INTRODUCTION

The explanation of physiological mechanisms involved in adaptation of the cardiovascular system to intrinsic and environmental demands is crucial for both basic science and clinical research. Computational algorithms integrating multivariable data that comprehensively depict complex mechanisms of cardiovascular reactivity are currently being intensively researched. Quantitative Complexity Theory (QCT) provides quantitative and holistic information on the state of a multifunctional dynamic system. The research was aimed to present the first application of QCT in integrative analysis of cardiovascular hemodynamic response to posture change.

METHODS

Three cases of healthy males are presented: S1 (aged 44 years), S2 (31 years) and S3 (36 years). The subjects underwent Head-Up Tilt Testing (HUTT), accruing to Italian Protocol. After stabilization phase (5 min in the supine position) the subject was tilted to the position of 60-70 degrees. The passive phase of tilting was followed by the provocation phase of further 15 min after 400 micrograms NTG sublingual spray. Test interruption (supine restored) was made when the protocol was completed in the absence of symptoms, or there was the occurrence of syncope/presyncope. Beat-to-beat hemodynamic cardiovascular response to tilting was evaluated by impedance cardiography (ICG) with use of the Niccomo™ device (Medis, Ilmenau, Germany) integrated with Tensoscreen™ module (Medis, Ilmenau, Germany). The collected data was analysed with use of QCT. Four moving-windows were tested: 50, 75, 100, 125 samples. The data sampling frequency was corresponding with heart rate frequency (beat-by-beat sampling).

RESULTS

The research was analyzed on the basis of the following parameters: MBP (mmHg), HR (bpm), SV (mL), CO (mL/min), TAC (s), MAP (mmHg), DP (mmHg), TP (mmHg), LVET (msec), HRV (value of HRV corresponding to 10.42; window 100, black), and complexity (beats/100 seconds). The MBP, HR, and CO parameters were calculated in the frequency band of 0.05-0.15 Hz.

Negative HUTT.

In the pre-tilting phase (5 minutes) complexity was stable (mean value 370 bits). After tilting (10:51:29) complexity suddenly rose to 6510 bits (10:53:01), then fell to baseline value (stabilization about 10.58:00). After nitrate administration (11:06:30) it increased to 4430 bits (11:10:20) and fell to baseline about 7.30 minutes. After supine restoration (11:22:20) complexity rose again to 4480 bits (11:24:49).

Positive HUTT - syncope type 1 (mixed) according to VASIS classification.

In the pre-tilting phase (5 minutes) complexity was stable (mean value 320 bits). After tilting (10:27:49) complexity suddenly rose till 4900 bits (10:29:24), then fell to baseline value (stabilization about 10.30). At approximately 10.40 complexity started to rise again reaching 1290 bits at 10.42.12, then temporally dropped to a minimum of 400 bits and eventually rose to 7500 bits during syncope (11.44:45). In the period of 10.30-10.40 complexity was in the range of 100-500 bits (mean 240 bits).

Positive HUTT - syncope type 1 (mixed) according to VASIS classification.

In the pre-tilting phase (5 minutes) complexity was stable (mean value 270 bits). After tilting (13:08:46) complexity suddenly rose up to 10090 bits (13:09:25), then fell to baseline value (stabilization about 13.12:00). At approximately 13.17:00 complexity started to rise again reaching 7170 bits during syncope (13:19:22).

In general, the narrowest window produces results with the highest variability but also the lowest lag in relation to the actual hemodynamics, preferred when the early detection of hemodynamic disturbances is the priority. The advantage of a wide window lies in higher resistance to „noise” and higher specificity to clinically relevant hemodynamic changes.

CONCLUSIONS

Complexity has been shown to be a sensitive marker of cardiovascular hemodynamic response to orotostatic stress and vasodilator administration. Its increase preceded changes of standard cardiovascular parameters.

Complexity profiling provided a detailed assessment of individual hemodynamic pattern of syncope and different complexity settings (window size) produced results of different clinical usability.