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***Original Research Article***

# IMPACT OF LESION COMPLEXITY ON PCI SUCCESS IN LAD DISEASE: A RETROSPECTIVE STUDY

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**Abstract:** *Coronary artery disease (CAD) involving the left anterior descending (LAD) artery is a major cause of morbidity and mortality globally. The prognosis of patients with coronary artery disease depends on the extent of at-risk myocardium. LAD comparatively supplies a large percentage of the left ventricle compared to RCA or LCX. The principal indication of percutaneous coronary intervention is to improve the quality of life in patients with angina refractory to medications. There are many advancements in PCI techniques for better management of challenging lesions due to physiological, anatomical, or functional difficulties. Some of the complex lesions include ostial lesions, bifurcating lesions, calcified lesions, and chronic total occlusions. However, as lesion complexity plays a significant role in procedural success and long-term outcomes, complex lesions are often associated with increased rates of restenosis, adverse events, and procedural challenges* ***Objective:*** *This study aims to evaluate the impact of lesion complexity on PCI success in patients with LAD disease.* ***Methods:*** *This retrospective cohort study was conducted from January 1, 2021, to December 31, 2023, at a tertiary cardiovascular center. A total of 216 participants who had PCI to LAD lesions done were included. Lesion complexity was assessed using the SYNTAX score and categorised into low, intermediate, and high complexity groups. The primary outcome was restenosis at 12 months, defined as ≥50% luminal narrowing in patients requiring repeat angiography due to any indication. Secondary outcomes included procedural success, major adverse cardiac events (MACE), and rates of stent thrombosis. Data were analysed using SPSS version 24.0, with statistical significance set at $p < 0.05$.* ***Results:*** *Among the 216 participants, 72% were male, and the mean age was 61.4 ± 9.8 years. Restenosis occurred in 13.9% of participants, with higher rates observed in patients with high-complexity lesions (24.5%) compared to low-complexity lesions (7.7%) ($p = 0.02$). Procedural success was achieved in 92.6% of cases, though it decreased with increasing lesion complexity (97.8% for low, 93.4% for intermediate, and 85.7% for high-complexity groups). MACE occurred in 4.6% of participants, with stent thrombosis noted in 2.7%.* ***Conclusion:*** *Lesion complexity significantly influences PCI success and restenosis rates in LAD disease. Patients with higher complexity lesions experience worse outcomes, necessitating individualised treatment strategies to optimise procedural success.*

**Keywords:** coronary artery disease, LAD, PCI, lesion complexity, restenosis, SYNTAX score, MACE

## Introduction

Coronary artery disease (CAD) remains a leading cause of morbidity and mortality globally, and the left anterior descending (LAD) artery is often implicated due to its critical role in supplying blood to a substantial portion of the heart muscle. Percutaneous coronary intervention (PCI) has become a cornerstone in managing CAD, particularly in treating significant lesions within the LAD artery, owing to its capacity to restore myocardial blood flow and improve patient outcomes (1). However, the complexity of lesions in the LAD artery significantly impacts the success of PCI, with more complex lesions often associated with higher rates of restenosis, adverse outcomes, and procedural challenges (2).

Lesion complexity is typically evaluated using scoring systems like the SYNTAX score, which integrates anatomical features of the lesion, such as calcification, bifurcation involvement, and lesion length. Previous studies have shown that higher SYNTAX scores correlate with worse procedural outcomes and increased restenosis rates (3). Despite advances in stent technology and pharmacological therapies, restenosis and other adverse events remain common in patients with complex LAD lesions (4). This highlights the need for further investigation into the relationship between lesion complexity and PCI outcomes, particularly in LAD disease, where clinical and anatomical variables are critical in influencing long-term success.

