State University – Education-Science-Production Complex

SCIENTIFIC-EDUCATIONAL CENTER BIOMEDICAL ENGINEERING

http://www.bmecenter.ru/en

SPE "LAZMA"

www.lazma.ru/eng

Experimental studies of the relationship parameters of microcirculation and redox ratio

V.V. Dremin[1], I.N. Novikova[1], S. Zhu[2], A.P. Baklanova[3], A.V. Dunaev[1], V.V. Sidorov[3]

[1]State University – Education-Science-Production Complex, Scientific-Educational Center of Biomedical Engineering, Oryol, Russia,

[2]University of Dundee, Dundee, UK

[3]SPE "LAZMA" Ltd., Moscow, Russia

Introduction

Quantitative spectroscopic analysis methods, such as **fluorescence spectroscopy (FS)** are a rapidly developing area of medical optical diagnostics. In particular, the study of redox-processes (redox ratio – RR) is important in the assessment of the metabolic activity of tissues.

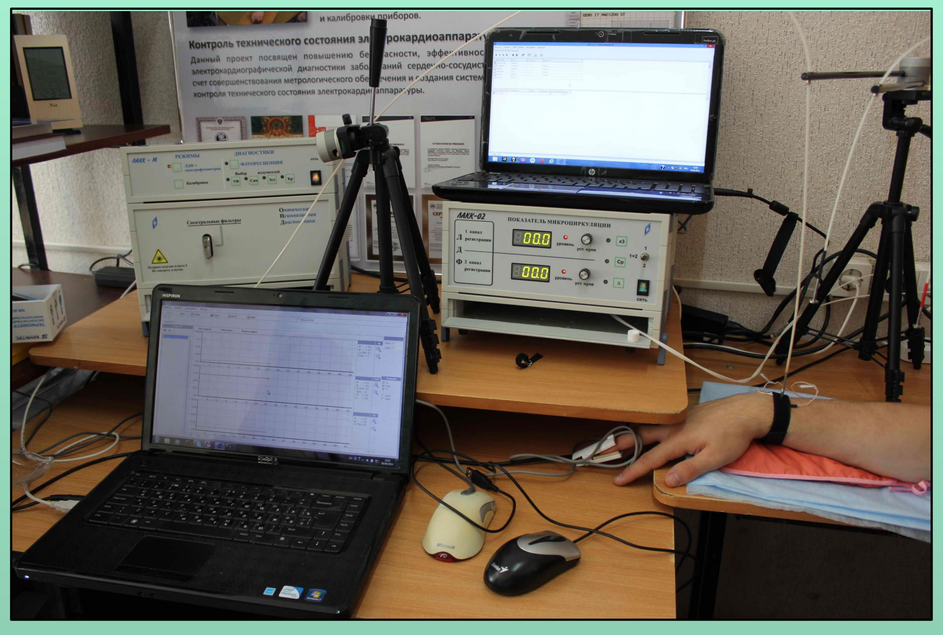
The aim of research

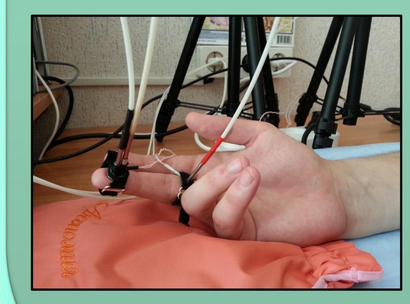
The aim of this work was the experimental search for the relationship between the RR, defined by FS, and nutritive blood flow, defined by the methods **of laser Doppler flowmetry (LDF)**.

