

Chapter 7

Conceptualizing a Real-Time Remote Cardiac Health Monitoring System

Alex Page

University of Rochester, USA

Moeen Hassanalierragh

University of Rochester, USA

Tolga Soyata

University of Rochester, USA

Mehmet K. Aktas

University of Rochester, USA

Burak Kantarci

Clarkson University, USA

Silvana Andreescu

Clarkson University, USA

ABSTRACT

In today's technology, even leading medical institutions diagnose their cardiac patients through ECG recordings obtained at healthcare organizations (HCO), which are costly to obtain and may miss significant clinically-relevant information. Existing long-term patient monitoring systems (e.g., Holter monitors) provide limited information about the evolution of deadly cardiac conditions and lack interactivity in case there is a sudden degradation in the patient's health condition. A standardized and scalable system does not currently exist to monitor an expanding set of patient vitals that a doctor can prescribe to monitor. The design of such a system will translate to significant healthcare savings as well as drastic improvements in diagnostic accuracy. In this chapter, we will propose a concept system for real-time remote cardiac health monitoring, based on available and emerging technologies today. We will analyze the details of such a system from acquisition to visualization of medical data.

INTRODUCTION

Conventional tests to assess the risk of cardiovascular diseases (CVD) involve clinical history, physical examination and electrocardiogram (ECG), which are highly observational and relatively insensitive (Petr, et al., 2014; Prasad, et al., 2013; Saul, Schwartz, Ackerman, & Triedman, 2014; Vatta, 2009). Although the pathology of CVD starts at earlier stages than it is observable by conventional methodologies, there are no clinical tests that can detect the onset and progression of CVD. Continuous disease monitoring

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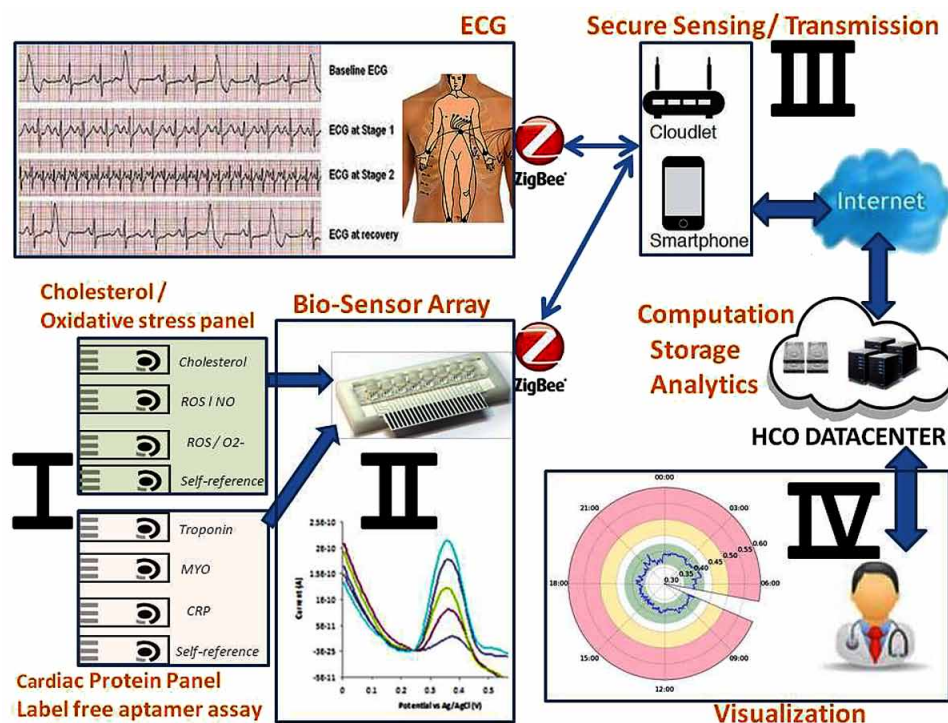
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at a healthcare organization (HCO) is difficult as most tests rely on extensive hospital based procedures, and results can vary (Ndumele, Baer, Shaykevich, Lipsitz, & Hicks, 2012; Loon, et al., 2011; Kobza, et al., 2014; Juntilla, et al., 2014). Long-term real-time monitoring of clinically-relevant cardiac biomarkers remotely (e.g. at the patient's house) could provide invaluable diagnostic information, while eliminating the need to administer such tests at the HCO could translate to substantial cost savings.

Currently, there are no suitable methods to assess and predict the risk of CVD and chronic heart failure in real time to enable effective therapeutic intervention (Lin, Zhang, & Zhang, 2013; Jiao, et al., 2014; Gonzales, White, & Safranek, 2014). Mechanisms that are involved in the development of CVD are complex and involve a variety of interrelated processes including changes in blood cholesterol, lipid metabolism, inflammation and oxidative stress. Pathological role of reactive oxygen species (ROS) in the development of CVD, especially in conditions related to cardiac ischemia and chronic heart failure is well studied (Nojiri, et al., 2006; Otani, 2004; Searles, 2002; Singh, 1995; Tsutsui, 2001). Among ROS species, superoxide radicals and nitric oxide (NO) have both been identified as important parameters in the pathophysiological alterations in myocardial and vascular function (Kundu, 2012; Salamifar & Lai, 2013). Other studies have related cardiac proteins including cardiac troponins (cTn), myoglobin (MYO), b-type natriuretic peptide (BNP) and C-reactive protein (CRP) with the onset of cardiac infarction (Wojciechowska, et al., 2014).

The proposed system in Figure 1 will enable physicians to monitor patients and have automatic alarm providing feedback on patient long-term health status. This monitoring can be continuous in patients with high risk for life-threatening events, or periodic with a recording frequency depending on disease

Figure 1. Proposed cardiac monitoring system: I) sensory acquisition, II) sensor interface, III) secure data transmission, IV) visualization and analytics.



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