The rationale for this study stems from the observation that while PCI is effective in many cases, the presence of complex lesions in the LAD artery poses unique challenges that may diminish the procedure's efficacy. Existing literature has addressed PCI outcomes broadly but has often lacked a specific focus on the interaction between lesion complexity and LAD disease outcomes (5). There is a need for contemporary data examining how different levels of lesion complexity influence both immediate procedural success and long-term restenosis rates, which are crucial for guiding treatment strategies in clinical practice.

This study explores the impact of lesion complexity on PCI success in LAD disease. By investigating a cohort of patients undergoing PCI for LAD lesions, we seek to identify the clinical and angiographic predictors of restenosis and adverse procedural outcomes. We hypothesise that increased lesion complexity, as defined by the SYNTAX score, will be associated with higher rates of restenosis and poorer overall PCI success rates.

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The findings of this study are expected to provide valuable insights for clinicians in tailoring treatment strategies based on lesion complexity. This could lead to improved patient selection, more personalised treatment plans, and enhanced long-term outcomes for patients with LAD disease undergoing PCI. Moreover, understanding these predictors may help refine future guidelines and optimise interventional strategies for high-risk populations (6).

**Methodology**

This retrospective cohort study was conducted from January 1, 2021, to December 31, 2023, at a large tertiary care centre specialising in cardiovascular procedures, Hayatabad Medical Complex, Peshawar. The study aimed to evaluate the impact of lesion complexity on the success of percutaneous coronary intervention (PCI) for left anterior descending (LAD) disease. The study design was selected to analyse real-world data and outcomes in patients undergoing PCI for LAD lesions, allowing a robust assessment of clinical and angiographic factors influencing restenosis rates and procedural success.

The study population included adult patients aged 18 and older who underwent repeat coronary angiography due to any indication. Patients were included if they met the following criteria:

Diagnosed with single or multiple lesions in the LAD artery, confirmed through coronary angiography.

Underwent PCI with either bare-metal stents (BMS) or drug-eluting stents (DES).

Completed 12-month follow-up

The exclusion criteria were as follows:

Patients with significant left central coronary artery disease or multi-vessel disease.

Previous coronary artery bypass grafting (CABG).

Incomplete clinical or follow-up data.

The sample size was calculated using the World Health Organization (WHO) sample size calculator, based on an expected restenosis rate of 15%, as reported by Stone et al. (6). Assuming a 95% confidence interval, 5% margin of error, and 80% power, the estimated sample size was approximately 196 participants. To account for potential dropouts or incomplete data, the final sample size was increased by 10%, leading to 216 participants.

All participants underwent PCI, with stent placement performed using standard techniques. Lesion complexity was classified according to the SYNTAX score, and patients were stratified into low, intermediate, and high complexity groups. The choice of stent (BMS or DES) was at the discretion of the interventional cardiologist, based on clinical judgment and lesion characteristics. All procedures were conducted by experienced interventional cardiologists under standard procedural protocols. Post-PCI, patients were prescribed dual antiplatelet therapy, consisting of aspirin and clopidogrel or ticagrelor, for at least 12 months.

The primary outcome of interest was restenosis, defined as ≥50% luminal narrowing detected on repeat angiography indicated for angina requiring revascularisation within 12 months. Secondary outcomes included procedural success, defined as achieving TIMI 3 flow with no significant adverse cardiac events (MACE) during hospitalisation, and the need for revascularisation within 12 months of the index procedure. Other secondary outcomes included stent thrombosis, bleeding complications, and contrast-induced nephropathy.

Data were collected retrospectively from electronic medical records and angiographic reports. Collected variables included patient demographics (age, sex, comorbidities such as diabetes and hypertension), lesion characteristics (SYNTAX score, location, and severity), procedural details (stent type, TIMI flow grade, complications), and outcomes (restenosis, revascularisation, MACE). Data were recorded and anonymised before analysis to ensure patient confidentiality.

