Section: Miscellaneous

Original Research Article

EARLY OUTCOMES OF CORONARY ARTERY BYPASS GRAFTING FOLLOWING RECENT PERCUTANEOUS CORONARY INTERVENTION FAILURE: DOES PCI DELAY DEFINITIVE REVASCULARIZATION?

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ABSTRACT

Background: Despite significant advancements in percutaneous coronary intervention (PCI) technology with the advent of drug-eluting (DES) and bare-metal stents (BMS), early stent failure necessitating coronary artery bypass grafting (CABG) remains clinically relevant. This study evaluates outcomes of CABG performed within one year following PCI, assessing whether PCI delays rather than prevents definitive surgical revascularization.

Materials and Methods: A retrospective observational, single-center analysis was conducted on 142 patients undergoing CABG within one year of PCI between November 2024 and November 2025. Demographic, angiographic, and perioperative data were analyzed, comparing outcomes between DES and BMS recipients. SYNTAX score and Euro SCORE II were recorded for operative risk stratification. Primary endpoint was 30-day mortality; secondary endpoints included in-stent restenosis (ISR), proximal stenosis, major adverse cardiovascular events (MACE), and hospital stay duration. Follow-up at 3 and 6 months was performed to assess MACE and graft-related events.

Results: Mean age was 55.1 ± 7.9 years; 57.7% were male. Diabetes and hypertension were present in 53% and 59%, respectively. Among 142 patients, 108 (76%) had DES and 34 (24%) BMS. The primary cause of CABG referral was ISR (31%), followed by proximal disease progression (35%) and stent thrombosis (12%), with combined mechanisms in the remainder. ISR occurred in 26% of DES and 42% of BMS patients ($p<0.05$). Off-pump CABG (OPCABG) was performed in 82% of cases. Overall complication rate was 7.7%, mortality 0.7%, and mean hospital stay 6.8 ± 1.4 days. At 3-month follow-up, MACE occurred in 4.2% of patients; at 6 months, cumulative MACE rate was 6.3%. Institutional mortality and MACE rates were comparable to contemporary published series.

Conclusion: CABG within one year of PCI can be performed safely with favorable short- and mid-term outcomes. Early stent failure remains clinically relevant, particularly in complex coronary artery disease. However, this study does not establish whether PCI delays definitive surgical revascularization, and further comparative studies are required.

Keywords: PCI, in-stent restenosis, proximal stenosis, off-pump CABG, stent failure, coronary revascularization, MACE.

INTRODUCTION

Percutaneous coronary intervention (PCI) transformed coronary artery disease management by providing less invasive alternatives to coronary artery bypass grafting (CABG). Despite continuous refinement in stent design and deployment techniques, in-stent restenosis (ISR), thrombosis, and progressive atherosclerosis remain unresolved challenges.[1,2] Drug-eluting stents (DES) have reduced restenosis rates compared to bare-metal stents (BMS), but the problem persists, especially in diabetics and patients exhibiting diffuse atherosclerosis, multivessel disease, and small-caliber vessels — all subsets in which biological responses to stenting are amplified and durability is compromised.[3,4]

Approximately 1–3% of patients undergoing PCI require CABG within the first year due to ISR, stent thrombosis, or progression of native coronary disease.[5,6] These patients often represent high-risk subsets with complex anatomy, diffuse atherosclerosis, and reduced ventricular function. Managing such cases remains challenging due to ongoing dual antiplatelet therapy (DAPT) and technical difficulties during surgery.[7,8]

The SYNTAX score provides an objective, angiography-based assessment of coronary disease complexity and has been validated as a predictor of adverse outcomes after both PCI and CABG.[9] EuroSCORE II offers complementary operative risk stratification and is now widely adopted in cardiac surgery audit.[10] Incorporating both tools enables more robust comparison of institutional outcomes against benchmarked registry data.

This study aims to characterize patients undergoing CABG within one year of PCI, analyze stent-related failure mechanisms — including ISR, stent thrombosis, and proximal disease progression — and assess whether early PCI delays rather than prevents definitive surgical revascularization. Short- and mid-term follow-up at 3 and 6 months is also reported.

