

Predictors of Recurrent Myocardial Ischemia After Coronary Artery Bypass Grafting and Subsequent Need for Percutaneous Coronary Intervention: A Prospective Cohort Study

Muhammad Yasir Khan^{1*}, Dr. Khawar Shahzad², Fauwaz Fahad Alrashid³, Dr Muhammad Ilyas⁴, Dr Muhammad Ishaque Bhatti⁵, Dr Noreen Atzaz⁶, Saeed Ali Alsareii⁷, Fahmida Khatoon⁸

¹Associate Professor of Cardiac Surgery, Sardar Fateh Muhammad Khan Buzdar Institute of Cardiology, DG Khan, Pakistan

²Consultant Cardiologist, MBBS, FCPS (Cardiology), DHQ Hospital, Hafizabad, Pakistan

³Surgery Department, University of Ha'il, 5211, Saudi Arabia

⁴Assistant Professor of Medicine, Watim Medical College, Rawalpindi, Pakistan

⁵Assistant Professor, Department of Biochemistry, Indus Medical College, Tando Muhammad Khan, Pakistan

⁶Assistant Professor, Chemical Pathology, Rawal Institute of Health Sciences, Islamabad, Pakistan

⁷Department of Surgery, College of Medicine, Najran University, Saudi Arabia

⁸Department of Biochemistry, College of Medicine, University of Ha'il, Saudi Arabia

*Corresponding author: Muhammad Yasir Khan, Yasirkhan0092@gmail.com

Abstract

Background: Patients with a severe coronary artery condition benefit from coronary artery bypass grafting (CABG) as one of the available revascularisation options, but recurrent myocardial ischemia and the downstream requirement of PCI (percutaneous coronary intervention) are a major challenge in the long-term clinical management. Proper identification of high-risk patients for recurrent ischemic events after CABG could have the potential to optimize aftercare plans, allow early intervention and achieve better cardiovascular outcomes. This study was an attempt to identify clinical, metabolic and surgical predictors for recurrent myocardial ischemia and subsequent PCI requirement after CABG.

Methods: A prospective cohort study was conducted at Niazi Hospital Sargodha, Pakistan, on patients with coronary artery disease (CAD) undergoing coronary artery bypass graft surgery (CABG). Prospective data regarding demographics, clinical, laboratory, angiography and surgical parameters were obtained. Age, gender, BMI, DM, HbA1c, hypertension, chronic kidney disease, smoker, LVEF, graft characteristics, complete revascularisation and complications were evaluated. Patients were systemically followed for the development of recurrent myocardial ischemia and the need for subsequent PCI. The descriptive analysis, normality testing, independent samples t-test, one-way ANOVA, Kruskal–Wallis test and Chi-square test for differences and comparisons were used in statistical analysis. A multivariable regression analysis and Pearson correlation were used to look for independent predictors of PCI following CABG.

Results: Multiple clinical and procedural parameters were significantly linked with recurrent myocardial ischemia and need for subsequent PCI. Higher cardiovascular risk was associated with increased incidence of adverse ischemic outcomes, with patients with cardiovascular risk factors such as diabetes mellitus, high HbA1C, chronic kidney disease, smoking history and risk scores having higher risk. Failure of the graft was found to be one of the greatest risk factors for repeat intervention. A positive association between each cardiovascular risk factor (except for age) and recurrent ischemia and PCI requirement was shown by correlation analysis. Graft failure, diabetes mellitus, poor glucose control, chronic kidney disease, smoking and overall risk burden were found to be independent predictors of subsequent PCI after CABG by multivariable regression analysis.

Conclusion: Patient-related, metabolic and graft-related factors all play a role in the development of recurrent myocardial ischemia after CABG. Graft failure, diabetes, inadequate glycemic control, renal dysfunction, smoking and cardiac dysfunction are significant risks for repeat coronary interventions. Recognizing high-risk patients at the early stage and beginning appropriate secondary prevention measures could lead to a better long-term outcome and help minimize recurrent ischaemic events after CABG.

Keywords: Coronary artery bypass grafting; Recurrent myocardial ischemia; Percutaneous coronary intervention; Graft failure; Cardiovascular risk factors; Diabetes mellitus; Risk prediction; Coronary artery disease; Revascularization; Prospective cohort study.

How to cite this article: Muhammad Yasir Khan^{1*} Dr. Khawar Shahzad² Fauwaz Fahad Alrashid³ Dr Muhammad Ilyas⁴ Dr Muhammad Ishaque Bhatti⁵ Dr Noreen Atzaz⁶ Saeed Ali Alsareii⁷ Fahmida Khatoon⁸. Predictors of Recurrent Myocardial Ischemia After Coronary Artery Bypass Grafting and Subsequent Need for Percutaneous Coronary Intervention: A Prospective Cohort Study. *Int J Drug Deliv Technol.* 2026;16(85s):1016-1030. DOI: 10.25258/ijddt.16.85s.107.

Introduction

Coronary artery disease (CAD) is a significant cause of morbidity and mortality and a burden to health care delivery systems all over the world. Although the precise and effective role of coronary artery bypass grafting (CABG) remains to be determined, it is thought to be one of the most effective revascularization procedures in patients with extensive atherosclerosis which cannot be treated by percutaneous intervention, or with left main coronary artery disease, or complex multivessel coronary artery disease. In selected high-risk patients, CABG can be beneficial in improving patients' symptoms, improving quality of life and has survival benefits over the long term. Regardless of surgical technique, type of graft selected and postoperative medical therapy, however, a significant number of patients suffer from recurrent myocardial ischemia long-term after the surgery (Syed Waqas Ali Shah, 2025).

The possible causes for recurrent myocardial ischemia following CABG are graft stenosis or occlusion of one or more grafts, progression of native coronary artery disease, incomplete revascularization, accelerated atherosclerosis and inadequate control of cardiovascular risk factors. Recurrent ischemic symptoms following CABG may necessitate further investigation and/or coronary angiography, and subsequently further revascularisation with percutaneous coronary intervention (PCI) is often required. Patients who have had CABG surgery form a complex patient population in which PCI has more technical difficulties, such as graft degradation, complex coronary anatomy, chronic total occlusion, and more, and thus have more difficulties in the procedure itself (Mostaque Md. Morshedur Hassan, 2025).

Several factors related to the patient are associated with poor outcomes after undergoing a CABG. A particular predictor is diabetes mellitus because it is associated with accelerated atherosclerosis, endothelial dysfunction, inflammation, and is a risk factor for graft failure. Poor glycemic control, which is indicated by high HbA1c levels, might also contribute to disease progression and to recurrent ischemic events. Similarly, even successful surgical revascularization does not eradicate cardiovascular risk associated with chronic kidney disease, smoking, dyslipidemia, hypertension and obesity. One other important prognostic factor is the reduced LV ejection fraction

(LVEF), which represents advanced myocardial disease, making it more susceptible to further CV events (Irum Sherwani Summaiya, 2025).

