EXPERIMENTAL COMPARATIVE EVALUATION OF ULTRASONIC MEASUREMENTS OF POST-COMPRESSIVE AND POSTRADIAL (NARROW SPECTRAL INFRA-RED RAY IRRADIATOR) CHANGES IN THE DIAMETER OF THE BRACHIAL ARTERY

Azizbek Ashurmetov, Gulnora Rozyhodzhaeva

Central Clinical Hospital №1 of Medical-Sanitary Association, Tashkent, Uzbekistan, e-mail: gulnoradm@inbox.ru

Summary: Purpose of this research was **t**o identify influence of narrow spectral infra-red (IR) irradiators on endothelium-dependent vasodilatation in patients with cardiovascular diseases (CVD), risk factors and without them. Thirty-six males with CVD and risk factors were examined. Twelve practically healthy males comprised a control group. An endothelial function of the brachial artery (BA) was determined with a reactive hyperemia assay according to Celermajer. An original Dopplersonography- technique was used in the same patients examined following application of an IR radiator to the brachial artery. An endothelial dysfunction (ED) of BA revealed with a known method according to Celermajer in the main group was also proved at the use of the original technique. Paradoxical vasoconstriction which was found during utilization of a reactive hyperemia assay was identified in some patients. A direct correlation between these techniques was revealed and the correlation ratio was $r=0.66$ ($p<0.05$). Also, this method is developed as informative in diagnostics of ED of BA, and we think that it will take a relevant place in a comprehensive examination of patients with CVD and risk factors.

Keywords: Dopplerography, endothelial dysfunction, narrow spectral infra-red irradiators

Relevance. Vascular atherosclerosis begins with functional changes in endothelium. ED is an important clinical correlate of atherosclerosis in an early phase of its development and is associated closely with such risk factors as arterial hypertension, smoking, an elevated level of cholesterol, diabetes mellitus and obesity. It is important to note a secretory function of endothelial cells, viz. NO-dependent relaxation of smooth muscular cells of the vascular wall. NO participates in many physiological and pathophysiological processes of the majority of bodily systems. Disturbance of NO synthesis with endothelial NO-synthase and its oxidation by free radicals is one of pathogenetic chains of cardiovascular diseases.

A state of an endothelial function *in vivo* was investigated for the first time by Ludmer et al. proceeding from coronary angiography data prior to and after administration of acetylcholine [1]. Although this technique estimates vessels, identification of pathology of which has an important clinical value, its utilization is limited with its invasiveness, technical complexity and high cost.

Celermajer et al. were the first to describe a method of non-invasive evaluation of an

endothelial function of the brachial artery in 1992 [2]. Compression of the artery with a cuff undertaken during the study leads to ischemia of a distal arm. Elimination of compression results in development of reactive hyperemia. An enhanced blood flow produces a mechanical effect on the artery wall resulting in activation of ionic channels of endothelial cells [3] and calcium buildup in them. The last activates an endothelial NO-synthase accompanied by NO excretion, which produces a relaxation effect on the vascular wall [4].

It is known that hemoglobin NO-complexes are photosensitive and break down with emission of nitrogen oxide. Besides, infra-red light (HeNe laser) activates blood phagocytes and tissue macrophages that causes development of primary radicals (O_2, NO). The laser, however, only stimulates radical production but does not provide their inactivation that can result in adverse events (peroxynitrite formation).

Narrow spectral IR irradiators have a peculiarity that the power spectrum of their influence corresponds to a human energy radiation spectrum or is below it. Within these ranges ultrasonic irradiators do not produce any negative effect in healthy individuals [5].

Purpose of the research: evaluation of original method for identification of an endothelial function in patients with cardiovascular diseases and risk factors.

Materials and methods. Results of follow-ups of 36 males (the main group) aged 24 to 61 years (a mean age was 46.2), and 12 males (the control group, the mean age was 40.7 y.o.) who had no vascular risk factors were analysed. All subjects underwent a comprehensive examination which included collecting of the past history, general examination, study of blood lipid and glucose levels, electrocardiography and echocardiography.

To evaluate an endothelial function all males included in the research underwent a reactive hyperemia assay according to Celermajer, viz. ultrasonic measurement of a pulse systolic rate (PSR) and the diameter of the brachial artery before and after compression (5 min. exposition). The absence of the arterial blood flow in the brachial artery more distally to compression was controlled with ultrasonic Doppler. Repeated measurement was done after the cuff had been taken off in the same place. Changes of indicators were estimated in dynamics in 30 sec, 60 sec, 90 sec, 180 and 240 sec. Enlargement in the diameter (ED) of the brachial artery was taken as the basic indicator of estimation of the endothelial function. The result was calculated according to the formula: $ED = 100\% \times (D_2 - D_1) / D_1$, where D_1 is the diameter of the brachial artery prior to compression; D_2 - the maximal diameter of the brachial artery following compression. The threshold value of ED of the brachial artery for estimation of ED makes 10%.

An original ultrasonic technique of estimation of an endothelial function in the brachial artery with utilization of narrow spectral IR irradiator (ZB – working range of wave-length of useful irradiation of 22.5 mcm) was used in the same patients.

