

Relationship between Heart Rate Excursion and Apnea Duration in patients with Obstructive Sleep Apnea

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1. Motivation

Obstructive Sleep Apnea (OSA) is a sleep disorder with a high prevalence in the general population, and a risk factor for many cardiovascular diseases. During repetitive sleep apnea episodes, heart rate exhibits cyclical decreases and increases. These changes are low frequency variations superimposed to the higher frequency oscillations caused by the normal respiratory activity, also known as Respiratory Sinus Arrhythmia (RSA). We hypothesized that the relative excursion in heart rate (ΔHR), defined as the percentage difference between the maximum and the minimum heart rate values associated to an obstructive apnea event, is related to the apnea duration (AD).

2. Material and Methods

We used PSG signals recorded in subjects suspected from OSA at the Pneumology Service at Hospital Universitari Germans Trias i Pujol (Badalona, Spain). We studied the relationship between apnea-related ΔHR and AD in a population of eight patients with severe OSA, that met the criteria $AHI \geq 30h^{-1}$ and $AHI \geq 10h^{-1}$. For each subject, we extracted the single lead ECG from their PSG recording. The time series of the cardiac inter-beat interval ($RR(t_k)$) was extracted automatically using a custom algorithm. The heart rate time series was obtained as $HR(t_k) = 1 / RR(t_k)$. A heart rate signal ($HR(nT)$) was obtained by 4Hz resampling of the interpolated original time series. Finally, this heart rate signal was filtered with a 6th order Butterworth low-pass filter with cut-off frequency 0.1Hz to remove the RSA component. The apnea-related heart rate excursion ΔHR was computed as the percentage difference between the maximum heart rate following an apnea (HR^M), and the minimum heart rate during the same apnea (HR^m).

3. Results and Discussion

Heart rate excursion and apnea duration exhibit a moderate but statistically significant correlation in most patients. In general, patients with a low (high) average apnea duration also have a low (high) average heart rate excursion.

We observed that patients with similar Apnea-Hypopnea Index (AHI) may exhibit remarkably different distributions of ΔHR and AD, and that patients with a high AHI need not have a higher average ΔHR than others with a lower severity index (Figure 1).

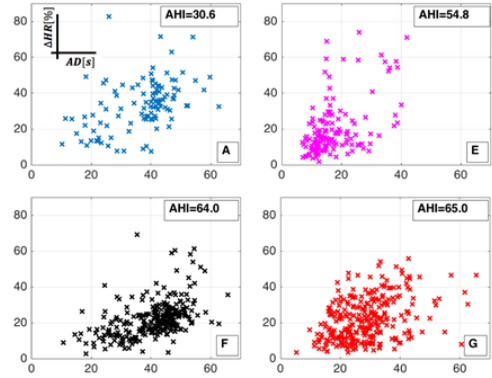


Figure 1. Scatterplots of heart rate excursion versus apnea duration from patients A, E, F and G.

For each patient, apneas were divided into three groups according to their duration: GAD1, $AD \in [10, 20)s$; GDA2, $AD \in [20, 30)s$; and GAD3, $AD \geq 30s$. Despite the observed intra-individual variability in heart rate excursion for a given apnea duration, the average heart rate excursion for apneas with the longest duration $AD \geq 30s$ was significantly greater than for apneas with short or intermediate durations, with $p < 0.005$ (Figure 2).

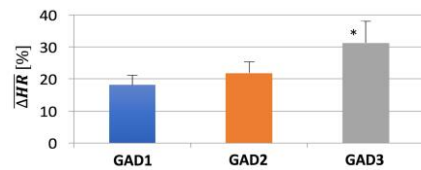


Figure 2. Average heart rate excursion in each apnea duration group; * = statistically significant differences between group GAD3 and groups GDA1 and GDA2.

4. Conclusions

The apnea-induced heart rate excursion may be partially explained by the duration of apnoeic episodes, and it is a cardiovascular stress measure not directly reflected in the AHI.

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