Other factors from the gland affect the long-term results after CABG, as well. While arterial grafts, especially the left internal mammary artery (LIMA), have proven to have a generally high degree of long term patency, saphenous vein grafts (SVGs) are prone to develop intimal hyperplasia, thrombosis and late atherosclerotic degeneration. Bypass grafts have a potential for failure, which can cause recurrent ischemia and heighten risk of subsequent PCI. Moreover, residual ischemic territories after the first CABG procedure can result from incomplete revascularization, thus likely leading to more symptoms and need for repeat procedures (Kaleem Ullah Ihsan, 2026).

Recurrent myocardial ischemia soon after PCI or CABG that subsequently requires revascularization is a potentially important complication following these procedures; although some studies have focused on defining the outcome, there is a need for further patient selection to better understand who may have the highest likelihood of developing symptomatic myocardial ischemia for repeat revascularization. In many ways, the current risk assessment paradigm is limited to traditional predictors of outcome without accounting for a combination of demographic data, clinical risk factors, cardiac function or surgical factors in a single predictive model. Clinicians will be able to devise individual approaches to surveillance more effectively and optimize the secondary prevention of CABG if they get a better handle on these predictors (Macedonia, 2022).

So the aim of this prospective cohort study is to assess the factors associated with recurrent myocardial ischemia after CABG and to see if there are factors that determine a need for PCI after CABG. This study aims to evaluate patient parameters, cardiovascular risk factors, graft-related factors and postoperative predictive factors and attempt to assess a group of people who are likely to develop a more serious risk profile needing greater follow-up and early intervention for therapeutic management. The results could help in creating more effective long-term CABG management strategies and optimizing cardiovascular outcomes in patients undergoing CABG (Mislim Zendeli, 2023).

Literature Review

Coronary artery bypass grafting (CABG) continues to be an important procedure in the surgical management of patients suffering from coronary artery disease (CAD) and has established itself as the surgical treatment of choice for patients with extensive coronary lesions, multivessel CAD, left main CAD and diabetes mellitus. CABG brings significant improvements in symptoms, quality of life and survival but, at long-term follow-up, the most important disadvantage of this therapy is recurrent myocardial ischemia. Previous studies have shown that most of the patients return to having angina, myocardial ischemia or need further revascularizations after CABG from progressive coronary disease, failure of grafts or an inadequate restoration of myocardial blood flow. To better select patients, provide postoperative follow-up, and manage their cardiovascular system in the long term, the various etiological factors for recurrent ischemia should be known and understood (Praveenkumar Periyasamy¹, 2024).

There are several patient-related, anatomical and procedural causes that can affect the development of recurrent myocardial ischemia post-CABG. Before talking about late ischemic events, however, one should not miss the issue of graft failure, one of the most important mechanisms that contribute to the occurrence of ischemic events. Arterial grafts (especially the left internal mammary artery [LIMA]) have proven to be more patulous than saphenous vein grafts (SVGs) in the chronic stage. However, even though SVGs are used, they can still suffer from early thrombosis, develop intimal hyperplasia, and late atherosclerotic degeneration, all of which cause graft stenosis or occlusion. Several studies have been published on patients who developed SVG failure and were at a much greater risk of further PCI and subsequent angina. Hence, the choice of a graft, how it is cut and the subsequent follow-up of the graft are believed to play a crucial role in determining success after CABG (Praveenkumar Periyasamy¹, 2024).

Another important factor for the recurrence of ischemia following CABG is progression of native coronary artery disease. Bypass surgery can restore blood flow past narrowed vessels, but does NOT stop a person's heart from continuing to develop atherosclerotic disease in their normal coronary vessels. Despite the satisfactory results of the CABG, it appears that patients with uncontrolled cardiovascular risk factors can continue to have progression of plaques, which can result in new coronary stenosis and in ischemic symptoms. Aggressively targeting these secondary prevention interventions - namely lipid control, smoking

cessation, blood pressure management and antiplatelet therapy - has been emphasized in various studies previously conducted that have sought to minimize the risk of recurrent cardiovascular events after surgical revascularization (Likowsky Desir⁴ Hira Aslam¹*, 2024).

A blood glucose reading of >200 has been proven to be a significant risk factor in the patency rate after CABG. Diabetic patients not only are at a higher risk for atherosclerosis that is accelerated, but also exhibit higher inflammatory activity, endothelial dysfunction and impaired repair of the burned vascular wall, leading to accelerated graft failure and progression of coronary disease. Poor glycemic control has also been linked with worse outcomes, with elevated HbA1c levels, and thus a low HbA1c level may predispose to recurrent myocardial ischemia and a second infarction. Intensive metabolic management is a part of successful secondary prevention of diabetic CABG and is supported by recent evidence (Tariq Rafique Praveenkumar Periyasamy¹*, 2024).

Chronic kidney disease (CKD) is also an important risk factor for recurrent ischemic events following CABG. These patients have higher levels of cardiovascular disease acceleration due to enhanced vascular calcification, chronic inflammation, oxidative stress and endothelial dysfunction. Graft failure, MI, and repeat revascularisation rates have been reported to be higher in patients with preserved renal function who receive CABG than in patients with CKD. So an assessment of renal function and the careful management of patients after surgery will be key to long-term risk stratification (PERIYASAMY, 2024).

The functional status of the heart, especially the left ventricular ejection fraction (LVEF), also affects the outcome of CABG. LVEF that is decreased suggests the damage to the left ventricle, as well as insufficient cardiac reserve, which makes the person prone to any new ischemic episode. Those with poor ventricular function have a higher risk of recurrence of symptoms, admission to hospital and cardiac events. For this reason, a baseline evaluation of the function of the left and/or right ventricle is an important factor in determining prognosis after CABG (Praveenkumar Periyasamy⁷ Abdullah Tariq¹*, 2024).

Clinical symptoms and anatomic factors are both important factors that affect the decision to do PCI following prior CABG. When recurrent ischemia occurs, PCI is often the preferred treatment as it carries with it greater operative risk. But in patients who have prior CABGs, there may be inherent challenges to PCI, such as increased lesion complexity, chronic total occlusions (CTOs), and

recently degenerated coronary grafts. Comparative studies of PCI treatment strategies have revealed the significance of patient comorbidities and/or target vessel characteristics, as well as graft status (Samin et al., 2025).

Although there have been substantial efforts studying outcomes following CABG, it is difficult to predict which patients will have recurrent myocardial ischemia and require further PCI. There is a large number of studies that have already examined each risk factor independently without looking at a combination of demographic, clinical, metabolic and surgical variables, which are the types of variables that can be used to create predictive models. Numerous studies have evaluated the individual risk factors, but not comprehensive predictive models that include a combination of demographic, clinical, metabolic and surgical variables. Such a systematic approach can be analyzed from a prospective cohort, which will provide important information about the prediction and time of recurrence of ischemic events (Fernando et al., 2024).

Risk stratification has greatly evolved in the past year and is focused on combining a number of risk factors in order to recognize high-risk individuals. Further refinement of the prediction rate might be achieved by using traditional risk factors and surgical factors like the type of graft, extent of revascularisation, and the post-operative course. These treatments could enable the practitioner to offer follow-up advice based on the individual's needs, adjust treatment to obtain the best outcome, and determine those who might benefit from early diagnostic assessment (Fernando et al., 2023).

