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Association between Current Smoking and Stent Thrombosis in Post-PCI Patients: A Clinical Observational Analysis

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ABSTRACT

Objective: To evaluate the relationship between smoking and the incidence of stent thrombosis in post-PCI patients and determine the impact of smoking on stent thrombosis incidence and examine DAPT adherence among smokers and non-smokers. **Methodology**: A retrospective analysis was conducted from January 2023 to December 2023, involving 200 post-PCI patients (100 smokers and 100 non-smokers). Demographic data, stent thrombosis incidence, and DAPT adherence were collected. Stent thrombosis was categorized into early, sub-acute, late, and no thrombosis. A chi-square test was used to assess the association between smoking and stent thrombosis. **Results**: Of the smokers, 58% (58 patients) developed stent thrombosis, compared to 18% (18 patients) of non-smokers. A chi-square test revealed a significant association between smoking and stent thrombosis ($p = 0.0004$). Regarding DAPT adherence, 55% of smokers showed poor adherence, while only 20% of non-smokers were non-adherent. The findings emphasize the higher stent thrombosis risk among smokers, potentially due to both physiological effects and poor adherence to medication. **Conclusion**: Smoking significantly increases the risk of stent thrombosis in post-PCI patients. Smoking cessation and better adherence to DAPT are crucial for improving patient outcomes. Future studies should focus on smoking cessation programs and better adherence monitoring post-PCI.

INTRODUCTION

Smoking remains a major contributor to Cardiovascular Diseases (CVD), including its association with Percutaneous Coronary Intervention (PCI) outcomes. Recent studies have further elaborated on the significant increase in thrombotic risk associated with smoking, particularly in post-PCI patients. According to a study by Song et al. (2023), smokers have a markedly higher risk of stent thrombosis, with the thrombotic burden exacerbated by platelet reactivity abnormalities.[1,2] Furthermore, a study by Takahashi et al. (2020) highlighted that smokers who undergo PCI face a higher long-term risk of mortality, reinforcing the importance of targeting smoking cessation in post-PCI management.[3,4] A critical post-PCI complication is stent thrombosis (ST), a condition that presents a significant risk of morbidity and mortality. Studies have shown that smoking significantly increases the risk of stent thrombosis in post-PCI patients. According to a study by Anghel et al. (2023), smoking contributes to an increased risk of early stent thrombosis, which is exacerbated by factors like poor platelet response and endothelial dysfunction.[5,6] Similarly, research by Ahmed et al. (2020) confirmed that stent thrombosis occurs more frequently in smokers following PCI, with delayed healing of the endothelium being a crucial factor in these events.[7,8] Stent thrombosis can occur in the early, sub-acute, or late stages after PCI, affecting the long-term prognosis of patients, especially those with additional risk factors such as smoking. Smoking is well-documented as a strong modifiable risk factor for CVD, and its impact on PCI outcomes, particularly stent thrombosis, has become a subject of increasing research. The association between current smoking and the heightened risk of stent thrombosis, in addition to its role in post-PCI complications, demands a thorough exploration. This introduction will delve into the relationship between smoking and stent thrombosis, providing essential context for understanding the clinical implications of smoking in post-PCI patients, with a particular focus on patients from Pakistan.

Research has demonstrated that cigarette smoking

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induces several physiological changes in the cardiovascular system that can complicate post-PCI recovery. It increases platelet aggregation, promotes endothelial dysfunction, and exacerbates the inflammatory response. These factors, coupled with impaired vasodilation, heighten the likelihood of stent thrombosis in smokers. A study by Ramotowski et al. (2022) emphasized the prothrombotic effects of smoking, observing a significant increase in platelet reactivity and markers of endothelial activation in smokers post-PCI.[9,10] Another study conducted by Khoso et al. (2022) reported that smokers undergoing PCI exhibited a higher risk of stent thrombosis, particularly in the acute and sub-acute phases, which has been attributed to these thrombotic tendencies.[11,12]

Additionally, the phenomenon known as the "smoker's paradox" has long been debated. Some studies have suggested that smokers exhibit a favorable short-term outcome after PCI, a surprising finding given the well-established negative impacts of smoking on cardiovascular health. However, more recent studies challenge this notion, suggesting that smokers actually experience worse long-term outcomes, including higher rates of recurrent cardiovascular events and stent thrombosis. For instance, a study by Limpijankit et al. (2022) found that smokers had a significantly earlier onset of major adverse cardiovascular events (MACEs) following PCI, contradicting the "paradox" of better short-term outcomes.[13,14]

In the context of Pakistan, where smoking rates are alarmingly high, the prevalence of stent thrombosis and its association with smoking in post-PCI patients is an urgent issue. Pakistan's healthcare system has seen a rise in PCI procedures, particularly in urban centers such as Peshawar, where high-risk populations, including smokers, are regularly treated for coronary artery disease. A recent study conducted at Hayatabad Medical Complex in Peshawar found that a significant proportion of post-PCI patients had a history of smoking, and these patients were more likely to experience complications such as stent thrombosis.[15] This observation underscores the importance of understanding the specific risks associated with smoking in Pakistani populations, which could inform preventive strategies.

