Use of Signal Averaged ECG and Spectral Analysis of Heart Rate Variability in Antiarrhythmic Therapy of Patients with Ventricular Tachycardia

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Summary

Methods of signal averaged ECG (SAECG) and spectral analysis of heart rate variability (SAHRV) give new opportunities for investigating the mechanisms initiating ventricular tachycardia (VT), and for the most effective methods of treatment. For this, SAECG and SAHRV parameters of VT patients as well as the influence of antiarrhythmic drugs such as [etmozin, propaphenon and propranolol were studied. It was found that etmozin can be prescribed to patients with ventricular tachycardia with registered late potentials of the heart ventricles and disturbance of the autonomic control of the heart rate in the form of increased parasympathetic activity. Propranolol is preferable for patients with registered late potentials of the heart ventricles and enhanced sympathetic activity of the autonomic nervous system (ANS). Propaphenon is recommended for patients without late potentials of the heart ventricles but with increased sympathetic influence of the ANS on heart rate.

Key Words

Signal averaged electrocardiogram, late ventricular potentials, spectral analysis of heart rate variability, ventricular tachycardia, antiarrhythmic drugs

Introduction

In recent years great success has been achieved in clarifying the pathogenesis of ventricular tachycardia (VT) [1], and in suggesting corrective methods [2]. Along with that, problems have arisen in the treatment of VT, including side effects and resistance to antiarrhythmic drugs. Initiation of these arrhythmogenic effects has forced researchers to study the mechanisms of VT development and to search for new ways of treatment. The signal averaged ECG (SAECG) method is being widely disseminated. The method reveals late ventricular potentials (LVP) [3]. Antiarrhythmic drugs can change the parameters of the SAECG and have an effect on the LVP [4]. So an opportunity appears to decrease the risk of fatal VT, and of sudden cardiac death as its main complication. Nevertheless, the problem of the influence of antiarrhythmics has not been studied in detail.

Examination of heart rate variability using spectral analysis (SAHRV) [5], and variable parameter changes under the influence of antiarrhythmic drugs [6] have a great value for investigating VT-initiated mechanisms. They may help to treat patients with arrhythmia in more appropriate ways and evaluate the effects of antiarrhythmics.

Our goal was to examine the SAECG and SAHRV parameters of patients with VT of different etiologies, clarify the influence of etmozin, propaphenon and propranolol on these parameters, and formulate a different approach to prescribing antiarrhythmic drugs for VT patients.

Materials and Methods

We examined 97 patients aged 18 to 72. All the patients had VT of differing degrees in accordance with the B. Lown classification [7]. The group consisted of patients having ischemia with postinfarctial cardiosclerosis (32 men), a history of ischemia without

myocardial infarction (19 men and 6 women), dilative cardiomyopathy (14 men), hypertrophic cardiomyopathy (7 men, 1 woman). Eighteen patients with ventricular arrhythmia had no symptoms of organic pathology (11 men, 7 women). 16 patients had a history of paroxysms of ventricular tachycardia, 2 patients had been admitted to the emergency room because of cardiac arrest due to ventricular fibrillation, 8 patients had a history of syncopeof unknown origin. The examinations took place a week after the patients had been hospitalized at the Kazan cardiac dispensary. The patients had not been administered antiarrhythmic drugs, digitalis and diuretics in the treatment preceding our examinations.

We used echocardiography to evaluate the ejection fraction by the Teicholtz method, and Holter monitoring for all the patients. We performed a standard 12-lead ECG and determined the potassium and sodium blood plasma levels to exclude any electrolytic rhythm disturbances.

In addition, we included a control group of 17 healthy subjects (age 17 to 48) without any heart rhythm disturbances into our investigation. Evaluation of heart rate variability was made using the computer device system "SPECTRUM" developed at the Department of Internal Disease and Propaedeutics of the Kazan State Medical University. Not less than 500 consecutive cardiac complexes were recorded. Power wave spectra were determined in the following frequency domains: 0-0.50 Hz including low frequency band (0-0.07 Hz), medium frequency band (0.07-0.15 Hz) and high frequency band (0.15-0.50 Hz); contributions of all the bands were calculated. High frequency bands reflect parasympathetic ANS to control heart rate, low and medium frequency bands characterize the sympathetic ANS. For intensifying and averaging the ECG, we used a native computer based system. Noise level in the LVP was registered at 1-2 mV, the main signal gain factor was 256, the main channel filter was 60 Hz, and the recording time was 400 ms. To obtain a high quality electrogram, we usually used averaging over 110-150 series. We applied the Frank system of corrected ECG leads. LVP were determined by the M. Simson criteria [8].