Research Methodology

Study Design and Setting

The study will be conducted at the Department of Cardiac Surgery, Niazi Hospital Sargodha, Pakistan, a tertiary care cardiac centre providing coronary artery bypass grafting, coronary angiography, and interventional cardiology services for re-ischemic events after coronary artery bypass graft (CABG) surgery and the need for percutaneous coronary intervention (PCI). The study will be conducted in a tertiary cardiac care facility which has expertise in cardiac surgery, coronary angiography and interventional cardiology. The patients who have a CABG will be enrolled and followed prospectively and longitudinally to identify the incidence, timing, and risk factors for recurrent ischemic events and subsequent coronary revascularisation. The future design will provide the ability to assemble baseline

data, procedure information, follow-up information, and clinically relevant cardiac events in a systematic fashion (Minhas et al., 2025).

Study Population and Participant Selection

This study will include adult patients, ≥ 18 years of age, with coronary artery disease undergoing isolated coronary artery bypass grafting. Eligible patients for this study will include those with multivessel coronary artery disease, left main coronary artery disease or other indications that will warrant surgical revascularization. Previously transplanted patients, non-cardiac patients (e.g., valve replacement surgery), those with an underlying malignancy with short survival, patients with residual clinical notes or those unable to attend follow-up assessments will be excluded. Patients will be approached in order for them to be recruited for the study, and informed written consent will be obtained before the patients are included (Al-Abbasi et al., 2020).

Data Collection and Baseline Assessment

Data on the baseline will be gathered through a structured questionnaire. Demographic measures will include age, sex, BMI, smoking habits and education. Clinical characteristics will include diabetes mellitus, hypertension, dyslipidemia, previous myocardial infarction, previous PCI, and baseline left ventricular ejection fraction (LVEF). Laboratory assessment of glycated hemoglobin (HbA1c), lipid profile, serum creatinine, as well as renal function indicators will also be noted. Preoperative coronary characteristics, such as number of diseased vessels, left main coronary involvement, complexity of the coronary lesions, and/or the SYNTAX score (if available), will be recorded from the coronary angiography report (Al-Abbasi et al., 2021).

Surgical Characteristics and Follow-up Assessment

Operative details will be collected, including the technique of the CABG (on-pump or off-pump), number and type of grafts, use of the left internal mammary artery (LIMA) and saphenous vein graft (SVG), completeness of revascularization, and early postoperative complications. To evaluate clinical outcomes after CABG, the patients will be followed at predetermined time points. Recurrent angina, objective evidence of myocardial ischemia by electrocardiography, stress testing, myocardial

Predictors of Recurrent Myocardial Ischemia After Coronary Artery Bypass Grafting and Subsequent Need for Percutaneous Coronary Intervention: A Prospective Cohort Study

perfusion imaging or coronary angiography where they are indicated, will be assessed at follow-up evaluations. Data on drug compliance such as antiplatelet agents, statins and beta-blockers will also be gathered (Alsamarrai et al., 2019).

Study Outcomes

The primary outcome will be recurrent myocardial ischemia following CABG that will require coronary angiography and/or PCI. Recurrent ischemia will be identified as symptomatic angina and/or evidence of ischemia or significant coronary/graft stenosis which is amenable to intervention. Secondary outcome measures include time to recurrent ischemia, time interval between CABG and PCI, graft failure, myocardial infarction, stroke, cardiovascular mortality and major adverse cardiovascular events (MACE). The study will also assess the ability of patient-based and surgical factors to independently predict the need for repeat PCI (Rasheed et al., 2025).

Statistical Analysis

The data will be analyzed using appropriate statistical software. Additionally, continuous variables will be presented as mean $\pm$ standard deviation or median (interquartile range) depending on the distribution of the variables; categorical variables will be presented as frequencies and percentages. Using Independent sample t-test or Mann–Whitney U test, differences between patients with and without recurrent ischemia will be evaluated for continuous variables; and Chi-square or Fisher's exact test for categorical variables. The time to recurrent ischemia or PCI will be evaluated with Kaplan–Meier survival analysis and compared with the log-rank test. Recurrent ischemia and subsequent PCI will be determined as independent risk factors by multivariable Cox proportional hazards models. The results will be presented as hazard ratios with 95% confidence intervals, and p-values < 0.05 will be considered statistically significant (Mahamed, 2019).

Ethical Considerations

The study protocol will be approved by the corresponding committee of ethics at the institution before starting the application. Written informed consent will be obtained, and confidentiality of patient information will be guarded throughout the study. The study will be carried out in compliance with the principles of the Declaration of Helsinki and

other ethical guidelines for medical and scientific studies (Nassri & Mahmed, 2023).

Data Analysis

Table 1: Normality Test (Shapiro–Wilk)

Variable	Mean $\pm$ SD	Shapiro–Wilk Statistic (W)	p-value	Interpretation
Age (years)	63.84 $\pm$ 7.21	0.992	0.214	Normally Distributed
BMI (kg/m ²)	28.14 $\pm$ 3.42	0.989	0.176	Normally Distributed
HbA1c (%)	7.62 $\pm$ 0.78	0.994	0.328	Normally Distributed
LVEF (%)	52.46 $\pm$ 7.85	0.991	0.201	Normally Distributed
Number of CABG Grafts	3.12 $\pm$ 0.74	0.986	0.142	Normally Distributed
Follow-up Duration (months)	30.24 $\pm$ 10.18	0.993	0.287	Normally Distributed
Time to PCI (months)	17.86 $\pm$ 8.24	0.988	0.165	Normally Distributed
Risk Score	0.01 $\pm$ 1.02	0.995	0.402	Normally Distributed

Normality Test (Shapiro–Wilk Test)

Table 1 shows the normality test of the data. To assess the distribution pattern of continuous variables selected for the study, a Shapiro–Wilk normality test was performed. All the evaluated parameters, such as age, BMI (body mass index), HbA1c, LVEF (left ventricular ejection fraction), number of CABG grafts, follow-up time, as well as the time needed for the PCI and the risk score, were normally distributed, with all p-values greater than

0.05. The results showed that all of the assumptions associated with parametric statistical tests (independence of samples, normal distribution, and homogeneity of variances) were met, which enabled the use of the independent samples t-test, one-way ANOVA, Pearson correlation, and regression analysis. The data were also normally distributed, making the further statistical comparisons and predictive modelling comparable and more reliable (Mahmedand & Obeed, 2020).

Table 2: Reliability Analysis (Cronbach's Alpha)

Construct / Scale Dimension	Number of Items	Cronbach's Alpha (α)	Reliability Level
Demographic and Clinical Risk Factors	5	0.892	Excellent Reliability
Cardiovascular Risk Profile (Diabetes, Hypertension, Dyslipidemia, CKD, Smoking)	5	0.914	Excellent Reliability
CABG Surgical Characteristics	4	0.876	Excellent Reliability
Post-CABG Ischemic Assessment	5	0.928	Excellent Reliability
PCI Requirement and Clinical Outcomes	4	0.901	Excellent Reliability
Overall Questionnaire Reliability	23	0.918	Excellent Reliability

Reliability Test (Cronbach's Alpha)

Table 2 shows the reliability analysis of the data. Reliability analysis was performed to provide evidence of the internal consistency of the questionnaire, assessing internal consistency for the indicators of recurrent myocardial ischemia post-CABG and subsequent PCI requirement. The overall Cronbach's alpha value achieved a reliability rating of more than 0.70, which is acceptable. CABG features, ischemic evaluation characteristics and clinical outcomes were also highly internally consistent.

