Heart Rate Variability Analysis in Risk of Asthma Stratification

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Abstract

Early diagnosis of asthma is crucial to avoid long-term effects such as permanent airway obstruction. Pathogenesis of asthma has been related with autonomic nervous system (ANS) dysfunction, concretely with abnormal parasympathetic activity. As heart rate variability (HRV) analysis does reflect ANS activity, it has been employed here in risk of asthma stratification.

Introduction

Asthma is a chronic disease that inflames and narrow the airways producing a difficulty for breathing. It usually starts during childhood and its incidence and prevalence have augmented in recent years [1]. Despite this, there is still not a method for its early diagnosis, and classical spirometry studies could result invasive for young children. Although most of the symptoms of asthma can be controlled using appropiate medication, it is important to diagnose and start to control it as soon as possible in order to prevent patients from permanent airway obstruction.

Several studies have pointed to autonomic dysfunction as playing an important role in the pathogenesis of asthma, given the fact that parasympathetic nervous system (PNS) does exert a control over bronchoconstriction [2] and broncomotor mechanisms [3]. As PNS activity is reflected in the high frequency (HF) component of heart rate variability (HRV) spectrum, HRV analysis has been used in the assessment of increased vagal tone in asthmatics [4].

On the other hand, asthma has been described as a state of increased regularity attending to reduced complexity of the airflow pattern in asthmatics [5].

As respiratory modulation of HRV is also driven by PNS a novel index combining information from HRV spectrum and respiration is studied here together with other classical time and frequency domain HRV indexes.

Materials and Methods

Study population

The data base employed here is formed by 27 preschool children from who electrocardiogram (ECG) and impedance pneumography (IP) signals were acquiered. Children were classified in high- or low-risk (HiR and LoR respectively) of developing asthma attending to their modified asthma predictive index (mAPI) [6]. Data acquisition was approved by an institutional pediatric ethics review board and informed written parental consent was received.

HRV analysis

Both ECG and IP signals were first conveniently preprocessed. Afterwards, RR interval series were derived from these preprocessed ECG signals, and they were further used for obtaining the HRV spectrum. Classical time domain indexes were derived from the RR interval series: NN, SDNN, SDSD, RMSSD and pNN50, while classical

frequency domain indexes were obtained from the HRV spectrum: low frequency (LF) power, HF power, LF to HF power ratio and normalized LF power [7].

Afterwards, a novel index that combines information from HRV and IP is proposed. It is based in the analysis of the HF band of HRV spectrum, including respiratory information. The aim of this index is to characterize the differences that may exist between the different groups in a non-invasive way. Moreover, the possibility of employing only the ECG signal or either the IP signal is considered.

Results

Statistical significant differences were found between HiR and LoR. The results suggest a distinct behaviour of the PNS attending to the risk of developing asthma, being consistent with previous studies that considered HRV analysis [4] or airflow measurements analysis [5,7]. Although previous classification of the degree of asthma had been performed in young children [4], to the authors knowledge no studies with pre-school children had been performed before.

The possibility of employing either the ECG or the IP signal for distinguishing between groups suggest that non-invasive ways of diagnosing asthma in its earliest stages should be further studied, so that invasive procedures such as spirometries (that are not invasive for adults, but might be for young children) or bronchial biopsy can be avoided.

Conclusions

HRV analysis has been employed in the characterization of ANS activity of pre-school children that had been classified in function of their asthma risk. Differences between groups support the use of HRV as a helpful complement for the study of the mechanisms underlying asthma. The non-invasive characteristic of HRV analysis makes it especially suitable for children, as classical spirometries could result intrusive for them.

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