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# Imaging photoplethysmography to study blood supply in patients with systemic lupus erythematosus and systemic scleroderma

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**Abstract**— The parameters of facial blood supply were studied in patients with systemic lupus erythematosus and systemic scleroderma using a non-contact imaging photoplethysmography method synchronized with an electrocardiogram. Statistically significant differences in the amplitude and time of arrival of the pulse wave to different areas of the face were revealed in sick patients compared with the control group.

**Keywords**— *blood circulation; microcirculatory disorders; systemic lupus erythematosus; systemic scleroderma; imaging photoplethysmography; electrocardiogram.*

## I. INTRODUCTION

Systemic lupus erythematosus (SLE) and systemic scleroderma (SSD) are chronic multisystem autoimmune diseases characterized by lesions of the skin, blood vessels, musculoskeletal system, heart, kidneys and other internal organs and systems. Diagnosis of these diseases is difficult due to the erased symptomatic picture, and the mechanisms that trigger autoimmune reactions in individuals predisposed to the disease are not fully understood [1]. In this work, patients with SLE and SSD were studied using the imaging photoplethysmography (IPPG) method [2] to identify disturbances in microcirculation parameters in the facial area in comparison with healthy controls.

## II. MATERIALS AND METHODS

The study involved 46 female volunteers aged  $46.3 \pm 12.9$  years (18 patients with SLE and 10 with SSD), the control group consisted of 18 healthy women. All studies were carried out with the permission of the ethics committee (protocol No. 1 of March 21, 2023). The amplitude (APC) and arrival time of blood pulsations (PAT) were assessed in 6 areas of the face. To evaluate microcirculation parameters, a module consisting of a video camera (UI-3060CP-M-GL, IDS, Germany) and a specially designed light source comprising 250 green LEDs was used. Video of the subjects' faces was acquired at a rate of 30 frames per seconds with a resolution of  $1800 \times 750$  pixels synchronously with an electrocardiogram. The data was uploaded to a computer for subsequent processing using software developed on the Matlab platform (see Fig.1).

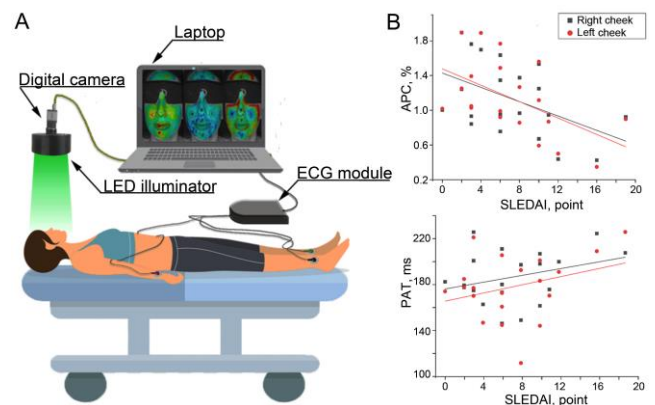


Fig. 1. Study of microcirculation in the facial area using IPPG. A - layout of the experimental setup; B - APC and PAT parameters as functions of Systemic Lupus Erythematosus Disease Activity Index (SLEDAI).

## III. RESULTS

The APC and PAT were assessed simultaneously in different regions of the face: the right and left cheeks, nose, chin, forehead and labrum. A significant reduction in PAT was revealed in patients with SSD compared to the control group, which was apparently caused by excessive collagen formation and high rigidity of the vascular wall. It has been established that the amplitude of pulsations in patients with SLE is significantly less than in healthy people, which can be explained by impaired microcirculation due to inflammatory processes and vascular endothelium lesion. It was found that a high degree of disease activity in patients with SLE (according to the SLEDAI classification) leads to a decrease in APC and an increase in PAT in the studied areas.

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