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Article

Hemostatic and Inflammatory Biomarkers Associated with Coronary In-Stent Restenosis: A Single-Center Comparative Study

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Bukhara Regional Multidisciplinary Medical Center, Bukhara, Uzbekistan
Original Research Article

Abstract: Background: Coronary in-stent restenosis (ISR) is a multifactorial process involving vascular injury, neointimal proliferation, inflammatory signaling, and altered hemostasis. Objective: To compare hemostatic and inflammatory biomarkers in patients with coronary artery disease with and without restenosis after coronary stenting. Methods: This single-center comparative analysis used aggregate findings reported for 75 patients evaluated in 2024 at the Bukhara Regional Multidisciplinary Medical Center. The ISR group comprised 45 patients and the non-ISR group 30 patients. Prothrombin time, prothrombin index, international normalized ratio, activated partial thromboplastin time, fibrinogen, D-dimer, C-reactive protein (CRP), interleukin-6 (IL-6), and tumor necrosis factor-α (TNF-α) were compared. Results: The ISR group had higher fibrinogen (4.1 ± 0.9 vs 3.5 ± 0.7 g/L), D-dimer (690 ± 120 vs 540 ± 110 ng/mL), CRP (4.2 ± 1.3 vs 2.7 ± 1.1 mg/L), IL-6 (6.8 ± 2.5 vs 4.1 ± 1.9 pg/mL), and TNF-α (8.3 ± 2.7 vs 5.9 ± 2.1 pg/mL). The source reported $p < 0.05$ for these comparisons. Other conventional coagulation indices were not significantly different. Conclusions: The reported group differences support a hypothesis that inflammatory and fibrin-turnover markers may help characterize patients with ISR. Prospective validation, verified angiographic outcome definitions, and adjusted analyses are required before these biomarkers can be used as an independent predictive test.

Keywords: coronary artery disease; percutaneous coronary intervention; in-stent restenosis; D-dimer; fibrinogen; C-reactive protein; interleukin-6; TNF-α.

Introduction

Percutaneous coronary intervention (PCI) is a cornerstone of treatment for selected patients with coronary artery disease. Nevertheless, restenosis remains a clinically important cause of recurrent ischemic symptoms and repeat target-lesion intervention. ISR should be distinguished from stent thrombosis: restenosis principally involves progressive luminal renarrowing, whereas thrombosis is an acute thrombotic complication with different management implications. The biological mechanisms of ISR vary with stent type and include smooth-muscle-cell proliferation, extracellular matrix deposition, chronic vascular inflammation, and neoatherosclerosis. [1]

The interaction between inflammation and coagulation is of particular interest. Endothelial injury activates platelets and thrombin generation, while cytokines modulate vascular remodeling. Fibrinogen and D-dimer reflect overlapping but distinct pathways; CRP, IL-6, and TNF-α characterize

systemic inflammatory activity. The present analysis examines these markers in the clinical dataset described in the source methodological report, without claiming a validated prediction model.[2]

Materials and Methods

Study design and setting. A single-center observational comparison was reported in 2024 in the Cardiology Department of the Bukhara Regional Multidisciplinary Medical Center, Uzbekistan. The source describes 75 patients with coronary artery disease who had undergone coronary stent implantation. Patients were categorized by the reported presence of coronary restenosis: 45 with ISR and 30 without ISR. The source does not specify consecutive recruitment, time from implantation to restenosis evaluation, or standardized angiographic definitions. Consequently, the analysis should be interpreted as a comparison of reported groups rather than a prospective prediction cohort.[3]

Patient characteristics. The ISR group included 26 men and 19 women; the non-ISR group included 20 men and 10 women. Mean age was 62.4 ± 8.2 versus 60.1 ± 7.9 years (source $p = 0.18$). Body mass index was 28.7 ± 3.5 versus 27.9 ± 3.2 kg/m² (source $p = 0.32$). Information on diabetes prevalence, smoking, renal function, concomitant medications, stent type, lesion characteristics, and imaging adjudication was not available in the supplied material.[4]