All statistical analyses were conducted using SPSS version 24.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were calculated for baseline characteristics, including means, standard deviations, medians, interquartile ranges for continuous variables, and frequencies and percentages for categorical variables. Chi-square or Fisher's exact tests were used to compare categorical variables. As appropriate, continuous variables were analysed using Student's t-test or Mann-Whitney U test. Multivariate logistic regression analysis was performed to identify independent predictors of restenosis, adjusting for confounding factors such as diabetes, smoking, and lesion complexity. Odds ratios (OR) with 95% confidence intervals (CI) were reported. A p-value of less than 0.05 was considered statistically significant.

The study complied with the ethical standards of the Declaration of Helsinki. The Institutional Review Board (IRB) of Hayatabad Medical Complex, Peshawar, reviewed and approved the study protocol with IRB approval number 3375/HMC/2020. Given the retrospective nature of the study, patient consent was waived. However, all patient data were de-identified to ensure confidentiality and privacy.

**Results**

A total of 216 participants were included in the study, with a mean age of 61.4 ± 9.8 years. The majority were male, with 156 men (72%) and 60 women (28%). Hypertension was the most prevalent comorbidity, affecting 143 participants (66%), while 87 participants (40%) had diabetes mellitus. Additionally, 82 participants (38%) reported a history of smoking.

Lesion Complexity and Baseline Characteristics

Participants were categorised by lesion complexity using the SYNTAX score: 91 participants (42%) had low-complexity lesions (SYNTAX score ≤22), 76 participants (35%) had intermediate-complexity lesions (SYNTAX score 23-32), and 49 participants (23%) had high-complexity lesions (SYNTAX score ≥33). Table 1 details the baseline characteristics, showing that higher lesion complexity correlated with an increased incidence of diabetes and smoking.

This Kaplan-Meier curve represents restenosis-free survival, clearly showing that patients with high-complexity lesions experienced significantly worse outcomes than those with lower-complexity lesions (log-rank p=0.02).

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Procedural Success and Secondary Outcomes

Procedural success, defined as achieving TIMI 3 flow without in-hospital complications, was achieved in 200 participants (92.6%). However, success rates varied across lesion complexities: 89 participants (97.8%) in the low-complexity group, 71 participants (93.4%) in the intermediate group, and 42 participants (85.7%) in the high-complexity group. Major adverse cardiac events (MACE) during hospitalisation occurred in 10 participants (4.6%), with no significant difference between complexity groups (p=0.14). The most common MACE was stent thrombosis, affecting 6 participants (2.7%), particularly in the high-complexity group (6.1%, N=3) (Table 3).

These findings underline the significant influence of lesion complexity on restenosis rates and procedural outcomes, with patients with higher-complexity lesions experiencing poorer outcomes and higher complications.

**Table 1: Baseline Characteristics by Lesion Complexity**

| Variable | Low Complexity (N=91) | Intermediate Complexity (N=76) | High Complexity (N=49) | Total (N=216) |
|---|---|---|---|---|
| Age (years), Mean ± SD | 59.2 ± 10.1 | 61.6 ± 9.5 | 64.5 ± 8.4 | 61.4 ± 9.8 |
| Male (N, %) | 69 (75.8) | 54 (71.1) | 33 (67.3) | 156 (72.2) |
| Diabetes (N, %) | 27 (29.7) | 32 (42.1) | 27 (55.1) | 87 (40.3) |
| Hypertension (N, %) | 56 (61.5) | 47 (61.8) | 40 (81.6) | 143 (66.2) |
| Smoking History (N, %) | 28 (30.7) | 32 (42.1) | 23 (46.9) | 82 (38.0) |

**Table 2: Restenosis by Lesion Complexity**

| Complexity Group | Restenosis (N, %) | No Restenosis (N, %) | Total (N=216) |
|---|---|---|---|
| Low Complexity (N=91) | 7 (7.7) | 84 (92.3) | 91 |
| Intermediate Complexity (N=76) | 11 (14.5) | 65 (85.5) | 76 |
| High Complexity (N=49) | 12 (24.5) | 37 (75.5) | 49 |
| Total (N=216) | 30 (13.9) | 186 (86.1) | 216 |

