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Original Research Article

UNVEILING CLINICAL AND ANGIOGRAPHIC PREDICTORS OF RESTENOSIS FOLLOWING PERCUTANEOUS CORONARY INTERVENTION (PCI) IN LEFT ANTERIOR DESCENDING (LAD) ARTERY LESIONS: INSIGHTS FROM A RETROSPECTIVE COHORT STUDY

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Abstract: *Restenosis, the re-narrowing of coronary arteries post-stenting, continues to be a significant clinical issue, particularly in Left Anterior Descending (LAD) artery lesions. Despite advances in stent technology, including drug-eluting stents (DES), restenosis remains a significant contributor to adverse cardiovascular events such as myocardial infarction and repeat revascularisation. Understanding the clinical and angiographic factors that predict restenosis is crucial for improving patient outcomes.* ***Objective:*** *This study aims to identify clinical and angiographic predictors of restenosis in patients undergoing Percutaneous Coronary Intervention (PCI) for LAD artery lesions.* ***Methods:*** *A retrospective cohort study was conducted at MTI-Hayatabad Medical Complex from January 1, 2023, to December 31, 2023. A total of 162 patients who underwent PCI for de-novo LAD lesions were included. Data regarding patient demographics, comorbidities, lesion characteristics, and stent types were extracted from hospital records. Angiographic follow-up was performed at 12 months post-PCI to assess restenosis, defined as ≥50% luminal narrowing. Multivariate logistic regression analysis was used to identify independent predictors of restenosis.*
Results: *Among the 162 patients, 15.4% (n=25) developed restenosis within 12 months. Diabetes mellitus (OR: 2.74; 95% CI: 1.21–6.24; p=0.014), lesion length (OR: 1.08 per mm; 95% CI: 1.01–1.15; p=0.025), and stent type (DES vs. BMS; OR: 0.42; 95% CI: 0.18–0.98; p=0.046) were identified as significant predictors. Smoking and hypertension were not found to be statistically significant.* ***Conclusion:*** *Diabetes mellitus, lesion length, and the use of drug-eluting stents are independent predictors of restenosis in LAD artery lesions. These findings underscore the need for tailored stenting strategies and enhanced post-PCI management in high-risk patients to reduce restenosis rates and improve long-term outcomes.*

Keywords: Restenosis, Left Anterior Descending artery, Percutaneous Coronary Intervention, Drug-eluting stents, Diabetes mellitus, Lesion length

Introduction

Percutaneous Coronary Intervention (PCI) has become the go-to treatment for coronary artery disease, particularly for lesions in the Left Anterior Descending (LAD) artery, a critical vessel supplying blood to a large portion of the heart. Despite advances in stent technology—such as drug-eluting stents (DES) and bare-metal stents (BMS)—restenosis, re-narrowing the artery following PCI remains a significant challenge. This issue is particularly troubling since restenosis can lead to severe complications, like repeat interventions, myocardial infarctions, or other significant adverse cardiovascular events (MACE) (1, 2). Understanding what causes restenosis is crucial to improving patient outcomes, especially for those who fall into high-risk categories.

Historically, specific clinical and angiographic factors have been closely associated with an elevated risk of restenosis after PCI. Diabetes mellitus, long lesion lengths, and the type of stent used (DES vs. BMS) are some of the most frequently identified risk factors (3, 4). Even though DES has shown better outcomes in reducing restenosis than BMS, concerns remain, particularly in patients with complex lesions or underlying conditions like diabetes (5). Other factors such as smoking, hypertension, and hyperlipidemia have also been suspected of contributing to restenosis, although their influence varies across studies (6). This study was born out of the need to address the scarcity of real-world data focusing specifically on restenosis in LAD lesions—a subset known for its high risk. Previous research often examined general coronary artery disease populations, overlooking the unique challenges posed by LAD lesions. These lesions tend to be longer and more calcified, which adds to the complexity of the procedure. Furthermore, limited data exist from resource-constrained regions where access to state-of-the-art PCI technologies and post-procedural care may not align with practices in high-income countries. By concentrating on LAD lesions, this study aims to bridge a critical gap in the literature and provide practical insights for clinical decision-making.

The primary goal of this retrospective cohort study is to identify the clinical and angiographic predictors of restenosis in patients who have undergone PCI for LAD lesions. Specifically, the study will examine how diabetes, lesion length, stent type, and other comorbidities influence restenosis rates at the 12-month follow-up. Additionally, it will evaluate the incidence of MACE, including myocardial

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infarction, repeat revascularisation, and death. Through these analyses, the study sheds light on critical variables that could inform better patient selection and management in PCI, ultimately improving long-term outcomes.

