Investigation of Doppler Spectra of laser radiation scattered inside hand skin during occlusion test

Kozlov Igor Olegovich[1], Zherebtsov E.A.[1], Zherebtsova A.I.[1], Dremin V.V.[1], Dunaev A.V.[1]
[1]Orel State University named after I.S.Turgenev

Эл. почта: igor57_orel@mail.ru

Laser Doppler flowmetry (LDF) is method widely used in diagnosis of microcirculation diseases. It is well known that Doppler shift of the laser radiation scattered by moving red blood cells (RBC) can be quantitatively assessed throw analyzing photocurrent produced by photodetector. Today, there are several mathematical models of this process, based on the fundamental work of Bonner and Nossal [1]. This model links integral characteristics of photocurrent's power spectrum with the average concentration of red blood cells in a sampling volume of tissue and their average velocity. The measuring result is relatively linear to velocity and concentration of RBC in diagnostic volume.

Photocurrent's spectrum distribution contains valuable diagnostic information about velocity distribution of the RBC [2]. This information usually disappears after integration procedure. In this research it is proposed to compute the integrals (indexes of microcirculation) in the sub-ranges of the spectrum. Appropriate hardware and software were developed. Single mode 1064 nm laser was selected as the source of sounding radiation. Optical fibers were used to deliver radiation to the skin and to collect backscattering light. Signal processing was conducted in the NI LabVIEW environment.

Applying standard physiological functional tests to a limb results in changing RBC velocity distribution inside the skin. Fourteen experiment of shoulder occlusion were performed in order to record such alternations during the occlusion test [3]. Experiments involved only healthy volunteers. During the experiments simultaneously obtained parts of power spectra from fingers in consecutive frequency ranges 60 – 400 Hz, 400 – 800 Hz, 800 – 1600 Hz, 1600 – 3200 Hz, 3200 – 6400 Hz were processed. Every experiment was conducted following the protocol: recording of the background level of perfusion (3 min); occlusion test (3 min); post-occlusion recording (5 min).

Processing of the obtained experimental data has shown that at the moment of the post-occlusion reactive hyperemia (PORH), Doppler power spectrum undergoes broadening and the spectrum maximum shifts to the high-frequency range. This effect can be explained by increasing number of ensembles of RBC with higher velocity in the optical sampling volume of the skin. The main statistical parameters (mean and standard deviation) of perfusion alteration during the occlusion test were calculated in the selected spectral ranges of power spectrum integration.

Further, experimental studies in the group of patients with microcirculation diseases are planned. The comparison of the data from the patients with the data from healthy volunteers will allow to substantiate new diagnostic criteria.

The work was supported by RFBR grant for research projects carried out by young scientists (My first grant) № 16-32-00662.

Список литературы

1. Bonner R. and Nossal R., Model for laser Doppler measurements of blood flow in tissue, Appl. Opt., 20, 2097-2107, 1981;

2. Dunaev A.V. and Zherebtsov E.A., Novel measure for the calibration of laser Doppler flowmetry devices, Proc. SPIE 8936, Design and Quality for Biomedical Technologies VII, 2014;

3. Zherebtsova A.I and Zherebtsov E.A., Study of the functional state of peripheral vessels in fingers of rheumatological patients by means of laser Doppler flowmetry and cutaneous thermometry measurements, Proc. SPIE 9917, Saratov Fall Meeting 2015: Third International Symposium on Optics and Biophotonics and Seventh Finnish-Russian Photonics and Laser Symposium (PALS), 2016, 99170M

URL: http://physica.spb.ru/data/uploads/physica2016thesises.html#Optika_i_spektroskopiya