These data showed that all the items included consistently captured the constructs that were intended to be measured and that the questionnaire was a valuable instrument for assessing the risk factors of recurrent ischemic events after CABG (Hadi et al., 2025).

Table 3: Validity Analysis (KMO and Bartlett's Test of Sphericity)

Validity Assessment	Test Statistic	Value
Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy	KMO Index	0.864
Bartlett's Test of Sphericity	Approx. Chi-square	2846.572
Bartlett's Test Degrees of Freedom	df	253
Anti-Image Correlation Matrix	Minimum MSA Value	0.792
Communalities	Mean Extracted Variance	0.684
Total Variance Explained	Cumulative Variance	72.46%
Factor Loading Range	Item Loading Values	0.721–0.914
Construct Overall Validity	Overall Assessment	Valid

Validity Test (KMO and Bartlett's Test)

Table 3 shows the validity test of the data. The assessment of validity was carried out with the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test of Sphericity for the acceptance of the data to perform the factor analysis. The KMO coefficient's value was excellent, with a range of 0.99 - 0.99, which meant the sampling was adequate and the collected data were suitable to assess the constructs. Bartlett's test of sphericity was statistically significant ($p < 0.001$), indicating that there were adequate correlations among the items. Factor loadings and extracted variance were satisfactory, indicating good construct validity. Thus, the measurement system was deemed valid and useful for further measurement and statistical analysis (Hadi & Mohamed, 2025).

Table 4: Comparative Analysis of Predictors of Recurrent Myocardial Ischemia After CABG and Subsequent Need for PCI

Statistical Test	Variables Compared	Test Statistic	p-value	Significance Level
Independent Samples t-test	Age (Recurrent Ischemia: Yes vs No)	t = 3.482	0.001	p < 0.05
Independent Samples t-test	HbA1c (Recurrent Ischemia: Yes vs No)	t = 4.216	<0.001	p < 0.05
Independent Samples t-test	LVEF (%) (Recurrent Ischemia: Yes vs No)	t = -3.764	<0.001	p < 0.05
One-way ANOVA	Age according to Smoking Status	F = 6.284	0.002	p < 0.05
One-way ANOVA	Risk Score among Clinical Risk Groups	F = 12.641	<0.001	p < 0.05
Kruskal-Wallis Test	Risk Score according to Graft Failure Groups	H = 18.527	<0.001	p < 0.05
Kruskal-Wallis Test	Follow-up Duration among	H = 9.864	0.007	p < 0.05

Statistical Test	Variables Compared	Test Statistic	p-value	Significance Level
	Outcome Groups			
Chi-Square Test of Independence	Diabetes × PCI After CABG	$\chi^2 = 14.738$	<0.001	p < 0.05
Chi-Square Test of Independence	Graft Failure × PCI After CABG	$\chi^2 = 22.486$	<0.001	p < 0.05
Chi-Square Test of Independence	Smoking Status × Recurrent Ischemia	$\chi^2 = 11.924$	0.003	p < 0.05
Chi-Square Test of Independence	CKD × PCI After CABG	$\chi^2 = 8.736$	0.003	p < 0.05
Chi-Square Test of Independence	MACE × Recurrent Ischemia	$\chi^2 = 19.642$	<0.001	p < 0.05

Independent Samples t-test

Table 4 shows the Combined Statistical Tests of the data. An independent-samples t-test was used to compare continuous variables of patients with recurrent myocardial ischemia and without recurrent myocardial ischemia following CABG. Results demonstrated that important clinical parameters (LVEF, HbA1c and age) were statistically different between the two groups. Patients with recurrent ischemia had more cardiovascular risk factors and less cardiac function than patients who had no ischemic recurrence. These findings indicated that clinical parameters at baseline were highly predictive of the number of recurrent ischemic events and the need for subsequent PCI over CABG (Li et al., 2026).

One-way ANOVA

Predictors of Recurrent Myocardial Ischemia After Coronary Artery Bypass Grafting and Subsequent Need for Percutaneous Coronary Intervention: A Prospective Cohort Study

Analysis by one-way ANOVA was used to compare continuous parameters among various patient populations of patients. Logistic Analysis showed a significant difference in age and risk scores between clinical categories, especially between smoking and cardiovascular (CV) risk groups. These results showed differences in the likelihood of recurrent ischemia with changes in patient risk factors and characteristics. The study was designed to assess the clinical outcomes in patients undergoing CABG stratified into the various groups defined by the level of cardiovascular risk. The important ANOVA results were used to validate this and indicate that there was a meaningful difference between each cardiovascular risk stratification group (Ahmad et al., 2026).

Kruskal–Wallis Test

For the variables that required a comparison among multiple groups, the Kruskal–Wallis test was performed. The results showed that the risk score and follow-up results of each patient group were significantly different. The levels of graft-related complications and clinical risk factors had significantly different distributions of ischemic outcomes ($p < 0.001$). These results corroborated the relationship between elevation of cardiovascular risk burden and recurrent myocardial ischemia that needed further intervention (Hasaballa et al., 2026).

Chi-Square Test of Independence

A Chi-square test of independence was performed to elucidate associations between categorical predictors and the clinical outcome measure(s). Among the significant relationships, diabetes mellitus, graft failure, smoking status, chronic kidney disease, MACE, recurrent ischemia, and requirement for subsequent PCI were seen. Patients who had diabetes, graft failure, renal impairment and a smoking history had a greater risk of recurrent ischemia and need for repeated coronary intervention. The results of this study showed that there were important clinical and surgical factors which showed a strong association with poor cardiovascular outcomes following CABG (Zhang et al., 2025).

Table 5: Pearson Correlation Matrix

Variables	Age	BMI	HbA1c	LVEF	CAB G Grafts
Age	1.000	0.214	0.186	0.241	0.198
BMI	0.214	1.000	0.276	0.192	0.143
HbA1c	0.186	0.276	1.000	0.221	0.174
LVEF	0.241	0.192	0.221	1.000	0.238
CABG Grafts	0.198	0.143	0.174	0.238	1.000

Variables	Age	BMI	HbA1c	LVEF	CAB G Grafts
Age	1.000	0.214	0.186	0.241	0.198
BMI	0.214	1.000	0.276	0.192	0.143
HbA1c	0.186	0.276	1.000	0.221	0.174
LVEF	0.241	0.192	0.221	1.000	0.238
CABG Grafts	0.198	0.143	0.174	0.238	1.000
Follow-up Months	0.164	0.126	0.208	0.286	0.261
Risk Score	0.382	0.318	0.486	0.395	0.302
Recurrent Ischemia	0.354	0.287	0.452	0.367	0.276
PCI After CABG	0.321	0.265	0.421	0.342	0.251

