Ordinal pattern statistics for RR intervals during head-up tilt test in patients with the history of vasovagal syncope


Abstract—We apply ordinal pattern analysis to quantify differences in distribution of patterns of length 3 and 4 in basal state and during head-up tilt test (HUTT) in patients with history the history of syncope and positive (HUTT(+)) or negative (HUTT(-)) responses to the test. We identify the patterns related to prevalence of sympathetic or parasympathetic cardiac modulation as well as describe the relations between the response to the test and distribution of the patterns.

I. INTRODUCTION

The pathophysiology of vasovagal syncope (VVS) is still not fully understood. In patients with fainting the head-up tilt test (HUTT) is widely used to provoke syncope, but it has many limitations according to sensitivity, specificity and reproducibility. Recently, a phenomenon of heart rate asymmetry related to unequal contribution of heart rate accelerations and decelerations has been observed [1], [2]. Moreover, symbolic dynamics methods were reported to be able to mirror sympathetic and vagal modulation of heart rate during supine rest [3] and tilting [4], [5]. The aim of the study was to use ordinal pattern statistics for the analysis of heart rate in patients with the history suggesting vasovagal faints.

We compare features of heart rhythm during supine and tilted positions as well as patterns of heart rate in subgroups with positive (vasovagal faint as a result of HUTT) and negative (no syncope) reactions to the test.

II. METHODS

A. Ordinal patterns

Ordinal patterns analysis is a new and promising method of investigation of a complex time series based on concept of order [6], [7]. For a given time series \( \{x_1, \ldots, x_N\} \) a sliding window of length \( L \), \( x_{n+L}^n := x_{n+1}, \ldots, x_{n+L}, 0 \leq n \leq N - L \) is considered. Elements of the window are ordered in ascending order (in case \( x_i = x_j \), we set \( x_i < x_j \) for \( i < j \)) and we get

\[
x_{n+\pi_1} < x_{n+\pi_2} < \cdots < x_{n+\pi_L},
\]

which defines the ordinal pattern of \( x_{n+L}^n \) as the permutation \( \pi = (\pi_1, \pi_2, \ldots, \pi_L) \) of \( \{1, 2, \ldots, L\} \). There are \( L! \) ordinal patterns of length \( L \).

III. RESULTS

In this research we examine the ordinal patterns of length \( L = 3 \) and \( L = 4 \) for consecutive RR intervals, studying differences in distribution of patterns in basal state and during head-up tilt test.

B. Subjects and measurements

30 patients with a negative HUTT result (HUTT(-) group) and 20 patients with a cardiodepressive reaction (HUTT(+) group) were included in the study. All patients have the history suggesting vasovagal syncope but did not have structural heart disease. Each patient remained supine for 20 minutes and then the table was tilted to 60 degrees. Either a passive test or concomitant active test with nitroglycerin (NTG) was then performed. Passive test lasted 30 minutes, active test lasted 20 minutes or until syncope occurred. In cases of contraindications to NTG, just a 45 minutes passive test was performed. Series of 500 RR intervals recorded in a supine position and during first minutes of tilting were analyzed.

TABLE I DISTRIBUTION OF ORDINAL PATTERNS FOR HUTT(+) GROUP BEFORE AND AFTER TILT TEST.
The asymmetry between acceleration and deceleration runs was observed (bigger contribution of (321) than (123) patterns and bigger contribution of (4321) than (1234) patterns).

3. In HUTT(+) patients the asymmetry between the contribution of acceleration and deceleration runs is bigger than in HUTT(-) patients.

4. The percentage of patterns with just one change ((3421), (2134), (4312), (1243), (1423), (2314), (3241), (4123), (1432), (3214)) have decreased in the upright position, which may mirror the lower vagal activity. Similar reaction was previously reported in healthy subjects [5].

**Fig. 1.** Distribution of ordinal patterns for HUTT(-) group during supine and tilt.

**Fig. 2.** Distribution of ordinal patterns for HUTT(+) group during supine and tilt.

**IV. CONCLUSIONS**

The results of the study confirm that the ordinal pattern statistics method is able to reflect autonomic modulation changes in patients with vasovagal syncope. It seems that the method is also able to show differences between heart rate response during first minutes of tilting in patients with positive and negative reactions to HUTT.

**REFERENCES**


