

Imaging photoplethysmography reveals specific manifestations of systemic lupus erythematosus

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Abstract— Imaging photoplethysmography synchronized with electrocardiography was used to diagnose systemic lupus erythematosus. It was found that patients had significant changes in the microcirculatory blood flow of the facial skin in the cheek area compared with the control. Therefore, the proposed technique can claim to be an objective instrumental criterion of the disease.

Keywords— imaging photoplethysmography; systemic lupus erythematosus; microcirculation; autoimmune diseases.

I. INTRODUCTION

Systemic lupus erythematosus (SLE) is one of the most common connective tissue diseases, which is often difficult to diagnose due to the atypical course of the disease. Most of the clinical criteria are related to skin lesions. The most striking manifestations are caused by acute and subacute facial lesions. The most distinctive rash appears as butterfly-shaped lesions on the cheeks. However, typical skin symptoms, including discoid rash, only occur in about half of cases. In this regard, objectification and increasing the sensitivity of diagnostic methods for skin lesions is an urgent problem.

II. METHODS

In this study, imaging photoplethysmography (iPPG) was employed to measure blood supply to the facial region. The amplitude of the pulsatile component (APC) of the iPPG waveform and pulse wave arrival time (PAT) were analyzed in patients diagnosed with systemic lupus erythematosus without typical facial skin changes ($n=11$) and in healthy volunteers ($n=13$). Simultaneous recording of electrocardiogram (ECG) and iPPG signals was achieved using custom-designed equipment that combined a digital monochrome camera with a green LED illuminator and an ECG signal recording module in the first lead of Eithoven's triangle. Quantitative assessment of APC and PAT indicators was performed over the entire observation time (120 s). To do this, 4 regions of interest (ROI) were identified on the APC map: the left (#1) and right cheek (#2), the skin area above the upper lip (#3) and the chin (#4) of a typical shape that does not affect the nose and lip margins (Fig.1). ROI were selected for analysis with a 50% percentile of the maximum values of the pulsation amplitude. The regions selected on the APC map were automatically transferred to the PAT map. Further, the data obtained in different ROIs were compared with each other.

III. RESULTS

A comparative analysis revealed that average blood flow parameters across all four ROIs were similar in both SLE patients and the control group. However, examining the distribution of iPPG signal indicators among the groups uncovered significant differences. In the control group, APC values were comparable (Kruskal-Wallis test) in all areas, which indicated the relative symmetry of photoplethysmographic characteristics of facial blood flow in this group. Conversely, patients with SLE displayed notable variations in this parameter, with the highest APC levels observed in the cheeks. Furthermore, it was discovered that SLE patients exhibit not only APC asymmetry but also PAT, with the PAT value being particularly low in the cheek region.

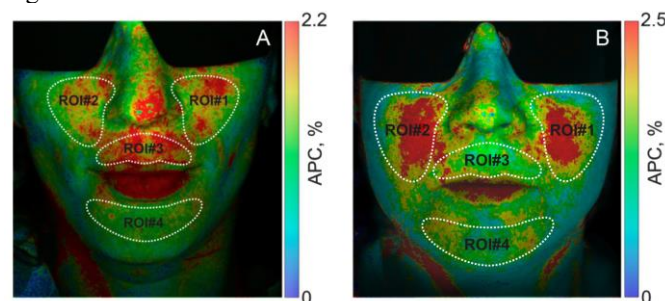


Fig. 1. Examination of the amplitude of the pulsatile component of the iPPG waveform in a control group (A) and patients with systemic lupus erythematosus (B).

IV. CONCLUSION

The study revealed significant disturbances in indices iPPG among patients with SLE, even in the absence of visible skin changes. The specific locations of these changes, typical of the disease, were also identified. The iPPG method allowed us to detect early pathological alterations in microcirculation that are not discernible during a routine physical examination, which is commonly used for clinical diagnosis. Consequently, this technique can be considered an objective instrumental measure of the disease.

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