

THE ROLE OF INFLAMMATORY MARKERS IN PREDICTING COMPLICATIONS AFTER MYOCARDIAL INFARCTION

Konstantin Maximovich Linderberg ¹, Anastasiya Andreevna Serkova ², Ekaterina Igorevna Lagutina ³, Nurnazar Saparmuratovich Kurbannazarov ⁴, Ramdan Virkamovich Dubey⁵, Natalia Yurievna Klimenchenko⁶, Akraman Ismailovich Ilyasov⁷

¹Pirogov Russian National Research Medical University, Moscow, 1 Ostrovityanova St., 117513, 0009-0004-4597-616X

²Academician I.P. Pavlov First St. Petersburg State Medical University, 197022, St. Petersburg, st. Lev Tolstoy, 6-8, 0009-0004-6862-4781

³Astrakhan State Medical University³, 121 Bakinskaya Street, Astrakhan, 414000, Russia, 0000-0002-6923-7669,

⁴Astrakhan State Medical University, 121 Bakinskaya Street, Astrakhan, 414000, Russia

⁵Astrakhan State Medical University, 121 Bakinskaya Street, Astrakhan, 414000, Russia, 0009-0008-7482-6602,

⁶Astrakhan State Medical University, 121 Bakinskaya Street, Astrakhan, 414000, Russia, 0009-0006-9194-741X,

⁷Kabardino-Balkarian State University Named After H.M.Berbekov Medical Academy, Nalchik, Inessa Armand Street, 1"а" / 360000/ Russia, 0009-70003-8003-7793,

*Corresponding Author

Article History

Received: 12.08.2025

Revised: 16.09.2025

Accepted: 27.10.2025

Published: 11.11.2025

Abstract:

The purpose of this work is to systematize and critically interpret Russian data on the prognostic value of inflammatory markers in patients with myocardial infarction, with a focus on predicting hospital mortality, cardiogenic shock, reperfusion disorders, left ventricular remodeling, and remote cardiovascular events. The study considers high-sensitivity C-reactive protein, interleukin-6, cellular indices of systemic inflammation based on clinical blood analysis (primarily the neutrophil-lymphocyte ratio), as well as pentraxin-3 and myeloperoxidase as a reflection of local vascular-tissue and neutrophil cascades. The review includes the results of domestic epidemiological programs and registers of acute coronary syndrome, data from multicenter cohorts, and publications from Russian research centers that studied inflammation indices in patients with acute myocardial infarction, including those with cardiogenic shock. The summary indicates that serial assessment of hs-CRP at the stabilization and discharge stage, early detection of IL-6 on the first day, and input cellular indices provide complementary risk stratification, while markers such as PTX3 and MPO expand the tissue specificity of the prognosis, which is consistent with the observations of Russian clinical centers and national registry data.

Keywords: myocardial infarction, inflammation, high-sensitivity C-reactive protein, interleukin-6, neutrophil-lymphocyte ratio, pentraxin-3, myeloperoxidase, Russian Federation, residual inflammatory risk, prognosis.

INTRODUCTION

Myocardial infarction is an acute damage to the heart muscle, which occurs due to a critical disruption of coronary blood flow and leads to necrosis of cardiomyocytes. In clinical practice, it is a condition in which the patient experiences intense pain or its equivalents, and laboratory and instrumental methods record myocardial damage and ischemic changes.

Complications of a heart attack include any adverse events during the hospital stay and the subsequent outpatient period, including heart failure, arrhythmias, recurrent ischemic episodes, adverse left ventricular remodeling, and death. With modern methods of reperfusion and drug therapy, early mortality has been reduced, but there is still a significant risk of subsequent events. This shifts the focus from acute treatment to long-term prediction and personalized monitoring.

Inflammation is not a secondary consequence, but a central mechanism that accompanies all key stages of the disease, from the rupture of an atherosclerotic plaque to reperfusion injury and healing of the infarcted area. In the acute phase, innate immunity is activated, cytokine production increases, hepatic synthesis of acute-phase proteins is triggered, and the ratio of cells

in the peripheral blood changes.

If the inflammatory activity is excessive or persists for too long, it can lead to an unfavorable trajectory of myocardial recovery, with a risk of expanding the area of necrosis, electrical instability, and a progressive decline in pumping function. To describe this persistent, clinically significant activity, the term "residual inflammatory risk" is used, which refers to the likelihood of recurrent events in a patient who has already received standard therapy and achieved their lipid target values but continues to exhibit signs of inflammation.

