

Feasibility of Telecardiology Solution to Connect Rural Health Clinics to a Teaching Hospital

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Abstract

Background: In spite of enormous progress in cardiac care in India, rural communities lack access to even basic cardiac care. One possible solution to this problem is to employ telecardiology. **Objectives:** To demonstrate feasibility of telecardiology system to link rural clinics to a teaching hospital. **Methods:** Five rural clinics were linked to a teaching hospital, using an inexpensive system of cardiographs and tablet PCs to transmit ECGs to hospital and have them interpreted by cardiologist. **Results:** Three hundred eighty ECGs were acquired at clinics with 98.9% of them noise-free and transmitted to the hospital with 99.7% success on first attempt. Interpretation of ECG was provided to primary care physician at the clinic on the same day for 95.3% of ECGs. Abnormal ECG findings were seen on 22.6% of these ECGs. **Conclusion:** This system performed well with high success rate of acquisition and transmission. Staff at rural clinics successfully acquired quality ECGs and transmitted them and the staff at the hospital were able to provide timely interpretation of ECGs and advice to patients.

Keywords: Electrocardiogram, remote cardiac diagnosis, telecardiology for rural clinics

INTRODUCTION

Prevalence of cardiovascular risk factors and the resulting heart disease is extremely high in India.^[1,2] Onset of heart disease, particularly, coronary artery disease, occurs at a much earlier age in Indian population compared with populations in the Western nations.^[3] Economic and societal burden of coronary artery disease in terms of early death, disability, and quality-adjusted life years is much higher in India than in many other countries.^[4]

Health care in India, particularly in the private sector, has made enormous progress during the last two decades, with major hospital chains establishing state-of-the-art hospitals in all major cities. However, patients in rural areas do not have adequate, affordable access to even basic cardiac care. As a result, many rural patients delay seeking care for cardiac ailments even when they are symptomatic or go to the nearest rural clinic where neither the equipment nor the clinical expertise to diagnose those conditions exists.

Providing simple diagnostic tools to remote rural clinics with training to operate them and connecting them to a hospital with cardiology expertise would alleviate this problem to a great

extent. Primary care physicians (PCPs) at these clinics can be trained to recognize the symptoms and perform an initial triage and the nursing/technical staff can be trained to perform basic diagnostic tests such as a 12-lead electrocardiogram (ECG) and transmit the report along with a brief history and symptoms (“data”) to the hospital. Cardiologist at the hospital would interpret the received data and provide interpretation and advice on the management of these patients.

There have been several implementations of region-wide telecardiology across the globe. Telecardiology has been applied to provide diagnostic support to general practitioners in primary care in United Kingdom.^[5] To provide consultation service to small towns without advanced cardiac care, telecardiology has been implemented in Italy.^[6] A successful implementation of a state-wide telecardiology service has been reported in the state of Minas Gerais in Brazil.^[7]

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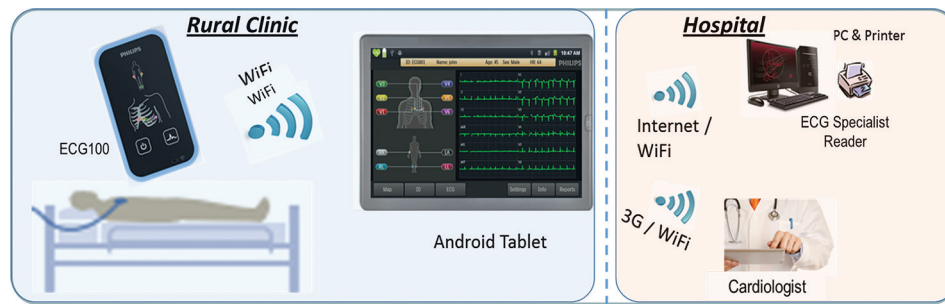


Figure 1: Schematic representation of Tele-ECG system. ECG100: Efficia ECG100 electrocardiograph, Android Tablet: Android-based tablet PC

Although some of these systems started with an initial goal of improving care for patients with symptoms of acute coronary syndromes (ACSs), they have been very effective for routine remote diagnosis of a wide range of nonemergent cardiac conditions and in serving remote small towns with clinics without cardiology expertise, a situation very similar to the healthcare system in rural India. There have been a few successful implementations of telecardiology for ACS care in India, particularly for ST-elevation myocardial infarction (STEMI).^[8]

Reported here is a feasibility study conducted during a 3-month period (October 2015 to January 2016), linking five rural clinics to a teaching hospital to provide remote ECG diagnosis. This study was not intended to focus on acute chest pain patients only, rather to demonstrate technical feasibility of acquiring and transmitting ECGs from remote clinics to a hospital and the process of interpreting these ECGs and communicating the diagnosis to patients through their PCPs.