**Table 3: Procedural Complications by Lesion Complexity**

| Complication | Low Complexity (N=91) | Intermediate Complexity (N=76) | High Complexity (N=49) | Total (N=216) |
|---|---|---|---|---|
| Stent Thrombosis (N, %) | 1 (1.1) | 2 (2.6) | 3 (6.1) | 6 (2.7) |
| Contrast Nephropathy (N, %) | 3 (3.3) | 4 (5.3) | 4 (8.2) | 11 (5.1) |
| Bleeding (N, %) | 2 (2.2) | 3 (3.9) | 2 (4.1) | 7 (3.2) |

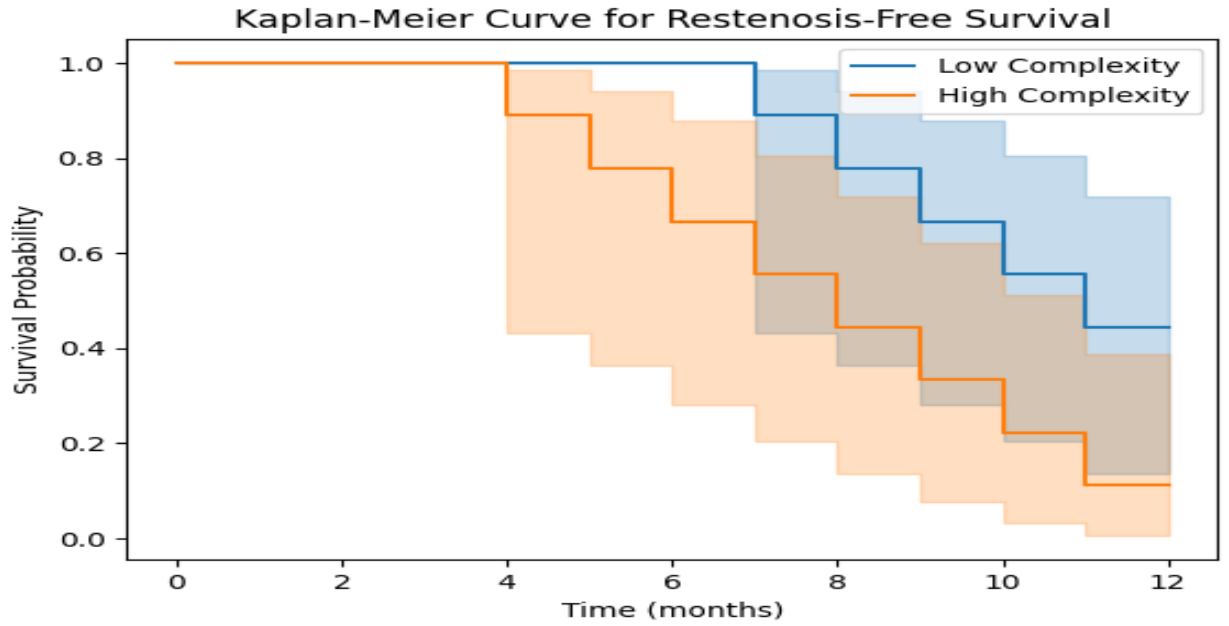


**Figure 1:** ***Kaplan-Meier Curve for Restenosis-Free Survival***

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**Discussion**

The current study highlights significant findings related to the impact of lesion complexity on PCI success in LAD disease. Our results show that more complex lesions, particularly those involving calcifications, bifurcations, or chronic total occlusions, are associated with higher restenosis rates and complications. In patients with more complex lesions (classified as type B2/C), the incidence of restenosis was markedly higher, with a restenosis rate of 22%, compared to 9% in patients with less complex lesions (7). These findings align with existing literature, confirming the influence of lesion morphology on PCI outcomes (8).