Results and Discussion

We found that 33.4% of VT patients had late ventricular potentials after myocardial infarctions. For patients without a history of myocardial infarction, LVP took place in 20.0% of cases. For patients with dilative cardiomyopathy, LVP took place in 35.7% of cases. VT combined with hypertrophic cardiomyopathy led to LVP in 25% of cases. For patients without known organic pathology of the cardiovascular system, we found LVP in 11.1% of cases. Thus, LVP appeared quite often in patients with VT (on the background) postinfarctial cardiosclerosis and dilative cardiomyopathy (33.4% and 35.7% of cases respectively). We rarely found LVP in patients with a history of VT following hypertrophic cardiomyopathy and ischemia without myocardial infarction. For the group of VT patients without organic pathology, the number of registered LVP was small and did not significantly exceed the percentage of LVP for healthy subjects found in the literature.

In evaluating SAHRV parameters, we found that there was a certain decrease of part of the high frequency band (up to 40.5 ± 17.1%) in patients with postinfarctial cardiosclerosis that was 38.8% less than the control group. This fact signified the depression of the parasympathetic activity of the ANS. A similar tendency took place for the group of patients with dilative cardiomyopathy. Part of the high frequency band was 42.4 ± 17.1%; that was 36.0% less than for the control group. For patients with hypertrophic cardiomyopathy, the contribution of the parasympathetic ANS was 48.6 ± 15.2%; that was 26.6% less than for the control group. A significant decrease of the high frequency band of the variable heart rate spectrum took place for all these groups of patients. The situation differed for the group of patients with ischemia without a history of myocardial infarction. Part of the high frequency band was 51.3 ± 18.1%; that signaled domination of the parasympathetic activity of the heart. For the group of VT patients without known organic pathology, a part of the high frequency band was 54.5 ± 9.9%. Hence, it was established that the parasympathetic ANS dominated ischemic patients without myocardial infarction, and for VT patients without known organic pathology. No definite difference between the heart rate spectrum parameters of these two groups of patients, compared with the control group was found.

We determined the features of the autonomic control of the heart rate for patients with VT combined with LVP, and for patients with VT without LVP. We found that part of the high frequency band was certainly smaller, and parts of the low and medium frequency bands were

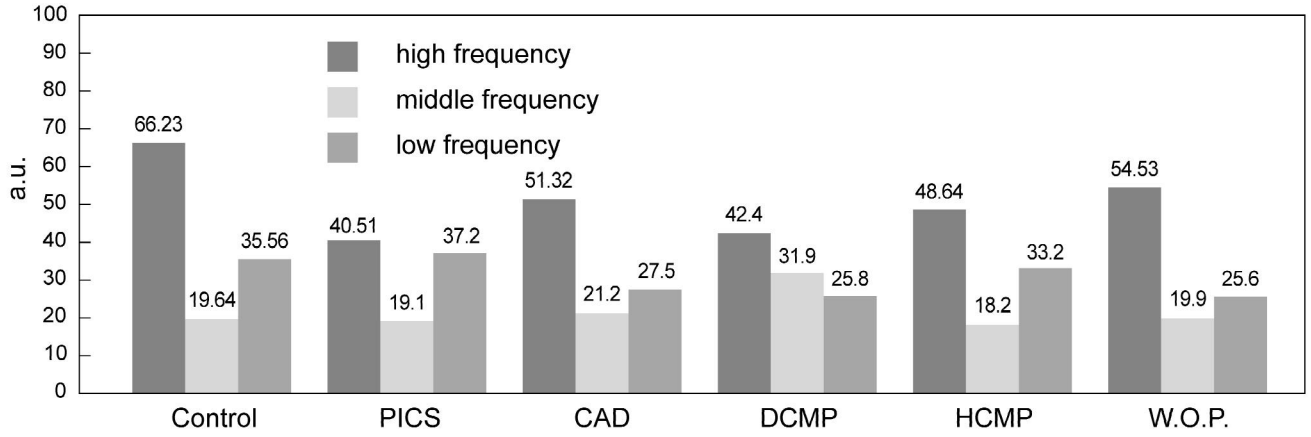

Figure 1. HRV spectral analysis parameters of the control group of healthy subjects and of different groups of patients: PICS - postinfarction cardiosclerosis, CAD - coronary arterial disease, DCMP - dilative cardiomyopathy, HCMP - hypertensive cardiomyopathy, W.O.P. - without organic pathology.

certainly larger for the first group in comparison with the second group. Thus, the parasympathetic influence of the autonomic nervous system on the heart rate was smaller, and sympathetic activity was larger for patients with VT combined with LVP, in comparison with patients without registered LVP.

