Analysis of Transient Heart Rate Response to the Active Orthostatic Maneuver

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Abstract

This study aimed to find the new indices quantitatively characterizing the dynamics of heart rate changes following standing up from the supine position and assess their relationship with age.

The intervals between heart beats (R-R) automatically obtained from continuous recording of ECG during the orthostatic maneuver were investigated in 41 healthy men aged 20-59 years, classified into three groups: (22-26 years, n = 14), (33-49 years, n = 13) and (51-59 years, n = 14).

The indices describing static differences between steady states and dynamic phase of the response to standing up were analyzed by checking their correlations with age.

In transient phase the strongest relationships with age was observed for index describing overshoot in R-R occurring within 30 seconds, above the value of R-R in 8th minute of standing (r= -0.614).

Most of the indices characterizing the amplitude of R-R changes following standing up showed a tendency towards attenuation with age.

1. Introduction

Orthostatic syndrome is a rapid and transient loss of consciousness accompanied by decrease in skeletal muscle tension. Despite the careful medical diagnosis still in 40% of patients the cause of orthostatic syndrome remains unrecognised [1, 2].

1.1. Importance of orthostatic test

Application of a orthostatic tests (head-up tilt test - HUTT- or just standing-up) allows selection of patients who have vasovagal syncope-impairment of the regulation processes in the cardiovascular system. There are some attempts to use methods which could continuously measure cardiac output and other hemodynamic parameters. However, the application of echocardiography has failed, because they disturbed patients decreasing the test's sensitivity and long term monitoring is not possible due to errors caused by changes in projection [3-5].

The etiology of vasovagal syncope is not fully recognized, which is caused by the lack widely distributed, reliable tools allowing continuous determination of parameters characterizing heart hemodynamics (stroke volume - SV, arterial blood pressure BP). Some authors have pointed out the importance of HUTT in clinical practice [1, 5].

1.2. Transient phase of heart rate analysis

The mechanism of HR and BP changes and their relationship during the transient phase of the response to postural tests has been described in numerous papers [6, 7]. However the physiological mechanism of HR, SV and BP regulation and the pathophysiological causes of the vasovagal syncope remain unclear [1].

1.3. The aim

The tilt-test is long-lasting procedure and requires the specialized equipment which limit the number of patients that may be examined during one day. Our idea is to find the a description of the early response to the orthostatic maneuver which could help in screening patients using these indices as the early predictors of the syncope. Such a test could be done in any general practitioner clinic.

This study aimed to find the new indices quantitatively characterizing the dynamics of heart rate changes following standing up from the supine position and assess their relationship with age.

2. Material and methods

The intervals between heart beats (R-R) were automatically obtained from continuous recording of ECG during the orthostatic maneuver.

2.1. Subjects

Forty-one healthy men (age: 20-59 years) without any cardiovascular, respiratory or metabolic disorders participated in this study. The 12-lead ECG recordings taken from each subject did not show any abnormalities. The experimental protocol was carefully explained before starting the investigations and the informed consent was obtained from each subject. The experimental protocol was approved by the local ethical committee and all persons gave their informed consent prior to their inclusion in the study. The participants did not reported low orthostatic tolerance symptoms.

The subjects were classified into three groups according to their age: (22-26 years, n = 14), (33-49 years, n = 13) and (51-59 years, n = 14).

2.2. Experimental protocol

The tests were carried out always at the same time of day under controlled conditions (23 to 26°C and 50-60% humidity). The measurements of ECG R-R intervals were performed in the supine position at least 20 min after laying down and then during 8 minutes of standing. The subjects changed their body position in 2 to 4 s on verbal command, without any help.

2.3. Data analysis

We decided to reanalyze data obtained in one of the previous studies [8]. The initial R-R response to orthostatic maneuver was described by the following indices, determined according to the literature [8-10]:

A [ms]= the mean length of R-R interval during the 60 s before changing the position (steady state),

B [ms] = the shortest R-R interval within the period 5-40 s after changing the position,

C [ms]= the longest R-R interval occurring during 40 s after B,

D [ms] = the length of the R-R interval 60 s after standing up,

E [ms] = the mean length of R-R interval at the end of the 8 min of standing (steady state).

In literature [6], most of the indices describing immediate R-R response are calculated as a function of the characteristic points related to the average length of the R-R in supine position as a reference. We calculated the indices showing the R-R oscillation just after standing up referring them to the value in 8th minute (the end) of standing. The indices describing static differences between steady states and dynamic phase of the response to standing up were analyzed by checking their correlations with age.