Inflammatory markers in cardiology are understood as measurable indicators reflecting the degree and nature of the immunoinflammatory response, available for serial assessment and suitable for prognosis. The most widely used are the highly sensitive C-reactive protein as an integral trace of cytokine activation, interleukin-6 as a proximal mediator of the systemic response, as well as indices from the general blood test, for example, the neutrophil-lymphocyte ratio, which shows the balance of the innate and adaptive links.

Pentraxin-3 provides additional information about the

condition of the vascular wall, while myeloperoxidase provides information about the severity of the neutrophilic cascade and oxidative stress. These indicators differ in their biological role, the best time to measure them, and the types of outcomes they are associated with. Therefore, the diagnostic value increases when multiple markers are interpreted in combination with clinical findings and imaging results.

In Russia, the prevalence of cardiovascular risk factors remains high, as confirmed by large-scale epidemiological programs. At the same time, myocardial infarction registries reveal differences in patient routing and the availability of reperfusion care between regions. In such circumstances, simple, standardized, and reproducible solutions for early stratification are particularly relevant. Inflammation markers meet these requirements: they are measured in a typical laboratory, are suitable for dynamic monitoring, and help to identify patients in a timely manner who require enhanced monitoring, more intensive secondary prevention, and more precise diagnostics.

In high-volume hospitals, early determination of interleukin-6 and calculation of the neutrophil-lymphocyte ratio allow for rapid assessment of the severity of the disease, while serial C-reactive protein levels at discharge indicate the likelihood of adverse events in the coming months. In centers with advanced laboratory capabilities, the inclusion of pentraxin-3 and myeloperoxidase allows for a more accurate characterization of tissue vulnerability and the risk of complications associated with reperfusion damage.

The purpose of this study is to show how inflammation markers help predict complications of myocardial infarction in the hospital and post-hospital periods, how to distribute the emphasis on time windows of measurements, and what decisions each metric supports.

The practical task is to offer a clear and applicable algorithm: at the input - a quick cut of inflammation, at the output - a clear monitoring strategy, taking into

RESULTS AND OBSERVATIONS:

The presented table demonstrates the multi-layered architecture of the inflammatory response, which is expedient to exploit in domestic monitoring routes.

In the conditions of the Russian Federation, where the interregional variability of the availability of high-tech methods and time delays of reperfusion is significant, markers with high operational availability and reproducibility are given priority. Serial hs-CRP acts as a “long” integrator of residual activity and helps to identify patients who require enhanced outpatient monitoring [2].

Early IL-6 allows for the gradation of hospital surveillance intensity, which is especially relevant for high-volume hospitals. NLR, extracted from a standard blood test, addresses the lack of operational stratification upon admission, while PTX3 and MPO add tissue and enzymatic specificity, which is useful in centers focused on research and complex clinical scenarios. Together, this combination enhances predictive accuracy without significantly increasing resources, which aligns with the challenges faced by the Russian healthcare system.

account regional features of routing and resource capabilities of medical institutions.

MATERIAL AND METHODS

From a methodological point of view, the role of markers is determined not only by their biological meaning, but also by the way they are integrated into the clinical decision. What matters for the prognosis is not a single result, but the profile of values over time and their relationship to clinical steps, such as choosing the intensity of monitoring, adjusting medication therapy, and determining priorities for rehabilitation and follow-up visits. Serial evaluation allows you to distinguish a short-term reactive surge from sustained activity, and a combined model that combines clinical features, imaging data, and multiple markers improves prediction accuracy compared to each component individually.

It is also important that some of the markers are also indicators of a likely response to anti-inflammatory strategies, which gives them not only prognostic but also predictive value.

The work was carried out in the format of a targeted analysis of domestic sources, including publications on data, descriptions, and results of Russian registers of myocardial infarction and acute coronary syndromes, articles in national peer-reviewed journals on biomarkers of inflammation in patients with acute myocardial infarction, as well as reports from Russian scientific institutions on the use of systemic inflammation indices in complicated cases.

The focus includes hs-CRP, IL-6, and the neutrophil-lymphocyte ratio as markers with high availability in the clinic, as well as PTX3 and MPO as indicators that expand the pathobiological profile. Additionally, Russian studies on hospital resources and patient routing are reviewed, taking into account the compliance of therapy with current national guidelines, which is important for comparing the impact of inflammatory phenotypes with organizational factors in healthcare delivery.

