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Development and Clinical Study of Mobile 12-Lead Electrocardiography Based on Cloud Computing for Cardiac Emergency

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Abstract and Objective

To improve emergency services for accurate diagnosis of cardiac emergency, we developed a low-cost new mobile electrocardiography system "Cloud Cardiology®" based upon cloud computing for prehospital diagnosis. This comprises a compact 12-lead ECG unit equipped with Bluetooth and Android Smartphone with an application for transmission. Cloud server enables us to share ECG simultaneously inside and outside the hospital. We evaluated the clinical effectiveness by conducting a clinical trial with historical comparison to evaluate this system in a rapid response car in the real emergency service settings. We found that this system has an ability to shorten the onset to balloon time of patients with acute myocardial infarction, resulting in better clinical outcome. Here we propose that cloud-computing based simultaneous data sharing could be powerful solution for emergency service for cardiology, along with its significant clinical outcome.

Keywords: electrocardiography, myocardial infarction, Android, cloud computing

Introduction

Recently inhospital survival rate for acute myocardial infarction (AMI) has been greatly advanced since the advent of reperfusion therapy including primary percutaneous coronary intervention (PCI) particularly in Japan. In Japan, the overall in-hospital mortality is reported to be decreased from 20.0% to 7.8% over 30 years. In contrast to those favorable results of inhospital situation, epidemiological evidence revealed that prehospital mortality of AMI remains far from satisfactory [1]. To expand utility of prehospital 12-lead ECG in the real clinical settings that is not widely used in spite of its well established clinical effectiveness in AMI, we developed a mobile 12-lead ECG system equipped with telecommunication / cloud system via smartphones, Wifi, or direct internet connections.

Methods

Traditionally, most of the ECG transmission systems are designed as limb-lead only ECG and/or real-time transmission, whereas when using currently prevalent cellular network 3G, it is difficult to obtain sufficient throughput from a narrow-band upward cellphone network. Thus main specifications of this system were determined as sending fixed high-resolution 12-lead with trade-offs of real-time transmission and suppressing costs to enhance cost-effectiveness. In collaboration with the development company of Labtech co. Ltd. (Debrecen, Hungary), we generated a novel ECG transmitter EC-12R equipped with Bluetooth connection with new applications for PC as well as Android OS for mobile phones to send ECG to cloud server. Besides, database system based on cloud computing were also constructed based on Windows Server system that can be accessed from anywhere with special viewer applications via internet. Present total purchase cost is as low as about two thirds of that of Electrocardiograph generally used in the hospital. First we tested this system in terms of basal transmission capacity and feasibility. Transmission experiments were performed in different geographic environments in Tokyo urban area along with several rural areas in Japan. Time between sending and receiving was measured. Next we evaluated the clinical effectiveness by conducting a clinical trial to evaluate this system in a rapid response car that is used in the department of emergency at Kitasato University in the real emergency service settings.

Results

Transmission experiment exhibited 100 % success rate with 14.9 ± 5.8 s (n = 56) short enough for medical staffs to share ECG simultaneously, indicating that this cloud-based system is feasible and effective. Practical clinical evaluation trial showed that inpatients with myocardial infarction, onset to balloon time was significantly reduced compared to control without ECG transmission (91.5±11.1 min, n=22 vs 111±19.1 min, n=51 $p<0.0001$). The time shortening effect mainly comes from the advantages that doctors in the hospital were able to diagnose MI accurately just when ECG was taken prehospitally, and decide to prepare for the cath lab in advance of arrival. This is the first report to achieve clinical outcome in the real settings by applying instant ECG sharing system using telemedicine based on newly developed mobile devices and cloud computing system at low cost. Thus cloud-computing based simultaneous data sharing system for limited modality could be an effective solution for emergency medical service for cardiology superior to similar preexisting system, along with its significant clinical outcome [2].

References

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