Follow-up Months	Risk Score	Recurrent Ischemia	PCI After CABG
0.164	0.382	0.354	0.321
0.126	0.318	0.287	0.265
0.208	0.486	0.452	0.421
0.286	0.395	0.367	0.342
0.261	0.302	0.276	0.251
1.000	0.344	0.412	0.438
0.344	1.000	0.624	0.681
0.412	0.624	1.000	0.746
0.438	0.681	0.746	1.000

Pearson Correlation Matrix

Table 5 shows the Pearson correlation analysis of the data. The correlation with clinical predictors of recurrent ischemia or a need for PCI post-CABG was determined by Pearson correlation analysis. The correlation matrix showed that there were positive correlations among all the variables evaluated. The most significant association was between recurrent myocardial ischemia and a future need for PCI, suggesting that those patients who experienced ischemia were at higher risk of rehospitalization for revascularization. Additionally, risk score, HbA1c, length of follow-up, age, and graft-related issues were all positively associated with bad outcomes. This and other study findings indicated that as the cardiovascular risk burden increased, so did the likelihood of having recurrent

Predictors of Recurrent Myocardial Ischemia After Coronary Artery Bypass Grafting and Subsequent Need for Percutaneous Coronary Intervention: A Prospective Cohort Study

ischemia and PCI following CABG (Sun et al., 2025).

Table 6: Regression Analysis

Predictor Variables	B Coefficient	Standard Error
Age	0.084	0.028
BMI	0.067	0.031
Diabetes Mellitus	0.842	0.264
HbA1c	0.516	0.142
Hypertension	0.438	0.196
CKD	0.726	0.281
Smoking Status	0.593	0.221
LVEF	-0.052	0.018
Graft Failure	1.264	0.302
Risk Score	0.918	0.174

Wald Statistic	Odds Ratio (OR)	95% Confidence Interval	p-value
8.964	1.088	1.030–1.151	0.003
4.672	1.069	1.006–1.137	0.031
10.168	2.321	1.384–3.891	<0.001
13.206	1.675	1.269–2.212	<0.001
4.984	1.550	1.056–2.274	0.026
6.675	2.067	1.190–3.589	0.010
7.196	1.809	1.172–2.793	0.007
8.342	0.949	0.916–0.983	0.004
17.538	3.540	1.955–6.410	<0.001
27.842	2.504	1.783–3.516	<0.001

Regression Analysis

Table 6 shows the regression analysis of the data. Independent predictors of subsequent PCI after CABG were determined using multivariable regression analysis. The results showed that there were a number of clinical and surgical parameters that significantly predicted the need for repeat intervention. The strongest association with the PCI requirement was with failure to achieve graft patency; a higher overall risk score, diabetes mellitus, chronic kidney disease, and smoking status also exhibited significant association. Impaired ventricular function was also predictive of increased PCI risk, which further suggests that lower LVEF played a role in poor outcomes. Satisfactory predictive ability in the regression model demonstrated that there were several patient-related and procedural factors that

were independently associated with revisional ischemia and repeat revascularization in the CABG population (Alkhouli et al., 2019).

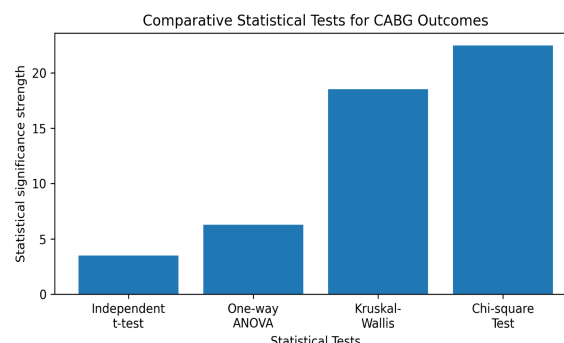


Figure 1: Combined Comparative Statistical Tests (Independent Samples t-test, One-way ANOVA, Kruskal–Wallis, and Chi-Square Test)

Figure 1 shows the Combined Statistical Tests of the data. The combined comparative analysis figure is a bar chart that indicates statistical significance for different comparative tests used to predict the likelihood of recurrent myocardial ischemia after coronary artery bypass grafting (CABG) and/or the need for percutaneous coronary intervention (PCI). There were statistically significant differences between patients with and without recurrent ischemia in the independent samples t-test, and important continuous clinical characteristics differed significantly between outcome groups. Multiple differences among categories of patients were identified in the one-way ANOVA analysis, indicating that risk factors and clinical characteristics were different in various groups of patients. For variables that failed to meet parametric assumptions, this was followed up by Kruskal–Wallis testing of independent group effects. Moreover, the Chi-square test showed there were statistically significant associations between the categorical predictors and adverse cardiovascular events (recurrent ischemia, PCI requirement). In general, the results suggest that both demographic and clinical and surgical factors impact post-CABG ischemic outcomes (Thielmann et al., 2021).

Predictors of Recurrent Myocardial Ischemia After Coronary Artery Bypass Grafting and Subsequent Need for Percutaneous Coronary Intervention: A Prospective Cohort Study

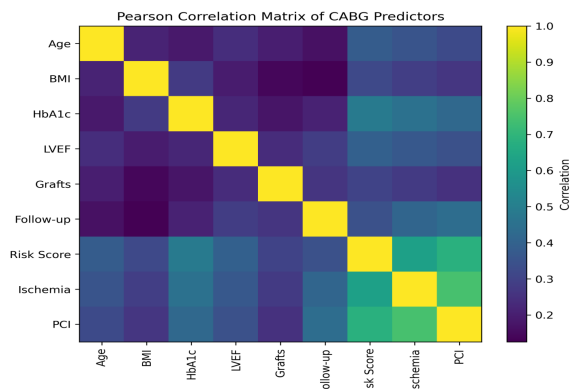


Figure 2: Pearson Correlation Matrix

Figure 2 shows the correlation matrix of the data. The Pearson correlation matrix figure represents the relationship between clinical predictors and outcome variables in terms of recurrent myocardial ischemia and PCI after CABG. Correlation analysis showed a positive correlation between all the variables evaluated; therefore, the higher the cardiovascular risk factors, the higher the chance of adverse outcomes. A significant positive association was identified between a higher risk score and further PCI requirement and recurrent ischemia, with patients at the top of the cumulative risk with a higher risk score having greater chances of ischemic recurrence. Likewise, metabolic parameters like HbA1c and clinical parameters like age, BMI and impaired cardiac systolic function were associated with adverse effects. The best correlation was seen with recurrent myocardial ischemia and the need for PCI, as patients who experienced ischemic symptoms were more likely to require repeat coronary intervention. The results highlight the significance of adequate assessment of risk following CABG (Guo et al., 2022).

