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Use of smartphone technology in cardiology

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ABSTRACT

Smartphone-based technologies along with broadband connectivity are changing the way modern cardiology is practiced. The ever broadening connectivity and increasing capabilities of smartphone-based technologies can better monitor, diagnose, and prevent cardiovascular diseases. Researchers can leverage the ubiquitous use of smartphone-based technologies and their constant stream of biometric data to establish large community-based clinical research studies. Patient engagement is enhanced with constant and on-demand access to physicians, daily self-monitoring, and expanding social networks. On the other hand, the exponential growth of smartphone-based technologies invariably disrupts the traditional healthcare model and leaves a vacuum in the infrastructure, medico-legal apparatus, and reimbursement systems that need to be addressed. In this review, we present a comprehensive discussion of the various applications utilizing smartphone-based technologies in cardiology.

Key words: Smartphone, Cardiology.

Introduction

The ubiquitous use of smartphones coupled with expanding mobile broadband connectivity are changing the way healthcare is accessed, monitored, and delivered. By 2020 the number of mobile broadband subscriptions is expected to reach 7.7 billion while the number of smartphone subscriptions is expected to equal about 70% of the world's population [1]. Mobile broadband connectivity has spurred the development of a wide array of devices embedded with sensors and microprocessors that can connect individuals to the Internet. It is estimated that the number of health-related wearable sensors will reach 80 million in 2017 [2]. Since smartphones have the capability to interface with peripheral devices, they serve as a personal digital hub integrating different monitoring devices and health applications (apps) in the collecting and transmitting of individualized health-related data. In a consumer survey, about half of responders would choose to have an electrocardiogram or check their vital signs at home using a device attached to their smartphone and have the results sent to their physician [3]. Large scale and sophisticated data analysis, using Big Data analytics and cloud computing, help deliver precision medicine that is focused on convenience, prevention, and cost efficiency.

Smartphones have seen an increased and pervasive use in cardiology. Cardiac patients have benefited from a wide array of smartphone-connected cardiac monitoring devices [4] and health apps aimed at diagnosis and prevention of cardiovascular disease. In this review, we present a comprehensive examination of smartphones and smartphone-connected devices currently employed in cardiology.

Arrhythmia detection

The identification and management of heart rhythm abnormalities in the outpatient setting often rely on 24-h ambulatory Holter monitors, external event monitors, or implantable loop recorders. These devices are often time limited and make data collection difficult for those patients with

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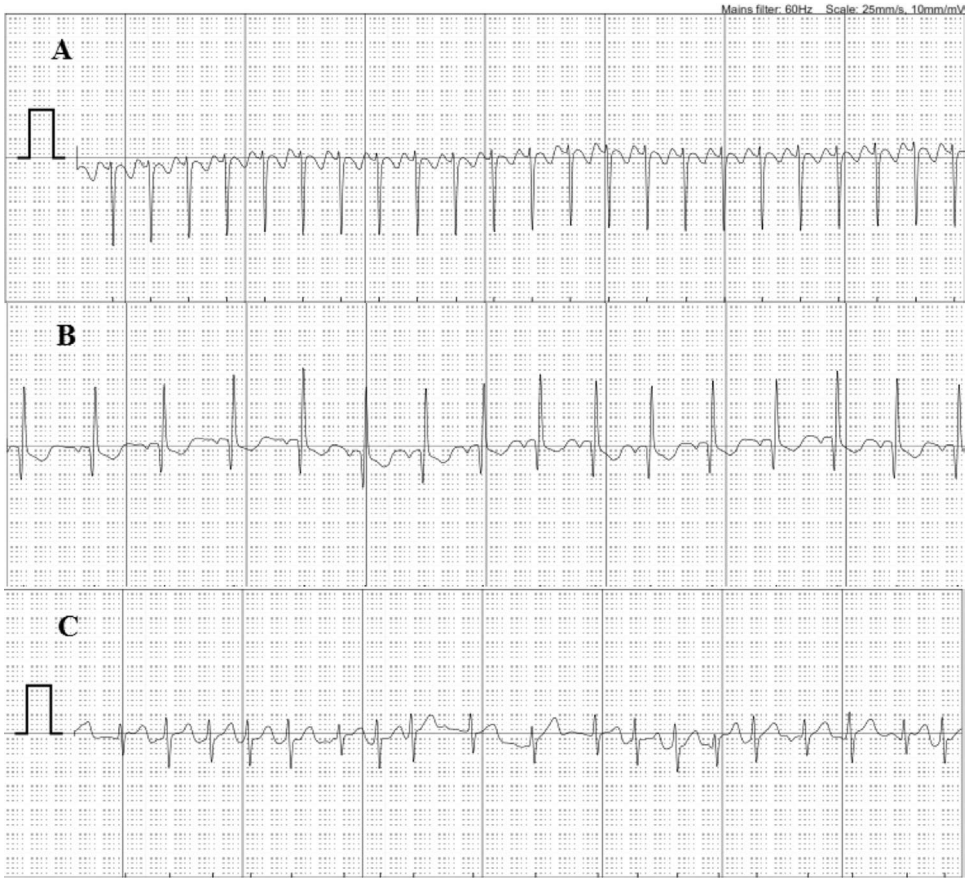

