Changes of Heart Rate High Frequency Components During the REM Sleep Stage Over Night

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Introduction. Changes in cardiovascular functions during sleep reflect changes in autonomic nervous system dominance. Sympathetic nerve activity (SNA), blood pressure and heart rate (HR) are lower in a Non-REM sleep than in wakefulness. During the rapid eye movement (REM) sleep, sympathetic nerve activity increases, reaching values greater than those measured in wakefulness [1]. These data suggest that during REM sleep, SNA of cardiovascular function increases.

Spectrum analysis of heart rate variability (HRV) is a non-invasive procedure that provides quantitative information on sympathetic and parasympathetic (PNS) systems control. During increase in PNS, respiration effect on the HR oscillations is increased. However, it is important to note that the main driver of HRV in high frequency (HF) band is respiration, which produces the vagally mediated respiratory sinus arrhythmia. The magnitude of HF power is highly dependent on the depth of respiration, which often varies from one recording epoch to another [2] and may fluctuate during the REM stage.

It is not entirely clear whether the HF of HRV is the same during the REM stage, or it changes.

The aim of this work is to investigate the dynamics of heart rate HF components during the REM sleep stage.

Methods and results. Recordings were made from 8 healthy subjects, men aged 44 ± 6 years. Polysomnograms have been recorded on „Somnologica Embla N7000" system (Klaipeda University Hospital in a Sleep Medicine Centre (KUL SMC)) in a sleeping room. In this study, the main methodical requirement is strict synchronization of all processes. ECG was recorded with 2000 Hz sampling frequency. Using specially designed algorithms, maintaining a strict real-time structure, RR intervals were identified [3]. Discretisation of RR intervals and sleep stages was carried out with a period of 0.5 s. In order to achieve the main aim there was used the RR interval filtering, separately distinguishing the high-frequency components within range from 0.15 Hz to 0.4 Hz. For HF excretion, there was used band pass IIR filter designed using Butterworth approximation. After filtering frequencies lower than 0.15 Hz and higher than 0.40 Hz were attenuated [4].

The Butterworth filters effectiveness depends on value of stop-band attenuation. We found that changing stop-band attenuation value from 60 dB to

10 dB number the order of this filter decreases from 74 to 26. In our case we used 60 dB attenuation in stop-band and the order of the filter was 62.

In order to avoid the time shift or resynchronization with sleep-stages the filter was used twice, forward and backward. The fragment of one of RR intervals of 5 minutes before and after filtering is shown in Fig. 1. Choosing the observation window size depends on particular task of investigation. One minute duration for observation window was chosen for further analysis.

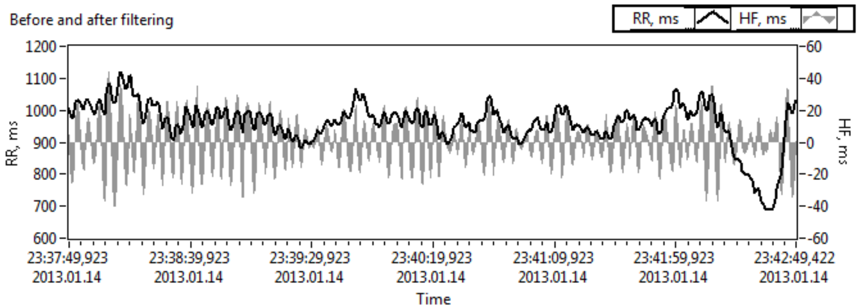

Fig. 1. Fragment of RR interval before (RR, ms) and after filtering (HF, ms)

HF combined aggregate amplitude was calculated using the standard deviation (SD) values over selected time interval. The calculations were performed with programs developed on NI LabVIEW 2012 basis.

Analysis of HF dynamic data of all subjects revealed that HF trends are diverse: one increased and the other decreased. Obtained data were divided into three stages of the night - the first half of the night (I stag.), middle of the night (II stag.), before the morning (III stag.). From the data obtained for every minute averages and standard deviation values were calculated (Fig. 2).

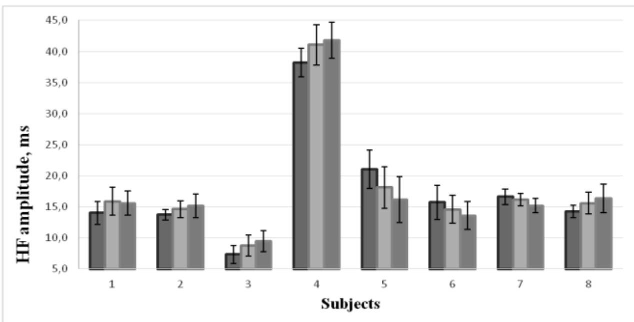

Fig. 2. Dependence of HF amplitude, on the stage of the night. The first column shows mean and SD of the first stage of the night, second column - stage II, and the third column – stage III.

ANOVA calculation for each subject indicated that amplitude of HF during REM decreased in subject 4 ($p < 0.02$) and subject 8 ($p < 0.05$), increased in subject 5 ($p < 0.05$). Out of the eight only the differences between the three subjects were significantly important. We can assume that sympathetic and parasympathetic neural balance fluctuates differently during the REM period and this study method may become the first step for future research in sleep disorders.

Conclusions. The results of investigation indicated that HF trends are diverse: some increased and the others decreased. In our case, the HF values were scattered. The usage of filter allowed us to observe HRV and its changes within desirable observation window.

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Sympathetic nerve activity (SNA), blood pressure and heart rate (HR) are lower in a Non-REM sleep than in wakefulness. Spectrum analysis of heart rate variability (HRV) is a non-invasive procedure that provides quantitative information on sympathetic and parasympathetic (PNS) systems control. The aim of this work - to investigate the dynamics of high frequency (HF) of heart rate during the REM sleep stage. The results of investigation indicated that HF trends are diverse: some increased and the others decreased.