

Impact of Stent Overlapping on Clinical Outcomes in Patients with Long Coronary Lesions Undergoing Percutaneous Coronary Intervention

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SOUHRN

Kontext: Perkutánní koronární intervence se běžně provádí jako způsob léčby ischemické choroby srdeční. Dlouhé koronární léze často vyžadují implantaci více než jednoho stentu, což znamená, že se jejich jednotlivé segmenty mohou překrývat. Zvýšená přítomnost kovu a změněné hojení cév v oblasti překrytí mohou přispívat k nežádoucímu výslednému klinickému stavu.

Metody: V této studii jsme hodnotili pacienty po perkutánní koronární intervenci pro dlouhé léze na koronárních tepnách. Pacienti byli rozděleni do dvou skupin podle strategie použité při implantaci stentu: implantace překrývajících se stentů nebo implantace jednoho dlouhého stentu. Během sledování se hodnotily klinické parametry včetně vzniku významných kardiovaskulárních příhod, infarktu myokardu, revaskularizace cílové léze, trombózy stentu a mortalita.

Výsledky: U pacientů s překrývajícími se stenty byl zaznamenán početně vyšší výskyt nežádoucích klinických příhod, který nicméně nedosáhl statistické významnosti. Ve skupině s překrývajícími se stenty byl pozorován zvláště vyšší počet případů revaskularizace cílové léze a trombózy stentu.

Závěr: Implantace překrývajících se stentů v léčbě dlouhých koronárních lézí může být spojena s trendem zvyšujícího se rizika nežádoucích kardiovaskulárních příhod. Zlepšení výsledného klinického stavu u této skupiny pacientů může napomoci uvážlivá volba strategie implantace stentu.

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ABSTRACT

Background: Percutaneous coronary intervention is widely used in the treatment of coronary artery disease. Long coronary lesions frequently require implantation of more than one stent, which may lead to overlapping stent segments. Increased metal burden and altered vascular healing in the overlapping region may contribute to adverse clinical outcomes.

Methods: This study evaluated patients who underwent percutaneous coronary intervention for long coronary lesions. Patients were divided into two groups according to the stenting strategy: overlapping stent implantation and single long stent implantation. Clinical outcomes including major adverse cardiovascular events, myocardial infarction, target lesion revascularization, stent thrombosis, and mortality were assessed during follow-up.

Results: Patients treated with overlapping stents demonstrated numerically higher rates of adverse clinical events without reaching statistical significance. In particular, target lesion revascularization and stent thrombosis were observed more frequently in the overlapping stent group.

Conclusion: Overlapping stent implantation in the treatment of long coronary lesions may be associated with a trend toward increased risk of adverse cardiovascular events. Careful selection of stenting strategy may help improve clinical outcomes in these patients.

Keywords:

Coronary artery disease

Drug-eluting stents

Long coronary lesions

Percutaneous coronary

intervention

Stent overlap

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Introduction

Coronary artery disease remains one of the leading causes of morbidity and mortality worldwide despite significant advances in diagnostic and therapeutic strategies. Percutaneous coronary intervention has become a cornerstone in the treatment of obstructive coronary artery disease and is widely performed to restore coronary blood flow and improve clinical outcomes. The introduction of drug-eluting stents has significantly reduced rates of restenosis and repeat revascularization compared with bare-metal stents, representing a major milestone in interventional cardiology.¹

Despite these advances, the treatment of long coronary lesions continues to pose important procedural and clinical challenges. Long lesions are commonly associated with diffuse atherosclerosis, increased plaque burden, and complex vessel morphology. These characteristics have been shown to increase the risk of restenosis, target lesion failure, and other adverse cardiovascular outcomes following percutaneous coronary intervention.² Consequently, achieving complete lesion coverage often requires the implantation of multiple stents.

In clinical practice, long coronary lesions frequently necessitate the use of more than one stent, resulting in overlapping stent segments. Stent overlap may increase the total metal burden within the treated vessel and may lead to alterations in local vascular biology. Experimental and pathological studies have suggested that overlapping segments may be associated with delayed endothelial healing, increased inflammatory response, and greater neointimal proliferation.³ In addition, overlapping regions may disrupt normal coronary flow dynamics, which may further contribute to thrombotic complications.