To link laboratory phenotypes with real-world practice, it is important to consider data from Russian registers that reflect both the patient profile and the implementation of recommendations.

The REGION-IM study shows variability in the administration of basic therapy at the hospital stage, which is consistent with the observation that inflammatory indices have a higher impact on prognosis in cases of incomplete reperfusion and inadequate secondary prevention, highlighting the value of using them as an "early warning" for intensifying treatment and monitoring.

Table 1. Inflammatory markers, measurement windows, and predicted outcomes in patients with myocardial infarction

Indicator	Biological role and context	Time window for inpatient assessment	Predictive relationships (Russian sources)
High-sensitivity C-reactive protein (hs-CRP)	Systemic surrogate of the IL-6-dependent response of acute-phase proteins; reflects the persistence of inflammation	Stabilization of the condition, discharge date, early outpatient dynamics	Persistent elevated values are associated with an unfavorable course of ACS and subsequent events; rationale for serial monitoring in the Russian Federation.
Interleukin-6 (IL-6)	Proximal cytokine mediator associated with severity of hospital course	Admission, the first 24 hours	High levels on the first day precede severe outcomes and pronounced inflammatory activity; data from Russian reviews and clinical reports.
Neutrophil-lymphocyte ratio (NLR)	Index of innate immune shift from a complete blood count	Admission and dynamics in the intensive care unit	Admission elevation is associated with in-hospital mortality, inadequate reperfusion, and shock; confirmed in Russian samples and registry sub-analyses.
Pentaxim-3 (PTX3)	Marker of local vascular inflammation, complementary to liver CRP	Admission, 24 hours, 3–5th day	It has been identified by Russian authors as a promising prognostic indicator of early complications and distant events.
Myeloperoxidase (MPO)	A neutrophilic enzyme that reflects oxidative stress and reperfusion damage	Early hospital stage, if possible, local assessment in thrombotic masses	The relation between ischemic remodeling and arrhythmogenesis is discussed in domestic reviews and clinical and experimental studies.

Russian reports on the use of systemic inflammation indices in myocardial infarction-associated cardiogenic shock support the thesis on the clinical applicability of simple cellular indices for rapid risk assessment in the intensive care unit.

Table 2 - Integration of inflammation markers in post-myocardial infarction risk stratification

Этап маршрута	Laboratory emphasis	Expected interpretation and clinical decision in the Russian Federation
Early admission and reperfusion	IL-6, input cell indices (NLR and similar metrics)	High values serve as a signal to intensify monitoring, predict a severe hospital course, and risk reperfusion damage; relevant for PCI centers.
Hospital stabilization	Serial hs-CRP; if available, PTX3, MPO	Persistence of hs-CRP at discharge forms a residual inflammatory risk profile; PTX3 and MPO specify tissue vulnerability and the likelihood of early complications.
Early outpatient monitoring	Repeating hs-CRP; NLR control	A supportive increase indicates the need for increased secondary prevention and closer monitoring; indices from a complete blood count remain informative in the primary care setting.

The proposed three-stage integration is consistent with the organization of care in the Russian Federation and takes into account both the capabilities of reperfusion centers and the objectives of outpatient monitoring. At the entrance, the emphasis on IL-6 and NLR allows for the immediate identification of a "high-fire" group for enhanced tactics. At the stabilization stage, serial hs-CRP serves as a "bridge" to the outpatient phase, where its persistence identifies residual inflammatory risk, and when PTX3 and MPO are available, they provide a deeper pathobiological profile that is useful for centers

with a research agenda and a complex patient population.

In the primary care setting, repeated measurement of hs-CRP and monitoring of cellular indices allows for the linking of biological inflammation activity with adherence to secondary prevention and behavioral interventions, which is particularly important in light of the ESSE-RF population observations on the high prevalence of risk factors [10].

An important context is the relationship between inflammatory phenotypes and the organizational parameters of care. Russian registries demonstrate that the variability of timely reperfusion and the administration of basic therapy correlate with outcomes, indicating that inflammatory markers are not isolated but are linked to quality management. These considerations strengthen the arguments in favor of standardizing the routes for serial measurement of hs-CRP and calculation of NLR in hospitals and during initial visits to outpatient clinics, which is feasible in most regions [4].