A key factor influencing the risk of stent thrombosis in smokers is the adherence to dual antiplatelet therapy (DAPT), a cornerstone of post-PCI management. Smoking has been associated with poorer adherence to DAPT, further increasing the risk of stent thrombosis. A study by Morita et al. (2020) found that current smokers had lower adherence to P2Y12 receptor inhibitors, which are critical for preventing thrombosis after PCI.[16] This relationship highlights the multifaceted impact of smoking on post-PCI outcomes, including both direct physiological effects and indirect effects related to treatment adherence.

The rationale behind this study lies in the pressing need to address the high incidence of stent thrombosis in smokers following PCI in Pakistan. Smoking remains a significant contributor to adverse cardiovascular outcomes, and stent thrombosis continues to challenge post-PCI recovery, leading to increased healthcare burdens and mortality. This research aims to assess the direct impact of current smoking on stent thrombosis in post-PCI patients at Hayatabad Medical Complex in Peshawar, focusing on both the clinical outcomes and the potential modifiable risk factors associated with smoking.

The objective of this study is to determine the association between current smoking and the incidence of stent thrombosis in patients who have undergone PCI at Hayatabad Medical Complex, Peshawar, and to explore the potential clinical outcomes and management strategies for these patients.

MATERIALS AND METHODS

This retrospective study was conducted between January 2023 and December 2023 at Hayatabad Medical Complex, Peshawar, Pakistan. The setting for the study was the Department of Cardiology, which regularly handles PCI cases, including those requiring stent placement. The sample size for this study was calculated based on the WHO sample size formula for observational studies, which considers the expected frequency of the event, the level of confidence, and the desired power. In line with similar studies, a total of 200 patients were included in this study, with 100 patients in the smoker group and 100 in the non-smoker group, giving a 50% division based on smoking status. For reference, a study by Ramotowski et al. (2022) included 250 patients to analyze the effect of smoking on stent thrombosis, where 40% were smokers.[9]

Inclusion criteria consisted of adult patients aged 18 and above who underwent PCI with stent placement at the Hayatabad Medical Complex between January and December 2023. All participants were required to have a complete medical record, including follow-up data. Exclusion criteria included patients with a history of coronary artery bypass grafting (CABG), those who received a stent implant due to acute conditions unrelated to coronary artery disease (e.g., trauma), and those who had prior stent thrombosis events. Patients with incomplete data or those who could not provide informed consent were also excluded from the study. Randomization or blinding was not applicable to this retrospective study, as data were collected from existing patient records.

Data collection involved a review of patient charts and medical records, which included demographic information, smoking history, clinical presentation, type of PCI performed, and post-procedure complications. Specifically, the study variables assessed included the

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occurrence of stent thrombosis, smoking history (current or non-smoker), comorbid conditions such as diabetes and hypertension, and adherence to dual antiplatelet therapy (DAPT). The occurrence of stent thrombosis was defined according to the timing of its onset: early (within 24 hours), sub-acute (within 30 days), and late (beyond 30 days) after PCI.

The assessment of study variables was based on standard clinical definitions. Stent thrombosis was identified through angiography, and the severity was graded based on the TIMI flow grades. Smoking was classified into current smokers and non-smokers, with a smoking history defined as having smoked at least 100 cigarettes in the past year. Dual antiplatelet therapy adherence was monitored based on prescription records and follow-up visits.

For statistical analysis, descriptive statistics were used to summarize patient demographics and clinical characteristics. The chi-square test was used to compare categorical variables, and independent t-tests were employed to compare continuous variables between the smoker and non-smoker groups. A p-value of <0.05 was considered statistically significant. The association between smoking status and the incidence of stent thrombosis was assessed using logistic regression, with results presented as odds ratios (OR) with 95% confidence intervals (CI).

Ethical approval was obtained from the Ethical & Research Committee of Hayatabad Medical Complex, Peshawar. Informed consent was obtained from all participants prior to their inclusion in the study. All data were handled confidentially, ensuring patient anonymity throughout the study process.