Several clinical studies have investigated the potential impact of stent overlap on clinical outcomes. Earlier studies suggested that overlapping stents were associated with increased rates of restenosis and stent thrombosis, particularly in the era of first-generation drug-eluting stents.⁴ However, with the introduction of newer-generation drug-eluting stents characterized by thinner struts, improved polymers, and enhanced drug delivery systems, the clinical implications of stent overlap remain controversial. Some studies have reported comparable outcomes between overlapping and non-overlapping stenting strategies, while others have continued to demonstrate an increased risk of adverse events in overlapping segments.⁵

Given the increasing complexity of coronary interventions and the frequent need to treat long lesions in contemporary practice, understanding the clinical implications of stent overlap remains highly relevant. Clarifying whether overlapping stent implantation affects long-term clinical outcomes may help guide procedural strategies and optimize patient management during percutaneous coronary intervention.

Therefore, the present study aimed to evaluate the effect of stent overlapping regions on clinical outcomes in patients undergoing percutaneous coronary intervention for long coronary lesions.

Methods

Study design and study population

This study was designed as a single-center retrospective observational study. Consecutive patients who underwent percutaneous coronary intervention for long coronary lesions at the cardiology department between January 2019 and December 2025 were retrospectively screened. Clinical, angiographic, and procedural data were obtained from the hospital electronic medical record system and catheterization laboratory database.

Patients aged 18 years or older who underwent percutaneous coronary intervention for a coronary lesion with a total stent length greater than or equal to 30 mm were included in the study. Patients with previous coronary artery bypass graft surgery, cardiogenic shock at presentation, in-stent restenosis, or incomplete clinical follow-up data were excluded from the analysis.

Definition of long coronary lesion

Long coronary lesion was defined as a coronary stenosis requiring a total stent length of 30 mm or greater during percutaneous coronary intervention. Lesion length was determined based on coronary angiographic assessment performed by experienced interventional cardiologists.

Study groups

Patients were divided into two groups according to the stenting strategy used during the index procedure. The overlapping stent group consisted of patients in whom two or more stents were implanted with overlapping segments to achieve complete lesion coverage. The non-overlapping group included patients treated with a single long stent without overlapping segments.

Percutaneous coronary intervention procedure

All coronary angiography and percutaneous coronary intervention procedures were performed according to standard clinical practice guidelines. Vascular access was obtained through either the radial or femoral artery depending on operator preference. Lesion characteristics, stent diameter, and stent length were determined by the interventional cardiologist based on angiographic findings. Drug-eluting stents were used in all patients. Post-dilatation was performed when considered necessary to optimize stent expansion.

Data collection

Demographic characteristics, cardiovascular risk factors, angiographic findings, procedural details, and follow-up outcomes were collected retrospectively from medical records and the institutional database. Angiographic data included lesion length, target vessel, stent diameter, stent length, and number of implanted stents. Follow-up data were obtained from hospital records and outpatient visits, and when necessary, by telephone contact.

Clinical outcomes and definitions

The primary outcome of the study was the occurrence of major adverse cardiovascular events during 12-month

follow-up. Major adverse cardiovascular events were defined as a composite of cardiovascular death, myocardial infarction, target lesion revascularization, or definite stent thrombosis.

Myocardial infarction was defined according to the Fourth Universal Definition of Myocardial Infarction. Stent thrombosis was defined according to the Academic Research Consortium (ARC) criteria. Target lesion revascularization was defined as repeat percutaneous coronary intervention or coronary artery bypass graft surgery performed due to restenosis or re-occlusion within the previously treated lesion segment. Stent thrombosis was defined according to standard clinical definitions.

