ASSESSMENT OF SPECTRAL ANALYSIS OF HEART RATE VARIABILITY IN PATIENTS WITH HISTORY OF ATRIAL FIBRILLATION BY MEANS OF AGE-DEPENDENT PARAMETERS

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Heart rate variability evaluation is a useful diagnostic tool for autonomic nervous balance assessment. The role of the autonomic nervous system in aetiology of atrial fibrillation is sometimes clear as a trigger from a patient's history, but mostly it acts as a modulating factor which is not easy to detect. The present study demonstrates results of spectral analysis of short-term heart rate variability during ortho-clinostatic tests processed by means of age-dependent parameters. An original telemetric system and a unique method for heart rate variability assessment, developed by the Faculty of Physical Culture, were applied for the first time to examine patients with the history of atrial fibrillation.

INTRODUCTION

Atrial fibrillation (AF) has been underestimated for a long time as a cardiac arrhythmia with enormous consequences for the whole population, especially in industrialized countries. At present, it is generally accepted that atrial fibrillation impairs mortality¹. Its prevalence is increasing with ageing², and it represents an undeniable economic burden for health care systems^{3,4,5}. The contemporary level of knowledge on AF is able to recognize several risk factors associated with its development and describe mechanisms of its triggering and spread. The autonomous nervous system (ANS) is a commonly accepted factor participating in arrhythmogenesis.^{6,7,8} The examination of heart rate variability (HRV) is a noninvasive tool for autonomous nervous system assessment⁹. The measurements of heart rate variability enable analyses in both the time and frequency domain. It is possible to distinguish between three main spectral components via spectral analysis (SA) of the frequency domain, i.e. very low frequency VLF (10–50 mHz), low frequency LF (50–150 mHz), and high frequency HF (150–400 mHz). The high frequency component reflects an efferent parasympathetic activity, the low frequency component is considered as reflecting sympathetic and parasympathetic interactions as well as baroreceptor sympathetic activity. Interpretation of very low frequency is not unambiguous^{9,10}. The majority of studies targeting to cardiac autonomous nervous system evaluation in patients with atrial fibrilla-

tion describe autonomic tone changes before initiation¹¹ or after termination¹² of atrial fibrillation paroxysms. In this study the authors examined patients with the history of atrial fibrillation by means of a new methodology of heart rate variability evaluation, previously not used in this indication.

METHODS

Subjects

Thirty persons (20 men, 10 women) admitted to hospital because of atrial fibrillation, with the left atrium diameter within the abnormal range according to Gregor¹³, were examined after sinus rhythm restoration (spontaneously in 17%, electrically in 20%, pharmacologically in 63%). The group of patients was characterized by average values of BMI 28 kg/m², TSH 2.46 mIU/l, left atrium 39 mm, NYHA I 63%, NYHA II 37%. No cause of arrhythmia initiation was detected in 30% of the patients. In the remainder part of the group an acute trigger factor was revealed in 13%, and there was one or several risk factors, namely hypertension, structural heart disease and diabetes mellitus in 47%, 37%, an 13% of the patients, respectively.

The results of HRV spectral analysis of healthy persons in supine and upright positions published by Šlachta et al.¹⁴ were used as a control. The control group consisted of 216 healthy persons 12 to 70 years old ($x = 35.05 \pm 14.30$ years), where the age dependence of

single spectral analysis of HRV parameters was assessed. The results of 30 persons (19 men, 11 women) belonging to this group were selected to ensure the age and gender compatibility with the patients.

Data collection

The patients were examined between 8 and 11 a.m., eupnoic, at a room temperature ranging from 22 to 25 degrees C, according to standard conditions having abstained from cigarettes, alcohol, and coffee before the examination. Drugs potentially influencing HRV were stopped in half of the patients. In the cases where therapy could not be interrupted, the last dose was administered one day before the examination. Out of the total number of the patients Digoxin therapy was used in 10%, Propafenon in 30%, betablocker in 17%, angiotensin converting enzyme inhibitors in 33%, and Sotalol in 3%.

The original diagnostic systems VARIA PULSE TF3¹⁵ and VARIA CARDIO TF4¹⁶ were used for recording R-R intervals as well as for a short-term (5-minute-duration and 300 R-R intervals at least) HRV analysis. The test with ortho-clinostatic stimulation (5-minute-duration in each of the supine-standing-supine positions) was performed. The first position served for standardization, and the next two positions with their specific indexes served for alternating sympathetic and vagal stimulation. Incidentally recorded artifacts were removed by manual filtration.

