Feasibility Study of the Heart Rate and Cuff-Less Blood Circulation Holter Device

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**Project goal**
Project goal is to evaluate the preconditions for developing a portable heart rate and blood circulation Holter device, recording patient’s 24-hour ECG simultaneously with pulse wave signal from peripheral arteries and evaluation of myocardial electrical instability i.e. predisposition to potentially life-threatening ventricular arrhythmias assessing markers of ventricular repolarization (VR) prolongation and inhomogeneity during routine 24-hour ECG recording.

**Introduction**
Major cardiovascular changes include in-flight reductions in heart rate and arterial blood pressure (BP) as well as changes in autonomic control of arterial BP. Evidence-based research is required to resolve cardiovascular risks that could most likely compromise long-duration space missions. To date, there has been no compelling clinical evidence to estimate the likelihood of occurrence of autonomic or vascular dysfunction, cardiac arrhythmias or manifestation of asymptomatic cardiovascular diseases. In addition, research concerning the evaluation of novel diagnostic tools has important implications for people on Earth – any research directed at obtaining a better understanding of how the cardiovascular system works can help us with many types of cardiovascular problems in everyday life.

**Actions**
The systolic blood pressure calculation method is based on a quasi-linear relationship between routinely estimated blood pressure values and pulse arrival time (PAT) detected between the ECG R-peak and the forehead photoplethysmographic (PPG) pulse wave rising front.

In the current feasibility research we made a stress test study and 24-hour ECG, PPG and blood pressure monitoring study. Data from 65 patients with different cardiovascular problems were analysed. The study group comprised systolic BP values and pulse arrival time (PAT) detected between the ECG R-peak and the forehead photoplethysmographic pulse wave rising front.

**Results**
The good and stable relationship between pulse arrival time and systolic blood pressure was found and well reproduced in different patient categories. It is shown that the proposed method facilitates beat-to-beat blood pressure estimation and the detection of 24-hour ECG parameters, including a promising myocardial-electrical-instability indicator - QT interval variability. The method is applicable during both short-term recordings in stress tests as well as 24-hour measurements in everyday clinical practice. The conducted study proved the feasibility of non-invasive 24-hour blood pressure recording on a beat-to-beat basis. A properly calibrated prototype device demonstrated good, stable correlation between the estimated systolic BP values and the oscillometric and manual auscultatory measurements throughout the whole recording period.

The information obtained includes clinically valuable data as the measurements are conducted on a beat-to-beat basis with almost no loss in BP information. It is very important that the rapid and short term BP increase episodes that often occur between oscillometric measurements would remain undetected with the routine ambulatory non-invasive blood pressure study. It is proven that the recording could be performed during daily activities without substantially disturbing the patient.

The device prototype and developed algorithms open up many new opportunities – superimposition of data analysis of main cardiovascular properties (RR, QT interval and pulse wave arrival time variability) during 24-hour period discriminate diagnostically and prognostically different patients with high sensitivity and specificity.

**Further steps**
In the near future a number of improvements have to be carried out on the device development, such as: PPG sensor enhancements for long term monitoring; prototype miniaturisation up to clinically rational dimensions; development of a calibration device; and, finally, development of the integrated software tool that combines the processing of 24-hour ECG with additional QT and PAT interval analysis. The application interface of the software requires a design that is convenient for users.

**Project team**

Avo Tölg is CEO of Tensiotrace OÜ. He is an entrepreneur and angel investor. He is also acting CEO and Accountable Manager of Airest Inc., the Estonian cargo aviation company.

Kalju Meigas (PhD, Dipl. Eng) is a professor of Biomedical Engineering, Head of Chair and Director of Technosound of Tallinn University of Technology.

Jüri Kaik (MD, PhD) is a professor of electrophysiology of Technosound of Tallinn University of Technology.

Jaanus Lass (PhD, Dipl. Eng) is a senior researcher.

Mar-Rein Rosmann (PhD) is a development engineer.

Kristjan Pilt (MSc, Eng) is a researcher and PhD student.

Deniss Karali is a technician and software developer. He has more than 10 years of experience in physiological signal registration as well as analysis and device prototyping.

**Actions completed**

**Contact**
Indrek Raig MSc; indrek@tensiotrace.ee / info@tensiotrace.ee