Laboratory measurements. The reported hemostasis panel included prothrombin time (PT), prothrombin index (PTI), international normalized ratio (INR), activated partial thromboplastin time (aPTT), fibrinogen, and D-dimer. The inflammatory panel comprised CRP, IL-6, and TNF-α. Tests were reportedly performed using standardized certified assay kits. Specific assay manufacturers, sampling intervals, fasting status, and analytical coefficients of variation were not provided.[5]

Statistical analysis. The source states that Student's t test and the chi-square test were used, with a significance threshold of $p < 0.05$. This manuscript reproduces the published aggregate group means, standard deviations, and reported p values. Individual-level data were not available, and no new multivariable analysis, ROC curve, cutoff optimization, or independent validation was performed. The diagnostic characteristics of the original restenosis assessment could not be independently verified.[6]

Results

The study population comprised 45 patients classified as having ISR and 30 classified as non-ISR. The groups had broadly similar reported mean age and BMI. Differences were more apparent for inflammatory and selected hemostatic indices (Table 1). Fibrinogen was 0.6 g/L higher in ISR patients; D-dimer was 150 ng/mL higher. The Figure 1. corresponding differences were 1.5 mg/L for CRP, 2.7 pg/mL for IL-6, and 2.4 pg/mL for TNF-α. These are unadjusted between-group contrasts and should not be interpreted as causal effects or prospective predictive performance.[7]

Table 1. Clinical laboratory measurements according to reported restenosis status (mean ± SD).[8]

Parameter	ISR (n = 45)	No ISR (n = 30)	Reported p
PT, seconds	13.2 ± 1.5	12.8 ± 1.4	0.18
PTI, %	87.5 ± 6.3	90.1 ± 5.8	0.12
INR	1.14 ± 0.09	1.11 ± 0.08	0.22
aPTT, seconds	32.8 ± 4.2	31.5 ± 3.9	0.15
Fibrinogen, g/L	4.1 ± 0.9	3.5 ± 0.7	0.02
D-dimer, ng/mL	690 ± 120	540 ± 110	0.01
CRP, mg/L	4.2 ± 1.3	2.7 ± 1.1	<0.01
IL-6, pg/mL	6.8 ± 2.5	4.1 ± 1.9	<0.01
TNF-α, pg/mL	8.3 ± 2.7	5.9 ± 2.1	<0.01

Reported p values are reproduced from the source and were not independently recalculated. ISR, in-stent restenosis; PT, prothrombin time; PTI, prothrombin index; INR, international normalized ratio; aPTT, activated partial thromboplastin time; CRP, C-reactive protein.[9]

