Smart Algorithms for Cardiovascular Disease: Screening of Sleep Apneas through ECG-Derived Respiration Signals

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***Abstract*— We present a novel exemplary application of smart algorithms to address specific pathologies related to cardiovascular health. Here, ECG-derived respiration (EDR) signals are obtained from 24-hours Holter recordings and are automatically analyzed in order to detect sleep apneas. Different algorithms for EDR estimation were implemented and the obtained results were compared with the standard clinical diagnosis based on polysomnigraphy. A group of 13 patients, who underwent sleep recording for apnea diagnosis, were included in the present study. The numbers of detected apneas and the estimated apnea hypopnea index (AHI) correlated well with the standard diagnosis, confirming that the proposed methodology could provide a tool for apnea screening to be applied on all the patients undergoing Holter recording.**

I. Introduction

Sleep disordered breathing (SDB) represents an important risk factor for cardiovascular health. The clinical context is of increasing severity, ranging from simple snoring (e.g. upper airway resistance syndrome, UARS) to more serious obstructive sleep apnea syndrome (OSAS). The failure in recognizing this condition is critical, considering that the major cases of OSA produce arterial hypertension and cardiovascular diseases [1]. For all these reasons, sleep apnea syndrome is a serious social and medical problem, and diagnostic strategies are necessary to reduce their prevalence and limit their consequences. The gold standard procedure to analyze sleep and diagnosis sleep disorders is a sleep study performed in a sleep laboratory.

These considerations call for new, more accessible and easy to implement diagnostic techniques, without the need of a specialized laboratory, and optimized for a fast and simple screening and diagnostic phase.

Although sleep apnea is a breathing event, its effects can clearly be seen on other peripheral systems such as the cardiovascular system [2]. In this direction there is a close relationship between the electrocardiographic signal (ECG) and the respiratory signal. Therefore, evaluating the respiratory signal from the ECG, and in particular through a portable minimally invasive device as a Holter recorder, can be a viable alternative.

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The main goal is to detect the presence of OSA through the analysis of the Holter ECG signal in two steps: 1) apply and compare different algorithms for the estimation of the derived respiratory signals (EDR); 2) automatically recognize OSAs on EDR through proper algorithms [3].

II. Methods

Polysomnography and a 24h ECG Holter exam were recorded for one night from 13 patients with SDB of obstructive/central nature (age between 34 and 60 years, 49 ± 8 years, weight between 102 and 198 Kg, 148.1 ± 31.4 Kg).

Three categories of algorithm are applied to the recordings.

a) Algorithms based on the study of the variability in the morphology and alignment of the vectorcardiographic loop (VCG) and in the direction and measure of the mean cardiac electrical axis.

b) Algorithms related to the modulations in the amplitude of the R peaks, R-S amplitude and baseline wander of the ECG trace. A specific method, which has proved very effective relative to its simplicity of implementation, estimates respiration traces from the area under the QRS complex of the ECG.

c) Algorithms related to heart rate variability (HRV) as computed from the inter-beat (RR) intervals.

III. Results and Conclusions

Results obtained through the automatic analysis of the EDR were compared with the standard clinical OSA diagnosis obtained through polysomnography. The numbers of detected apneas and the estimated apnea hypopnea index (AHI) correlated well with the standard diagnosis. The best procedure was the one based on the evaluation of the area under the QRS complex which provided a correlation coefficient $r = 0.81$. The encouraging results suggest the use of this technique for effective screening of subjects with symptoms and signs peculiar of the pathology.

References

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