

Predictors of Stent Thrombosis and Their Outcomes After Percutaneous Coronary Intervention

Rafiullah Jan*, Abidullah, Kiran Jamal, Nasir Khan, Maryum Masoud, Muhammad Ishaq Khan

Peshawar Institute of Cardiology, Peshawar- Pakistan

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Corresponding Author

Rafiullah Jan
Department of Cardiology
Peshawar Institute of Cardiology,
Peshawar- Pakistan
Email:rafiullah.lrh@gmail.com

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Abstract

Objective: Stent thrombosis (ST) is a significant complication of percutaneous coronary intervention (PCI), a widely performed procedure for managing coronary artery disease (CAD). While PCI, particularly with the use of coronary stents, has substantially improved patient outcomes and reduced the need for coronary artery bypass grafting, ST remains a potentially fatal complication associated with high morbidity and mortality. This study aimed to identify the predictors of ST and evaluate its outcomes in patients undergoing PCI at the Peshawar Institute of Cardiology (PIC).

Methodology: In this retrospective study, we analyzed the data of 153 patients who presented with stent thrombosis and underwent PCI at PIC between December 2020 and September 2024. Data were extracted from the hospital's electronic medical records system, with a focus on demographic, clinical, procedural, and outcome variables and Statistical analysis was performed using SPSS software version 26.0

Results: Key predictors of ST included patient-related factors such as diabetes mellitus, hypertension, their presentation as ACS, procedural factors like stent under-sizing and under-expansion, and issues related to non-adherence to dual antiplatelet therapy. The majority of ST cases occurred in the subacute phase (70.6%), followed by acute thrombosis (20.9%) and late thrombosis (8.5%).

Conclusion: Our findings emphasize the critical importance of optimal stent deployment, strict adherence to dual antiplatelet therapy, and the management of comorbidities in reducing the risk of ST. Addressing these modifiable risk factors and identifying high-risk patients are essential for improving the prevention and management of stent thrombosis post-PCI.

Keywords: Acute coronary syndrome, Coronary artery disease, Dual antiplatelet therapy, Stent, Stent thrombosis.

Introduction

Percutaneous coronary intervention (PCI) has become the cornerstone in the management of coronary artery disease (CAD), offering an effective solution to restore blood flow in patients with obstructed coronary arteries. The advent of PCI, especially with the use of coronary stents, has significantly reduced the need for coronary artery bypass grafting (CABG) and better patient outcomes. However, despite the success of PCI, complications such as stent thrombosis (ST) remain a significant concern, as it is one of the rare but a very fatal complications and its management poses a significant challenge to clinicians worldwide.¹

Stent thrombosis (ST) is a very fatal complications of PCI, with a mortality rate of 5–10% at the time of first presentation during the in-hospital stay and 10–25% beyond 30 days. It is categorized as either acute (occurring within 24 hours post-implantation), subacute (occurring between 1 and 30 days), or late (occurring beyond 30 days). The pathophysiology of ST is multifactorial, involving a complex interplay of factors including patient characteristics, procedural variables, and stent-related features. Clinical factors such as diabetes mellitus, acute coronary syndrome (ACS), and previous history of ST have been associated with increased risk.² Moreover, patient adherence to antiplatelet therapy plays a pivotal role; non-compliance or early discontinuation of dual antiplatelet therapy (DAPT) significantly elevates the risk of thrombotic events.³ Click or tap here to enter text.

Identifying the predictors of stent thrombosis and understanding the associated outcomes is essential for improving patient care and preventing these potentially life-threatening events. Several factors have been identified as potential predictors of stent thrombosis. These include patient-related factors such as age, comorbidities (diabetes mellitus, hypertension), smoking status, and renal function, as well as procedural factors, such as stent type, stent deployment technique and procedural complications.⁴ Click or tap here to enter text.

The outcomes following stent thrombosis are grave, with studies indicating that ST is linked to a high rate of adverse cardiovascular events, including recurrent myocardial infarction and increased mortality. The urgency of addressing ST necessitates a focus on both prevention and management strategies, including advancements in stent design, improved antithrombotic therapies, and patient education on medication adherence.⁵

Furthermore, adherence to post-PCI care, including the timely and appropriate use of antiplatelet therapy, has also been shown to significantly influence the risk of stent thrombosis. The emergence of high-risk groups, such as those with incomplete revascularization or those who prematurely discontinue antiplatelet

therapy, warrants closer monitoring and individualized management strategies.