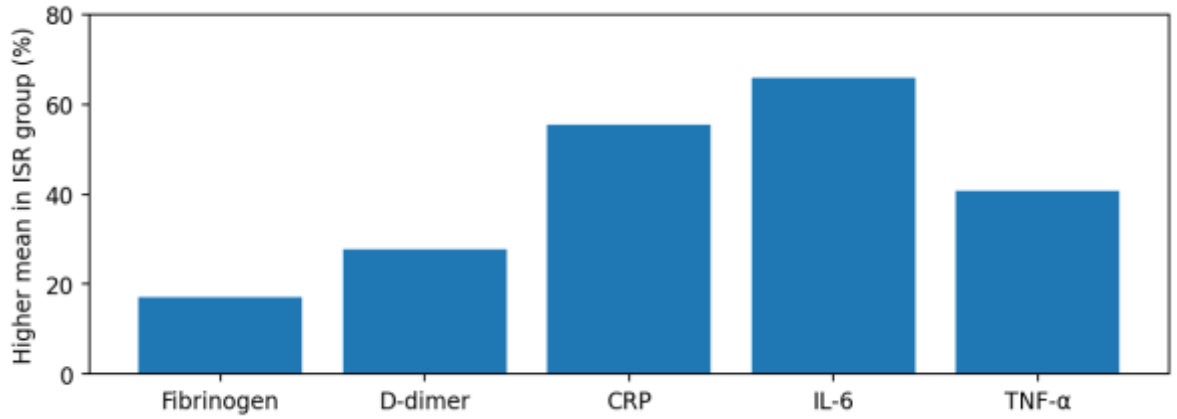

Figure 1. Relative between-group differences calculated from reported means: (ISR − no ISR) / no ISR × 100. Descriptive visualization only; not a predictive model.[10]

Discussion

The supplied clinical dataset shows a consistent pattern of higher circulating inflammation markers and selected hemostatic markers in patients categorized as having coronary ISR. These findings support the biological plausibility of inflammatory–thrombotic crosstalk after coronary intervention. However, the direction and magnitude of the associations may be influenced by residual confounding, selection effects, the timing of blood sampling, and treatment exposure.[11]

Fibrinogen is both a coagulation substrate and an acute-phase reactant. Its higher concentration in the ISR group could reflect inflammatory burden as well as a procoagulant milieu. D-dimer reflects cross-linked fibrin turnover, but its specificity is low, particularly in older patients and those with infection, venous thromboembolism, malignancy, or recent procedures. Neither elevated D-dimer nor fibrinogen alone establishes restenosis or warrants anticoagulation. The non-significant differences in PT, PTI, INR, and aPTT indicate that routine clotting times may be less discriminative in this dataset, although the current sample does not permit definitive statements about diagnostic utility.[12]

The elevation of CRP, IL-6, and TNF-α among ISR patients is compatible with an inflammatory contribution to vascular healing and remodeling. Yet systemic biomarker elevation is not synonymous with local neointimal growth. Coronary angiography and, when indicated, intracoronary imaging remain essential to establish the anatomical mechanism of a suspected ISR lesion. A reliable risk model should incorporate lesion length, vessel diameter, stent expansion, prior revascularization, diabetes, kidney function, and pharmacotherapy alongside candidate blood markers. [13]

Clinical implications should remain conservative. Current European recommendations individualize post-PCI antiplatelet treatment by clinical presentation and bleeding risk. Neither a D-dimer threshold nor an elevated cytokine level is an established indication for intensifying anticoagulation or starting cytokine-targeted treatment specifically to prevent ISR. In patients with chronic coronary syndromes, the default course after PCI is commonly six months of dual antiplatelet treatment, with tailored shorter or longer strategies; after acute coronary syndrome, 12 months remains the usual default unless clinical factors justify modification. [14]

The study is hypothesis-generating. A prospective follow-up study should prespecify the ISR endpoint (e.g., quantitative angiographic diameter stenosis or clinically driven target-lesion revascularization), the biomarker sampling time points, candidate confounders, and validation strategy. Model performance should be reported with calibration, discrimination, confidence intervals, and decision-curve analysis rather than an isolated p value.

This report relies on aggregate information from a methodological publication. Major limitations include missing patient-level data, unavailable ethics approval and consent details, unspecified ISR ascertainment criteria and follow-up duration, uncertain assay timing, and absence of adjustment for confounding. The 45/75 proportion is a proportion within the sampled comparison groups, not an estimate of the incidence of restenosis after PCI.[15]

Conclusion

In this single-center reported comparison, patients categorized as having coronary ISR showed higher fibrinogen, D-dimer, CRP, IL-6, and TNF-α than patients without ISR, while conventional clotting indices did not differ significantly. The findings indicate potential value in further investigating combined hemostatic and inflammatory phenotyping. They do not yet establish independent prediction, validated decision thresholds, or the effectiveness of biomarker-directed treatment. A prospective, angiographically adjudicated cohort with multivariable adjustment is needed before clinical implementation.

