Letter to the Editor

Effect of terahertz irradiation of 240 GHz of nitrogen oxide occurrence on blood rheological properties

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Abstract: The presented research aimed to study biophysical effects of exogenic and endogenic nitrogen oxide (NO) molecules in crossed magnetic and electric fields, with their molecular emission and absorption rotation spectra (MEAS) of 240 GHz occurrence, on blood rheological properties in the patients with unstable angina. 60 patients, aged 55.6±0.93 years, with unstable angina were included in this study. The study results display that the further research is necessary in normalizing influence of MEAS of 240 GHz nitrogen oxide occurrence in crossed magnetic and electric fields on defected blood rheological properties.

Keywords: nitrogen oxide, terahertz irradiation, blood rheology

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Introduction

Ischemic heart disease (IHD) is one of the most widespread diseases not only in Russia, but in other developed countries. At this nosology a high percent of death rate is fixed, and also temporal and persistent disability.

In this connection the question of IHD takes one of the major places among the most significant medical problems of the 21st century. There had been indicated that in 80s there was a reducing trend of the death rate, but, nevertheless, according to statistical data in European developed countries, it was about 1/5 of the whole population death rate and it was a significant irregularity in the distribution in contingent (age and sex) [1].

In the patients with IHD, and with unstable angina, there is an evident hemorheology defect: blood viscosity, blood serum and blood plasma, aggregation and erythrocytes deformability [2]. Classical drug treatment of unstable angina does not always lead to a proper result, as it has many side effects and short remission; it is also rather expensive [2].

Active EHF-therapy usage in modern cardiology proves its efficiency in different forms of IHD treatment [3-9]. The most significant biologically active substances, oxygen and nitrogen oxide (NO) take important places in regulation of hemorheology system functioning [10-12]. The role of nitrogen oxide had been experimentally proved in prevention of cardiovascular dysfunction and, as a result, an increase of a long-term survivability [13].

Normalization of hemorheology parameters is fixed in experimental model of blood rheological properties after immobilization stress in white rats, the model can be considered as a model of imitation of a blood viscosity change in the patients with unstable angina in THz radiation of MEAS (molecular emission and absorption spectrum) of 150.176-150.664 GHz NO occurrence [3]. In the recent experiments [2] there had been also shown a positive effect of extremely-high frequencies (EMI) with 150.176-150.664 GHz frequencies on blood rheological properties in the patients with unstable angina at in vitro conditions.

In many of researches there had been received data of a normalization of a hyperviscosity, antianginal, hypocoagulative effect of THz-irradiation of MEAS (molecular emission and absorption spectrum) of 150.176-150.664 GHz nitrogen oxide occurrence, this lets speak of its possible usage in the patients with IHD, an with unstable angina, as well. A 240 GHz nitrogen oxide occurrence has more evident quantum energy, so, it has stronger reactivity [14]. So, we can suppose, that NO molecules reactivity, as in a whole blood (endogenic nitrogen oxide molecules) as the molecules diffusing in an air flow (exogenic nitrogen oxide molecules), would be maximal in the mentioned THz-band. Taking this into account, we may assume that the character of an interaction of NO of atmospheric oxygen molecules stimulating by EMI of THz-band of 240 GHz occurrence with a whole blood will significantly depend not only on standard parameters of EMI of THz-band exposure (the power density, time of exposure, modulation type, etc.), but on a topology and values of crossed magnetic and electric fields in which there is no interaction.

In this connection for experimental study of the interaction of a whole blood and THz waves, the most completely reflecting natural processes, it is necessary to take into account the effects of constant electric and magnetic fields (constantly in the environment and change depending on different natural and non-natural events) on blood rheological properties.

The presented research aimed to study biophysical effects of exogenic and endogenic NO molecules in crossed magnetic and

electric fields, with their molecular emission and absorption rotation spectra of 240 GHz occurrence, on blood rheological properties in the patients with unstable angina.

Material and Methods

The whole blood samples of the patients with unstable angina had been taken as an object of this study. The main group consisted of 60 patients with unstable angina, aged 55.6±0.93 years. There was the following criterion of including into the study: administration to the emergency department with unstable angina appeared during last 48 hours in the forms: rest angina (pain progressing in rest and in minimal strength, more than 5 minutes and less than 30 minutes), effort angina (in activity which had not caused it before), increase of angina episodes after confirming in ECG (T-wave inversion, ST segment increase more than 0.5 mm: not enough to detect an acute myocardial infarction).

There was the following criterion of excluding out of the experiment: incipient postinfarction angina; new-oneset angina; new insults (less than 6 months); age is older than 70 years; the weight of the patients is 40 kg or more than 110 kg; blockade of the left bundle of atrioventricular bundle (except the initial obstinate blockade); ST segment increase more than 1 mm in two contiguous ECG leads; implanted cardiostimulator; renal failure (creatinine more than 200 mcmole/l); thrombocytopenia (less than $150*10^9$ ml^{-1}); liver failure; bacterial endocarditis; native or nonheritable hemostasis pathology.

All of the patients signed a written consent of taking part in the research which included clinical examination, echocardiography, 12-lead ECG, and biochemical blood count (concentration of: creatinine, sodium and kalium ions, glucose, lipids, triglycerids).