SAECG and SAHRV were registered prior to the treatment, 1.5-3 hours after a sharp medication test and on the 6th-10th days of the antiarrhythmic therapy. A poor subjective reaction to VT was grounds for giving the antiarrhythmic therapy. Twenty-seven of the patients were administered etmozin in a dose of 300-600 mg per day, 28 of them were administered propranolol in a dose of 120-160 mg per day, 31 of them were administered propaphenon (450-900 mg per day). We evaluated the effects of etmozin on the 4th-5th days of treatment, of propaphenon on the 5th day, and of propranolol on the 8th - 9th days. In a number of cases we stopped the antiarrhythmic therapy because of side effects. Thus, we stopped administering etmozin for 2 patients, propaphenon for 2 patients and propranolol for 3 patients. We used the following criteria for evaluating the effectiveness of antiarrhythmic therapy: decreasing the ventricular extrasystole number by 75%, decreasing the ventricular extrasystole paired number by 90%, total vanishing of the ventricular tachycardia paroxysms. A criterion for partial antiarrhythmic effect of the therapy was decreasing the general number of ventricular extrasystoles by 50%.

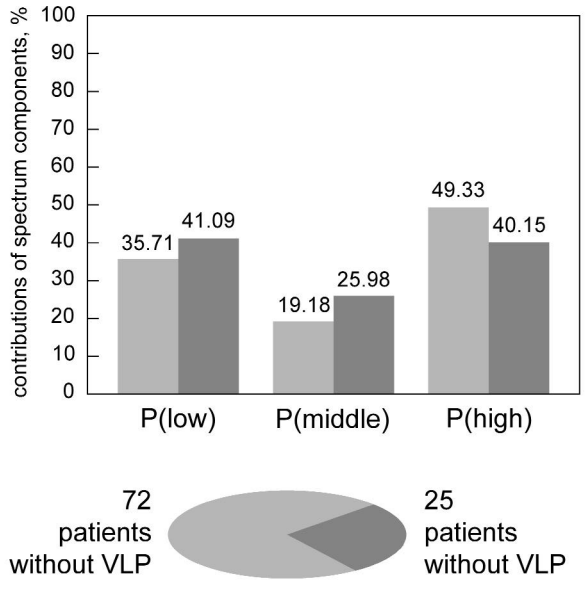

Figure 2. Comparison of HRV spectral analysis parameters in ventricular rhythm disturbance patients without late ventricular potentials (LVP) (dark columns) and with LVP (light columns).

Eleven VT patients were not administered antiarrhythmic drugs. We recorded their SAECG and SAHRV parameters on the 1st and 7th days of examination, in order to evaluate the reproducibility of the results.

It was found that etmozin and propaphenon had great antiarrhythmic effects. Etmozin was effective in 68.0% of the patients, and propaphenon - in 55.2% of them. The antiarrhythmic activity of propranolol was smaller and we achieved full antiarrhythmic effect in only 28.0% of the patients.

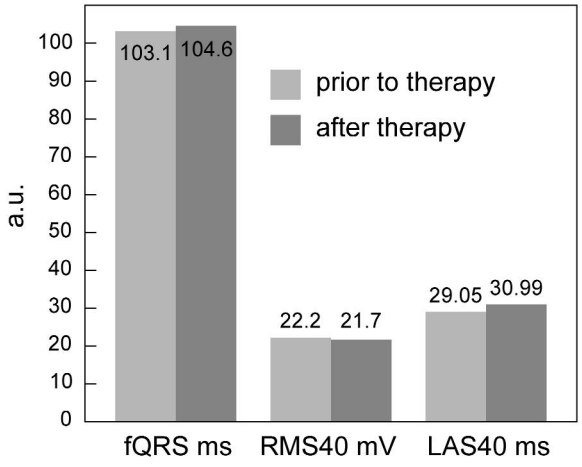

Figure 3. Effect of Etmozin on parameters of the signal averaged ECG: fQRS - duration of the filtered QRS complex (ms), RMS40 - duration of the low-amplitude QRS component (ms), LAS - amplitude of the last part of the QRS complex (mV). Light columns - prior to therapy, dark columns - after therapy.

