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ТИББИЁТДА ЯНГИ КУН НОВЫЙ ДЕНЬ В МЕДИЦИНЕ NEW DAY IN MEDICINE

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ROC ANALYSIS OF IMMUNOLOGICAL MARKERS IN PREDICTING POSTOPERATIVE COMPLICATIONS IN PATIENTS WITH IHD AFTER CORONARY ARTERY BYPASS GRAFTING

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✓ Resume

Background. Ischemic heart disease is associated with pronounced immune-inflammatory disturbances that significantly contribute to postoperative complications after coronary artery bypass grafting. **Objective.** To evaluate the prognostic value of immunological markers for postoperative complications in patients with coronary artery disease after CABG using ROC analysis. **Materials and Methods.** Thirty CAD patients undergoing CABG with cardiopulmonary bypass were analyzed, including 15 patients with postoperative complications; ROC analysis was performed with determination of AUC, cut-off values, sensitivity, and specificity ($p < 0.05$). **Results.** The highest predictive accuracy was observed for $CD4\pm$ ($AUC=0.733$; $p=0.029$), $CD8\pm$ ($AUC=0.740$; $p=0.024$), IL-6 ($AUC=0.740$; $p=0.024$), and IFN- γ ($AUC=0.744$; $p=0.022$). Identified cut-off values demonstrated high specificity (up to 100.0%), enabling reliable discrimination of patients at high risk of postoperative complications. **Conclusions.** Immunological markers demonstrate high prognostic potential for predicting adverse outcomes after CABG. Their combined application improves early risk stratification and postoperative management.

Keywords: coronary artery disease, coronary artery bypass grafting, ROC analysis, immunological markers, postoperative complications.

РОС-АНАЛИЗ ИММУНОЛОГИЧЕСКИХ МАРКЕРОВ В ПРОГНОЗИРОВАНИИ ПОСЛЕОПЕРАЦИОННЫХ ОСЛОЖНЕНИЙ У ПАЦИЕНТОВ С ИШЕМИЧЕСКОЙ БОЛЕЗНЬЮ СЕРДЦА ПОСЛЕ КОРОНАРНОГО ШУНТИРОВАНИЯ

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✓ Резюме

Ишемическая болезнь сердца сопровождается выраженными иммунновоспалительными и метаболическими нарушениями, которые существенно влияют на риск послеоперационных осложнений после аортокоронарного шунтирования. Цель исследования. Оценить прогностическую значимость иммунологических маркеров в развитии послеоперационных осложнений у больных ИБС после аортокоронарного шунтирования с использованием ROC-анализа. **Материалы и методы.** Обследовано 30 пациентов с ИБС после АКШ в условиях искусственного кровообращения, включая 15 больных с послеоперационными осложнениями; применялись методы ROC-анализа с определением AUC, cut-off, чувствительности и специфичности при $p < 0,05$. **Результаты.** Наибольшую дискриминационную способность продемонстрировали маркеры $CD4\pm$ ($AUC=0,733$; $p=0,029$), $CD8\pm$ ($AUC=0,740$; $p=0,024$), IL-6 ($AUC=0,740$; $p=0,024$) и IFN- γ ($AUC=0,744$; $p=0,022$). Пороговые значения этих показателей характеризовались высокой специфичностью (до 100,0%), что позволяло достоверно идентифицировать пациентов с высоким риском осложнений. **Выводы.** Иммунологические маркеры обладают высокой прогностической значимостью в оценке риска послеоперационных осложнений после АКШ. Их комплексное использование повышает точность ранней стратификации риска и клинического прогнозирования.

Ключевые слова: ишемическая болезнь сердца, аортокоронарное шунтирование, ROC-анализ, иммунологические маркеры, послеоперационные осложнения.

