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High-Resolution Heart Rate Variability Analysis in Patients with Chronic Obstructive Pulmonary Disease

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Abstract. The paper describes the features of heart rate variability in COPD. 58 male patients with COPD and 38 participants without COPD, aged 45 to 74, were enrolled in the study. Rhythmocardiography was performed in order to assess heart rate variability in all the participants enrolled in the study. We analyzed the following parameters of heart rate variability: RR, SDNN, ARA, σm, σs, σl, VLF%, LF%, and HF% in patients with and without COPD. Reduction of heart rate variability (SDNN), predominance of humoral-metabolic regulation of pacemaker activity of the sinus node (this regulation factor makes a minimum contribution in healthy individuals) were found in COPD compared to participants without COPD. We detected very low frequency waves with upward deviation from the main RCG waves corresponding to the bronchial obstructive syndrome in patients with COPD. We also analyzed the heart rate variability parameters of patients with COPD within the group. Heart rate variability changes were more severe in patients with pulmonary hypertension. Segments of the rhythmocardiogram with identical R-R intervals can be detected in patients with pulmonary hypertension.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is an important public health problem throughout the world. COPD has been one of the leading causes of death and disability for many years in a row. The functional and structural changes of the respiratory system in COPD are closely associated with the cardiovascular function. Pulmonary hypertension is a severe complication of chronic obstructive pulmonary disease (COPD). This complication is associated with increased risks of exacerbation and decreased survival [1, 2]. Some studies have shown that pulmonary hypertension appears to be primarily affected by heart rate variability alterations and ventricular arrhythmic burden, indicating a high risk of malignant arrhythmic events [3]. The assessment of the autonomous nervous system is important for patients with COPD [4, 5]. The heart rate variability (HRV) parameters have prognostic value in patients with COPD [6]. The increase in some indexes of HRV can have prognostic value in patients with acute exacerbation of chronic obstructive pulmonary disease [7]. However, it is proved that HRV determined by 24-hour monitoring has many factors contributing to measurement inaccuracies (changes in breathing, body position during the day) [8]. Thus, the assessment of heart rate variability using the method of high-resolution rhythmocardiography (RCG), devoid of the above disadvantages, can be the most promising method for identifying violations of the regulation of the pacemaker activity of the sinoatrial node of the heart. The aim of this study is to evaluate the presence of autonomic dysfunction in patients with COPD by the method of high-resolution rhythmocardiography.

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MATERIALS AND METHODS

We enrolled 58 male patients with COPD aged 45 to 74. The diagnosis of COPD is established according to the criteria of GOLD 2016. We excluded persons with severe comorbid pathologies, as they may distort the parameters of rhythmocardiography. The control group consisted of 38 participants without COPD. The patients of both groups were examined by standard clinical methods. Rhythmocardiography was performed for all the participants enrolled in the study. The patients with COPD were investigated in remission. We used high-resolution rhythmocardiography with the MICOR hardware and software complex. Rhythmocardiography was performed at rest and during autonomic mixed incentives: Valsalva maneuver, Aschner-Dagnini test, active orthostatic test, loading test. We evaluated the following indicators: the average value of RR; the standard deviation of all waves – SDNN; ARA – the amplitude of respiratory arrhythmia; the ratio of the effects of parasympathetic, sympathetic, and humoral factors regulating the pacemaker activity of the sinus node – VLF%, LF%, and HF%. Statistical analysis was performed using the Gretl (GNU Regression, Econometrics and Time-series Library) software for Windows, version 1.10.1. We used the Mann-Whitney U test, Student's t and z tests. The P value < 0.05 was considered statistically significant. The nonparametric Spearman method was applied to analyze the correlation of the HRV data with the data obtained from standard investigations.

RESULTS AND INTERPRETATION

The patients of both groups (the control group and the COPD group) were male and they did not differ in average age (p=0.77).

A decrease in heart rate variability (SDNN) and the predominance of humoral-metabolic regulation of the pacemaker activity of the sinus node (this regulation factor makes a minimum contribution in healthy individuals) were found in COPD compared to the participants without COPD. The results are presented in Table 1.