The method of research

Comprehensive studies on the devices "LAKK-02" and "LAKK-M" (SPE "LAZMA" Ltd)

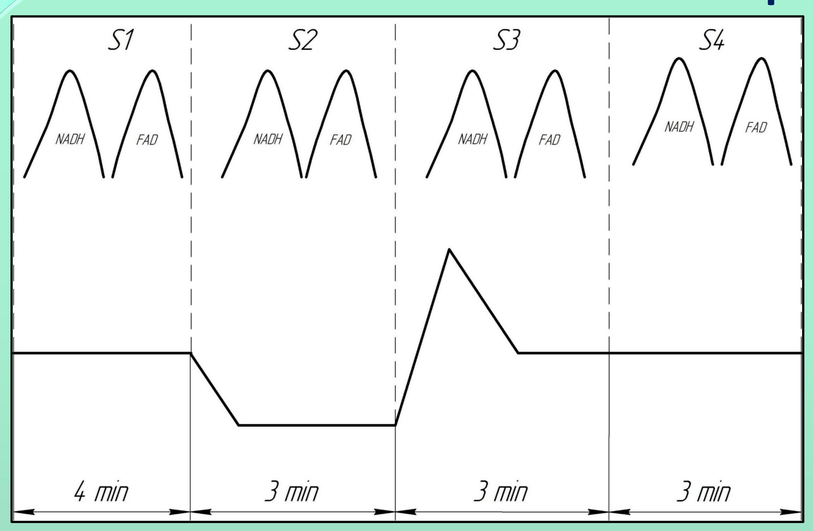
Experimental studies were carried out in two points on the skin: **skin pads** (palmar surface) of the right middle finger and on the outside of the right **forearm**.





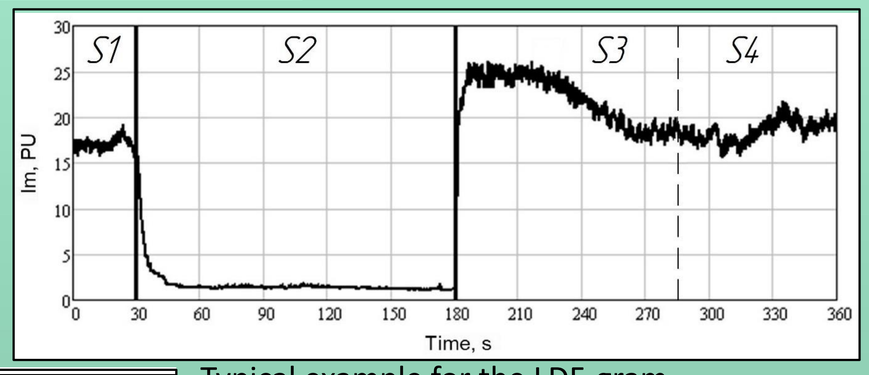
The perfusion (Im – index of microcirculation) and the fluorescence amplitude of **NADH** and **FAD** (at excitation wavelengths of 365 nm and 450 nm respectively) were simultaneously measured at each point by using two devices: the "LAKK-02" (**LDF channel**) and the "LAKK-M" (**FS channel**) by combining fibers.

The Concept

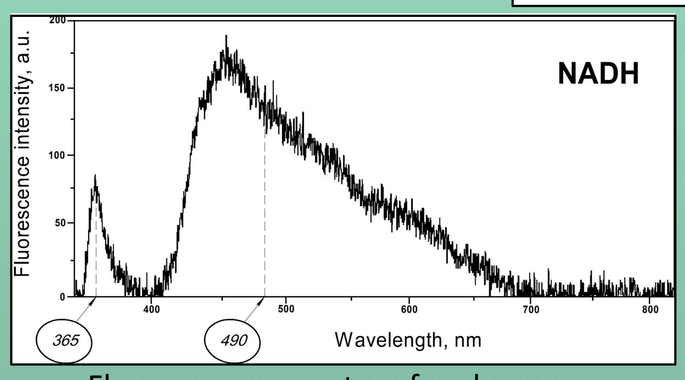


The study consisted of **4 stages**: state of rest, artificial ischemia (occlusion of the forearm), reactive hyperemia and recovery (relaxation).
Experimental studies were carried out with the participation of 34 apparently healthy volunteers (**34 recordings** to the fingertip and **17 recordings** to the forearm) of approximately the same age.