Median cubital vein blood sampling had been performed at 8.30-9.00 o'clock before meals after hospitalization. 3.8% sodium citrate fluid was used as a blood anticoagulant in proportion 9:1. There were 20 relatively healthy donors-subjects, an average age was 54.3±0.67 years.

The research was organized with the help of the rotation viscosimeter with a free-floating cylinder. The rotational viscosimetry method corresponds to requirements of blood rheological properties estimating [15, 16]. The whole blood viscosity had been estimated under the specific rate-of-shear of 300, 200, 100, 50, 20, 10 and 5 sec^{-1}. According to the received results the erythrocytes aggregation index (EAI) and erythrocytes deformability index (EDI) had been measured.

Experiments in studying of the interaction of THF-field and the whole blood of 240 GHz of MEAS of nitrogen oxide had been performed with the help of a quasi-optical EHF generator of determinate noises, developed in the Central Scientific Institute of Measuring Equipment (Saratov, Russia) [17]. The formation of irradiating electromagnetic field had been performed, imitating MEAS of nitrogen oxide on the frequencies given above.

To improve the diffusion efficiency of NO molecule from atmospheric oxygen into plasma, there had been used crossed magnetic and electric fields and laminar air flow organized along the blood surface. In the previous studies of these authors the electrodynamical model had been examined in more detail [18]. The experimental blood sample had been set in crossed magnetic (0.7 TTL) and electric (intensity 1 kv/cm) fields and influenced by the electromagnetic irradiation of MEAS of (240 GHz) nitrogen oxide ($P = 1$ mV/cm^2), during 5, 15 and 30 minutes.

Statistical manipulation of the data had been organized with the help of the Mann-Whitney U-test (Statistica 6.0 soft).

Results and Discussion

The results of the study display an evident (statistically valid) increase of a blood viscosity under the low and high rate-of-shear in the patients with unstable angina, comparing with healthy donors, and this corresponds to other results [2, 19, 20].

During the 5-minute irradiation of the whole blood in THz-band of 240 GHz nitrogen oxide occurrence in crossed magnetic and electric fields, there was a reduction of whole blood viscosity in high rates-of-shear and erythrocytes deformability index. There had not been fixed statistically valid differences between parameters of a blood viscosity, in low rates-of-shear and in erythrocytes aggregability.

In the 15-minute irradiation of the whole blood there was a reduction (statistically valid) of whole blood viscosity in rates-of-shear of 300, 200, 100, 50, 20, 10 and 5 sec^{-1}, and a (statistically valid) reduction of erythrocytes aggregation index comparing with the patients with unstable angina the whole blood of whom had not been irradiated. An erythrocytes deformability index had not been changed (statistically valid).

In the 15-minute irradiation of the whole blood there was a reduction (statistically valid) of whole blood viscosity as in high as in low rates-of-shear, but there were no statistically significant differences between the erythrocytes aggregation and deformability indices.

It is known that blood viscosity properties are caused by erythrocytes aggregation and deformability, hematocrit, fibrinogen concentration, soluble fibrin-monomer complexes and fibrin degradation products [21]. The blood viscosity is also determined by the proportions albumin/fibrinogen and albumin/globulin, and vasculature geometry [21].

Erythrocytes take a significant place in formation of blood viscosity cell component, because of their big diameter and quantitative concentration in blood [22]. Erythrocytes aggregation and deformability properties, their form and size have influence significantly on blood viscosity [22].

Erythrocytes aggregation mediates due to its adhesive strength between cells. This process depends much on a fibrinogen concentration in blood plasma, as it is absorbed easily to erythrocytic membrane, leading to an aggregation and erythrocytes deformability increasing. An electric charge of erythrocytic membranes is one of the most significant physicochemical erythrocytes properties. Erythrocytes with normal Z-potential have electrostatic repulsion force, enough to countermeasure of erythrocytes aggregation.

One of the most important rheological phenomena, which let erythrocytes go through vessels, is erythrocytes deformability [23]. This parameter is determined by three basic factors: viscoelastic properties of membrane, viscosity of intracellular fluid and cell geometry.

Normalization of blood viscosity parameters in the patients with unstable angina in the THz-irradiation of MEAS of 240 GHz nitrogen oxide occurrence in crossed magnetic and electric fields, may be caused by high reaction ability of free endogenic and exogenic nitrogen oxide, and, probably, by an increase of its concentration in THW influence on NO-synthase and their catalyzation [18, 24]. Nitrogen oxide can normalize a defected

conformational fibrinogen structure – one of the basic factors determining blood viscosity properties [21].

Normalization (in some degree) of erythrocytes aggregation in the patients with unstable angina in the THz-irradiation of MEAS of 240 GHz nitrogen oxide occurrence in crossed magnetic and electric fields, can also be determined by restoration of a defected structure of fibrinogen adhesive protein and physicochemical of erythrocytes membrane properties, and their electric charge as well.

Normalization of erythrocytes deformability may be as in nitrogen oxide influence on erythrocytes membrane and their intracellular fluid viscosity [10] as in by change in geometric parameters of vessels because of their dilation [25]. This effect may be caused by blood cells velocity influenced by MM-irradiation energy in blood and lymphatic vessels [26].

Conclusion

The presented data display that the further research is necessary in normalizing influence of MEAS of 240 GHz nitrogen oxide occurrence in crossed magnetic and electric fields on defected blood rheological properties.

Conflict of interest: none declared.

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