Percutaneous revascularization is a reliable and efficient treatment option for patients who are suitable candidates for this approach. The only short and mid-term fear is of Stent thrombosis which is very rare in current practice but does occur and is associated with considerable mortality and morbidity. The goal of our study is to identify and evaluate the risk factors that predict stent thrombosis in patients undergoing PCI and to figure out whether it is patient-related, procedural, or stent-related factors. Through this research, we aim to address the knowledge gap regarding the risk factors for ST in the local population and provide insights into how best to manage patients to reduce the incidence of stent thrombosis and improve long-term outcomes.

Methodology

This retrospective cohort study was conducted at the Peshawar Institute of Cardiology (PIC) from December 2020 to September 2024. Peshawar Institute of Cardiology is one of the largest dedicated cardiology hospitals of the province of Khyber Pakhtunkhwa. The province of Khyber Pakhtunkhwa, Pakistan has a total population of 35 million, making up 11.9% of Pakistan's total population. The study included 153 patients who underwent percutaneous coronary intervention (PCI) for stent thrombosis. All patients who were eligible for procedure were shifted to Cardiac Catheterization Laboratory and thrombosed vessel was treated according to standard protocol. Ethical approval was obtained from the hospital's institutional review board committee (IRC/24/139).

Inclusion criteria:

- Patient's age 18 years to 80 years
- Patients of either gender
- Patients who have undergone percutaneous coronary intervention (PCI) for ST (Stent Thrombosis)

Exclusion criteria:

- Age < 18 years
- Patients who didn't undergo PCI
- Patients with missing or incomplete medical records
- Patients with severe non-cardiac illnesses

Sampling Technique: A non-probability consecutive sampling technique was used. All patients who satisfied the inclusion criteria and were admitted within the study timeframe were enrolled.

Sample size: A minimum sample size of 153 was calculated keeping 4.5% proportion of patients with Acute Stent Thrombosis with confidence interval 95%, margin

of error 5% calculated on WHO Sample Size Formula.

Data analysis procedure:

Data was retrieved retrospectively from the electronic medical record (EMR) system. Statistical analysis was performed using SPSS version 26.0 (IBM-SPSS Inc., Chicago, USA). Descriptive statistics were employed to summarize the characteristics of the sample, including the mean and standard deviation (\pm SD) for continuous variables such as age, stent length, and diameter. Frequencies and percentages were calculated for categorical variables including gender, risk factors, procedural characteristics, and postprocedure outcomes. Associations between variables were assessed using the chi-square test at ($P < 0.05$).

Results

The study included a total of 153 patients who underwent percutaneous coronary intervention (PCI) after meeting the inclusion criteria for Stent Thrombosis.

Mean Age of the Patients were 58.97 ± 10.55738 years. 29.4% were Female. The Risk profile 45.8% and 36.8% were Diabetic and Hypertensive Respectively.

All these patients had Intervention with 4.7% in Catheterization Laboratory Mortality.

The presentation and lesion morphology is shown in Table.

Majority of the patient with Stent thrombosis were with Moderate to Severe LV dysfunction, however Undersized, Under expanded Stents, Dissection and Non Compliance were not uncommon as given in table.

Table 1 illustrates that the mean age of the patients (58.9739 ± 10.55738), mean LVSD (2.3464 ± 0.78069), mean stent length (mm) (36.5132 ± 17.29755), mean stent diameter (mm) (2.9161 ± 0.26518).

Table 3 illustrates the association of age with risk factors, presentation and association of stent thrombosis timing with post-operative outcomes shows a significant results at ($P < 0.05$).

Table 1. Clinical baseline traits, Pre-operative and Intra-operative data of the research population (n=153)

Characteristics	Mean	\pm SD
Age (years)	58.9739	± 10.55738
LVSD	35.5678	± 4.58971
Stent length (mm)	36.5132	± 17.29755
Stent Diameter (mm)	2.9161	± 0.26518

Table 2. Demographic profile, risk factors, CAD presentations of the patients, peri procedural characteristics, and postoperative outcomes and follow up (n=153)

Variables	Frequency	%age
Gender		
Male	108	70.6%
Female	45	29.4%
Risk Factors		
Hypertension	56	36.6%
Diabetes	70	45.8%
CAD Presentation		
STEMI	140	91.5%
NSTEMI	2	1.3%
Shock	11	7.2%
Diseased Vessel		
LAD	144	74.5%
LCX	2	14.4%
RCA	17	11.1%