MATERIALS AND METHODS

Study Design and Population: A retrospective observational study was conducted on patients undergoing CABG within 12 months following PCI between November 2024 and November 2025 at a tertiary cardiac surgery center where we operate 80-90 cases per month out of which 50-60 cases are CABG. Patients were included if angiography confirmed stent failure (ISR, thrombosis, or disease progression).[11,12]

Inclusion Criteria

- CABG performed within 12 months of PCI
- Documented ISR
- Stent thrombosis
- New proximal lesion progression
- Complete perioperative and follow-up data

Exclusion Criteria

- CABG performed beyond 12 months post-PCI
- Incomplete data records
- Isolated valve or aortic procedures

Risk Stratification: SYNTAX score was calculated for all patients from pre-operative coronary angiography to quantify disease complexity: low (≤22), intermediate (23–32), and high (≥33). EuroSCORE II was used to predict 30-day operative mortality and to enable benchmarking against international cardiac surgery registries.[9,10]

Operative Technique: CABG was performed via median sternotomy. Off-pump CABG (OPCABG) was preferred when hemodynamically feasible. The left internal mammary artery (LIMA) was grafted to the LAD in all cases. Sequential reverse saphenous vein grafts (RSVGs) and the right internal mammary artery (RIMA) were used for circumflex and right coronary targets.[13,14] Cardiopulmonary bypass was reserved for complex anatomy.

Endpoints: Primary endpoint was 30-day mortality.
Secondary endpoints included ISR rate, proximal stenosis, stent thrombosis, MACE, and hospital stay. MACE was defined as a composite of all-cause mortality, non-fatal myocardial infarction, repeat revascularization, and stroke. Follow-up assessments were conducted at 3 and 6 months via clinic visits and telephone interviews.

Statistical Analysis: Continuous variables were expressed as mean ± SD; categorical variables as percentages. Group differences between DES and BMS were analyzed using chi-square and t-tests. Multivariate logistic regression was performed to identify independent predictors of 30-day MACE and in-hospital complications. Variables with $p<0.10$ on univariate analysis were entered into the multivariate model. Results are expressed as odds ratios (OR) with 95% confidence intervals (CI). Institutional data were compared against international registry reports for validation.[15,16]

Multivariate analysis is exploratory given sample size limitations. This study conforms to the STROBE guidelines for observational studies.

RESULTS

Baseline Demographics: A total of 142 patients underwent CABG within one year following PCI.

The mean age was 55.1 ± 7.9 years (range: 38–72), with a male predominance (57.7%). Diabetes mellitus and hypertension were highly prevalent (53% and 59%, respectively). Prior myocardial infarction was documented in 21%. Mean left ventricular ejection fraction (LVEF) was 44.2 ± 8.3%, with 30% demonstrating moderate to severe dysfunction (LVEF ≤40%). These demographics align with previously published data on high-risk PCI populations.[17,18]

Risk Scores: Mean SYNTAX score was 28.4 ± 7.2. Distribution was as follows: low SYNTAX (≤22) in 24%, intermediate (23–32) in 51%, and high (≥33) in 25% of patients. Mean EuroSCORE II was 2.8 ± 1.4%. DES recipients had slightly lower mean SYNTAX scores compared to BMS recipients (27.1 ± 6.8 vs 31.9 ± 7.6, $p<0.05$), reflecting a trend toward higher disease complexity in the BMS group.

Angiographic Findings and Causes of CABG Referral: Among the cohort, 108 (76%) had DES and 34 (24%) BMS. The primary cause of CABG referral was proximal disease progression (35%), followed by ISR (31%), combined ISR with progression (21%), and acute/subacute stent thrombosis (13%). ISR was the most common cause for CABG in BMS (42%) versus DES (26%) ($p<0.05$). Stent thrombosis occurred in 11% of DES and 15% of BMS cases. Proximal disease progression was higher in BMS (46%) versus DES (31%), consistent with prior registry data.[19,20] These findings underscore persistent restenosis risks even with DES in complex or diabetic cases.

Operative and Postoperative Outcomes: Off-pump CABG (OPCABG) was performed in 82% of patients, and on-pump CABG in 18%. LIMA-to-LAD grafting was universal, with sequential RSVGs in 88% and RIMA use in 12%. Mean graft number was 3 ± 1. IABP support was required in 10%. Mean operative time was 220 ± 45 minutes. Overall complication rate was 7.7%; atrial fibrillation occurred in 3.5%, wound infection in 2.1%, and transient renal dysfunction in 1.4%. One death (0.7%) occurred due to hypoxic encephalopathy. Mean ICU stay was 2.6 ± 0.8 days; total hospital stay averaged 6.8 ± 1.4 days.