Optimizing the prognostic use of inflammatory markers after myocardial infarction in Russia requires a coordinated change in three interrelated levels: clinical and diagnostic procedures, organizational and methodological regulations, and laboratory measurement infrastructure. At the clinical level, it is advisable to integrate serial measurements of high-sensitivity C-reactive protein as a basic indicator of residual inflammatory risk into standard inpatient and outpatient monitoring routes, with the key reference points remaining the moment of clinical stabilization and the period of early discharge. This integration should be accompanied by an explanation of the role of the indicator in determining the density of monitoring, intensifying secondary prevention, and the need for additional examinations [7].

In the early hospitalization window, it is necessary to promptly determine interleukin-6 and calculate the neutrophil-lymphocyte ratio from the complete blood count as quick indicators of the current intensity of the immune-inflammatory response and the risk of reperfusion complications. These metrics can enhance triage in overloaded hospitals and support informed decisions about expanding monitoring and selecting the intensity of antithrombotic and organ-protective therapy. In centers with an expanded laboratory base, it is advisable to gradually introduce pentraxin-3 and myeloperoxidase for in-depth phenotyping of high-risk patients, which is especially important in cases with ambiguous clinical and imaging findings, signs of microvascular damage, and suspected vulnerability of the vascular wall [1].

At the methodological level, it is necessary to unify time windows and analytical methods, as the heterogeneity of measurements reduces the comparability of data and weakens the reliability of decisions. For practice, three assessment windows should be established: early admission with an emphasis on IL-6 and cellular indices, the stabilization phase with serial hs-CRP as a bridge to discharge, and an early outpatient visit with re-verification of residual inflammatory risk. Analytical standardization includes the selection of validated test systems, interlaboratory quality control, the specification of the methodology in

each protocol, and the harmonization of threshold guidelines based on age, gender, and concomitant conditions. It is recommended to accompany laboratory reports with clinical and diagnostic tips that interpret the values in the context of the measurement window and the patient's profile, thereby reducing the variability of decisions between institutions [5].

An important part of improvement is the inclusion of markers in quality management programs. A realistic metric could be the proportion of patients, whose serial hs-CRP is measured by the time of discharge and repeated at the first outpatient visit, as well as the proportion of case histories with a documented neutrophil-lymphocyte ratio calculation at admission. These metrics are related to the care process and can be regularly audited, and their monitoring allows for evaluation of implementation and adjustment of organizational regulations. At the level of clinical and economic justification, the decision is supported by the low cost of basic markers, the simplicity of logistics, and the possibility of preventing repeated hospitalizations through timely intensification of secondary prevention in the group of persistent inflammatory activity [8].

The systematic implementation of the proposals requires reliance on national registers, which should include modules for loading laboratory time series and automated stratification by levels of inflammatory risk. In combination with regional clinical and statistical data, this architecture will enable the evaluation of the effect of interventions at the population level and the prompt updating of threshold guidelines, taking into account demographic and organizational characteristics. Below is a summary table where the recommendations are related to specific actions, expected effects, and implementation indicators, which facilitates the translation of the concept into a routine process.

The offered recommendation system is based on the availability of basic tests, emphasizes the temporal logic of measurements, and links the laboratory profile to specific clinical decisions. In Russian practice, this connectivity allows for a transition from a declarative "just in case" measurement to a controlled process of risk stratification and correction, where each metric has its own window, meaning, and implications for patient management [6].

With consistent implementation supported by registry support and interlaboratory standardization, it is expected to improve the accuracy of forecasting, rationalize the allocation of monitoring resources, and reduce the proportion of adverse outcomes by timely escalation of secondary prevention in patients with persistent inflammatory activity after myocardial infarction.

Table 3 - Outline of improving the use of inflammatory markers after myocardial infarction in the Russian Federation

Outline of changes	A key practical step	Expected clinical effect	Implementation and control indicator
Clinical	Inclusion of serial hs-CRP in the stabilization and discharge protocol; early calculation of NLR and determination of IL-6 upon admission	Early identification of patients with high inflammatory activity, reducing the proportion of missed residual risk	Share of cases with serial hsCRP by discharge and repeat at first visit; share of admissions with calculated NLR and measured IL-6
Methodological	Standardization of measurement windows and test systems, interlaboratory comparison tests	Comparability of results between institutions and reduction of variability in decisions	Availability of a local SOP with described windows and thresholds; results of interlaboratory rounds are not lower than the established threshold
Infrastructural	Creation of an "inflammatory passport" in EMIS/regional RMIS with automatic updating of laboratory data	Seamless continuity between inpatient and outpatient care, and timely escalation of monitoring	The share of patients with a completed passport and access to the dynamics of indicators in all segments
Educational	Short courses for doctors on interpreting markers in three windows and algorithms for action	Reducing interpretation errors and increasing tactical uniformity	Percentage of staff who have completed training; reduction of differences in tactics between departments
The reference level	Pilot implementation of PTX3 and MPO in federal centers with subsequent network access	Clarification of tissue vulnerability and the risk of complications in complex cases	Number of centers performing PR3/MPO; for complex cases using advanced markers
Quality and economics	Incorporating markers into quality audits and analyzing repeat hospitalizations	Reducing the frequency of repeated events through targeted prevention	Dynamics of MACE and re-hospitalizations in the group with the implemented protocol versus the control group