KORONAR ARTERIYA BYPASS TRANSPLANTATIDAN KEYIN YURAK ISHEMIK KASALLIGI (YIH) BO'LGAN BEMORLARDA OPERATSIYADAN KEYINGI ASORATLARNI BASHORAT QILISHDA IMMUNOLOGIK MARKERLARNING ROC TAHLILI

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✓ Rezyume

Ishemik yurak kasalligi immun-yallig'lanish va metabolik disbalanslar bilan kechib, aortokoronar shuntlashdan keyingi asoratlar xavfini oshiradi. Tadqiqot maqsadi. ROC-tahlil asosida AKShdan keyingi asoratlarni bashoratlashda immunologik markerlarning prognostik ahamiyatini baholash. Materiallar va usullar. Sun'iy qon aylanishi sharoitida AKSh o'tkazilgan 30 nafar IYuK bilan kasallangan bemor tekshirildi, jumladan 15 nafarida operatsiyadan keyingi asoratlar kuzatildi; AUC, cut-off, sezgirlik va spetsifiklik $p < 0,05$ darajasida baholandi. Natijalar. $CD4\pm$ ($AUC=0,733$; $p=0,029$), $CD8\pm$ ($AUC=0,740$; $p=0,024$), $IL-6$ ($AUC=0,740$; $p=0,024$) va $IFN-\gamma$ ($AUC=0,744$; $p=0,022$) eng yuqori prognostik ahamiyatga ega bo'ldi. Belgilangan chegaraviy qiymatlar yuqori spetsifiklik (100,0% gacha) bilan asoratlar xavfi yuqori bo'lgan bemorlarni aniqlash imkonini berdi. Xulosalar. Immunologik markerlar AKShdan keyingi asoratlarni bashoratlashda muhim ahamiyatga ega. Ularni kompleks qo'llash xavfni erta aniqlash va davolash taktikasini optimallashtirish imkonini beradi.

Kalit so'zlar: ishemik yurak kasalligi, aortokoronar shuntlash, ROC-tahlil, immunologik markerlar, operatsiyadan keyingi asoratlar.

Relevance

Coronary heart disease (CHD) remains a leading cause of mortality, and its progression is closely linked to an imbalance in immune and biochemical processes. Current research confirms the importance of assessing immune cells, humoral factors, and general clinical parameters for more accurate patient risk stratification. Correlation analysis of these parameters allows for the identification of hidden patterns inaccessible by traditional research methods. Identifying such relationships facilitates a comprehensive assessment of systemic inflammation, oxidative stress, and homeostatic disorders that accompany CHD. This makes the study of clinical and immunobiochemical markers a key area of modern cardiology [30, pp. 514–520; 79, pp. 123–132].

Furthermore, the combined study of immune cells, protein fractions, and red blood cell parameters opens the possibility of early detection of progressive disorders in patients with coronary heart disease. Systemic inflammation and endothelial dysfunction, which underlie the pathogenesis of the disease, manifest themselves through changes in both cellular and humoral immunity. Correlations between these parameters enable us to understand the mechanisms of decompensation and the progression of the disease to severe forms. Analysis of such relationships facilitates a more targeted selection of therapy focused on immunomodulatory and metabolic approaches [136, pp. 2241–2248].

ROC analysis is a highly informative statistical tool that allows for quantitative assessment of the prognostic value of immunological markers in the development of complications after coronary artery bypass grafting in patients with coronary artery disease. This method enables the precise determination of optimal biomarker thresholds with maximum sensitivity and specificity. This enables the development of objective criteria for early risk stratification and timely adjustment of treatment strategies. Incorporating ROC analysis into a comprehensive patient assessment enhances the prognostic value of clinical and immunological parameters and contributes to improved surgical outcomes.

Purpose of the study: To evaluate the prognostic significance of immunological markers in the development of postoperative complications in patients with coronary heart disease after coronary artery bypass grafting based on ROC analysis with determination of their diagnostic sensitivity, specificity and threshold values.

Materials and methods of research: To conduct this analysis, we selected 30 patients with coronary artery disease (out of 108) who underwent coronary artery bypass grafting under artificial circulation; 15 of them developed postoperative complications (SIRS, pneumonia, stroke, acute renal failure, etc.).

Comparison of two groups for a quantitative indicator with a normal distribution in each group was performed using the Student's t-test under conditions of equal variances; for unequal variances, the Welch t-

test was used. Comparison of two groups for a quantitative indicator with a non-normal distribution was performed using the Mann-Whitney U-test. To assess the discriminatory power of quantitative indicators in predicting a specific outcome, ROC curve analysis was used. The separating value of a quantitative indicator at the cutoff point was determined by the highest value of the Youden index. Differences were considered statistically significant at $p < 0.05$.