Evaluation of SA HRV

All the commonly used parameters of HRV spectral analysis were included in the evaluation, namely total spectral power TOT.PWR (ms²), spectral power in individual frequency bands PWRVLF, PWRLF and PWRHF (ms²), relative spectral power in individual frequency bands REL.PWRVLF, REL.PWRLF, REL.PWRHF (%), and the ratio of spectral performances LF/HF RAT.LF/HF.

In addition to these parameters, the coefficients of variation were used¹⁷ in the respective frequency bands CCVVLF, CCVLF, CCVHF (%) to reduce different effects of heart frequencies on the power field SA HRV. All the measured and calculated values of age-dependent parameters were correlated to reference values of healthy persons¹⁸ and expressed as points on a -5.0 to +5.0 score scale¹⁹. It allowed for SA HRV to take advantage of a new original assessment method using complex indexes of vagal activity (VA), sympathovagal balance (SVB), baroreceptors activity (BR) and total score (TS)¹⁹. TS values were converted to the functional age of ANS for easier interpretation¹⁹. As compared to the standard parameters, the new method enables easier orientation, easier interpretation of the results and undeniable identification of less pronounced changes in the power spectrum.

The functional age of 71 years was allocated to the patients with significantly low total spectral power, when the computer program was not able to calculate the

functional age because of the extended age range of the control group (up to 70 years). This step enabled to measure objective differences, and thus the statistical evaluation was affected to a minimum extent.

RESULTS

There was a significant decline in the total spectral performance as well as in all the three individual components in supine positions between the group of patients and the control as shown in Table 1.

Table 1. Statistical significance of differences between values of SA HRV parameters and complex indexes during ortho-clinostatic test in patients and healthy control.

		Patients	Control	SSD
CA (years)	X	54.86	50.33	NS
	SD	10.62	8.25	
L TOT.PWR (ms ²)	X	585.7	1873.5	p < 0.001
	SD	481.5	1368.2	
L CCV VLF (%)	X	1.17	1.81	p < 0.01
	SD	0.68	0.83	
L CCV LF (%)	X	1.35	2.48	p < 0.001
	SD	0.81	1.16	
L CCV HF (%)	X	1.41	2.4	p < 0.001
	SD	0.77	0.99	
L VLF (%)	X	29.3	22.6	NS
	SD	18.8	14.5	
L LF (%)	X	32.1	40.2	NS
	SD	18.2	17.2	
L HF (%)	X	38.6	37.2	NS
	SD	21.4	16.3	
L LF/HF	X	1.39	1.40	NS
	SD	1.49	1.02	
VA (points)	X	-1.997	0.537	p < 0.001
	SD	1.8128	1.88	
SVB (points)	X	-0.408	-0.353	NS
	SD	2.3552	1.6183	
BR (points)	X	0.297	0.395	NS
	SD	2.2022	2.3883	
TS (points)	X	-2.483	0.158	p < 0.001
	SD	2.2742	1.7213	
FA (years)	X	62.04	49.07	p < 0.001
	SD	11.36	11.01	
CA - FA (years)	X	7.178	-1.258	p < 0.001
	SD	8.67	5.41	

Explanatory notes: CA – calendar age, L – second supine position, CCV coefficient of variation of the individual component, TOT.PWR – total spectral power, VA – complex index of vagal activity, SVB – complex index of sympathovagal balance, BR – baroreceptor activity, TS – total score, FA – functional age of ANS, SSD statistical significance of differences between patient and control values

On the contrary, there was no significant difference in power participation of the respective spectral component in total power and LF/HF ratio between the patients and the healthy control. The complex index of vagal activity (VA) was significantly lower in the group of patients than in the healthy control. However, there were no significant differences between SVB and BR values (Table 1). The total ANS efficiency expressed as

Fig. 1. SA HRV in a 3D graph: a 45-year-old man with history of AF, functional ANS age 55 years.

Fig. 2. SA HRV in a 3D graph: a healthy man aged 46 years from the control group, functional ANS age 41 years.

the total score was significantly lower in the group of patients, corresponding with a remarkably higher functional age. The difference between the calendar and functional age was approaching zero (-1.26 ± 5.41) in the group of healthy persons, but it was significantly higher in the group of patients (7.18 ± 8.67) (Table 1.).