METHODS

Study protocol was approved by the Institutional Review Board of a teaching hospital in South India. Study was designed in a *hub-and-spoke* model with the cardiology department of the teaching hospital acting as the hub and five rural clinics affiliated with the hospital as the spokes (Community Health Center, Hospital Outreach Clinic, Primary Healthcare Center, Ayurveda Clinic that also offers other medical services, and a rural hospital).

Tele-ECG system consisted of a portable electrocardiograph and an Android tablet personal computer (tablet PC) at the rural clinics. At the hospital, it consisted of a computer to receive ECGs and a printer [Figure 1].

The electrocardiograph used in this study was a portable, compact, resting ECG device that would establish a WiFi hotspot to interface with the tablet PC. Tablet PC displays ECG waveforms acquired by the electrocardiograph and generates a standard 12-lead ECG report and a password-protected PDF file. An application on tablet PC was preconfigured to transmit ECG report via email to the hospital.

Training was provided on study protocol and individual responsibilities to all staff; use of ECG device/tablet PC

to acquire and transmit ECG to technicians at clinics; and workflow of receiving, reading, and referring ECGs to cardiologist to ECG reader at hospital.

When a patient with symptoms suggestive of any cardiac condition (e.g., shortness of breath, palpitations, and chest pain) walks into a rural clinic, examining PCP ordered an ECG. Technician would take the ECG and transmit it to the ECG reader at the hospital where a trained reader would classify them as “normal” or “suspect acute condition” or “potentially abnormal-others” [Figure 2].

If any acute condition (e.g., STEMI/high-risk pattern) was suspected, ECG was immediately sent to cardiologist. If it was an acute condition, cardiologist called the PCP with advice for immediate patient transfer to hospital and activated Cath Lab or gave instructions for admission to cardiac care unit.

If an ECG had a normal pattern, the ECG reader sent the initial interpretation to the PCP via email. In addition, all ECGs initially classified as “normal” were spooled for review and confirmation by cardiologist once in 2 days and missed abnormalities, if any, were communicated to the referring PCP.

If the ECG revealed other abnormalities, it was sent to cardiologist for interpretation later. Cardiologist emailed the ECG interpretation along with advice to the PCP for communication to patient. Target was to communicate ECG interpretation/advice to PCP on the same day the ECG was taken.

Analysis of the data included metrics of data quality, system performance, and operational variables related to recording of quality, noise-free ECGs, transmission of ECGs from the clinics to hospital, ECG interpretation, and response to PCP. In addition, data on the prevalence of ECG abnormalities in enrolled patients and cardiologist’s advice to patients on further follow-up were also analyzed.

RESULTS

ECGs were acquired on 380 patients (age: 57 ± 14 years; males/females: 189/191) at the clinics and transmitted to the hospital. Only 4 out of 380 ECGs had noise, giving a noise-free rate of 98.9%. Those four noisy ECGs were also interpretable by the ECG reader and cardiologist. ECG

transmission from clinics to hospital was successful on first attempt in all but one ECG, giving success rate of 99.7%. Transmission of one ECG was successful on second attempt. All 380 ECGs (STEMI 3, normal 291, other abnormalities 86) received at the hospital were read/interpreted by the ECG reader and cardiologist. ECG reader or cardiologist called back the PCP at the clinics on the same day for 362 ECGs (95.3%), the next day for 10 ECGs (2.6%), and 2 days later for 8 ECGs (2.1%).

Cardiologist found 86 ECGs (22.6%) with abnormal findings. Most common abnormalities were left ventricular hypertrophy (25), ventricular conduction defects (14), and cardiac arrhythmias (11) and others (8). Three ECGs had STEMI findings. Cardiologist advised cardiac echo for 59 patients and further evaluation for 13 patients. No recommendation was made for 11 patients with borderline

ECG abnormalities. Immediate reperfusion was advised for three STEMI patients who were transported to hospital by ambulance and treated with primary percutaneous coronary intervention (PCI) with patient arrival at clinic to balloon times of 140, 129, and 86 min [Table 1].