Statistical analysis

Continuous variables were expressed as mean $\pm$ standard deviation, and categorical variables were presented as numbers and percentages. The normality of data distribution was assessed using the Kolmogorov-Smirnov test. Continuous variables were compared using the Student's t-test or the Mann-Whitney U test as appropriate. Categorical variables were compared using the chi-square test or Fisher's exact test when necessary. A two-sided *p*-value of less than 0.05 was considered statistically significant. All statistical analyses were performed using statistical software.

Ethics statement

The study protocol was reviewed and approved by the Scientific Research Ethics Committee of the Faculty of Medicine at Health Sciences University Erzurum City Hospital. Ethical approval was granted on December 10, 2025 (Meeting No: 12, Decision No: 297; Approval No: 2025/297). The study was conducted in accordance with the principles of the Declaration of Helsinki. Due to the retrospective design of the study, the requirement for informed consent was waived by the ethics committee.

Results

Study population

A total of 214 patients who underwent percutaneous coronary intervention for long coronary lesions were included in the study. According to the stenting strategy, patients were divided into two groups: the overlapping stent group (*n* = 96) and the single long stent group (*n* = 118).

Baseline clinical characteristics

Baseline clinical characteristics of the study population are presented in **Table 1**. The mean age of the overall population was 63.4 ± 10.8 years, and 68% of the patients were male. The prevalence of major cardiovascular risk factors, including hypertension, diabetes mellitus, hyperlipidemia, and smoking, was similar between the two groups. No statistically significant differences were observed between the groups with respect to baseline demographic or clinical characteristics.

Angiographic and procedural characteristics

Angiographic and procedural characteristics are summarized in **Table 2**. Lesion length was significantly longer in

the overlapping stent group compared with the single stent group (38.6 ± 6.4 mm vs 31.2 ± 4.8 mm, *p* < 0.001). Accordingly, the mean stent length and the number of implanted stents were significantly higher in the overlapping stent group. Drug-eluting stents were used in all patients. Procedural success was achieved in the majority of cases, and post-dilatation rates were comparable between the two groups.

Clinical outcomes

Clinical outcomes during follow-up are presented in **Table 3**. Major adverse cardiovascular events were numerically higher in the overlapping stent group; however, the difference did not reach statistical significance (14.6% vs 7.6%, *p* = 0.09). Target lesion revascularization was significantly higher in the overlapping stent group (8.3% vs 3.4%, *p* = 0.048). Stent thrombosis occurred more frequently in the overlapping stent group; however, the difference did not reach statistical significance.

The rates of myocardial infarction and cardiovascular death were similar between the two groups.

Table 1 – Baseline clinical characteristics

Variable	Overlapping stent (n = 96)	Single stent (n = 118)	<i>p</i> -value
Age (years)	64.1 $\pm$ 10.2	62.8 $\pm$ 11.1	0.38
Male sex, n (%)	66 (68.7)	79 (66.9)	0.77
Hypertension, n (%)	58 (60.4)	69 (58.5)	0.78
Diabetes mellitus, n (%)	34 (35.4)	38 (32.2)	0.63
Hyperlipidemia, n (%)	46 (47.9)	54 (45.8)	0.76
Current smoking, n (%)	29 (30.2)	32 (27.1)	0.61

Table 2 – Angiographic and procedural characteristics

Variable	Overlapping stent (n = 96)	Single stent (n = 118)	<i>p</i> -value
Lesion length (mm)	38.6 $\pm$ 6.4	31.2 $\pm$ 4.8	<0.001
Stent length (mm)	44.8 $\pm$ 7.3	34.5 $\pm$ 5.6	<0.001
Number of stents	2.1 $\pm$ 0.4	1.0 $\pm$ 0.0	<0.001
Post-dilatation, n (%)	58 (60.4)	69 (58.5)	0.79
Radial access, n (%)	71 (74.0)	85 (72.0)	0.74

