The "ANS-Explorer": A newly developed instrument for measuring autonomic regulation ability by analyzing heart rate variability

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The autonomic nervous system (ANS) with its branches sympathicus and parasympathicus provides the organism with a regulatory system which is able to flexibly adapt to the demands of the body's organs. While the sympathetic system usually activates bodily processes to prepare them for appropriate dealing with stress situations the parasympathetic system usually has the antagonistic function in order to relax and restore bodily processes and to regain functional balance of the organs and to maintain homeostasis. In general, it is of great importance that these both branches act flexibly to increase and decrease nervous activity. Disturbances of the ANS such as high levels of sympathetic activity of low levels of parasympathetic activity are directly involved in a multiplicity of somatic and psychosomatic illnesses especially if the cardiac and circulatory system is affected. While sympathetic innervation for example accelerates the beat frequency, parasympathetic innervation slows it down.

Concerning cardiac functions the procedure which is most suitable at present to meet the requirements of measuring sympathetic and parasympathetic activity is the analysis of heart rate variability (HRV). The most important parameters of the HRV are derived from time analysis methods at the one hand and from frequency or spectral analytic procedures (power spectrum analysis) at the other hand. Among time related parameters "SDRR" (standard deviation of all RR times during the measured period) and "RMSSD" (differences between the RR intervals of successive heart beats) are mostly considered. Concerning frequency related parameters "high frequency power" ($HFms^2$; including faster fluctuations in heart rate frequency between 0.15 – 0.40 Hz), "low frequency power" ($LFms^2$; including slower fluctuations between 0.04 – 0.15 Hz), "total power" ($TPms^2$; addition of the power of different frequency bands), "$LFms^2/HFms^2$ ratio" (measures the relative degree of the sympathetic versus parasympathetic activation; sympathovagal balance) are of most importance. Especially $HFms^2$ is considered as a measure of sympathetic activity while $LFms^2$ is considered as a measure of parasympathetic activity.

At the Center for Neuropsychological Research (University of Trier) a special device was developed which fulfils all requirements for measuring HRV. The "ANS-Explorer" consists of three networked modules: ANS-Tracer, ANS-Explorer und ANS-Trend.

The ANS-Tracer module is a patient administration system which receives electrocardiographic data from a medical 3-channel ECG amplifier via a secured bluetooth radio connection and provides these data for further processing in chronological order using all the necessary patient information. The ANS-Explorer as a central module prepares the imported RR intervals and calculates the different time and frequency related parameters of HRV. In order to calculate these parameters and to arrive at a valid conclusion it is necessary to make various mathematical calculations of the measured output data prior to being fed for instance for spectral analysis. The data pre-calculated in this way can be displayed in various ways, for instance some forms of representation are more suitable for practical diagnostic purposes, others for research purposes. Finally all the individual data can also be shown numerically and graphically as deviations from a population norm in order to clarify the individual's position in a reference group. This method of representation makes it easy to assess the measured values of an individual with respect to age, gender, patient or training group and his ranked position in his comparison group.

Up till now some studies demonstrated the possibility to predict the risk of disease in healthy people on the bases of HRV data such as the mortality risk after myocardial infarction, the occurrence of malignant arrhythmias, sudden cardiac death, and diabetes and autonomic neuropathy. Studies of our research group dealt with, for example, influences of personality traits in normal healthy subjects and in psychosomatic patients on HRV variations. Healthy subjects who are characterized by a flexible HRV show a much more positive prevailing mood, are more socially oriented, less withdrawn, more empathic, and tend to express both positive and negative feelings. In a study on 50 chronic psychosomatic patients compared to healthy subjects it could be shown that psychosomatic patients in general show an impairment in the regulation of ANS activity. Correlated with this impairment are an increased stress reactivity, an increased number of physical complaints, and a generally raised level of psychiatric symptoms. Furthermore, it is important to note that a reduced ability to regulate ANS activity goes along with a higher level of psychological and physiological complaints.

In times of growing stress und stress-related strain we have furthermore developed an additional and innovative version of the ANS-Explorer based on a mobile phone which allows at any time to get information about the personal body's stress level. This knowledge enables an individual to change stress-related behavior to reduce the danger to suffer from stress-induced diseases, for example sudden cardiac death . This system determines fast and reliably the individual's autonomic level. The device consists of a common mobile phone with an integrated or blueblooth-connected ECG which measures heart activity by finger electrodes. Analysis of HRV and the presentation of the individual autonomic regulation state is presented immediately after recording. It is possible for the user to have a look at changes of his stress-related autonomic processes any time and directly at the mobile phone or via an internetportal.

Taken together, HRV measurement seems to be an innovative and appropriate tool for diagnosis and prognosis of health and disease. Concerning these questions the "ANS-Explorer" is a tool which fulfils all necessary methodological and statistical requirements to answer these questions.

References

1. W. Wittling, E. Schweiger & R. A. Wittling (2008). Diagnostik der Herzratenvariabilität: Einblicke in die autonom-nervöse Regulation von Stressverarbeitung, Befindlichkeit, Verhalten und Gesundheit. Research Report, Center for Neuropsychological Research, University of Trier, Germany.