CHANGES IN CEREBRAL OXYGENATION DURING VASOVAGAL SYNCOPE INDUCED BY TILT – TABLE TEST

E. Szufladowicz[1], R. Maniewski[2], A. Nosek[2], R. Bodalski[1], E. Kozluk[3], A. Zbiec[2], F. Walczak[1]

[1]National Institute of Cardiology, Alpejska 42, 04-628 Warsaw, Poland
[2]Institute of Biocybernetics and Biomedical Engineering PAS
Trojdena 4, 02-109 Warsaw, Poland
[3]Warsaw Medical University, Banacha 1a, 02-297 Warsaw, Poland

Abstract: Near – infrared spectroscopy (NIRS) offers a non-invasive, real time monitoring of cerebral oxygenation. This method was used in a series of patients to evaluate brain function during induced vasovagal syncope (VVS). Study with NIRS monitoring was performed in group of 69 patients with history indicative of vasovagal syncope. Tilt table test was performed according to Westminster protocol. Tilt test was positive in 42 patients. There were 16 cardioinhibitory, 13 vasodepresive and 13 mixed type of vasovagal syncope. Results of the examination have shown that changes in cerebral oxygenation measured with NIRS technique are clearly expressed during the time period preceding the syncope, during syncope and recovery. The oxyhaemoglobin changes recorded by NIRS significantly precede the appearance of patient's presyncopal symptoms ($p<0,005$) as well as changes in the blood pressure, heart rate ($p<0,0001$) and arterial blood saturation ($p<0,00001$).
The study proved that NIRS technique is useful and sensitive method of the cerebral monitoring during tilt–table test. Specially, NIRS allows evaluation of time relations changes between cerebral oxygenation and cardiovascular parameters, presyncope and syncope symptoms. This is valuable technique in studies of pathophysiology of vasovagal reaction.

INTRODUCTION

Syncope is defined as a sudden loss of consciousness with the loss of the postural tone followed by a spontaneous recovery. VVS is the most common type of syncope and one of the most difficult to manage. Confirmation of the diagnosis is based on positive tilt-table test. This test consists of two phases: supine pre-tilt phase and passive phase with the angle of the tilt 60 or 65 degrees. Each phase lasts 20 minutes. The test is positive if syncope occurs. If the passive phase is negative the subject is given sublingual nitroglycerine or alternatively intravenous isoproterenol infusion and test is continued for an additional 20 min. The technique of tilt-table test and classification of positive responders are well described in guidelines of task force committee.[1]
The direct cause of syncope is cerebral hypoxia. The exact pathophysiology of the vasovagal reaction is still unclear. The possible examination techniques of brain function during syncope include: electroencephalography, jugular venous oximetry, positron emission tomography, transcranial Doppler (TCD) and near-infrared spectroscopy. Only TCD and NIRS have practical value in VVS. TCD indirectly assesses the cerebral tissue perfusion changes through the measurement of blood flow velocity changes in the large cerebral arteries but this technique has several limitations.[2] NIRS technique offers practical, relatively easy and non-invasive method of evaluation of cerebral oxygenation. NIRS is based on the oxygenation dependent absorption of the near–infrared light in the specific tissue compounds, called chromophores.[3] The main brain tissue chromophores are oxyhaemoglobin and deoxyhaemoglobin. The light in near-infrared wavelength penetrate deep in brain tissue and changes in absorption are directly proportionate to fractions of oxygenated and deoxygenated haemoglobin.[4,5]
The purpose of this study was the application of NIRS monitoring of brain oxygenation during vasovagal syncope. We specially evaluated time

relations between observed changes in brain oxygenation and symptoms observed during induced VVS.

METHOD

This study received approval from the Research Ethics Committee and all patients signed an informed consent form. Study was performed at the National Institute of Cardiology in Warsaw and involved 69 patients (45 females and 24 males; mean age 35± 17 years) with a history of syncope. The tilt-table test was performed according to the European guidelines[1] and protocol with the angle of the tilt 60 degree. During the tilt-table test 12-lead ECG, Holter ECG and heart rate (HR) were monitored. Blood pressure (BP) was measured every 15 seconds and continuous arterial blood saturation (SpO_2) was recorded using the pulse oximeter with the sensor fixed to patient's ear [6,7]. Changes in oxygenated and deoxygenated haemoglobin concentration were monitored with NIRO 500 instrument (Hamamatsu Photonics, Japan). The NIRO 500 spectroscope operated with wavelengths: 775, 825, 850, 905 nm. The following parameters were continuously monitored: oxyhaemoglobin (HbO_2), deoxyaemoglobin (Hb) and cytochrome oxidase ($CytO_2$)[7]. Total tissue haemoglobin concentration changes were expressed as $\Delta Hb_{tot}=\Delta HbO_2 + \Delta Hb$.