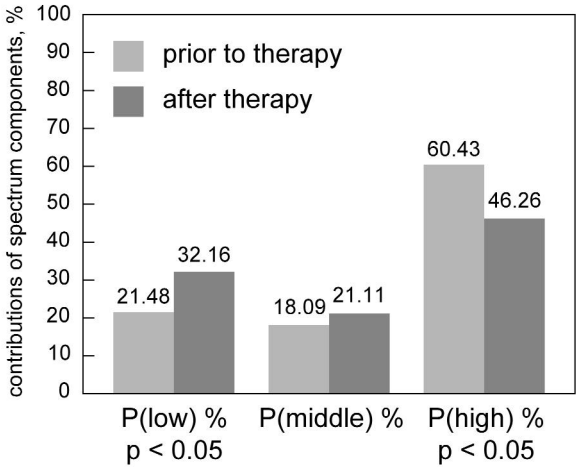

Figure 4. Effect of Etmozin on the HRV spectral analysis parameters: light columns - prior to therapy, dark columns - after therapy. Abbreviations as in Figure 2.

It became clear that etmozin did not have a great influence on SAECG parameters. We only noticed an insignificant increase of the filtered QRS complex duration (by 1.4%) and a low amplitude in part of the QRS complex duration (by 6.7%). Amplitude of the final part of the ventricular complex decreased by 2.1%. A number of LVPs in the patient group did not change after administering the antiarrhythmic therapy. We found LVP in 6 of the patients (24.0%) before and after the treatment.

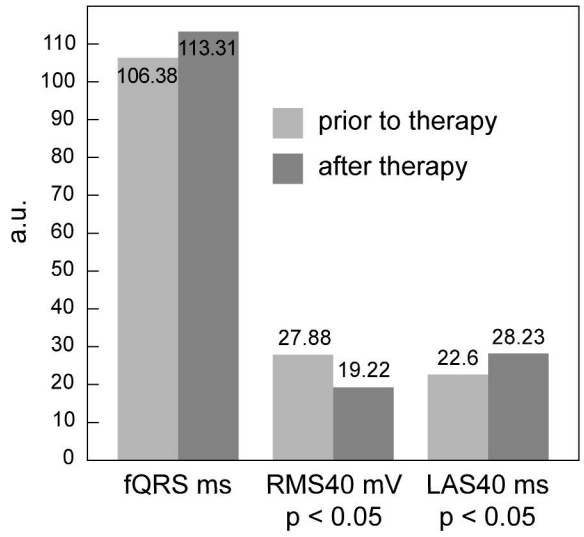

Figure 5. Effect of Propaphenon on the parameters of the signal averaged ECG. Abbreviations as in Figure 3.

At the same time, etmozin had a great influence on SAHRV parameters. We found a 23.4% decrease in part of the high frequency spectral band . In addition, part of the low frequency band increased strongly by 49.7%, and part of the medium frequency band increased by 16.7%. Etmozin depressed parasympathetic activity of the ANS and activated the sympathetic system. The changes we found confirm the hypothesis that antiarrhythmic drugs of the Ic class, and etmozin in particular, have a vagolitic effect.

We found that propaphenon influences SAECG parameters. The filtered QRS complex duration increased by 6.5%, duration of the low amplitude part in the final QRS complex increased significantly by 24.9%, amplitude of the final part of the QRS complex decreased significantly by 31.1%. LVP were registered in 6 patients before the treatment, and in 10 patients after the treatment. We explained the changes, hypothesizing that propaphenol led to further slowing of fragmented electrical activity for patients that alreadyhad electrophysiological ventricular arrhythmias. Propaphenon made SAECG parameters worse and led to the appearance of new LVP.

Propaphenon was found to influence SAHRV parameters; parasympathetic activity of the ANS increased. It was evidenced by the significant increase of part of the

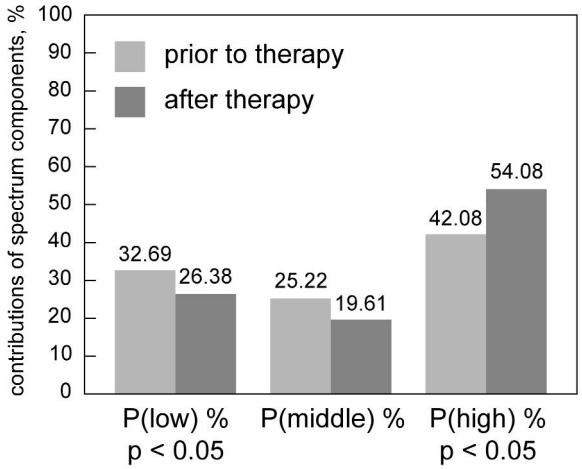

Figure 6. Effect of Propaphenon on the HRV spectral analysis parameters. Abbreviations as in Figures 2 and 4.