Existence of Significant CAD		
SVCAD	112	73.2%
MVD	41	26.8%
Fibrinolytic therapy	9	5.9%
Peri procedural Characteristics		
TIMI flow pre		
I	115	75.2%
II	33	21.6%
III	5	75.2%
IVUS	3	2%
Glycoprotein IIb/IIIa inhibitor	148	96.7%
Treatment of stent thrombosis		
Additional Stent	30	19.6%
DEB	16	10.5%
Predictors of Stent thrombosis		
Calcification	10	6.5%
Diffuse Disease	62	40.5%
Ostial Lesion	11	7.2%
Undersize	11	7.2%
Under expansion	30	19.6%
Disease Outflow	5	3.3%
Disease Inflow	10	6.5%
Bifurcation	6	3.9%
Post dilation	81	52.9%
TIMI FLOW		
1	115	75.2%
2	33	21.6%
3	5	3.3%
Post-operative outcomes		
Stent Thrombosis Timing		
Acute	32	20.9%
Subacute	108	70.6%
Late	13	8.5%
Post-operative Complications		
CVA	3	1.9%
CPR	7	4.6%
Perforation	1	0.7%
Intubation	7	4.6%
CPR	7	4.6%

Death (on table)	7	4.6%
Follow Up		
Discontinuation of antiplatelet therapy	9	5.9%
Death	14	9.2 %

Table 3. Association of Age with risk factors, Presentation and association of stent thrombosis timing with post-operative outcomes

Variables	Hypertension	Diabetes Mellitus	STEMI	NSTEMI	Shock
Age	0.552	0.734	0.067	0.986	0.089
-	CVA	CPR	Perforation	Intubation	Death(table)
Stent Thrombosis timing	0.357	0.287	0.06	0.287	0.759

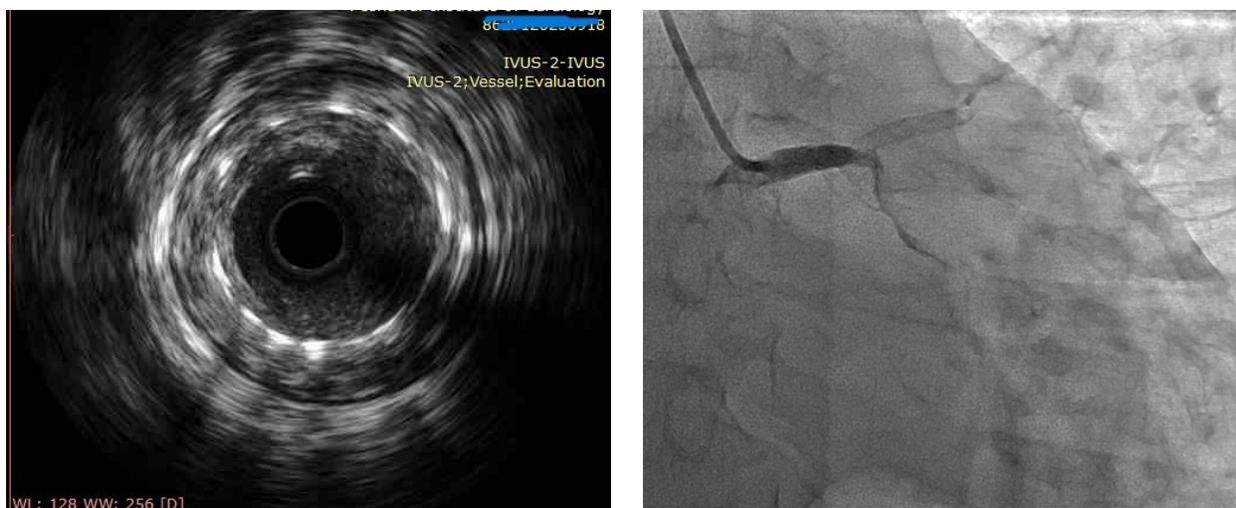


Figure 1A&B: IVUS and Angio Picture Showing Undersized Stent in a Patient with stent thrombosis