TABLE 1. Parameters of heart rate variability in the control group and the COPD group

Diagnosis	Tests	RR	SDNN	ARA	VLF%	LF%	HF%
COPD group (n=58)	At rest	0.804±0.11	0.025±0.01	0.032±0.02	49.3±17.5	18.9±12.7	31.8±19.0
	Valsalva maneuver	0.814±0.09	0.024±0.01	0.032±0.01	48.1±18.5	20.6±11.3	31.3±20.1
	Aschner-Dagnini test	0.785±0.10	0.022±0.01	0.029±0.02	49.2±20.1	19.2±11.8	30.7±18.7
	Active orthostatic test	0.686±0.11	0.017±0.01	0.018±0.02	54.3±19.4	24.5±13.1	21.2±19.1
	Loading test	0.822±0.12	0.026±0.01	0.037±0.01	42.9±16.2	19.8±12.4	37.2±17.3
Control group (n=38)	At rest	0.979±0.10	0.056±0.02	0.095±0.04	23.1±17.8	22.9±11.4	53.9±19.3
	Valsalva maneuver	0.922±0.09	0.059±0.01	0.098±0.03	25.1±17.8	22.5±12.3	52.4±18.4
	Aschner-Dagnini test	0.961±0.11	0.055±0.02	0.083±0.01	31.3±19.4	24.9±11.3	43.8±17.8
	Active orthostatic test	0.746±0.12	0.038±0.01	0.047±0.02	38.2±19.7	36.7±10.8	25.1±18.2
	Loading test	0.922±0.10	0.057±0.01	0.091±0.02	27.8±15.3	18.9±12.3	53.3±19.5

We also found very low frequency waves with upward deviation from the main RCG waves corresponding to the bronchial obstructive syndrome according to the clinical data and the spirometry parameters in the COPD groups (Fig. 1).

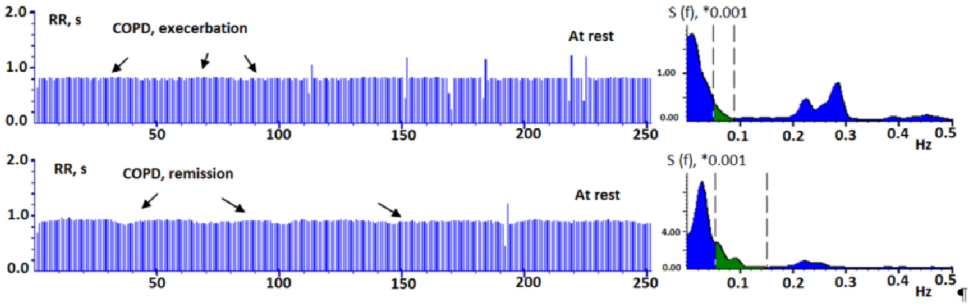

FIGURE 1. A rhythmocardiogram and a spectrogram of patients with COPD; very low frequency waves with upward deviation from the main RCG waves in patient with COPD are marked with arrows; predominance of humoral-metabolic regulation of the pacemaker activity of the sinus node on the spectrogram

The predominance of the parasympathetic regulation of the pacemaker activity of the sinus node and the absence of bronchial obstruction waves were found in the control group (Fig. 2).