Research results: ROC analysis showed that a number of immunological markers have significant discriminatory ability in predicting postoperative complications in patients with coronary artery disease after coronary artery bypass grafting. In particular, the CD4 \pm , CD8 \pm , CD16 \pm , and CD20 \pm lymphocyte subpopulations demonstrated a statistically significant increase in predictive power. Optimal cutoff values corresponding to the maximum Youden index were determined for each marker. These cutoff values allowed for the most accurate division of patients into high- and low-risk groups. Thus, for CD4 \pm , the cutoff was 31.7, and the sensitivity and specificity reached 46.7% and 100.0%, respectively. Similar results were established for CD8 \pm and CD20 \pm , confirming the importance of T- and B-cell immunity in the pathogenesis of complications. The identified patterns confirm the role of the cellular immune response in the development of adverse outcomes in the postoperative period.

Table 1.

Table of threshold values of immunological markers for the development of postoperative complications in coronary artery bypass grafting in patients with ischemic heart disease

		0.552–			≤ 31.7		
		0.560–			≥ 32.5		
		0.543–			≥ 32.4		
		0.552–			≥ 34.3		
		0.541–			≥ 29.8		
		0.546–			≥ 29.5		
		0.532–			≥ 2.32		
		0.546–			≥ 1.46		
		0.552–			≥ 15.6		
		0.538–			≥ 11.5		
		0.560–			≥ 10.5		
		0.557–			≥ 18.3		
INF- γ		0.566–			≤ 14.3		
TNF- α		0.538–			≥ 57.6		
		0.546–			≤ 976.9		
		0.543–			≤ 6.11		

The CD16 \pm marker also demonstrated significant ability to predict complications, emphasizing the involvement of the NK cell component of immunity. Its cutoff value was 32.4, with a specificity of



100.0%, indicating a high accuracy of a negative prognosis. Despite a slightly lower sensitivity (40.0%), this marker remains an important component of immunological risk assessment. CD25 \pm , as an indicator of T-cell activation, also proved significant, consistent with current understanding of the role of T-cell hyperactivation in postoperative inflammatory reactions. Its cutoff value was 29.8, with high specific characteristics of the prognostic model. The significance of CD95 \pm demonstrates the contribution of apoptotic mechanisms to the development of complications, especially in the context of a systemic inflammatory response. Thus, activation and apoptotic pathways of the immune response form key links in the pathogenetic chain of complications.

Humoral parameters also demonstrated significant prognostic value, including IgA, IgM, and IgG. IgA demonstrated a cutoff value of 2.32 with a specificity of 100.0%, emphasizing its diagnostic accuracy. IgM and IgG had similar characteristics, confirming the involvement of humoral factors in the development of complications. Increased levels of these immunoglobulins may reflect increased antigenic stimulation following surgical intervention. The established cutoff values allow these parameters to be used in clinical practice for early risk detection. Furthermore, the combination of humoral and cellular markers improves the accuracy of integrated prognostic models. Thus, immunoglobulins act as significant predictors, complementing the characteristics of adaptive immunity.

Cytokines IL-4, IL-6, and IL-17A demonstrated high prognostic properties, confirming the central role of proinflammatory and regulatory mediators in the development of complications after CABG. IL-4, with a cutoff of 11.5, demonstrated high specificity, making it a useful marker for excluding an unfavorable outcome. IL-6, known as a key mediator of the acute phase of inflammation, showed a cutoff of 10.5, reflecting the pronounced role of the systemic inflammatory response. IL-17A, associated with neutrophil activation, was also statistically significant with a cutoff of 18.3. Increased IL-17A production may indicate a pronounced immune-mediated reaction to surgical trauma. Cytokine markers are particularly important for assessing early postoperative reactions. Their use in the early prediction of complications appears clinically appropriate (Fig. 1).