Discussion

Stent thrombosis (ST) is a significant complication after percutaneous coronary intervention (PCI), with serious consequences, including recurrent myocardial infarction, stroke, and death. Our study, conducted at the Peshawar Institute of Cardiology (PIC), aimed to identify the predictors of ST and explore the outcomes in patients undergoing PCI. We found that patient-related factors such as diabetes mellitus and hypertension were the most prevalent comorbidities, with diabetes being associated with a higher risk of ST. Diabetes has long been recognized as a risk factor for adverse coronary events due to its impact on endothelial function, platelet aggregation, and thrombosis.^{6,7} Hypertension is one of the risk factor for stent thrombosis because of shear stress and clot formation in our study as there is high number of patients with raised blood pressure among our patients also mirrors findings from other studies, where hypertension has been linked to endothelial dysfunction and an increased risk of throm-

botic complications.⁸ We had significant patients who had stent thrombosis because of factors related to their procedure like stent under-sizing, under-expansion, Calcification and diffuse nature of coronary artery disease. These findings are commonly reported from the work of others in this field; however, these are the reasons that can be addressed meticulously by optimal expansion, adequate lesion preparation, and not missing thrombus or dissection.⁹ Stent under-expansion, in particular, has been identified as a key predictor of both early and late stent thrombosis, as it can lead to incomplete endothelial coverage and subsequent platelets aggregation.¹⁰ Click or tap here to enter text. In our study, the majority of STs were early (70.6%), which is the most common presentation post-procedure. This period is particularly sensitive, with inadequate or premature discontinuation of dual antiplatelets therapy (DAPT) being a well-established risk factor for thrombosis. The incidence of early stent thrombosis in our study was 20.9%, which is associated with a higher mortality rate and poorer outcomes,

corroborating the findings of other studies that have emphasized the severity of early ST.¹¹ The timing of ST is crucial as it has significant implications for treatment and prognosis, with early thrombosis being associated with more immediate, life-threatening complications, whereas late ST may occur despite prolonged DAPT, often due to factors such as incomplete revascularization or stent malposition. In our study, late thrombosis was less common (8.5%), but it underscores the need for long-term follow-up and sustained antithrombotic therapy in high-risk patients. Postoperative complications, including stroke, CPR, and intubation, were noted in our cohort, with a mortality rate of 4.6%, highlighting the severity of ST and its associated outcomes. These findings echo those of previous studies, which reported high mortality and morbidity rates in patients experiencing ST, particularly in the context of acute events.¹² A significant predictor of ST in our study was the discontinuation of antiplatelet therapy, with 5.9% of patients reported to have either non-adherence or early cessation of their prescribed therapy. This is a well-documented risk factor for thrombosis, as early discontinuation of DAPT leads to a loss of protection against thrombus formation in DES.¹³ Studies have shown that patient education on the importance of maintaining antiplatelet therapy and addressing barriers to adherence are essential components of post-PCI care to reduce ST incidence. While our study provides valuable insights into the predictors and outcomes of ST.

Limitations

The retrospective nature of the study introduces potential biases, including incomplete or inaccurate record-keeping. Additionally, the relatively small sample size may limit the generalizability of our findings to broader populations. However, our findings align with existing literature and provide useful information for clinicians in identifying high-risk patients and optimizing PCI management. Future research with larger cohorts and prospective designs is needed to validate these predictors and develop strategies for more personalized care in PCI patients. Intra Vascular Imaging is less frequently utilized to see the mechanism because of financial constrain in future IVUS should be done for all Stent thrombosis which will optimize the care.

Conclusion

Stent thrombosis remains a serious complication following PCI, and its prevention and management require a multifaceted approach. Our study confirms the importance of patient-related factors such as diabetes and hypertension, as well as procedural variables such as stent deployment techniques, in predicting ST. Time-

ly adherence to antiplatelet therapy, appropriate stent sizing and expansion, and careful monitoring during the early post-PCI period are crucial in reducing the risk of stent thrombosis and improving patient outcomes.

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Authors' Contribution Statement

RJ contributed to the conception, design, acquisition, analysis, interpretation of data, drafting of the manuscript, critical review, and final approval of the version to be published. A contributed to the design, acquisition, analysis, drafting of the manuscript, and critical review of the manuscript. KJ contributed to the acquisition, analysis, interpretation of data, and drafting of the manuscript. NK contributed to the acquisition, analysis, and interpretation of data. MM contributed to the acquisition, analysis, and interpretation of data. MIK contributed to the analysis, interpretation of data, and drafting of the manuscript. All authors are accountable for their work and ensure the accuracy and integrity of the study.

Conflict of Interest

Authors declared no conflict on interest

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None

Data Sharing Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.