RESULTS

Tilt test was positive in 42 patients. There were 16 cardioinhibitory (CD), 13 vasodepresive (VD) and 13 mixed (MIX) type vasovagal syncopes. This study shown that changes in the cerebral oxygenation measured by the NIRS are clearly visible during the time period preceding the syncope, rapidly increasing during syncope and normalize at the recovery phase of syncope (after table return to its normal position). Figure 1 is the illustration of typical changes observed during VVS.

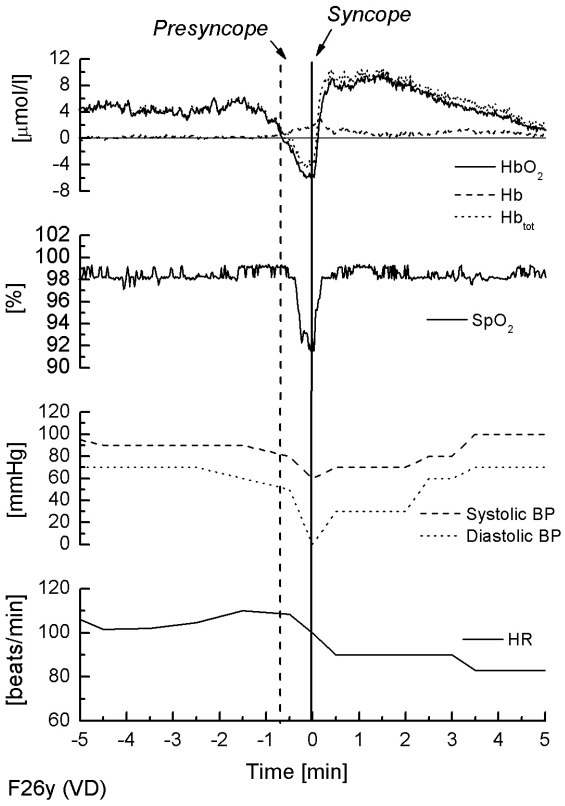

Figure 1. Parameters (HbO_2, Hb, Hb_{tot}, SpO2, BP, HR) measured during the head-up tilt table test of a 26 year old female patient with the syncope of the vasodepresive type.

Time courses presented in figure 1 show that oxygenated haemoglobin and total haemoglobin start to fall before the patient begins to experience the symptoms of presyncope (PS-presyncope symptoms are indicated by the vertical line). At the same time deoxygenated haemoglobin rises. The drop of blood saturation follows the changes in NIRS. The blood pressure and heart rate reactions clearly occur after the NIRS changes. A similar picture of gradual decrease of oxyhaemoglobin followed by a sudden drop was observed in all 42 patients with VVS. The shape of the haemoglobin change curves has been found to be independent of the syncope type.

The differences in time between the beginning of the observed changes in the heart rate, blood pressure, oxyhaemoglobin, deoxyaemoglobin, total haemoglobin, arterial blood saturation and patient subjective symptoms in respect to the

moment of syncope were calculated for each patient separately. This data are presented in table 1 as mean +/- SD for three types of syncope.

Table 1. The mean time ± SD (min) of the beginning of change in HR, BP, HbO_2, Hb, Hb_{tot}, SpO_2 and PS in respect to syncope time (t=0). The number of cases with positive tilt test results, for each type of syncope is indicated by *n*.

TYPE	SpO_2 [min]	HR [min]	BP [min]	PS [min]	HbO_2 [min]	Hb [min]	Hb_{tot} [min]
TOTAL (n=42)	**0.7±0.9**	**1.0±0.6**	**1.1±0.7**	**2.0±2.0**	**3.3±2.8**	**3.1±2.3**	**3.3±2.8**
CD (n=16)	0.7±0.9	1.0±0.5	1.0±0.6	1.6±1.9	3.3±3.0	3.1±2.3	3.3±3.0
VD (n=13)	0.8±1.1	0.8±0.3	1.0±0.8	1.9±2.0	2.7±1.6	2.5±1.8	2.7±1.6
MIX (n=13)	0.6±0.8	1.2±0.7	1.4±0.7	3.0±2.4	4.0±3.1	3.4±2.6	4.0±3.1

The oxyhaemoglobin changes recorded by NIRS significantly precede the apperance of the patient's presyncopal symptoms ($p<0,005$) as well as changes in the blood pressure, heart rate ($p<0,0001$) and arterial blood saturation ($p<0,00001$).

CONCLUSIONS

Our experience with NIRS during tilt-table test proved this technique to be reliable, sensitive, non-invasive method of the cerebral oxygenation monitoring in VVS [6,7]. The changes, predominantly in the oxygenated haemoglobin curve, were noted to start 3.3 +/- 2,8 min before the syncope, while changes in the heart rate and blood pressure 1.1 +/- 0.6 min before the syncope ($p<0.0001$). It is suggestive that the abnormal vasovagal reaction starts rather in the brain than in peripheral circulation.

References:

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