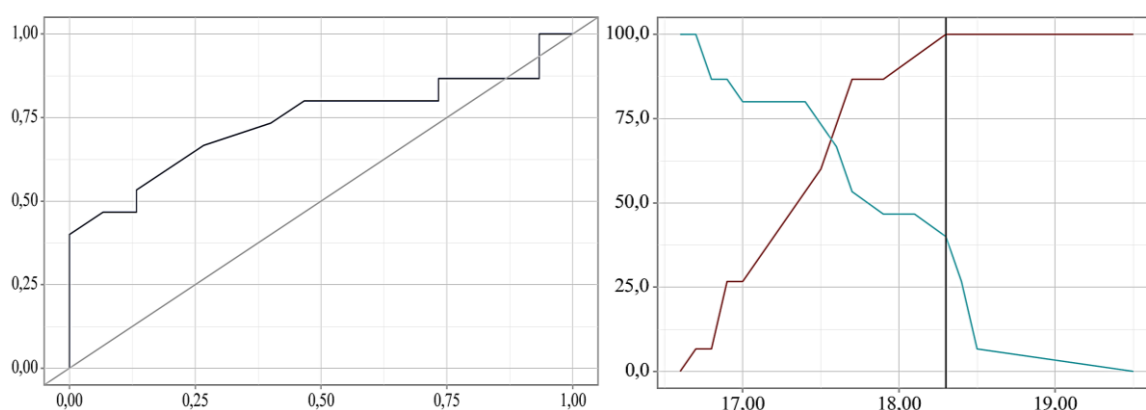


Fig. 1. Analysis of the sensitivity and specificity of IL-17 depending on the threshold values of complication probability assessments

INF- γ demonstrated a high level of predictive accuracy, despite its cutoff value being based on a decrease in concentration rather than an increase. This highlights the complexity of immune mechanisms, in which a deficiency in the Th1 cellular response may be associated with the development of complications. The INF- γ cutoff was 14.3, with a sensitivity of 53.3% and a specificity of 86.7%. These results suggest possible exhaustion of the immune response in some patients. Conversely, TNF- α was associated with a high risk at elevated values, consistent with its role in systemic inflammation. The TNF- α cutoff value was 57.6, with maximum specificity. These data confirm that an imbalance between proinflammatory and anti-inflammatory cytokines is a key pathogenetic mechanism for complications.

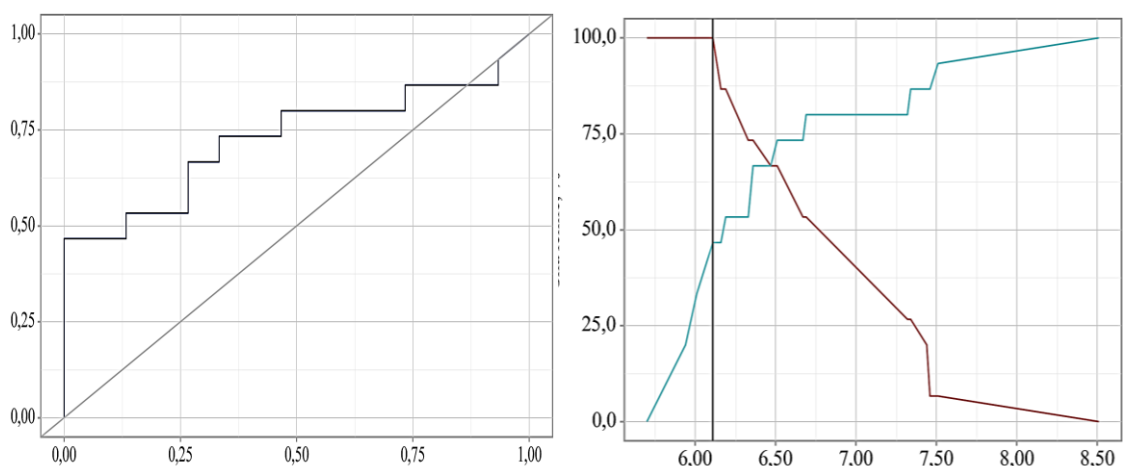


Fig. 2. Analysis of the sensitivity and specificity of the Klotho protein depending on the threshold values of complication probability assessments

Antioxidant and stress-associated markers, including COD and Klotho, also demonstrated statistical significance. COD had a cutoff value of 976.9, with complications predicted at lower levels. This reflects the role of oxidative stress in disrupting rehabilitation processes after CABG. Klotho, in contrast, proved significant at lower values, reflecting its known role as a protective, anti-aging-associated protein. The Klotho cutoff was 6.11, indicating high predictive specificity. These results highlight the need for a comprehensive assessment of immune status and systemic metabolic reactions. Antioxidant markers can serve as an additional tool for refining the risk of complications (Fig. 2).