REFERENCES

[1] F. Alfonso, R. A. Byrne, F. Rivero, and A. Kastrati, "Current treatment of in-stent restenosis," Journal of the American College of Cardiology, vol. 63, no. 24, pp. 2659–2673, 2014, doi: 10.1016/j.jacc.2014.02.545.

[2] F. J. Neumann, M. Sousa-Uva, A. Ahlsson, et al., "2018 ESC/EACTS Guidelines on myocardial revascularization," European Heart Journal, vol. 40, no. 2, pp. 87–165, 2019, doi: 10.1093/eurheartj/ehy394.

[3] R. A. Byrne, X. Rossello, J. J. Coughlan, et al., "2023 ESC Guidelines for the management of acute coronary syndromes," European Heart Journal, vol. 44, no. 38, pp. 3720–3826, 2023, doi: 10.1093/eurheartj/ehad191.

[4] C. Vrints, F. Andreotti, K. C. Koskinas, et al., "2024 ESC Guidelines for the management of chronic coronary syndromes," European Heart Journal, vol. 45, no. 36, pp. 3415–3537, 2024, doi: 10.1093/eurheartj/ehae177.

[5] P. Libby, "Inflammation in atherosclerosis," Nature, vol. 420, pp. 868–874, 2002, doi: 10.1038/nature01323.

[6] P. M. Ridker, B. M. Everett, T. Thuren, et al., "Antiinflammatory therapy with canakinumab for atherosclerotic disease," New England Journal of Medicine, vol. 377, pp. 1119–1131, 2017, doi: 10.1056/NEJMoa1707914.

[7] F. S. Mehmanov and S. A. Naimova, Method for Assessing the Risk of Coronary Artery Restenosis in Patients with Coronary Heart Disease. Bukhara, Uzbekistan, 2025. Methodological recommendation. Unpublished clinical source document.

[8] G. W. Stone, A. Rizvi, W. Newman, et al., "Everolimus-eluting versus paclitaxel-eluting stents in coronary artery disease," New England Journal of Medicine, vol. 362, no. 18, pp. 1663–1674, 2010, doi: 10.1056/NEJMoa0910496.

[9] R. Mehran, G. Dangas, A. S. Abizaid, et al., "Angiographic patterns of in-stent restenosis: Classification and implications for long-term outcome," Circulation, vol. 100, no. 18, pp. 1872–1878, 1999, doi: 10.1161/01.CIR.100.18.1872.

[10] J. A. Beckman, M. A. Creager, and P. Libby, "Diabetes and atherosclerosis: Epidemiology, pathophysiology, and management," JAMA, vol. 287, no. 19, pp. 2570–2581, 2002, doi: 10.1001/jama.287.19.2570.

[11] N. Marx, M. Federici, K. Schütt, et al., "2023 ESC Guidelines for the management of cardiovascular disease in patients with diabetes," European Heart Journal, vol. 44, no. 39, pp. 4043–4140, 2023, doi: 10.1093/eurheartj/ehad192.

[12] J. S. Lawton, J. E. Tamis-Holland, S. Bangalore, et al., "2021 ACC/AHA/SCAI Guideline for coronary artery revascularization," Journal of the American College of Cardiology, vol. 79, no. 2, pp. e21–e129, 2022, doi: 10.1016/j.jacc.2021.09.006.

[13] G. W. Stone, J. F. Moses, S. G. Ellis, et al., "Safety and efficacy of sirolimus- and paclitaxel-eluting coronary stents," New England Journal of Medicine, vol. 356, no. 10, pp. 998–1008, 2007, doi: 10.1056/NEJMoa067193.

[14] P. Libby, "The changing landscape of atherosclerosis," Nature, vol. 592, pp. 524–533, 2021, doi: 10.1038/s41586-021-03392-8.

[15] R. A. Byrne, M. Joner, and A. Kastrati, "Stent thrombosis and restenosis: What have we learned and where are we going?" European Heart Journal, vol. 36, no. 47, pp. 3320–3331, 2015.