In conclusion, this study's findings could have far-reaching implications for clinical practice, especially regarding how physicians approach high-risk patients. Identifying predictors of restenosis in LAD lesions could lead to more brilliant stent selection, more tailored procedural strategies, and more focused post-PCI management. These improvements could significantly reduce the incidence of restenosis and improve overall patient outcomes.

Methodology

This retrospective cohort study was conducted at MTI-Hayatabad Medical Complex to identify clinical and angiographic predictors of restenosis in patients who underwent Percutaneous Coronary Intervention (PCI) for Left Anterior Descending (LAD) artery lesions. Data were collected from January 1, 2023, to December 31, 2023. A retrospective design was chosen due to the availability of comprehensive clinical and angiographic data, which allowed for an in-depth assessment of post-PCI outcomes in real-world settings.

One hundred sixty-two participants were included and selected based on the calculated sample size. Eligible participants met the following inclusion criteria:

Adults aged 18 years or older.

Underwent PCI for de-novo LAD lesions

I had complete follow-up data at 12 months post-PCI.

Exclusion criteria included:

A history of coronary artery bypass grafting (CABG).Incomplete follow-up data.

Patients with multivessel coronary artery disease where restenosis in the LAD could not be reliably isolated.

The sample size was calculated using a standard formula for estimating the population proportion based on an expected restenosis prevalence of 12%, derived from the study by **Stone et al.** (2004) published in *The New England Journal of Medicine*. Using a confidence level of 95% and a margin of error of 5%, the required sample size was calculated as 162 participants. The formula used for the calculation was:

n=Z2×P× (1−P) E2n = \frac{{Z^2 \times P \times (1 - P) {{E^2}}n=E2Z2×P×(1−P)

Where:

n = required sample size

Z = 1.96 (for a 95% confidence level)

P = expected prevalence (0.12)

E = margin of error (0.05)

This sample size provided sufficient power to detect significant clinical and angiographic predictors of restenosis.

All patients underwent PCI for LAD lesions using either drug-eluting stents (DES) or bare-metal stents (BMS), as determined by the interventional cardiologist. Dual antiplatelet therapy (DAPT) was administered to all patients at least 12 months post-procedure according to standard clinical guidelines. Repeat Angiography was performed 12 months or earlier if clinically indicated due to ischemic symptoms.

Clinical and angiographic data were retrospectively extracted from the hospital's electronic medical records. Baseline clinical characteristics, including age, sex, comorbidities (such as diabetes mellitus, hypertension, and hyperlipidemia), smoking history, and procedural details (type of stent, number of stents, lesion length), were collected. Angiographic follow-up data were also collected to evaluate restenosis, defined as ≥50% luminal narrowing in the treated LAD segment on repeat angiography.

The primary outcome of interest was significant restenosis at the 12-month angiographic follow-up. Secondary outcomes included:

Major adverse cardiovascular events (MACE), such as myocardial infarction, death, or repeat revascularisation.

Clinical restenosis predictors include stent type, lesion length, diabetes, and smoking history.

Data analysis was conducted using SPSS version 24.0 (IBM Corp., Armonk, NY). Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables were presented as frequencies and percentages. The chi-square test was used for categorical comparisons, while t-tests or Mann-Whitney U tests were employed for continuous variables.

Multivariate logistic regression analysis was performed to identify independent predictors of restenosis, controlling for confounders such as age, sex, diabetes, hypertension, and stent type. The results were reported as odds ratios (OR) with 95% confidence intervals (CI). A p-value of <0.05 was considered statistically significant for all analyses.

The Institutional Review Board (IRB) of MTI-Hayatabad Medical Complex approved the study protocol. Due to the study's retrospective nature, the requirement for informed consent was waived. All data were anonymised and securely stored to protect patient confidentiality, which was in line with the ethical guidelines in the Declaration of Helsinki.

Results

One hundred sixty-two participants were included in this retrospective cohort study examining clinical and angiographic predictors of restenosis following Percutaneous Coronary Intervention (PCI) for Left Anterior Descending (LAD) artery lesions. Baseline clinical and procedural characteristics and primary and secondary outcomes were recorded and analysed, and the study period spanned from January 1, 2023, to December 31, 2023. The mean age of the study population was 62.4 years (±10.1), with 105 (64.8%) males and 57 (35.2%) females. Among the participants, 82 (50.6%) had diabetes mellitus, 91 (56.2%) were hypertensive, and 64 (39.5%) had hyperlipidemia. Smoking history was present in 68 (42%) participants. A total of 124 (76.5%) patients received drug-eluting stents (DES), while 38 (23.5%) received bare-metal stents (BMS).