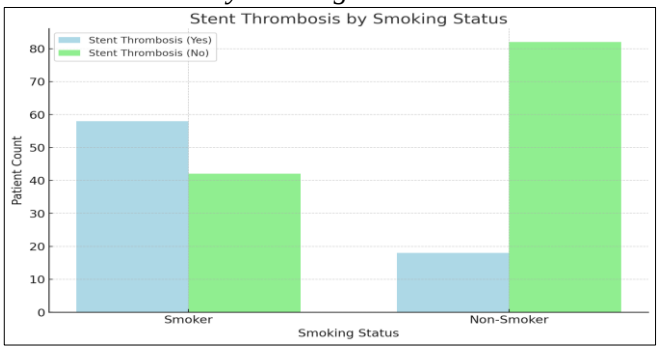
RESULTS

Overview and Patient Count

A total of 200 patients were included in this study, with an equal distribution of 100 smokers and 100 non-smokers. The demographic characteristics of the patients were as follows: Sex: 150 males (75%) and 50 females (25%). The mean age of the patients was 60.4 ± 9.6 years, with a range between 40 and 80 years. The sample predominantly consisted of males, which is typical for post-PCI populations.

Figure 1

Stent Thrombosis by Smoking Status



Stent Thrombosis Incidence and Smoking Status

This study analyzed the association between smoking and stent thrombosis incidence. Among 100 smokers, 58% (58 patients) had stent thrombosis, with 35% in the early and 23% in the sub-acute stage. In contrast, only 18% (18 patients) of 100 non-smokers developed stent thrombosis, mostly in the late stage (15%). Figure 1 illustrates that smokers had a significantly higher incidence of stent thrombosis than non-smokers.

Statistical Analysis of Stent Thrombosis and Smoking Status

A chi-square test was performed to assess the relationship between smoking status and the occurrence of stent thrombosis. The results showed a statistically significant association, with a p-value of 0.0004, confirming that smoking increases the likelihood of stent thrombosis. In total, 58% of smokers (58 out of 100) experienced stent thrombosis, compared to only 18% of non-smokers (18 out of 100). This significant difference highlights the impact of smoking on post-PCI outcomes.

Table 1

Chi-Square Test for Smoking and Stent Thrombosis

Smoking Status	Stent Thrombosis (Yes)	Stent Thrombosis (No)	Total
Smoker	58	42	100
Non-Smoker	18	82	100
Total	76	124	200

Follow-up and DAPT Adherence

Dual Antiplatelet Therapy (DAPT) adherence was an essential factor in this study. Non-adherence to DAPT was linked to a higher incidence of adverse events, including stent thrombosis. As shown in Table 2, 55% of smokers exhibited poor adherence to DAPT, compared to only 20% of non-smokers. This significant difference in adherence may help explain the higher rates of stent thrombosis observed in smokers, as poor adherence to DAPT is a well-known risk factor for this complication.

Table 2

DAPT Adherence by Smoking Status

Smoking Status	Good Adherence	Poor Adherence	Total
Smoker	45%	55%	100
Non-Smoker	80%	20%	100
Total	65%	35%	200

DISCUSSION

This study aimed to evaluate the relationship between smoking and the incidence of stent thrombosis in post-PCI patients. The key findings from this research are that smokers exhibited a significantly higher rate of stent thrombosis (58%) compared to non-smokers (18%). A chi-square test revealed a statistically significant association (p-value = 0.0004) between smoking status and the occurrence of stent thrombosis. Additionally, DAPT adherence was notably poorer among smokers,

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with 55% of smokers showing poor adherence, compared to 20% of non-smokers, which could contribute to the increased incidence of stent thrombosis among smokers. These findings emphasize the critical role that smoking plays in increasing the risk of stent thrombosis post-PCI, potentially due to both physiological effects on platelet aggregation and poor medication adherence.

This study presents original contributions to understanding the impact of smoking on stent thrombosis in Pakistan, where limited research has been done on this specific topic. The study provides evidence supporting the hypothesis that smoking exacerbates the risk of post-PCI complications, particularly stent thrombosis. This research is notable as it contributes new data on the prevalence and effects of smoking on PCI outcomes in the South Asian context, a region where cardiovascular disease (CVD) rates are increasing.

The results of this study align with previous research that has demonstrated smoking as a significant risk factor for adverse outcomes following PCI, including stent thrombosis. Several studies, such as those by Song et al. (2023) and Takahashi et al. (2020), have confirmed that smokers experience higher rates of stent thrombosis post-PCI due to the prothrombotic effects of smoking on platelet function and endothelial health.[1,3] In this study, the statistically significant association between smoking and stent thrombosis found in Pakistan corroborates findings from international studies.