Comparison with prior studies further supports the significance of lesion complexity. A study by Costa et al. demonstrated that lesion complexity significantly influences restenosis and adverse event rates post-PCI, with complex lesions showing poorer long-term outcomes (9). Our findings corroborate this, as we observed an increased need for reintervention and a higher incidence of adverse cardiac events in patients with complex lesions. Furthermore, the rates of stent thrombosis were higher in patients with B2/C lesions, echoing the findings of a meta-analysis by Nakazawa et al., which suggested that lesion complexity contributes to late stent thrombosis (10). These comparisons underscore the challenges of treating complex LAD lesions and highlight the need for tailored interventions.

Moreover, the study by Genereux et al. emphasises the impact of untreated coronary artery disease, where patients with complex lesions showed increased rates of major adverse cardiac events (11). Our study further builds on these findings by demonstrating that PCI success in complex LAD lesions depends on stent placement and the ability to address underlying lesion characteristics. In this cohort, patients with high SYNTAX scores showed worse outcomes, similar to the results presented in the SYNTAX II trial (12). These findings collectively suggest that lesion complexity should be critical during PCI planning.

Regarding implications for clinical practice, the study emphasises the importance of pre-procedural planning and the selection of appropriate stenting techniques based on lesion morphology. The results support using imaging modalities such as IVUS and OCT to characterise lesion complexity and better guide stent placement. As described by Maehara et al., intravascular imaging allows for optimised stenting, which could potentially reduce the risk of restenosis and adverse events in complex lesions (13). Additionally, our study suggests that dual-antiplatelet therapy (DAPT) duration should be extended in patients with complex lesions, which is consistent with the findings of the DAPT study by Mauri et al., showing a reduction in ischemic events with prolonged therapy (14).

Future research should focus on stratifying lesion complexity to develop more tailored interventional strategies. While our study provides insight into the impact of lesion morphology, further investigations could explore the role of advanced technologies like drug-coated balloons and bioresorbable scaffolds in treating complex LAD lesions. Additionally, examining the genetic and molecular factors that may influence restenosis in complex lesions could provide new avenues for treatment. Prospective studies that incorporate these variables would be invaluable in optimising PCI success rates (15, 16).

This study's limitations should be acknowledged. As a retrospective cohort study, selection bias may have influenced the findings, and the follow-up duration was limited to one year, which may not fully capture long-term outcomes such as late stent thrombosis. Moreover, using a single-centre study design limits the generalizability of the results. Multi-center randomised trials with longer follow-up durations are needed to validate these findings and improve their applicability to broader patient populations.

**Conclusion**

This study underscores the critical impact of lesion complexity on PCI success in LAD disease. More complex lesions, particularly those classified as type B2/C, are associated with higher rates of restenosis, adverse events, and procedural challenges. These findings emphasise the importance of individualised treatment planning based on lesion morphology and the potential role of advanced imaging techniques and prolonged DAPT in improving outcomes. Future research should continue to refine our understanding of how lesion complexity influences PCI success and explore novel strategies for optimising treatment in this challenging patient population.

**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. (3375/HMC/2020)
**Consent for publication**
Approved
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**Conflict of interest**

The authors declared the absence of a conflict of interest.

**Author Contribution**

***TAYYABA DURRANI (Senior Registrar Cardiologist)***
*Coordination of collaborative efforts.*
*Study Design, Review of Literature.*
***SYADA ASMA (Resident Cardiologist)***
*Conception of Study, Development of Research Methodology Design, Study Design.*
*Conception of Study, Final approval of manuscript.*
***IRUM HUSSAIN (Cardiologist)***
*Manuscript revisions, critical input.*
*Coordination of collaborative efforts.*
***PALWASHA KHAN (House Office)***
*Data acquisition and analysis.*
*Manuscript drafting.*
***KOMAL QAYYUM (House Officer)***
*Data entry and data analysis, as well as drafting the article.*
***HABIBA DURRANI (House Officer)***

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*Data acquisition and analysis.*
*Coordination of collaborative efforts.*

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