Follow-up Outcomes: Follow-up was completed in 138 of 142 patients (97.2%) at 3 months and in 131 patients (92.3%) at 6 months. At 3-month follow-up, MACE occurred in 6 patients (4.2%), comprising 2 non-fatal MI (1.4%), 2 repeat revascularizations (1.4%), 1 stroke (0.7%), and 1 late death (0.7%). At 6 months, cumulative MACE was recorded in 9 patients (6.3%), with 3 additional events (2 repeat revascularizations and 1 cardiac death) occurring between 3 and 6 months. No significant difference in 6-month MACE was observed between DES (5.6%) and BMS (8.8%) recipients ($p=0.52$). Freedom from MACE at 6 months was 93.7% overall.

Multivariate Analysis: On multivariate logistic regression, independent predictors of in-hospital MACE or complications were: LVEF ≤40% (OR 3.2; 95% CI 1.4–7.1; $p=0.005$), high SYNTAX score ≥33 (OR 2.8; 95% CI 1.2–6.5; $p=0.018$), diabetes mellitus (OR 2.1; 95% CI 1.0–4.4; $p=0.047$), and use of on-pump CABG (OR 2.5; 95% CI 1.1–5.8; $p=0.032$). Stent type (DES vs BMS) was not an independent predictor of in-hospital complications (OR 1.3; 95% CI 0.6–2.9; $p=0.48$).

Table 1: Baseline Demographics and Risk Factors

Variable	Overall (n=142)	DES (n=108)	BMS (n=34)	p-value
Age (years)	55.1 ± 7.9	54.8 ± 8.0	56.3 ± 7.4	0.31
Male (%)	57.7	59.3	52.9	0.47
Diabetes (%)	53	51	59	0.40
Hypertension (%)	59	60	56	0.66
Prior MI (%)	21	20	24	0.60
LVEF ≤40% (%)	30	28	35	0.43
Mean EuroSCORE II (%)	2.8 ± 1.4	2.7 ± 1.3	3.1 ± 1.6	0.19

DES, drug-eluting stent; BMS, bare-metal stent; MI, myocardial infarction; LVEF, left ventricular ejection fraction; SD, standard deviation.

Table 2: Angiographic, Risk Score and Operative Data

Parameter	DES (n=108)	BMS (n=34)	p-value
ISR (%)	26	42	<0.05
Proximal Stenosis (%)	31	46	<0.05
Stent Thrombosis (%)	11	15	NS
Mean SYNTAX Score	27.1 ± 6.8	31.9 ± 7.6	<0.05
High SYNTAX ≥33 (%)	21	35	0.09
OPCABG (%)	83	79	NS
IABP Use (%)	10	12	NS
Mean Grafts (no.)	2.9 ± 0.7	3.0 ± 0.6	NS
Mean EuroSCORE II (%)	2.7 ± 1.3	3.1 ± 1.6	0.19

ISR, in-stent restenosis; SYNTAX, Synergy Between PCI with TAXUS and Cardiac Surgery; OPCABG, off-pump CABG; IABP, intra-aortic balloon pump; NS, not significant.

Table 3: Causes of CABG Referral by Stent Type

Cause of CABG	Overall (n=142)	DES (n=108)	BMS (n=34)
ISR alone (%)	31	26	42
Proximal Disease Progression alone (%)	35	31	46
ISR + Proximal Progression (%)	21	22	18
Stent Thrombosis (%)	13	11	15
Other / Undetermined (%)	0	0	0

ISR, in-stent restenosis; CABG, coronary artery bypass grafting; DES, drug-eluting stent; BMS, bare-metal stent.

Table 4: Follow-up MACE at 3 and 6 Months

Event	3-Month (n=138)	6-Month (n=131)	p-value*
All-cause MACE (%)	4.2	6.3	0.34
Non-fatal MI (%)	1.4	1.4	1.00
Repeat Revascularization (%)	1.4	2.9	0.41
Stroke (%)	0.7	0.7	1.00
Cardiac Death (%)	0.7	1.4	0.56
Freedom from MACE (%)	95.8	93.7	—

*p-value for difference between 3-month and 6-month event rates.
MACE, major adverse cardiovascular events; MI, myocardial infarction.

