11–12 October 2012, Riga

Riga Technical University 53rd International Scientific Conference

Dedicated to the 150th Anniversary and
The 1st Congress of World Engineers and
Riga Polytechnical Institute / RTU Alumni

DIGEST

ISBN 978-9934-10-360-5

RIGA TECHNICAL UNIVERSITY
53rd INTERNATIONAL SCIENTIFIC CONFERENCE

DEDICATED TO THE 150th ANNIVERSARY AND

THE 1st CONGRESS OF WORLD ENGINEERS AND RIGA POLYTECHNICAL INSTITUTE / RTU ALUMNI

11-12 October 2012
Rīga, Latvija

Rīga-2012

Cardiosynchronous Transcutaneous Electrical Nerve Stimulation

Zane Bredriha (*Riga Technical University, Latvia*), Juris Lauznis *(Riga Technical University, Latvia*) and Paulis Butlers (*Riga Stradins University*)

Keywords **– electrical nerve stimulation, blood pressure, heart rite**

I. Introduction

Cardiosynchronous transcutaneous electrical nerve stimulation device is a new technology. In our studies to test the concept of new electrostimulator, we used electrical nerve stimulation 200ms after R-wave with 125ms long bipolar pulse package to decrease Rate - Pressure product, as previously it was proved in preliminary experiments. The aim of the present study is technical elaboration of the innovative ECG R-wave triggered transcutaneous nerve stimulation prototype device to further perform the feasibility studies of such a neurostimulation technology.

Recent studies [1] have demonstrated that augmentation of the sympathetic activity can be reduced if the intermittent sensory stimulation impulse is applied during each cardiac cycle with the time delay 200-400ms after ECG R-wave. Moreover previous pilot study showed that applying of such a cardio synchronous stimulation mode to the afferent nerve endings in human canal result in significant lowering of arterial systolic blood pressure if the initial arterial pressure values were elevated.

Up to now there is no such noninvasive neurostimulation device with being able to decrease high sympathetic neural system activity and myocardial oxygen consumption. There is a TENS device developed by CardioLa [2]. The device stimulates skeletal muscles and makes heart load easier by additional pumping of blood due to caused contractions. It is not possible to use it in long term because muscles get tired. Therefore a stimulator for long term use is needed.

II. Materials and Methods

According to aim the prototype of device for transcutaneous nerve stimulation was developed by INTEGRIS, Ltd and RTU, Latvia and tested in pilot experiments in RSU, Latvia.

Equipment used in pilot experiment is: ECG monitor with R-wave pulse output – Cardiac Trigger Monitor, Model 3100, IVY, USA, Fig.1(1);; Digital Storage Oscilloscope – TDS 2002B, Tektronix, USA, Fig.1(2); ECG Phantom 320, M&S, Germany (only for preparations work); Experimental Synchronous Programmable Electrostimulator (Experimental stimulator) developed by INTEGRIS, Ltd and RTU, Latvia.

Stimulation was done for the person who had initial average systolic blood pressure 153 and heart rate 84 to test and prove concept.

Pilot experiments block schematic is shown in figure 1.

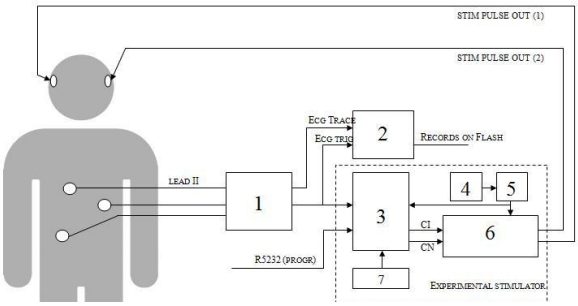

Fig. 1. Pilot Experiment block schematic

Pilot experiments were made for 2 simulation patterns after the R-wave:

In first experiment simulation provided 25 pulses (0.5ms positive pulse, 0.5ms negative pulse, 4ms pause) 200ms delay after R-wave, pulse current 6mA ±5%.

In second experiment stimulation provided 25 pulses (0.5ms positive impulse, 0.5ms negative impulse, 4ms pause) no delay, directly after R-wave, pulse current 9mA ±5%.

The ECG signal was obtained from chest electrodes (lead II) and simulation signal was applied to vagus nerve by special ear electrodes (Fig.1) that were made only for this experiment.

Systolic blood pressure, diastolic blood pressure and pulse rate was measured once per minute for 25 minutes during the stimulation. From measured data we calculated (1) Rate-Pressure Product RPP (as beats per minute (bpm) multiplied (*) by systolic blood pressure in mmHg), what characterizes heart workload and myocardial oxygen consumption.

$$RPP = SBP \times PR / 100 \qquad (1)$$

III. Results

Pilot experiments showed that innovative ECG R-wave triggered transcutaneous nerve stimulation prototype device was working properly and was user friendly. Device is programmable to obtain different pulse length, delay time (7 different patterns) and pulse amplitude.

Prototype device was used in two pilot experiments for vagus nerve stimulation with 200 ms delay after R-wave and right after R-wave. Stimulation with 200ms time delay causes approximately 12% RPP decrease in last 10 minutes. Moreover second experiment where stimulation was right after R-wave, RPP did not show changes.

IV. Conclusion

1) According to our aim new transcutaneous nerve stimulation prototype device was designed and built having possibility to synchronize it with ECG monitor. Experiments proved possibility to change delay after R-wave, pulse package length and pulse amplitude. Device is programmable so we could change all the pulse parameters and the number of pulses in package.

2) Primary hypothesis was partially accepted during pilot experiment, RPP dynamic depends on stimulation mode. The most rapid decline was when the intermittent burst stimulation was 200 ms after R-wave.

3) Experiments should be continued with different pulse parameters and delay time (patterns) to obtain optimal results.

V. References

[1] J Neurosci. 2009 Feb 11;29(6):1817-25. Following one's heart: cardiac rhythms gate central initiation of sympathetic reflexes. http://www.ncbi.nlm.nih.gov/pubmed/19211888

[2] http://www.cardiola.com/