Reduced high-frequency HRV during mental stress can be explained by vagal withdrawal

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Background

Previous studies showed stress reductions of high frequency, vagally-transmitted, heart rate variability (hf-HRV)[1]. However, the underlying mechanism of these effects remains unclear. The changes in hf-HRV could be explained by vagal withdrawal of cardiac control. Still, increased respiratory frequency, a common effect of stress, could also contribute to the decrease in hf-HRV. Furthermore, studies are missing to describe the magnitude of vagal withdrawal during mental stress.

In this study, Hf-HRV was measured in two groups of healthy and diabetic subjects during a paced breathing condition as well as in rest- and stress conditions, in which breathing was spontanous.

Unveiling these causal relations between stress, hf-HRV, vagal withdrawal and respiratory frequency was the central aim of the study.

Methods

Subjects:

N=19 (9 healthy and drug-free, 10 patients with Diabetes Mellitus [DM]), Age: 21-55 years

Procedure:

❖ every subject underwent 9 tests (randomized order, each over 5 minutes):

- **7 x "paced breathing"** (defined respiration frequencies of 0.15, 0.2, 0.25, ... - 0.45 Hz by auditory tape instructions)
- **2 x spontaneous breathing** (resting period and stressful adaptive choice-reaction-time task)

❖ cardiovascular and respiratory data were assessed during all tests

respiratory data:

❖ respiration signal was assessed by a respitrace-like proprietary system (non-callibrated)

❖ respiration frequency was defined as the dominant frequency revealed by spectral analysis (Fast-Fourier-Transformation, FFT)

cardiovascular data:

❖ heart rate signal was assessed by ECG (single lead II configuration) and Finapres (data not illustrated here)

❖ hf-HRV was calculated with WinCPRS software (WinCPRS 1.6, Absolute Aliens, Oy, Turku, Fi) in the frequency range of 0.15 to 0.45 Hz by FFT

All data were collected over 5 min and digitized by 12 bit resolution at 1 kHz. Artefacts were identified and corrected manually.

adaptive choice-reaction-time task (CRTT):

❖ During the stress period subjects had to perform an adaptive CRTT implemented by a Serial Response Box (Fig.1). They had to respond to colored lights which appeared in random sequence by pressing corresponding buttons as accurately and quickly as possible. Using a PC-based control algorithm the inter-stimulus-intervals were shortened or lengthened, thereby modifying task difficulty so that subjects' false-response rate within a continuously moving window, approached 50%.

Thus, the CRRT included a challenging and stressful component leading to increases in heart rate and blood pressure [2].

Fig.1: Serial Response Box (Psychology Soft-ware Tools, Inc.) includes an array of 5 colored LEDs and 5 buttons with corresponding colors and was placed on a table in front of the subject.

Results

❖ Respiratory frequency (RF) increased during stress compared to rest: in healthy subjects from 0.27 to 0.43 Hz [p< .001], in diabetic subjects from 0.29 to 0.41 Hz [p< .001],

❖ Hf-HRV was significantly decreased during stress (81.5 ms²/Hz) as compared to rest (676.5 ms²/Hz) [p= .01]. No such effect was found for diabetic subjects (72.3 vs. 107.7 ms²/Hz) .

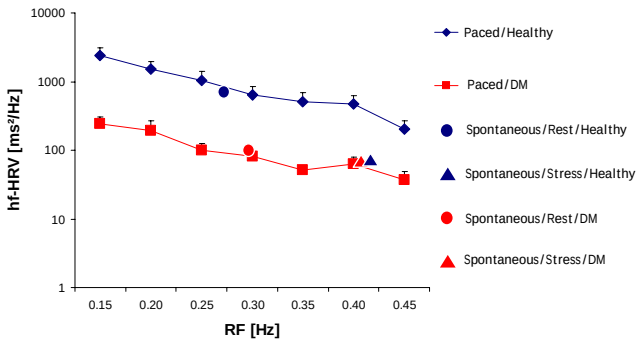

Fig.2: Hf-HRV changes according to the different respiration conditions: In healthy subjects, hf-HRV during the stress condition (CRTT) was significantly reduced, compared to rest period and differs from hf-HRV value that would be predicted from respiration frequencies (RF); this was not the case for diabetic subjects. Hf-HRV for diabetic subjects was significantly lower compared to healthy subjects in all but the stress condition.

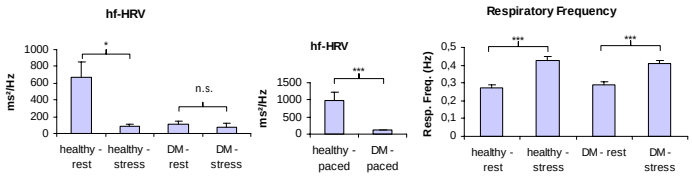

Fig.3: Differences between both groups in hf-HRV and respiratory frequency.

Discussion

➔Reduced hf-HRV can be explained by vagal withdrawal, not by respiratory frequency changes.

➔The fact that hf-HRV in DM patients is unaffected by stress may be attributed to missing vagal neural transmission due to autonomic neuropathy

➔During mental stress, hf-HRV of healthy subjects is reduced to the level of DM-patients suffering from autonomic neurodegeneration. This suggests a complete vagal withdrawal during stress.

References

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