DISCUSSION

Several successful programs have been implemented in United Kingdom, Italy, Brazil, and other countries to connect remote/rural clinics to hospitals with cardiology expertise.^[5-7] Apart from the STEMI-India program study that focused on acute chest pain patients,^[8] the authors are not aware of telecardiology programs in India similar to the one reported in this pilot study. In this study, we did not examine costs, either at the clinics or hospital.

Table 1: Details of time metrics for three STEMI patients

Description of metric	STEMI Patient 1 (min)	STEMI Patient 2 (min)	STEMI Patient 3 (min)
Time from patient arrival at rural clinic to ECG transmission to hospital	46	53	20
Time taken by cardiologist to confirm STEMI	9	1	3
Time taken by ambulance to arrive at the clinic	10	10	5
Time from ambulance arrival at clinic to transporting patient to hospital	45	42	40
Time from arrival at hospital to opening the blocked artery (door-to-balloon time)	30	23	18
Total (patient arrival at rural clinic to balloon time)	140	129	86

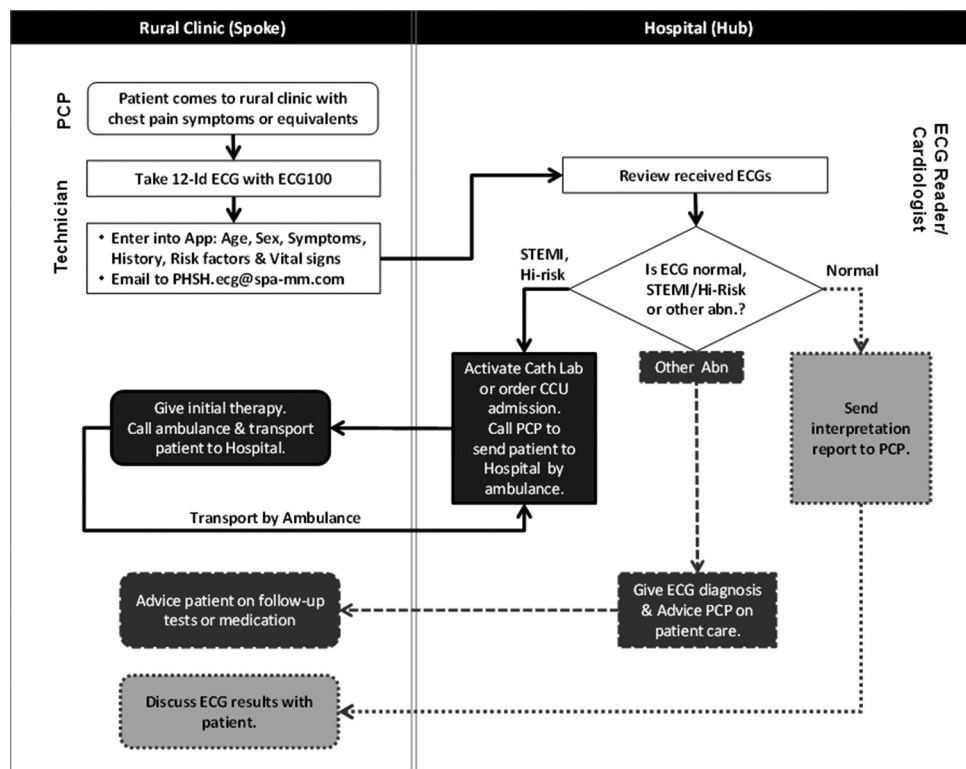


Figure 2: Data flow and patient care pathways in the hub-and-spoke model of telecardiology. Hi-risk: High-risk patterns in ECG, Other Abn: ECG abnormalities other than STEMI and high risk, PCP: Primary care physician, STEMI: ST elevation myocardial infarction

CONCLUSION

In this pilot study, we have successfully demonstrated the feasibility of an easy to use, portable ECG system to connect a diverse range of rural clinics to a teaching hospital for remote ECG diagnosis and guidance to patients through their PCPs.

- ECG system described here worked effectively to provide remote acquisition and transmission of standard 12-lead ECG
- An appreciable fraction of patients visiting rural clinics had abnormal ECG findings. Although not focused primarily on acute cardiac care, three STEMI patients who came to rural clinics were successfully triaged and treated with PCI.

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Conflict of interest

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