Table 1 summarises the baseline characteristics of the study population.

Restenosis, defined as ≥50% luminal narrowing of the treated LAD segment, was observed in 25 patients (15.4%). Figure 1 illustrates the distribution of restenosis cases among the study population.

Major Adverse Cardiovascular Events (MACE), including myocardial infarction (MI), death, or repeat revascularisation, were observed in 18 participants (11.1%). MI occurred in 9 (5.6%) patients, while repeat revascularisation was required in 7 (4.3%) patients. Two participants (1.2%) died during the study period.

Multivariate logistic regression identified diabetes mellitus (OR = 2.74, 95% CI: 1.21–6.24, p = 0.014), stent type (DES vs BMS, OR = 0.42, 95% CI: 0.18–0.98, p = 0.046), and lesion length (OR = 1.08 per mm, 95% CI: 1.01–1.15, p = 0.025) as significant independent predictors of restenosis. Smoking history and hypertension were not found to be essential predictors after adjusting for confounders.

A significant trend was noted where patients with longer lesion lengths had higher restenosis rates. The interaction between stent type and lesion length further emphasised that DES was protective, especially in patients with longer lesions.

These findings underscore the critical role of diabetes mellitus and lesion length as significant predictors of restenosis in patients undergoing PCI for LAD lesions. The lower rate of restenosis among patients receiving DES compared to BMS highlights the continued efficacy of DES in preventing restenosis, especially in patients with long lesions.

Table 1: Baseline Characteristics of Participants

Characteristic	N (%) or Mean ± SD
Age (years)	62.4 ± 10.1
Male Gender	105 (64.8%)
Diabetes Mellitus	82 (50.6%)
Hypertension	91 (56.2%)
Hyperlipidemia	64 (39.5%)
Smoking History	68 (42%)
Drug-Eluting Stent (DES)	124 (76.5%)
Bare-Metal Stent (BMS)	38 (23.5%)

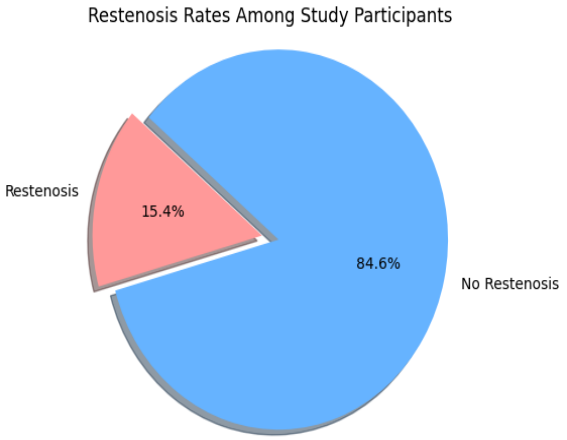

Figure 1: Restenosis Rates among Study Participants

Table 2: Secondary Outcomes (MACE)

Outcome	N (%)
Myocardial Infarction (MI)	9 (5.6%)
Repeat Revascularization	7 (4.3%)
Death	2 (1.2%)

Table 3: Multivariate Logistic Regression Analysis of Predictors of Restenosis

Predictor	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Diabetes Mellitus	2.74	1.21 – 6.24	0.014
Stent Type (DES vs BMS)	0.42	0.18 – 0.98	0.046
Lesion Length (per mm)	1.08	1.01 – 1.15	0.025
Smoking History	1.12	0.52 – 2.41	0.767
Hypertension	1.05	0.57 – 1.91	0.861

Discussion

The association between diabetes and restenosis has been well-documented in earlier studies. In this study, diabetes mellitus was identified as a significant predictor, with patients suffering from diabetes showing an almost three-fold increased risk of restenosis. This is consistent with previous research, which has established that diabetes adversely impacts endothelial healing and promotes neointimal hyperplasia, both of which contribute to restenosis after PCI (8). Studies by Sabatine et al. (2015) highlighted similar findings, where diabetic patients exhibited higher restenosis rates, particularly in the LAD artery (9). Furthermore, Kirtane et al. (2009) reported that patients with diabetes undergoing PCI often require more aggressive management due to their predisposition to restenosis (10).