Enlargement in the diameter of the brachial artery was calculated according to the formula: ED = 100 % x ($D_{prior\ to} - D_{after}$) / $D_{prior\ to}$, where $D_{prior\ to}$ – the diameter of the brachial artery prior to irradiation with IR irradiator; D_{after} - the maximal diameter of the brachial artery after irradiation with IR irradiator.

An experimental character of the test was explained to all participants and a written consent to its performance was obtained from them. All researches were carried out by the same specialist in ultrasonic diagnostics. Prior to the study patients were recommended to refrain from taking any medication affecting the cardiovascular system. HD3 Philips devise (Holland) with linear gauge L 5-7.5 MHz was used for taking ultrasonic measurement of PSR and the diameter of the brachial artery.

Results and discussions. All patients of the main group suffered from CVD or had risk factors. The analysis of mean values of ED of the brachial artery in the control and main groups measured with a reactive hyperemia assay according to Celermajer made 13.0±3.2% and 7.7±5.4 % respectively. A comparative analysis of mean values of ED demonstrated that the indicator was statistically less in the group with CVD in comparison with the control one.

Average values of ED of the brachial artery in the control and main groups which were obtained by our original ultrasonic technique made 13.5±3.8% and 5.9±3.9% respectively. A comparative analysis of average values of ED revealed that the indicator was statistically less in the main group with CVD in comparison with the controls. A correlation analysis established direct dependence ($r=0.66$, $p<0.05$) between the two techniques of identification of endothelium-dependent vasodilatation. The analysis of the data obtained allowed us to suggest a 10% threshold value of ED for identification of an endothelial dysfunction at carrying out of the test with utilization of a narrow spectral IR irradiator. We did not observe any side effects and complications at carrying out of the suggested diagnostic method even in a single case.

The basic principle of diagnostic methods for revealing an endothelial dysfunction is utilization of various stimuli (pharmacological, mechanical, reflex) impacting the endothelium and resulting in NO emission. Registered changes in the diameter of vessels reflect a functional state of endothelial cells. Previously a method of studying coronary arteries with utilization of acetylcholine during coronary angiography [1] was widely used. Now methods of studying peripheral arteries with utilization of a short-term compression enjoy great popularity [6-8]. A post-compression degree of enlargement of the vascular diameter makes it possible to judge on the state of an endothelial function.

We found it possible to use quantum energy of a narrow spectral IR irradiator as a stimulus and also developed new criteria for estimation of results.

Any pathological processes in the human body entail a change in the energy state of an

organ, its part or the entire body. The wavelength of IR radiation should not have quantum energy higher than that produced by an individual himself. At the same time, it should be such as that it could be used for adjustment of photochemical process rates in the body. The action of an IR irradiator (ZB series) is based on "shaking" of intermolecular bonds between "pathological" molecules of an alien tissue. Chemical bonds of molecules in the human body are strong. Bonds between molecules of a pathological connecting tissue are less strong and they break due to the action of an IR irradiator [9].

It is known that each substance and each intermolecular bond has its certain spectrum, both that of irradiation and absorption. It means that bodily tissues possess selective sensitivity, which supports their vital activity. Therefore, it is expedient to use narrow spectra of a far IR range for successful treatment and diagnostics. They are such narrow spectral ultrasonic irradiators that have been developed on the basis of oxidic ceramics at the Institute of Materiology (Tashkent, Republic of Uzbekistan). The spectrum of their radiation lies within the range from 8 to 50 mcm. It means that quantum energy of radiation transformed by ceramics lies within the limits of quantum energy of proper human radiation or below it, and in fact it cannot produce any negative effect on physiological processes of the human body [5, 9].

The analysis of the results obtained demonstrates that the percentage of vasodilatation of the humeral artery is considerably reduced in the main group in comparison with the controls and the suggested technique with use of the IR-irradiator gives results similar to those obtained according to the Celermajer's method. However, the technique proposed makes it possible to detect paradoxical vasoconstriction in a group with risk factors of CVD which is not revealed using a compression test. Peroxide-modified lipoproteins of low density play a direct role in development of endothelium dysfunction inhibiting NO production and causing enhancement in production of endothelin vasoconstrictor -1 [10-12]. Patients with hypercholesterinemia show paradoxical vasoconstriction following stimulation with acetylcholine [13]. In our opinion, stimulation with a narrow spectral IR irradiator reveals paradoxical vasoconstriction in cases of expressed disbalance between vasoconstrictors and vasodilators that is not observed at compression stimulation in patients with hypercholesterinemia.

From a practical viewpoint, the results obtained by us suggest on an opportunity of utilization of the non-invasive and technically simple test developed in a comprehensive examination of patients from CVD and risk factors.

Conclusion. Thus, the method of research offered by us, viz. measurements of the diameter of the brachial artery following impact of a narrow spectral IR irradiator, proves to be informative in diagnostics of ED, especially at a stage of functional disturbances. In the future it can become a routine method of examination of patients with CVD and vascular risk factors and will take its place

in a complex examination of patients.

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