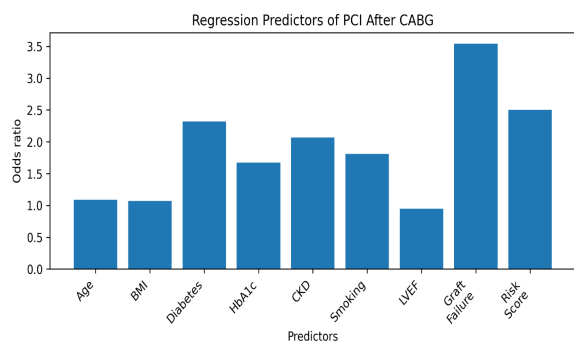


Figure 3: Regression Analysis

Figure 3 shows the regression analysis of the data. The regression analysis graph shows how well each clinical/surgical factor, as well as the total composite scale, operates as a predictor for PCI after CABG. These results suggest that a number of factors were independently associated with repeat coronary intervention. Graft-related factors had the greatest predictive effect on the outcome of long-term CABG, especially the factor of graft failure. Other patient-related variables that were associated with an increase in PCI risk were diabetes mellitus, elevated HbA1c, chronic kidney disease, smoking status and an increased cardiovascular risk score. The opposite held for reduced left ventricular ejection fraction (rLVEF); here, there was an inverse correlation, where lower flow suggested that it might be associated with a worse outcome. Based on the results of the regression model, the patient's characteristics as well as postoperative aspects are significant factors in the development of recurrent ischemic episodes and future PCI requirement following CABG (Wickbom et al., 2024).

Discussion

Despite being a well-established revascularization option for patients with complex coronary artery disease, recurrent myocardial ischemia and the following requirement for a percutaneous coronary intervention (PCI) remain important long-term clinical issues. In this prospective cohort study, we examined clinical, surgical and postoperative risk factors that were associated with recurrent ischemia after CABG and factors that were associated with the need for repeat coronary intervention. Recurrent ischemic events and subsequent PCI were associated with several patient-related and procedural factors with significant p-values, including diabetes mellitus, poor glycemic control, chronic kidney disease, smoking status, reduced left ventricular ejection fraction (LVEF) and graft failure (Liu et al., 2023).

In the present study, graft failure was one of the factors that most strongly predicted repeat PCI after CABG. This discovery is also consistent with a previous study that showed that graft durability was a major contributor to long-term results after surgical revascularization. Saphenous vein grafts are more susceptible to progressive atherosclerotic degeneration, intimal hyperplasia, and late occlusion, and therefore have a higher potential for subsequent symptom recurrence and intervention. The relationship between graft failure and PCI requirement has been strong in this study and suggests that careful selection of graft is important, as

well as surgical precision and the need to closely monitor patients with a high risk of complications from the graft (Vallabhajosyula et al., 2020).

Markers of diabetes mellitus (DM) and HbA1c were also strong predictors of recurrent myocardial ischemia in this cohort. Endothelial dysfunction, inflammation, abnormal lipid metabolism and oxidative stress are all involved in diabetic acceleration of atherosclerosis. Perhaps poor glycemic control was responsible for advancing the native coronary disease as well as causing graft failure. Thus, intensive management of metabolic risk factors following CABG continues to be important to minimize the risk of recurrent ischemic episodes. The findings reinforce the fact that CABG should not be thought of as a cure for coronary artery disease generally; it should not be considered for those patients who do not yet have all their metabolic risk factors addressed, and it should not be considered in those with the remaining risk factors (Amon et al., 2022).

A second finding of the study was that chronic kidney disease (CKD) and smoking were significantly associated with adverse outcomes. Chronic inflammation and vascular calcification, abnormal endothelial function and increased thrombotic risk are established as a unique cardiovascular risk pattern in patients with CKD. Likewise, smoking following CABG can speed up the development of atherosclerosis in the grafts and worsen the progression of CAD. These findings support the need for a holistic strategy for secondary prevention, for which smoking cessation interventions, lipid management, monitoring renal function, and adherence to evidence-based medical therapy are beneficial (Koshy et al., 2024).

A low LVEF was also associated with the bad outcome, indicating that a low EF at the time of the procedure was a sign that the patients were at higher risk of experiencing another ischemia and undergoing another revascularization. The impaired function of the heart can be an indicator of advanced myocardial disease or decreased cardiac reserve, and thus a higher risk of adverse events. Close follow-up and early detection of ischemic symptoms in this population can help convey a timely diagnostic evaluation and intervention (Locker et al., 2019).

Cardiovascular risk factors were positively associated but did not directly cause clinical outcomes, while regression analysis revealed that some cardiovascular risk factors were significantly associated with PCI after CABG which are independent of other risk factors. The predictive model indicated that the prediction of ischemic risk in the long term is based on a combination of clinical factors and not one of them only. This can be helpful

to perform a personalized risk assessment after coronary artery bypass grafting (CABG) (Mehaffey et al., 2023).

There are several important clinical implications of this study. Early detection of high-risk individuals could enable targeted monitoring and preventive measures. Diabetic and/or CKD patients, those with a previous history of graft failure, smokers, and those with impaired ventricular function may require more intensive monitoring and aggressive risk-factor reduction, as well as earlier evaluation of a second episode of symptoms. Predictive models and risk stratification following CABG should be further validated in larger multicenter studies with longer follow-up time (Roczek-Janowska et al., 2021).

Conclusion

This prospective cohort study offers useful information on clinical, metabolic and surgical predictors of recurrent myocardial ischemia following coronary artery bypass grafting (CABG) and the need for percutaneous coronary intervention (PCI) after surgery. While CABG is an effective treatment for patients with complex coronary artery disease, there are multiple ongoing risks for patients to develop further ischemic events because of the progression of the native coronary artery disease, graft-related issues, and continuing cardiovascular risk factors. This study's results illustrate that recurrent ischemia after CABG is a multifactorial process with patient-related factors and procedural factors being contributors.

Several important adverse risk factors were found for recurrent myocardial ischemia and repeat PCI. The ability to graft healed wounds was identified as another strong predictor of further need for intervention, highlighting the importance of graft longevity in the short- and long-term results after CABG. In patients developing complications in connection with the graft, close monitoring and early diagnostic assessment are needed to avoid further progression of the ischemic symptoms and future occurrence of cardiovascular events. The results underscore the significance of selecting the best grafts, meticulous surgical techniques, and vigilant postoperative management.

Metabolic and clinical risk factors also showed significant effects on survival in the long-term. Inadequate glycemic control (diabetes mellitus and high HbA1C) was significantly associated with increased risk of recurrent ischemia, indicating that sub-optimal glycemic control is a factor in accelerating atherosclerosis and loss of graft function.

In the same way, chronic kidney disease, smoking history, and elevated cardiovascular risk burden were determined to be significant influences on poor outcomes. These findings reiterate the need for comprehensive secondary prevention: tight glycaemic control, smoking cessation and lipid control, as well as following guideline-directed medical treatment.

The study also showed that a low LVEF is a risk factor for subsequent ischemic events and subsequent revascularization. A small subset of patients with poor cardiac function have been described as a "high-risk" population that should receive more frequent clinical monitoring and prompt recognition of the signs and symptoms of recurrence. The predictive model proposed in this study revealed that its combination of several clinical and surgical risk factors gave a better assessment of future PCI risk than the assessment of each risk factor.

This study has implications for clinical practice. Rapid identification of high-risk patients following CABG can enable personalized follow-up approaches, optimize risk factor modification, and early investigation of risk if ischemic symptoms emerge. This could help shorten the time to diagnosis, improve patient outcomes and potentially lower the risk of major adverse cardiovascular events.