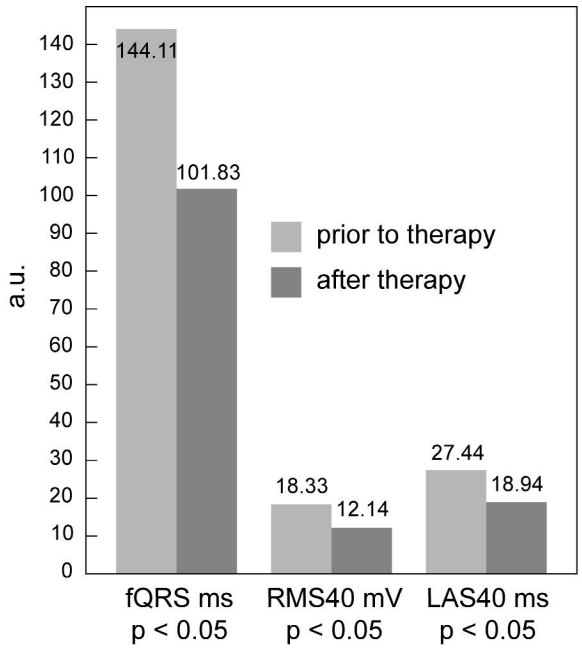

Figure 7. Effect of Propranolol on the parameters of the signal averaged ECG. Abbreviations as in Figures 3 and 5.

high frequency band by 28.5%. At the same time propaphenon depressed sympathetic activity; part of the low frequency band decreased by 19.3%, and part of the medium frequency decreased by 22.2%.

Hence, propaphenon differed in its influence on the ANS from another class of Ic drugs such as etmozin. The sympathetic effects of propaphenon can be explained by the fact that propaphenon has properties similar to the beta-adreno-blockers.

Propranolol differed from the other drugs under investigation in the influence on SAECG parameters. Propranolol was found to significantly decrease the duration of the filtered QRS complex by 29.3%, and the the low amplitude duration of the final part of the ventricular complex by 30.9%. In addition, the amplitude of the final part of the ventricular complex significantly decreased by 33.8%. As a result of antiarrhythmic therapy, a number of LVP in the patient group decreased: 6 patients had LVPs before the treatment (24.0%), and 3 patients - after the treatment (12.0%).

The influence of propranolol on the autonomic nervous system was such that a part of the high frequency spectrum band of the variable heart rate increased by 48.8%; part of the low frequency band decreased by 35.8%, and part of the medium frequency band decreased by 19.7%.

Propranolol had more influence on the high frequency band than propaphenon, effectively influencing the medium frequency band too. Thus, propranolol successfully effected LVP although it had less antiarrhythmic effect in comparison to etmozin and propaphenon. By changing SAECG parameters, propranolol led to complete vanishing of the LVP in a number of cases. This fact could be explained by the improved conduction of the fragmented electrical activity in the myocardium. In addition propranolol influenced auto-

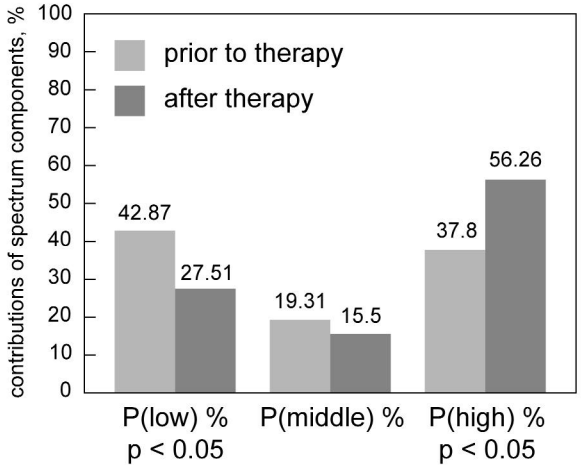

Figure 8. Effect of Propranolol on the HRV spectral analysis parameters. Abbreviations as in Figures 2, 4 and 6.

nomic control of the heart rate by depressing sympathetic activity and activating parasympathetic activity. This effect was especially important for patients who developed "rigid rhythm" in organic heart failures caused by high activity of the sympathetic nervous system.

Conclusions

In summary, it should be noted that:

- Examination of SAECG and SAHRV parameters can be useful for optimizing antiarrhythmic therapy.
- Etmozin can be prescribed to patients with ventricular tachycardia combined with registered late ventricular potentials and with disturbance of the autonomic control of heart rate in the form of increased parasympathetic activity.
- Propranolol is preferable for patients with ventricular tachycardia combined with registered late ventricular potentials and enhanced sympathetic activity of the ANS.
- Propaphenon is recommended for patients with ventricular arrhythmia that have no late ventricular potentials but have enhanced sympathetic influence of the ANS on heart rate.

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