ABSTRACT

Arrhythmia is one of the most difficult problems in cardiology and especially in pediatric cardiology. In this study, the authors present a mobile health (m-health) system that can be used for continuous monitoring of children (ages 0-16 years) with suspected cardiac arrhythmias. The system is able to carry-out real-time acquisition and transmission of ECG signals, and facilitate an alarm scheme able to identify possible arrhythmias so as to notify the on-call doctor and the relatives of the child that an event or something that denotes malfunction is happening. In general the problem has been divided into two cases. The first case is called “in-house case”, where the subject is located in his/her house. While the second case is called “moving-patient case”, where the subject might be located anywhere else. The authors’ goal is the continuous 24 hours, monitoring of the child. During the “in house case”, a sensor network installed in the child’s house is used in order to continuously record ECG signals from the patient as well as environmental parameters. The second case is more general. For this case, the child is monitored using the same ECG recording device but the signals are transmitted, through a mobile device, directly to the central monitoring system. The transmission is performed through the use of 2.5G, or 3G, mobile communication networks. The system design, development and technical tests (using an ECG simulator and 20 volunteers) are reported in this paper. The future steps will be the further evaluation of the system on children with suspected cardiac arrhythmias.

Keywords: Children Cardiac Arrhythmias, Home Monitoring, Mobile Health, Sensor Networks, Wireless Telemedicine

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1. INTRODUCTION

Telemedicine has been used for many years in order to improve health care provision or for patient monitoring. Several issues such as the computational capability, size of the devices, power efficiency and cost were limiting the availability of devices and services to a few special cases (Kyriacou, Pattichis, Pattichis, Panayides, & Pitsillides, 2007; Nugent et al., 2006). However, recent advancements in communications and computer systems including smart hand-held devices and sensing technology help us to develop health monitoring systems that are more efficient, much smaller and at lower cost.

Along this way, numerous systems have been presented until today. The main goal of these systems is the continuous and seamless monitoring of patients based on portable sensors and devices. Detailed surveys and several examples of such systems are presented in National Institute of Information and Communications Technology Japan (2009), Hao and Foster (2008), Gatzoulis and Iakovidis (2007), Muler, Schweizer, Helms, et al. (2010), and Pantelopoulos and Bourbakis (2010). The term Body Area Network or Body Sensor Network has been widely introduced in these papers. This term refers to the concept that the human body that is monitored is part of an area network, which might be a sensor ad-hoc network; the resource management of these networks has been recently studied by Wang et al. [2010]. Monitoring of adults with chronic heart failure has been an issue examined through many research projects, examples of which are presented in papers (Muler, Schweizer, Helms, et al., 2010; Kleinpell & Avitall, 2005; Polisena, Tran, Cimon, et al., 2010). Furthermore, monitoring of children with chronic diseases has also been proposed in Bergman, Sharek, Ekegren, Thyne, Mayer, and Saunders (2008) where telemedicine is applied in order to help children with asthma.

In this study, we will focus on the continuous monitoring of children with suspected cardiac arrhythmias. In order to evaluate the size and severity of the problem; arrhythmia is one of the most difficult problems in cardiology both in terms of diagnosis and management. The problem is particularly pronounced in pediatric cardiology because of the variety of etiologies and the difficulty that the children are having in trying to communicate their symptoms. For example in the case of hypertrophic cardiomyopathy, it is known that children are at higher risk for arrhythmias and sudden death than adults. In most of the cases an ECG tracing is required and this is sufficient for an accurate diagnosis, whereas in some cases, a more sophisticated modality is required (Kyriacou, Pattichis, Pattichis, Panayides, & Pitsillides, 2007; Moreira et al., 2006).

As an example a relatively recently recognized rare form of cardiomyopathy, the Isolated Noncompaction of the Left Ventricle (NCLV), which is a rare form of cardiomyopathy, poses new challenges. A subset of patients with this disease is especially prone to arrhythmia and sudden death. It is not always possible to estimate the risk of each patient with the available test modalities even if genetic testing is included. Current testing with the holter monitor has proved insufficient because it is limited to 24 or 48 hours of recording during which the patient may be asymptomatic. We care for a group of such children, some of whom are at imminent risk of sudden death (Moreira et al., 2006; Stollberger & Finsterer, 2004).

In this study, a mobile health (m-Health) system that will be able to monitor children continuously during their daily life activities is proposed. The system will be able to do real-time acquisition and transmission of ECG signals from the patient, and facilitate an alarm scheme able to identify possible arrhythmias so as to notify the on-call doctor and the relatives of the child that an event or something that denotes malfunction is happening. This system is a significant extension over our earlier telemedicine work in real-time ambulatory monitoring systems (Kyriacou et al., 2003), as well as of relevant preliminary publications on this topic (Kyriacou, Pattichis, Hoplaros, Kounoudes, Milis, & Jossif, 2010).
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