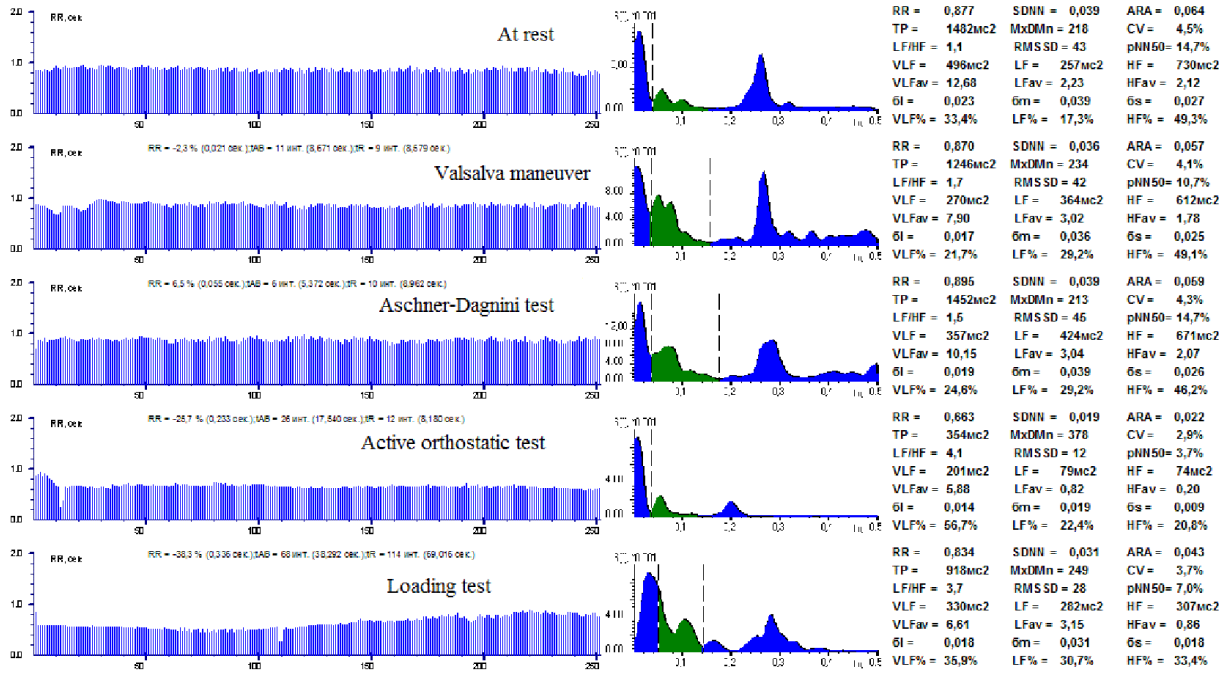

FIGURE 2. Rhythmocardiograms, spectrograms and the middle values of the HRV parameters of a healthy man; parasympathetic regulation of the pacemaker activity of the sinus node is a prevailing factor

We also analyzed the HRV parameters of patients with COPD within the group. We divided the participants into patients with and without pulmonary hypertension. A decrease in heart rate variability (SDNN) and the predominance of the humoral-metabolic regulation of the pacemaker activity of the sinus node were found in COPD with and without pulmonary hypertension. The HRV changes were more severe in patients with pulmonary hypertension ($p=0.02$ for SDNN and $p=0.04$ for VLF%).

We found segments of the rhythmocardiogram where the SDNN index was significantly lower than the average one only in the group with pulmonary hypertension (Fig. 3).

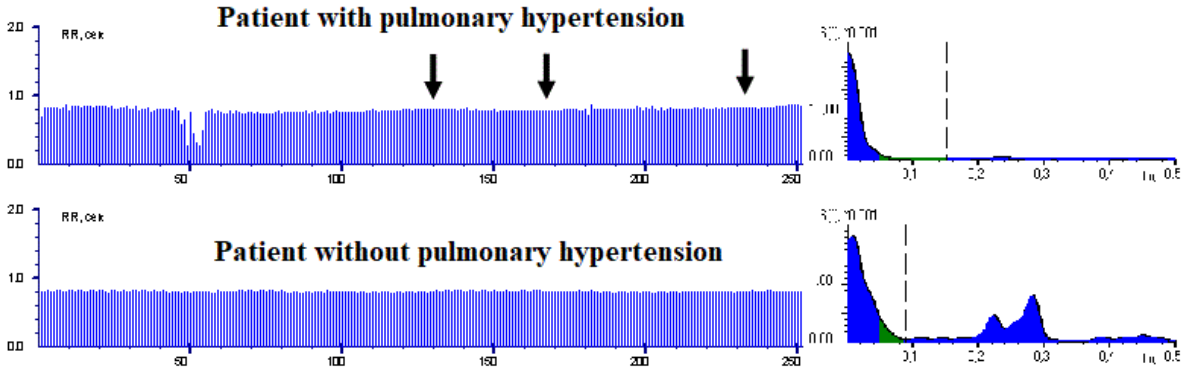

FIGURE 3. Rhythmocardiograms and spectrograms of patients with COPD with and without pulmonary hypertension; segments of the rhythmocardiogram with identical R-R intervals are marked with arrows; predominance of humoral-metabolic regulation of the pacemaker activity of the sinus node on the spectrogram in both cases (more severe in patients with pulmonary hypertension)

We can assume that these fragments are associated with overload of the right heart in pulmonary hypertension and the transition of the regulation of the activity of the sinus node at a lower level. This issue requires further study.

CONCLUSION

1. In the comparison with the control group, a decrease in heart rate variability, the predominance of humoral-metabolic regulation of the pacemaker activity of the sinus node have been found in patients with COPD.
2. Very low frequency waves with upward deviation from the main RCG waves corresponding to the bronchial obstructive syndrome have been detected in the COPD group.
3. HRV changes in the COPD group with pulmonary hypertension are more severe than those in the second group (without pulmonary hypertension).
4. Segments of the rhythmocardiogram with identical R-R intervals can be detected in patients with pulmonary hypertension.

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