



CYTOKINE IMBALANCE AND IMMUNE REMODELING IN THE CARDIORESPIRATORY FORM OF POST-COVID CONDITION

Safoev Nurali Nematullaevich

Umarov Bakhtiyer Yatgarovich

**Comprehensive Applicant of the Bukhara Medical University, Head of
the Navoi Regional Health Department**

National Children's Medical Center

<https://doi.org/10.5281/zenodo.17726549>

ARTICLE INFO

Received: 24th November 2025

Accepted: 25th November 2025

Online: 26th November 2025

KEYWORDS

post-COVID condition, cytokine imbalance, immune remodeling, inflammation, endothelial dysfunction, lymphocyte subsets, cardiorespiratory symptoms

ABSTRACT

This study investigates cytokine imbalance and immune remodeling in patients with the cardiorespiratory form of post-COVID condition. Comprehensive clinical, functional, and immunological assessments were conducted to characterize persistent symptoms and underlying mechanisms. Patients demonstrated sustained elevation of pro-inflammatory cytokines, impaired regulatory responses, altered lymphocyte composition, and markers of endothelial activation. These abnormalities correlated with dyspnea, tachycardia, reduced exercise tolerance, and prolonged convalescence. The findings highlight the central role of chronic immune dysregulation in driving cardiorespiratory impairment after COVID-19 and support the use of immunological markers for predicting severity and guiding post-COVID management.

Relevance

Persistent cardiorespiratory symptoms are among the most common and clinically significant outcomes of post-COVID condition, affecting a substantial portion of individuals long after the resolution of acute infection. Symptoms such as dyspnea, chest discomfort, palpitations, and reduced physical stamina often appear disproportionate to findings from standard cardiopulmonary imaging and functional tests. Growing evidence indicates that these manifestations arise not solely from structural damage but from prolonged immune dysregulation, including cytokine imbalance, disrupted adaptive immunity, and endothelial dysfunction contributing to microvascular impairment. Despite increasing research attention, the combined impact of cytokine alterations and immune remodeling on the cardiorespiratory phenotype remains insufficiently explored. Understanding these mechanisms is essential for improving diagnostic accuracy, early risk stratification, and targeted therapeutic interventions. This study addresses these gaps by evaluating key immunological and endothelial parameters associated with persistent cardiorespiratory symptoms following COVID-19.

Aim

To assess cytokine imbalance and immune remodeling and determine their contribution to persistent cardiorespiratory symptoms in post-COVID condition.

Materials and Methods

The study included adults with persistent cardiorespiratory symptoms lasting more than 12 weeks after confirmed SARS-CoV-2 infection. Clinical evaluation encompassed assessment of dyspnea severity, exercise tolerance via six-minute walk test, echocardiography, spirometry, and pulse oximetry. Laboratory investigations included quantification of IL-6, IL-10, TNF- α , CRP, D-dimer, vWF, and adhesion molecules (sICAM-1, sVCAM-1). Flow cytometry was performed to analyze lymphocyte subsets, including CD4+, CD8+, B cells, and NK cells. Inflammatory indices (NLR, PLR) were calculated. Statistical analysis involved correlation testing and ROC modeling to identify the most informative immune predictors.

Results

Patients exhibited significantly elevated IL-6 and TNF- α levels, reduced IL-10, and increased inflammatory indices, indicating persistent cytokine imbalance. Endothelial markers such as D-dimer, vWF, and adhesion molecules were elevated, suggesting microvascular injury. Immune remodeling was reflected in altered CD4+/CD8+ ratios and reduced NK cell counts. These immunological abnormalities correlated strongly with dyspnea intensity, reduced six-minute walk distance, exertional desaturation, and elevated resting heart rate. ROC analysis demonstrated that combined measurement of IL-6, NLR, and D-dimer provided high predictive accuracy for identifying severe cardiorespiratory impairment in post-COVID patients.

Conclusion

This study demonstrates that cytokine imbalance and immune remodeling play a crucial role in the pathogenesis of the cardiorespiratory form of post-COVID condition. Persistent inflammatory activation, impaired regulatory immunity, and endothelial dysfunction collectively contribute to prolonged respiratory and cardiovascular symptoms. The identified immunological markers show strong associations with clinical severity and functional limitations, underscoring their potential value for early detection of high-risk patients. Integrating cytokine and immune profiling into post-COVID evaluation may enhance diagnostic precision, support personalized therapeutic strategies, and improve long-term outcomes for individuals experiencing persistent cardiorespiratory complications.

Literature:

1. Абдурахманов З. М., Умаров Б. Я., Абдурахманов М. М. Современные биомаркеры эндотелиальной дисфункции при сердечно-сосудистых заболеваниях // Рациональная фармакотерапия в кардиологии. – 2021. – Т. 17. – №. 4. – С. 612-618.
2. Абдуллаева М. А. Эффекторное звено иммунитета у больных неспецифическим аортоартериитом // Проблемы науки. – 2018. – №. 6 (30). – С. 102-103.
3. Абдурахманов М. М., Абдуллаева М. А., Умаров Б. Я. Дисфункция эндотелия сосудов и профилактика острых расстройств мозгового кровообращения // Журнал теоретической и клинической медицины. – 2019. – №. 1. – С. 29-31.
4. Khamdamov B. Z., Umarov B. Y. COMBINED LOCAL TREATMENT OF LONG-TERM NON-HEALING WOUNDS://Collection of abstracts of the scientific and practical conference «Current Problems of Surgical Soft Tissue Infections»(2024), Tashkent, October 28 // JOURNAL OF EDUCATION AND SCIENTIFIC MEDICINE. – 2024. – Т. 1. – №. 5. – С. 7-8.