

# Wearable multimodal laser analyzers in assessing of microcirculatory disorders in the long COVID syndrome

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**Abstract** — The paper presents the results of the study of the effect of long COVID on the functional state of microcirculatory-tissue systems of the human body using wearable multimodal laser analyzers.

**Keywords** — *microcirculatory-tissue system, laser Doppler flowmetry, fluorescence spectroscopy, wearable devices, long COVID, blood microcirculation*

## I. INTRODUCTION

Numerous studies in recent years have shown that the microcirculatory disorders may be one of the potential mechanisms for the development of long COVID syndrome [1]. Our previous work demonstrated the use of laser Doppler flowmetry (LDF) to diagnose vascular disorders in patients after COVID-19 [2]. The aim of this work was to study with the use of wearable multimodal laser analyzers how long COVID affects the functional state of microcirculatory-tissue systems of the human body.

## II. MATERIALS AND METHODS

To conduct the study, 6 devices implementing LDF and fluorescence spectroscopy (FS) channels “LAZMA PF” (SPE LAZMA Ltd., Russia; in EU/UK this device is made by Aston Medical Technology Ltd., UK as “FED-1b”) were used. The devices were placed symmetrically in areas of the pads of the middle fingers, the back of the wrists, and the skin of the forehead. Thirty-eight patients who had suffered COVID-19 infection of varying severity and noted various symptoms of long COVID syndrome participated in the study. On admission, patients filled out a questionnaire about the presence and duration of long COVID symptoms, on the basis of which a conclusion about the severity of its course was formulated according to the sum of scores. According to the results of the survey, the subjects were divided into 3 groups: group 1 included 11 patients (mean age 50 years) with mild degree of long COVID syndrome, group 2 included 10 patients (mean age 49 years) with moderate degree, and group 3 included 17 patients (mean age 60 years) with severe degree. During the measurements, the subjects were in a sitting position at a table, hands placed on the table surface at heart level. The study involved taking a cognitive test in the form of completing Schulte tables, during and after which parameters were recorded

only in the forehead skin area. The study included recording the basal level of parameters for 10 min, conducting a cognitive test, depending on the individual taking from 3 to 5 min and recording the parameters upon completion of the cognitive task for 7 min.

## III. RESULTS AND DISCUSSION

The study showed that patients with moderate and severe course of long COVID are characterized by reduced values of the index of blood microcirculation in the forehead skin area ( $I_m = 15.9 \pm 2.7$  p.u.;  $11.2 \pm 3.4$  p.u.;  $12.3 \pm 4.6$  p.u.), due to decreased shunt blood flow ( $M_{shunt} = 10.6 \pm 2.3$  p.u.;  $6.4 \pm 2.0$  p.u.;  $7.6 \pm 3.9$  p.u.). In the forehead skin area of patients with moderate severity of the long COVID a decrease in amplitudes of all active mechanisms of microcirculation regulation (endothelial, neurogenic, myogenic) was noted.

The areas of fingers and wrists in patients with more severe course of long COVID are characterized by an increase in tissue perfusion, as well as a significant increase in the level of nutritive blood flow. In the area of fingers in patients of groups 2 and 3 there is a decrease in NADH fluorescence intensity and an increase in the oxidative metabolism index, which may be associated with an increase in nutritive blood flow in this area.

Thus, the study showed that patients with more severe course of long COVID are characterized by a decrease in forehead skin tissue perfusion and activity of mechanisms regulating microcirculatory blood flow. Assessment of the dynamics of these parameters can be used to evaluate the effectiveness of therapeutic actions in the process of rehabilitation measures.

## ACKNOWLEDGMENT

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## REFERENCES

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