The use of DES in this study was shown to significantly lower restenosis rates compared to bare-metal stents (BMS), aligning with the growing body of evidence supporting the efficacy of DES in reducing restenosis. Stone et al. (2004) also demonstrated a significant reduction in restenosis with DES compared to BMS, particularly in patients with complex lesions such as those in the LAD artery (3). This study's findings reinforce the long-term benefits of DES in preventing restenosis, especially in high-risk patients. This is further supported by contemporary trials such as those by Kimura et al. (2015), who reported reduced restenosis rates in DES-treated LAD lesions over a five-year follow-up period (11).

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Lesion length was another critical factor in predicting restenosis, with longer lesions correlating with higher restenosis rates. Previous studies, such as those conducted by Sianos et al. (2007), have emphasised the relationship between lesion complexity and restenosis, particularly in longer lesions within the LAD artery (12). The findings in this study echo these conclusions, suggesting that lesion length remains an essential factor to consider during stent placement and in post-procedural care. The ability of DES to mitigate the adverse effects of long lesion lengths is an area where additional research may yield further insights, particularly concerning newer-generation stents (13).

While the findings of this study align with established literature, they also contribute new insights regarding the interplay of multiple risk factors in restenosis after PCI for LAD lesions. Specifically, this study's multivariate analysis highlights the compounding effect of diabetes and lesion length on restenosis, which previous studies may not have fully explored. For example, the synergy between these risk factors and their influence on stent performance provides critical data for clinicians aiming to personalise treatment strategies (14). This is especially relevant in resource-limited settings, where selecting the optimal stent type and identifying high-risk patients for close monitoring can significantly impact outcomes.

In terms of implications for clinical practice, this study emphasises the importance of personalised treatment approaches in managing patients undergoing PCI for LAD lesions. For diabetic patients or those presenting with long lesions, clinicians should strongly consider the use of DES to minimise restenosis risk. Additionally, the findings suggest that more frequent follow-up and monitoring may be warranted for high-risk patients, such as those with diabetes or those who require stenting of long lesions (15). This can help detect early signs of restenosis and allow for timely interventions, potentially improving long-term outcomes. Clinicians should also consider adjunctive pharmacological therapies that target endothelial healing and reduce the risk of neointimal hyperplasia in diabetic patients, further enhancing the efficacy of DES (16).

The study's findings also open up several avenues for future research. Firstly, investigating the performance of newer-generation DES in patients with complex lesions or multiple comorbidities, such as diabetes and lung lesion lengths, would be valuable. Additionally, future studies should explore the role of adjunctive therapies, such as anti-inflammatory agents or glycemic control strategies, in reducing restenosis rates in diabetic patients undergoing PCI (17). Moreover, understanding how patient characteristics such as age, sex, and ethnicity interact with restenosis risk could help effectively tailor interventions (18). These findings underscore the need for multicenter trials with extended follow-up periods to clarify long-term restenosis rates in various patient subgroups.

Despite its strengths, the study is not without limitations. First, its retrospective design introduces inherent limitations related to data collection, including potential selection bias and missing data. Second, the study was conducted at a single centre, limiting the generalizability of the results to broader populations. More extensive, multicenter studies would be beneficial to validate these findings and explore their applicability in diverse healthcare settings. Additionally, while repeat angiography was conducted within 12 months, longer-term data would provide further insights into restenosis rates beyond one year. Lastly, the study did not evaluate the impact of different pharmacological regimens, which could have influenced restenosis outcomes (19). Addressing these limitations in future research will be essential for a more comprehensive understanding of restenosis risk factors in PCI for LAD lesions.

Conclusion

In conclusion, this study identifies diabetes mellitus, lesion length, and stent type as significant predictors of restenosis in patients undergoing PCI for LAD lesions. The findings reinforce the role of DES in reducing restenosis rates and highlight the need for personalised treatment strategies, particularly for high-risk patients. Future research should focus on the long-term efficacy of newer-generation stents and explore adjunctive therapies to minimise restenosis risks. Ultimately, these insights can improve patient outcomes by informing clinical decision-making and optimising post-PCI management strategies.

Declarations

Data Availability statement
All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate
Approved by the department concerned. (IRBEC-CAG-23/21)

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Conflict of interest

The authors declared the absence of a conflict of interest.

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Conception of Study, Development of Research Methodology Design, Study Design, Manuscript Review, and final approval of manuscript.
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Manuscript revisions, critical input.
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Data acquisition and analysis.
Manuscript drafting.
PALWASHA KHAN (House Officer)
Data entry and data analysis, as well as drafting the article.
AFAQ HAIDER (House Officer)
Data acquisition and analysis.
Coordination of collaborative efforts.

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