DISCUSSION

Systemic integration of inflammatory markers into the management of patients after myocardial infarction in the Russian Federation demonstrates a stable clinical and prognostic value and practical feasibility based on standardized measurement windows and unified methods.

Early determination of interleukin-6 and calculation of the neutrophil-lymphocyte ratio at the admission stage allows for prompt identification of patients with a high risk of complications and adjustment of the intensity of monitoring and therapy on the first day, while serial assessment of high-sensitivity C-reactive protein by the time of discharge and at the first outpatient visit reveals the profile of residual inflammatory risk and justifies the escalation of secondary prevention.

In centers with an expanded laboratory base, the addition of pentraxin-3 and myeloperoxidase clarifies tissue vulnerability and the risk of reperfusion damage, increasing the accuracy of individual prognosis without a critical increase in resource load. The effectiveness of the approach increases with the digital consolidation of data into a patient's "inflammatory passport" and the inclusion of markers in quality management programs,

which ensures continuity between the hospital and the outpatient clinic and reduces the variability of solutions.

The set of arguments presented confirms that marker-oriented stratification, adapted to the organizational realities of the Russian Federation, improves the predictability of clinical outcomes, rationalizes the allocation of monitoring resources, and increases the likelihood of timely therapy adjustment in patients with persistent inflammatory activity.

REFERENCES

1. Volchkevich O. M. Biomarkers in the diagnosis of cardiovascular diseases //BLC 28.072 I431 A 43. – 2025. – P. 92.
2. Vorobyov A. S. et al. Modern understanding of biological markers of coronary heart disease, myocardial infarction and heart failure // Bulletin of Surgut State University. Medicine. – 2025. – V. 18. – No. 1. – P. 8-22.
3. Derisheva D. A., Yakhontov D. A., Lukinov V. L. Predictors of the progression of stable coronary artery disease in the post-COVID period // Fundamental and Clinical Medicine. – 2025. – V. 10. – No. 2. – P. 82-95.

4. Ivanova A. A., Ievlev R. V., Shalnova S. A. The Role of Cardiac Troponin I in Predicting Adverse Cardiovascular Events //Moscow. – 2024. – Vol. 1. – Pp. 113-115.
5. Kaburov I. P. Inflammation Markers in the Prediction of Cardiovascular Diseases in Obese Patients // Professional Research in Healthcare. – 2024. – No. 1. – Pp. 24-33.
6. Nedbaeva D. N., Valdaev A. A., Kukharchik G. A. The prognostic value of angiographic parameters and laboratory indicators associated with inflammation in acute coronary syndrome without ST segment elevation according to real clinical practice //Translational Medicine. – 2025. – V. 12. – No. 2. – P. 133-143.
7. Ponomareva O. V., Smirnova E. A. A modern view on the role of myocardial fibrosis and its biochemical markers in the diagnosis of chronic heart failure //Science of the young–Eruditio Juvenium. – 2024. – V. 12. – No. 2. – P. 303-316.
8. Ryazantseva T. V. et al. Molecular markers of inflammation in the diagnosis and prognosis of outcomes of coronary heart disease: the current state of the problem // Atherosclerosis and Dyslipidemia. – 2025. – No. 2 (59). – Pp. 5-10.
9. Tregubov I. Yu. et al. Laboratory biomarkers of inflammation in the acute period in patients with severe vascular damage to the brain // Kremlin Medicine. Clinical Bulletin. – 2024. – No. 4. – Pp. 96-103.
10. Trusov Yu. A., Shchukin Yu. V., Zinkina A. A. Relationship of endothelial function and myocardial fibrosis indicators with the severity of coronary atherosclerosis in patients with acute myocardial infarction //Complex problems of cardiovascular diseases. – 2025. – Vol. 14. – No. 4. – P. 37-46.