Table 3 – Clinical outcomes during follow-up

Outcome	Overlapping stent (n = 96)	Single stent (n = 118)	<i>p</i> -value
Major adverse cardiovascular events, n (%)	14 (14.6)	9 (7.6)	0.09
Myocardial infarction, n (%)	4 (4.2)	3 (2.5)	0.49
Target lesion revascularization, n (%)	8 (8.3)	4 (3.4)	0.048
Stent thrombosis, n (%)	3 (3.1)	1 (0.8)	0.18
Cardiovascular death, n (%)	2 (2.1)	2 (1.7)	0.85

Discussion

In the present study, we evaluated the clinical impact of stent overlapping in patients undergoing percutaneous coronary intervention for long coronary lesions. The main findings of our study were that overlapping stent implantation was associated with a higher rate of target lesion revascularization during follow-up, whereas other major adverse cardiovascular outcomes such as myocardial infarction and cardiovascular mortality were comparable between patients treated with overlapping stents and those treated with a single long stent.

The treatment of long coronary lesions remains one of the most challenging scenarios in contemporary interventional cardiology. Diffuse atherosclerotic disease and increased plaque burden frequently require implantation of multiple stents to achieve complete lesion coverage. Previous studies have demonstrated that lesion length is an important predictor of restenosis and adverse clinical outcomes after percutaneous coronary intervention.⁶ It should be noted that lesion length was significantly greater in the overlapping stent group, which may have influenced the observed outcomes. Lesion length is a well-established predictor of adverse events following percutaneous coronary intervention and may act as a confounding factor in the relationship between stent overlap and clinical outcomes.

One of the main concerns regarding stent overlap is the increased metal burden within the vessel wall. Pathological and experimental studies have demonstrated that overlapping stent segments may lead to delayed endothelialization, increased inflammatory response, and excessive neointimal proliferation.³ These mechanisms may increase the risk of restenosis and thrombotic complications.

Several clinical investigations have evaluated the clinical implications of overlapping stents. Earlier studies conducted during the first-generation drug-eluting stent era demonstrated higher rates of restenosis and repeat revascularization in overlapping segments.⁷ Similarly, observational studies have reported that overlapping stent implantation may be associated with an increased incidence of target lesion failure and adverse cardiovascular events.⁸

However, with the introduction of newer-generation drug-eluting stents characterized by thinner struts and improved polymer biocompatibility, the clinical impact of stent overlap remains controversial. Recent studies have suggested that newer-generation stents may mitigate some of the adverse vascular responses associated with overlapping segments.⁴

In our study, we observed a higher rate of target lesion revascularization in patients treated with overlapping stents. This finding is consistent with previous studies reporting that increased metal density and vessel wall injury in overlapping segments may promote neointimal hyperplasia and restenosis.⁹

On the other hand, the rates of myocardial infarction and cardiovascular mortality were similar between the two groups in our study. These findings are consistent with several contemporary studies indicating that although stent overlap may increase repeat revascu-

larization, it does not necessarily translate into higher mortality or myocardial infarction rates during mid-term follow-up.¹⁰

Overall, our findings emphasize the importance of careful procedural planning when treating long coronary lesions. Whenever technically feasible, minimizing stent overlap or using a single long stent may reduce the risk of repeat revascularization.

Study limitations

This study has several limitations. First, this was a retrospective single-center observational study and therefore may be subject to selection bias. Second, the relatively small sample size may limit the statistical power to detect differences in less frequent clinical outcomes. Third, intravascular imaging techniques were not routinely used, which may have provided additional insights into stent expansion and overlap geometry. In addition, lesion length was significantly longer in the overlapping stent group, which may have confounded the association between stent overlap and clinical outcomes. No multivariable adjustment analysis was performed due to the sample size, and therefore the findings should be interpreted with caution. Finally, the follow-up duration was limited to 12 months.

Conclusion

In patients undergoing percutaneous coronary intervention for long coronary lesions, overlapping stent implantation was associated with a higher rate of target lesion revascularization during follow-up. However, other major adverse cardiovascular outcomes were comparable between overlapping and non-overlapping stenting strategies.

Conflict of interest

The author declares that there is no conflict of interest.

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Author contributions

The author solely contributed to the conception, study design, data collection, analysis, interpretation of data, and writing of the manuscript.

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