DISCUSSION

A significantly depressed vagal activity recorded in the patients with atrial fibrillation history not only reduced the total spectral performance, primarily dependent on vagal fluctuations, but it also remarkably limited the values of the complex vagal activity index VA. This finding is not very surprising, and it is related to the

depressed vagal activity in many other diseases, e.g. diabetes mellitus. The reduced vagal activity is a major reason for HRV decline as well as ANS efficiency reduction.

On the other hand, it was astonishing to find the sympathetic activity unchanged resulting from LF/HF ratio frequently used as a sympathetic tone index. It was identical in the groups of healthy persons and patients. The well-balanced values of the complex sympathovagal balance index SVB approaching zero in both the groups under study confirmed a parallel reduction in both vagal and sympathetic activities. Most diseases are accompanied by sympathetic predominance due to the reduced vagal activity characterized by an increasing LF/HF ratio, e.g. chronic heart failure⁹. It is fairly possible to detect a significant decline in SVB index by means of complex indices which gives evidence on the reduction in the overall ANS efficiency, and not only isolated dysfunction of one ANS branch. This finding is also related to a significant difference in the total score of TS values between the group of patients and the healthy control. In the patient group, the ANS activity was significantly beyond the normal range which signaled that ANS dystonia was still outlasting after an attack of the above mentioned arrhythmia.

Quantitative expression of the functional ANS dysfunction by means of the functional age versus the calendar age promoted the first of clear patient-oriented interpretations of the results. However, it has to be taken into account that it brought no further information, thus being redundant in view of the description of SA HRV results.

The activity of baroreceptors assessed as absolute and relative differences in LF component performances after orthostatic stimulation was identical in both the groups under consideration. It is in a good agreement with the fact that the baroreceptor arc is not affected in patients with atrial fibrillation, the cause being an isolated injury of the cardiac neural network peripheral part.

It has been documented that the total spectral performance is declining with ageing²⁰. The functional age index is a parameter that could distinguish between the two groups under study at the statistically significant level. This justifies the capacity of the methodology used in our study to differentiate the findings of the patients with autonomous regulation dysfunction from healthy persons. Patient results were classified at the level of significance as age inappropriate, and disadvantageous for them, in accordance with the generally low average of spectral performances.

STUDY LIMITATIONS

The processed records of the control group were obtained in a different laboratory because it was not possible to make up a relevant group of healthy persons in a clinical setting. Different modes of verticalization were used in both the groups under study, namely active in the patients and passive in the control. Nevertheless, abnormal findings were not probably due to supplementary effort resulting from active standing.

Half of the patients were examined under therapy possibly affecting HRV. The classification of these persons within the study group was based on literature references concerning the impact of drug therapy on ANS. Sotalol, Propafenon, Digoxin, and betablockers were reported to have a supportive effect on vagal activity, incidentally HRV. A favourable and/or neutral effect was found in angiotenzin-converting enzyme inhibitors^{21, 22}. A major problem revealed in the patient group was attenuation of vagal activity. It is therefore possible to assume that the unfavourable results were not impaired by therapy, but most probably an opposite effect could be expected. There was another limitation, namely the fact that the interval between termination of atrial fibrillation and HRV examination was not defined. The arrhythmia was terminated in early hours after admission to hospital. Consequently, it may be supposed that atrial electrical remodelling was not present when the examination was performed in a stable state on sinus rhythm after time delay in days or longer. The basic pre-requisite for inclusion in the study was a limitation in the atrial diameter, and its normal range demonstrated that anatomical remodelling was not present.

CONCLUSIONS

1. An ortho-clinostatic test enabled the assessment of cardiac ANS regulation dynamics.
2. There were statistically significant differences among numerous parameters discovered in the patient group via HRV analysis. The basic finding in the group of patients was a low total spectral performance. The most striking differences between the patients and the healthy control were due to the insufficient vagal activity.
3. Based on the fact that a postural manoeuvre was found an efficient tool for ANS screening integrity, there might be a cardiac autonomous regulation disorder in the group of patients.

4. The applied program offers quick orientation in the analyzed data and is able to differentiate healthy persons from patients with pathological findings. The results found in the patients were inappropriate for their age group. The findings were classified as disadvantageous, because the functional age of the patients was significantly higher in comparison with the control group.
5. It may be alleged that the results have confirmed a significantly higher presence of a cardiac ANS regulatory mechanism disorder in the group of patients with the history of atrial fibrillation as compared to the healthy control. Nevertheless, these findings cannot solve the problem of abnormal ANS reaction aetiology. They only show the coincidence with AF which could be considered a proof supporting the presence of ANS dysfunction as a modulating factor participating in AF origin.

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