Fig – Sample diagnostic quality Alivecor ECGs: (A) An infant with supraventricular tachycardia; (B) from a child in normal sinus rhythm with sinus arrhythmia; and (C) from a teenager with atrial fibrillation.

infrequent symptoms. Additionally, they can be expensive (up to $4000) and burdensome (skin breakdown from continuous wear electrodes, intervention for subcutaneous implantable loop recorder placement) to patients [5].

One of the novel technology is the real time smartphone-enabled ECG, such as the AliveCor (San Francisco, CA) ECG device, that combines minimal external hardware (plate containing electrodes) with a smartphone app and Wi-Fi connectivity or data enabled cellular network plan that allow patients to capture and transmit single-lead ECGs directly to their physicians. An ECG is obtained by placing fingers of each hand on either electrode or, alternatively, by placing the electrodes directly on the chest. The device modulates the electrical signal from the electrodes to an audio signal recorded by the smartphone's microphone. The tracing can be viewed in real time while being recorded. The tracing is stored locally on the smartphone and is automatically transmitted to AliveCor's HIPAA compliant servers over Wi-Fi (or data enabled cellular network). The addition of automated discrimination algorithms for arrhythmias (such as atrial fibrillation) and the ability to alert both users and physicians make this technology efficient at ECG analysis. The AliveCor device has been rated to be accurate at heart rates up to 300 bpm. This technology has been validated in the screening for atrial fibrillation [6], and event monitoring for pediatric arrhythmias [7]. Its ease of use and high retention rate were demonstrated in both the pediatric and adult population [7,8]. The Fig. shows samples of diagnostic quality ECGs from the AliveCor device.

Multi-lead intermittent ECG devices have been developed and approved for the detection of ischemia [9]. They also have the ability to locate and send first responders should the device alert for an ischemia event.

Current multi-channel continuous ECG monitoring devices can continuously transmit single-lead ECG data to a smartphone app or transmit in an offline Holter mode with 3-lead ECG data. These systems can also provide a comprehensive overview of the user's heart health when coupled with built-in analytic software, such as heart rate variability scan.

Continuous multi-parameter vital signs monitoring

Inpatient

Almost half of hospital deaths occur in the unmonitored patient [10] with a large proportion of deaths preceded by unrecognized deterioration in heart rate and respiratory rate hours prior to the cardiac arrest [11]. Cardiac patients' rising level of acuity and complexity place them even more at risk of these unrecognized decompensations. However, previous investigations of hospital-wide continuous telemetry monitoring have shown that overuse of traditional continuous