables were described as mean $\pm$ SE and compared using the Student *t* test, and the Wilcoxon rank-sum test was used for the D2B and CCL activation time because the times did not fit a normal distribution. Categorical variables were expressed as frequencies and compared using a χ^2 tests and where appropriate, a Fisher exact test. We used a linear regression analysis to examine the association between two outcomes: ECG interpretation by EP to CCL activation time and ECG interpretation by EP to balloon inflation time, and three potential predictors: after Line usage, atypical presentation, and the effect of off-hour presentation. We first

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