3. Results

3.1. Time course

The time course of the length of R-R intervals of ECG during the firs 35 s after standing up in three age groups are presented in Figure 1.

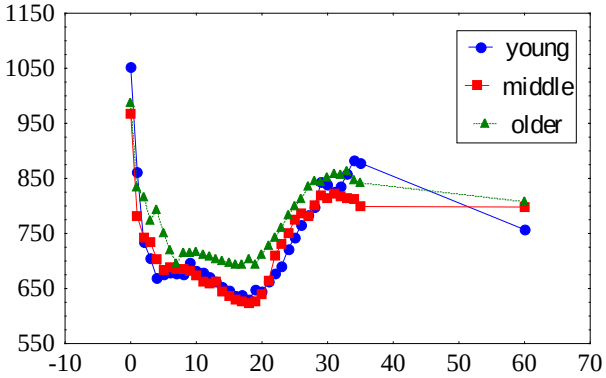

Figure 1. Changes in the length of R-R intervals in [ms] of ECG (vertical axis) during the first 35 s after standing up in three age groups. The time on the horizontal axis is expressed in [s] when 0 denotes the supine position.

3.2. Correlation with age

For the indices describing steady states - no correlation with age was found for R-R value in supine position and the highest was noted for value in 8th minute of standing (r=0.533). In transient phase the strongest relationships with age was observed for index describing overshoot in R-R (C-E) occurring within 30 seconds, above the value of R-R in 8th minute of standing (r= -0.614).

The correlation plot of (C-E) index of the initial heart rate response (R-R response) to standing up with age is presented on Fig. 2. For this index we observed the highest correlation with age.

Other indices were also highly correlated with age:

- for (B-A)/E correlation coefficient was 0.564,
- for (B-A)/A was 0.551.

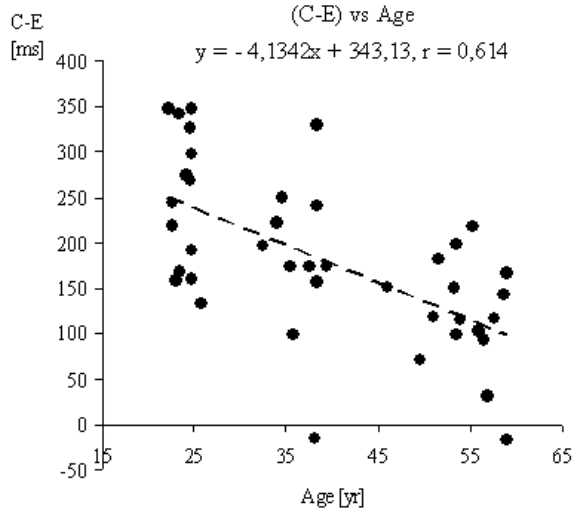

Figure 2. The correlation plot of C-E index of transient changes in R-R intervals and age.

4. Discussion and conclusions

The importance of the initial heart rate response to the postural test analysis was confirmed in the recent paper [11]. The authors have been characterizing the arterial baroreflex (ABR)-mediated regulation of cardiovascular hemodynamics and muscle sympathetic nerve activity (MSNA) during orthostatic stress in humans. They have found that under orthostatic stress, dynamic carotid baroreflex responses are modulated as exemplified by the increases in the MSNA, blood pressure, and HR responses elicited by carotid baroreflex unloading and the shorter period of MSNA suppression, comparable reduction and faster recovery of mean arterial blood pressure (MAP) and greater HR response to carotid baroreflex stimulation. They suggested that in humans, the modulation of ABR function under orthostatic stress may be one of the mechanisms by which blood pressure is maintained and orthostatic hypotension limited, and impairment of ABR control over sympathetic vasomotor activity leads to the severe hypotension associated with orthostatic syncope.

In another paper [12] authors found that simple autonomic function tests (including orthostatic maneuver) are superior to heart rate variability (HRV) based on 24-h ECG recordings in predicting all-cause mortality in the diabetic population.

Most of the indices characterizing the amplitude of R-R changes following standing up showed a tendency towards attenuation with age. The stronger correlations with age presented indices related to the R-R value in 8th minute of standing (E) than those based on R-R value in supine position (A).

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