Discussion of the results

The obtained results convincingly confirm that immunological markers play a key role in predicting postoperative complications in patients with coronary artery disease after coronary artery bypass grafting. Similar data are presented in international studies, which emphasize the importance of cellular and cytokine responses in the development of a systemic inflammatory response during cardiopulmonary bypass (Adlbrecht et al., 2023; Giacinto et al., 2019). The high prognostic significance of T- and B-lymphocyte subsets ($CD4^+$, $CD8^+$, $CD20^+$) is consistent with the data of Bauer et al. (2021), who demonstrated that cellular immunity parameters correlate with the severity of the postoperative course and the length of stay in the intensive care unit. The high specificity of these markers confirms their value in eliminating the risk of complications, which is especially important in clinical practice. The role of proinflammatory cytokines IL-6, IL-17A, and TNF- α in the development of complications after CABG is consistent with the data of Hatami et al. (2022), who consider systemic inflammation and oxidative stress as central mechanisms of myocardial reperfusion injury. Of interest is the decreased IFN- γ as a predictor of adverse outcome, consistent with the concept of immune exhaustion described in recent Scopus publications. The antioxidant markers COD and Klotho protein demonstrated additional prognostic value, confirming the role of oxidative stress and impaired cellular aging in the postoperative period. International studies emphasize that decreased Klotho is associated with an unfavorable prognosis in cardiovascular diseases, which is fully consistent with the results of this study.

Conclusions

Thus, the presented data confirm the high significance of immunological markers in predicting postoperative complications in patients with coronary artery disease after CABG. A comprehensive approach, including cellular, humoral, and cytokine parameters, offers the greatest potential. The high specificity of most markers allows for the effective exclusion of complications, which is important for optimizing patient management. Certain threshold values can be used in clinical practice for the early identification of high-risk patients.

LIST OF REFERENCES:

1. Adlbrecht C., Rohde S., Maurer G., et al. Complement activation in patients undergoing cardiac surgery with cardiopulmonary bypass: clinical implications // *Crit. Care Med.* 2023;31:217–224. doi: 10.1097/01.CCM.0000044001.74205.62.
2. Anderson T., Moore S., Reynolds K. Advances in pharmacological therapy for ischemic heart disease // *J.Cardiovasc. Pharmacol.* 2024;83(3):145–158.
3. Bauer A., Korten I., Juchem G., Kieseewetter I., Kilger E., Heyn J. EuroScore and IL-6 predict the course ICU after cardiac surgery // *Eur. J. Med. Res.* 2021;26:29. doi: 10.1186/s40001-021-00501-1.
4. Carter J., Evans K., Johnson P. Epidemiology of ischemic heart disease in Europe // *Eur. Heart J.* – 2025;46(4):412–423.
5. da Costa Soares LC, Ribas D., Spring R., Silva JMFd, Miyague NI Perfil Clínico Da Resposta Inflamatória Sistêmica Após Cirurgia Cardíaca Pediátrica Com Circulação Extracorporea // *Arq. Bras. Cardiol.* 2020;94:127–133. doi: 10.1590/S0066-782X2010000100019.
6. Evans C., Lewis A., Miller K. Coronary angiography in contemporary clinical practice // *Cardiol. Clin.* 2024;42(1):11–24.
7. Giacinto O., Satriano U., Nenna A., Spadaccio C., Lusini M., Mastroianni C., Nappi F., Chello M. Inflammatory Response and Endothelial Dysfunction Following Cardiopulmonary Bypass: Pathophysiology and Pharmacological Targets // *Recent Pat. Inflamm. Allergy Drug Disco.* 2019;13:158–173. doi: 10.2174/1872213X13666190724112644.
8. Hatami S., Hefler J., Freed DH Inflammation and Oxidative Stress in the Context of Extracorporeal Cardiac and Pulmonary Support // *Front. Immunol.* 2022;13:831-930. doi: 10.3389/fimmu.2022.831930.
9. Khalilov MA, Moshkin AS, Moshkina LV, et al. The impact of individual characteristics of the carotid arteries and heart on disease development // *Pharmateca.* 2025;32(6):16–21.
10. Johnson K., Williams R., Thompson L. Clinical presentation and management of stable angina: a review // *Am. J.Cardiol.* 2024;183:67-75.
11. Lee C., Park H., Kim S. Advances in imaging for cardiovascular risk assessment // *J.Cardiovasc. Imaging.* 2025;33(2):55-70.
12. Patel M., Desai N., Shah R. Coronary artery disease in diabetic patients: risk assessment and management // *DiabetesVasc. Dis. Res.* 2023;20(4):310–320.

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