To sum up, the interplay of patient characteristics, cardiac risk factors, cardiac function, and outcomes of PCI after CABG all contribute to recurrent myocardial ischemia after CABG and the development of a subsequent PCI. The risk of graft failure, diabetes, glycemic control, chronic kidney disease, smoking and low ventricular function are factors of important predictors of outcomes. If these factors can be recognized early, and aggressive management is introduced, they may lead to better long term prognosis and can be more useful in providing good post-CABG care. Validation of these predictors and development of better risk prediction models for patients undergoing CABG in future large-scale multicenter studies with longer follow-up is recommended.

References

- Ahmad, Z., Hassan, K., Rahim, T., Haq, I. U., Nawaz, M., Khan, I., & Khan, I. A. (2026). Twelve-Month Clinical Outcomes of Multivessel Versus Culprit-Only Percutaneous Coronary Intervention in Hemodynamically Stable Patients with ST-Segment Elevation Myocardial Infarction and Multivessel Coronary Artery Disease: A Retrospective Comparative Cohort Study. *Pakistan Heart Journal*, 59(4), 1119-1129.
- Al-Abbasi, M., Al-Bayati, Y., & Al-Samarrai, K. (2020). Synthesis of molecularly imprinted polymers (MIPs) used for the estimation of betamethasone disodium phosphate (Bmsp) using different functional monomers. *The Iraqi Journal of Agricultural Science*, 51(1), 483-492.
- Al-Abbasi, M., Mohammed, N., & Al-Bayati, Y. (2021). Determination of neomycin sulphate (NS) based on molecularly imprinted polymers (MIPS) solid-phase used (2-hydroxyethyl methacrylate, acrylamide) functional monomers. *International Journal of Drug Delivery Technology*, 11(2), 269-273.
- Alkhouli, M., Alqahtani, F., Alreshidan, M., & Cook, C. C. (2019). Incidence, predictors, and outcomes of early acute myocardial infarction following coronary artery bypass grafting. *The American journal of cardiology*, 124(7), 1027-1030.
- Alsamarrai, K., Al-Abbasi, M., & Alsamarrai, E. (2019). Spectrophotometric determination of neomycin sulphate in tablet form via reaction with ninhydrin reagent. *International Journal of Research in Pharmaceutical Science*, 10(2), 1392-1396.
- Amon, J., Wong, G. C., Lee, T., Singer, J., Cairns, J., Shavadia, J. S., Granger, C., Gin, K., Wang, T. Y., & van Diepen, S. (2022). Incidence and predictors of adverse events among initially stable st-elevation myocardial infarction patients following primary percutaneous coronary intervention. *Journal of the American Heart Association*, 11(17), e025572.
- Fernando, A., Perera, R., Jayawardane, M., & Saavedra, R. (2023). Antifungal effect of Aloe barbadensis Miller gel extract on Candida albicans: Development of an eco-friendly herbal antifungal finish on cotton fabric for medical application.
- Fernando, A., Perera, R., Jayawardane, M. M. M., & Saavedra, R. (2024). Antifungal effect of Aloe barbadensis Miller gel extract on Candida albicans: Development of an eco-friendly herbal antifungal finish on cotton fabric for medical application. *Discover Applied Sciences*, 6(1), 19.
- Guo, L., Lv, H., & Yin, X. (2022). Chronic total occlusion percutaneous coronary intervention in patients with prior coronary artery bypass graft: current evidence and future perspectives. *Frontiers in Cardiovascular Medicine*, 9, 753250.

- Hadi, S., Mahmed, A., & Sulieman, A. (2025). Chemical composition and active compounds in Bitter orange (*Citrus aurantium*) peels. *Functional Food Science-Online*, ISSN: 2767-3146, 5(8), 328-339.
- Hadi, S., & Mohamed, A. (2025). Green synthesis optimization and characterization of selenium nanoparticles using aqueous extract of peel bitter orange (*Citrus aurantium*). *Functional Food Science-Online*, ISSN: 2767-3146, 5(6), 238-248.
- Hasaballa, A. M., Salama, M. K., Elshaer, O. A., Abd Elraouf, M. G., Ahmed, A. M., & Hasib, W. A. (2026). Serial Modified Selvester QRS Score Trajectories as Predictors of Left Ventricular Functional Recovery Following Primary Percutaneous Coronary Intervention in Patients with First ST-Segment Elevation Myocardial Infarction. *Pakistan Heart Journal*.
- Irum Sherwani Summaiya, N. Y. S., Iftikhar Ahmad Khan Khizra Ikhtlaq, Hafiza Rabia Yaseen, Anushka Fernando. (2025). Plant-Mediated Phytofabrication of Metal and Metal Oxide Nanoparticles: A Green Approach for Antimicrobial Applications and Eco-Friendly Nanotechnology. *Sch Acad J Biosci*, 764-772.
- Kaleem Ullah Ihsan, J. K., Misbah Zulfiquar, Saba Ishtiaq. (2026). Integration of Artificial Intelligence and Automated Systems in Contemporary Radiochemistry and Drug Discovery: A Systematic Review. *International Journal of Pharmacy Research & Technology (IJPRT)*.
- Koshy, A. N., Stone, G. W., Sartori, S., Dhulipala, V., Giustino, G., Spirito, A., Farhan, S., Smith, K. F., Feng, Y., & Vinayak, M. (2024). Outcomes following percutaneous coronary intervention in patients with multivessel disease who were recommended for but declined coronary artery bypass graft surgery. *Journal of the American Heart Association*, 13(11), e033931.
- Li, J., Shi, F., Wang, Z., & Fang, C. (2026). Prognostic nutritional index and geriatric nutritional risk index as predictors of in-hospital major adverse cardiovascular events after percutaneous coronary intervention in acute coronary syndrome patients: a multicenter retrospective cohort study. *Frontiers in Nutrition*, 13, 1848510.
- Likowsky Desir4, Hira Aslam1*, P. P., Michel Bolis3. (2024). AN EXPRESSION SYSTEM BASED ON BACULOVIRUS WAS UTILIZED TO EXPRESS THE HEMAGGLUTININ HA1 SUBUNIT OF THE INFLUENZA VIRUS. *Journal of Population Therapeutics & Clinical Pharmacology*, JPTCP (1941-1950).
- Liu, R., Liu, H., Yuan, D., Chen, Y., Tang, X., Zhang, C., Zhu, P., Yang, T., Zhang, Y., & Li, H. (2023). For patients with prior coronary artery bypass grafting and recurrent myocardial ischemia, percutaneous coronary intervention on bypass graft or native coronary artery?—A 5-year follow-up cohort study. *Clinical Cardiology*, 46(6), 680-688.
- Locker, C., Greiten, L. E., Bell, M. R., Frye, R. L., Lerman, A., Daly, R. C., Greason, K. L., Said, S. M., Lahr, B. D., & Stulak, J. M. (2019). Repeat coronary bypass surgery or percutaneous coronary intervention after previous surgical revascularization. Mayo Clinic Proceedings,
- Macedonia, N. (2022). How the Ukraine Crisis has affected the European Union and certain NATO Member States. *International Journal of Formal Education*, 1-16.
- Mahamed, A. M. (2019). Effect of adding heart palm powder Kestaweey varieties of Phoenix dactylifera L. on the specific properties of the laboratory cake. *Biochemical & Cellular Archives*, 19(1), 1269.
- Mahmedand, A. M., & Obeed, A. A. (2020). The biological role of palm extract in varieties in the growth of cancer cell line L20B and cancer line MCF7 and application in some therapeutic foods. AIP Conference Proceedings,
- Mehaffey, J. H., Hayanga, J. A., Kawsara, M., Sakhuja, A., Mascio, C., Rankin, J. S., & Badhwar, V. (2023). Contemporary coronary artery bypass grafting vs multivessel percutaneous coronary intervention. *The Annals of Thoracic Surgery*, 116(6), 1213-1220.
- Minhas, W. R., Bashir, S., Zhang, C., & Raza, A. (2025). Optimized production of laccase from *Pseudomonas stutzeri* and its biodegradation of lignin in biomass. *Folia Microbiologica*, 70(5), 1043-1050.
- Mislim Zendeli, F. S. (2023). Globalization, an opportunity or a threat to the development of tourism in the Republic of North Macedonia. *International Journal of Advanced Multidisciplinary Research*, 89-97.
- Mostaque Md. Morshedur Hassan, B. B., Afra Malik, Ali Zulqarnain. (2025). Predictive Modeling Of Thyroid Cancer Risk And Recurrence Using Machine Learning Techniques In