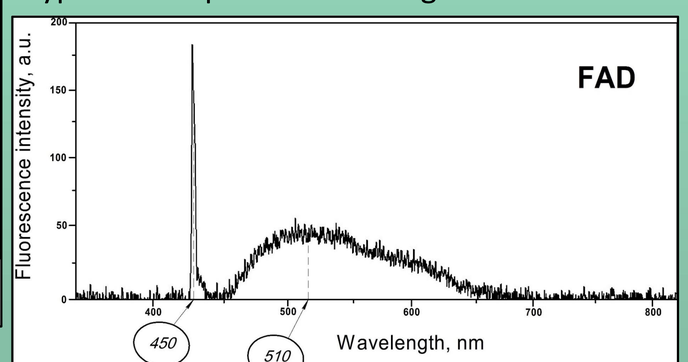
RR was calculated using four different approaches on the basis of fluorescence amplitudes of NADH and FAD. Nutritive blood flow was calculated on the basis of perfusion.



Typical example for the LDF-gram



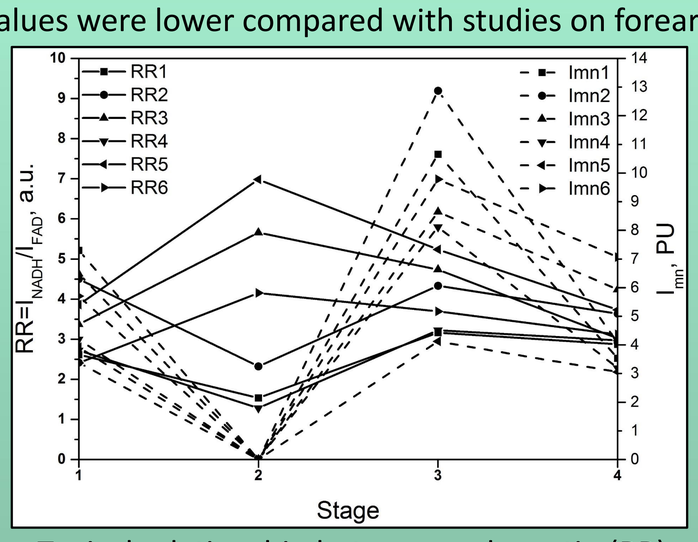
Fluorescence spectra of endogenous fluorophores (**NADH** and **FAD**) in the right forearm of Caucasian skin type



Results and Discussion

A direct correlation between the forearm measurements of RR and the level of blood flow in the stages of occlusion and hyperemia was noted in most of the volunteers. The highest correlation was noted using formula №3 (see Table). This is confirmed by theoretical data. On the skin of the fingertip (zone with arteriovenous anastomoses), the correlation values were lower compared with studies on forearm.

	The number of volunteers
$RR1=I_{NADH}/I_{FAD}$	9
$RR2=kf_{NADH}/kf_{FAD}$	10
$RR3=I_{NADH}/I_{FAD} \times I_{bs\_FAD}/I_{bs\_NADH}$	**13**
$RR4=I_{NADH}/(I_{NADH}+I_{FAD})$	9



Typical relationship between redox ratio (RR) and nutritive blood flow (Imn) registered on the forearm of 6 volunteers in an experiment of 4 stages with occlusion test.

This may be due to the changes in blood flow being related to thermoregulatory processes in addition to metabolism. In the last stage, the different volunteers were observed to undergo different types of relaxation on the forearm with the restoration of metabolic rate (up to occlusion RR = 1.43 ± 0.49 AU; at relaxation RR = 1.42 ± 0.50 AU), and with the maintenance of it at a constant high level (up to occlusion RR = 1.32 ± 0.84 AU; at relaxation RR = 2.10 ± 1.23 AU). This may be due to a variety of adaptive abilities of volunteers.

Conclusion:

Preliminary results in the study of a complex approach to diagnosis of the state of biological tissue were obtained. A positive relationship between the nutritive blood flow in the microcirculatory channel and RR of skin tissue is observed. The positive results of these experiments suggest the need to continue further studies, as this will result in the improvement of the methodological and the instrumental base for use of fluorescence spectroscopy technology in medicine.

Acknowledgements:

This work were supported by basic part of the state task of the Ministry of Education and Science of the Russian Federation (GZ №310), by the grant of State University ESPC (VK-3-2013), by the Russian Foundation on Innovations U.M.N.I.K. and by FP7 EU IAPP projects (ABLADE). The research were performed in collaboration with: University of Dundee (UK) and Priorov Central Research Institute of Traumatology and Orthopaedics (Russia).