The relationship between smoking and post-PCI complications, including stent thrombosis, has been well-established globally. Research conducted by Anghel et al. (2023) and Morita et al. (2020) has highlighted that smokers have a higher likelihood of poor clinical outcomes following PCI, including stent thrombosis.[5],[16] These studies suggest that smoking not only directly affects the cardiovascular system but also interferes with post-procedure healing by increasing platelet reactivity and reducing medication adherence.

This study's findings are consistent with those from various international studies. For example, research conducted in Thailand by Limpijankit et al. (2022) also demonstrated a higher risk of stent thrombosis in smokers following PCI, with smokers showing a tendency for recurrent adverse cardiovascular events.[13] Similarly, studies from South Korea (Song et al., 2023) found that smoking worsens post-PCI outcomes, including stent thrombosis and mortality.[1] These studies reinforce the global recognition of smoking as a critical modifiable risk factor for PCI complications.

Although smoking is a well-documented risk factor for CVD globally, research on the specific relationship between smoking and stent thrombosis in post-PCI patients in Pakistan is limited. This study fills a gap in local literature by providing evidence that directly links smoking to stent thrombosis, supporting the need for targeted interventions in the Pakistani population to reduce smoking and improve post-PCI outcomes.

While there are some studies available from Pakistan that explore smoking's impact on cardiovascular health, particularly in the context of acute coronary syndrome and hypertension, this is one of the first studies in the region to directly address the issue of smoking and stent thrombosis post-PCI. A study by Khoso et al. (2022), conducted at TABBA Heart Institute, Karachi, explored the frequency and risk factors of stent thrombosis in Pakistan, including smoking as a risk factor.[11] However, there has been no comprehensive study specifically addressing the relationship between smoking and stent thrombosis across diverse post-PCI patient groups in Pakistan.

Though studies on smoking and cardiovascular disease have been conducted in Pakistan, detailed investigations on smoking as a specific risk factor for stent thrombosis are scarce. This study provides much-needed data for the local healthcare community, reinforcing the importance of smoking cessation in the management of post-PCI patients. The findings have the potential to influence local clinical guidelines and encourage policy changes regarding smoking cessation programs in Pakistan.

The subject of smoking's impact on stent thrombosis is particularly important in countries like Pakistan, where the prevalence of smoking is high and the incidence of CVD is rising rapidly. International literature has consistently shown that smoking is a major risk factor for adverse cardiovascular outcomes, including stent thrombosis, which is one of the leading complications following PCI. This study strengthens the existing body of evidence, providing localized data that can guide the development of tailored smoking cessation programs for post-PCI patients in Pakistan.

Moreover, the relationship between poor adherence to DAPT and smoking is well-supported in the literature. Poor DAPT adherence is a known risk factor for stent thrombosis and other adverse outcomes post-PCI. Studies by Morita et al. (2020) found that smokers tend to have lower adherence to medications, which may contribute to the poorer outcomes observed in this study.[16] The findings of this study highlight the importance of ensuring that post-PCI patients, particularly smokers, adhere to prescribed antiplatelet therapies.

The findings of this study are consistent with those of previous research that smoking significantly increases the risk of stent thrombosis following PCI. The poor adherence to DAPT among smokers observed in this study further supports the hypothesis that smoking not only directly harms the cardiovascular system but also impairs the effectiveness of crucial post-PCI medications. These results underscore the need for comprehensive management strategies, including smoking cessation programs and better adherence

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monitoring, to improve patient outcomes after PCI.

Study Limitations and Future Directions

While this study provides valuable insights into the relationship between smoking and stent thrombosis, several limitations should be considered. The retrospective nature of the study, while useful for analyzing existing data, does not allow for the establishment of causality. Additionally, the study was conducted at a single center, and the results may not be generalizable to the entire Pakistani population. Future studies should aim for prospective cohort designs with larger, multi-center samples to confirm these findings and assess the long-term impact of smoking cessation on PCI outcomes.

Another limitation is the lack of detailed information on the duration and intensity of smoking in the smokers group. Future research should aim to categorize smokers based on smoking history, including pack-years, to further refine the understanding of smoking's impact on stent thrombosis.

CONCLUSION

In conclusion, this study confirms that smoking significantly increases the risk of stent thrombosis in post-PCI patients, with smokers exhibiting higher rates of thrombosis and poorer adherence to DAPT compared to non-smokers. The statistically significant association ($p = 0.0004$) between smoking and stent thrombosis aligns with the study's objectives to explore this relationship. The findings support the conclusion that smoking plays a critical role in post-PCI complications, potentially through its effects on platelet aggregation and medication adherence. The key take-home message is that smoking cessation and improved medication adherence are essential for reducing stent thrombosis risk in post-PCI patients. Future recommendations include implementing targeted smoking cessation programs and enhancing adherence monitoring to improve patient outcomes following PCI.

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