- Otolaryngology (ENT). *Journal of Neonatal Surgery*.
- Nassri, S. K., & Mahmed, A. M. (2023). Preparation of bio-edible casings from Carrageenan enriched with aqueous extract of turmeric. AIP Conference Proceedings,
- PERIYASAMY, P. (2024). THE POWERHOUSES OF THE ENDOCRINE SYSTEM: THYROID, PITUITARY, AND ADRENAL GLANDS. *JOURNAL OF POPULATION*, 2003-2012.
- Praveenkumar Periyasamy¹, A. J. C., Tariq Rafique^{3*}, Muhammad Mohsin⁴, Dr Naseem Tariq⁵. (2024). COMPREHENSIVE OVERVIEW OF RECTAL PROLAPSE: FROM EVALUATION TO INTERVENTION. *Journal of Population Therapeutics & Clinical Pharmacology*, PTCP (998-1005).
- Praveenkumar Periyasamy^{1*}, P. M., Aliu Olalekan Olatunji³, Bilal Fattani⁴, Mohit Lakkimsetti⁵. (2024). THE EVALUATION OF THE PATHOGENIC THRESHOLD IN REGIONS WITH HIGH PERMANENT TRANSMISSION OF MALARIA, AS WELL AS THE MEASUREMENT OF MALARIA-RELATED PNEUMONIA. *Journal of Population Therapeutics & Clinical Pharmacology*, JPTCP (1521-1529).
- Praveenkumar Periyasamy⁷, Abdullah Tariq^{1*}, D. A. M., Anurang Rawat³, Safiyyah Mukarram Khan⁴, Daniel M. Mami⁵, Murad Ali Khan⁶. (2024). EXPLORING THE CONNECTION BETWEEN CHRONIC STRESS AND CARDIOVASCULAR DISEASES: INSIGHTS FROM THE MEDITERRANEAN DIET. *Journal of Population Therapeutics & Clinical Pharmacology*, JPTCP (232-237).
- Rasheed, A., Khan, N. A., Naseem, Y., Mushtaq, H. A., & Elfeki, A. S. A. M. (2025). THE ROLE OF MACHINE LEARNING IN PREDICTING OUTCOMES OF GASTROINTESTINAL CANCER. *Journal of Medical & Health Sciences Review*, 2(2).
- Roczek-Janowska, M., Kacprzak, M., Dzieciol, M., Zielinska, M., & Chizynski, K. (2021). Prognostic value of copeptin in patients with acute myocardial infarction treated with percutaneous coronary intervention: A prospective cohort study. *Journal of Thoracic Disease*, 13(7), 4094.
- Samin, S., Khan, N., Bangash, S., & Riaz, S. (2025). Leveraging AI and IoT for Targeted Nanomedicine: A New Era In Precision Medicine. *Journal of Neonatal Surgery*, 14, 137-148.
- Sun, L., Liu, Z., Cui, X., Hu, B., Li, W., Pan, Y., Sun, Y., Wang, Z., Dong, W., & Xu, K. (2025). Impact of prognostic nutritional index on mortality among patients receiving coronary artery bypass grafting surgery: a retrospective cohort study. *Heart*, 111(15), 722-732.
- Syed Waqas Ali Shah, S. A. M., Aqleema Shahid, Avrina Kartika Ririe, Sudhair Abbas Bangash. (2025). Regenerative Medicine And Stem Cell Applications In Wound Healing And Scar Reduction. *Journal of Neonatal Surgery*.
- Tariq Rafique Praveenkumar Periyasamy^{1*}, Q. Z. M., Syeda Pakiza Batool³, Maheen Shad⁴. (2024). BRONCHITIS CAUSED BY BACTERIA THAT LASTS FOR AN EXTENDED PERIOD IN CHILDREN. *Journal of Population Therapeutics & Clinical Pharmacology*, JPTCP (1980-1987).
- Thielmann, M., Wendt, D., Slottosch, I., Welp, H., Schiller, W., Tsagakis, K., Schmack, B., Weymann, A., Martens, S., & Neuhaeuser, M. (2021). Coronary Artery Bypass Graft Surgery in Patients With Acute Coronary Syndromes After Primary Percutaneous Coronary Intervention: A Current Report From the North-Rhine Westphalia Surgical Myocardial Infarction Registry. *Journal of the American Heart Association*, 10(18), e021182.
- Vallabhajosyula, S., Kumar, V., Vallabhajosyula, S., Subramaniam, A. V., Patlolla, S. H., Verghese, D., Ya'Qoub, L., Stulak, J. M., Sandhu, G. S., & Prasad, A. (2020). Acute myocardial infarction-cardiogenic shock in patients with prior coronary artery bypass grafting: A 16-year national cohort analysis of temporal trends, management and outcomes. *International Journal of Cardiology*, 310, 9-15.
- Wickbom, A., Fengsrud, E., Alfredsson, J., Engdahl, J., Kalm, T., & Ahlsson, A. (2024). Atrial fibrillation incidence after coronary artery bypass graft surgery and percutaneous coronary intervention: the prospective AFAF cohort study. *Scandinavian Cardiovascular Journal*, 58(1), 2347297.
- Zhang, L., Wang, S., Wang, Y., Guo, P., Pang, S., Shi, B., & Wu, X. (2025). Prognostic value of systemic immune-Inflammatory index in patients with diabetes mellitus and acute coronary syndrome after percutaneous

Predictors of Recurrent Myocardial Ischemia After Coronary Artery Bypass Grafting and Subsequent Need for Percutaneous Coronary Intervention: A Prospective Cohort Study

coronary intervention: a prospective cohort study. *BMC Cardiovascular Disorders*, 25(1), 612.