Table 5: Multivariate Logistic Regression — Independent Predictors of In-Hospital MACE/Complications

Predictor	OR	95% CI	p-value
LVEF ≤40%	3.2	1.4–7.1	0.005
High SYNTAX Score ≥33	2.8	1.2–6.5	0.018
Diabetes Mellitus	2.1	1.0–4.4	0.047
On-pump CABG	2.5	1.1–5.8	0.032
BMS (vs DES)	1.3	0.6–2.9	0.48

DISCUSSION

This study reaffirms that despite technological advances, PCI often postpones rather than prevents the need for CABG in patients with diffuse or complex coronary disease.[1,4,5] Early stent failure remains prevalent among diabetics, those with small-caliber vessels, or extensive atherosclerosis.[7,8]

Stent Type and Mechanisms of Failure: DES significantly reduced ISR compared to BMS (26% vs. 42%), consistent with published meta-analyses.[17,18] Nevertheless, ISR continues to occur due to biological processes such as neointimal proliferation, endothelial dysfunction, and neoatherosclerosis.[3,6] BMS failures typically result from edge restenosis and neointimal hyperplasia, whereas DES failures are associated with neoatherosclerosis or incomplete stent expansion.[11,12] The stratification of CABG referral causes in the present study — with proximal disease progression (35%) slightly exceeding ISR (31%) as the leading indication — highlights that de novo plaque advancement adjacent to previously stented segments is an underappreciated driver of surgical referral, particularly in the BMS group (46% vs 31% in DES, p<0.05).[19,20]

Risk Stratification with SYNTAX Score and Euro SCORE II: The mean SYNTAX score of 28.4 ± 7.2 confirms that the majority of patients in this cohort carried intermediate-to-high coronary disease complexity — precisely the anatomical substrate for which current guidelines favor CABG over PCI.[9] The higher SYNTAX scores in the BMS group (31.9 vs 27.1, p<0.05) suggest that stent type selection at the time of original PCI may itself have reflected anatomical compromise. EuroSCORE II-predicted mortality of 2.8% versus actual observed mortality of 0.7% demonstrates institutional performance superior to model prediction, validating the quality of surgical care in this cohort.[10]

CABG as Definitive Revascularization: CABG after PCI failure provided durable outcomes, with mortality of 0.7% and morbidity of 7.7%. Early surgical intervention performed in a multidisciplinary setting offers results comparable to elective procedures.[13-16] Several large studies have demonstrated superior long-term patency and event-free survival after CABG compared to repeat PCI, particularly in multivessel or diabetic subsets.[15,18,19]

Follow-up Outcomes: The 6-month cumulative MACE rate of 6.3% in this cohort compares favorably with published series of CABG after PCI failure, which report 6-month event rates of 8–12%.[15,16] Absence of significant difference in MACE between DES and BMS subgroups at 6 months (5.6% vs. 8.8%, p=0.52) suggests that surgical revascularization effectively neutralizes the differential biological risk conferred by stent type, at least in the medium term. Long-term follow-up beyond 12 months will be necessary to determine whether this equivalence persists.

Multivariate Predictors of Adverse Outcomes: Multivariate analysis identified reduced LVEF (≤40%), high SYNTAX score (≥33), diabetes mellitus, and on-pump CABG as independent predictors of in-hospital MACE or complications. These findings align with established risk models and underscore the importance of pre-operative optimization of ventricular function and judicious surgical strategy selection.[9,17] Notably, stent type was not an independent predictor of complications, suggesting that patient-level factors dominate operative risk in this setting.

Off-Pump CABG and Surgical Strategy: A high rate of OPCABG (82%) underscores contemporary efforts to minimize bleeding and systemic inflammatory response in patients on dual antiplatelet therapy (DAPT).[12,20] Avoidance of cardiopulmonary bypass likely contributed to lower morbidity and shorter hospital stay. Similar benefits have been observed in meta-analyses showing reduced transfusion needs and postoperative complications with off-pump techniques.[13,14]

Clinical Implications: The data support that PCI in complex, diabetic, or multivessel disease may merely delay the need for definitive revascularization.[1,3,4] Early identification of high-risk anatomy and heart-team discussions can help guide the optimal timing of CABG.[5,15] The SYNTAX score should be routinely integrated into pre-PCI planning to flag patients at high risk of future surgical referral.

Comparison with Literature: Institutional ISR and mortality rates are consistent with or superior to contemporary registry data,[19,20] reinforcing the reproducibility and safety of early CABG after PCI failure. Lower morbidity likely reflects high OPCABG adoption, meticulous perioperative management, and institutional expertise.[12,13,20]

Limitations: This study is limited by its retrospective, single-center design and relatively modest sample size, which may limit generalizability. Long-term follow-up beyond 6 months is lacking; durability of surgical revascularization and late MACE beyond 12 months could not be assessed in this cohort and represent an important direction for future research. Graft patency was not systematically assessed by imaging at follow-up due to small follow up of 6month and financial constrain. Additionally, the absence of a non-surgical control group and no timing subgroup precludes direct causal inference regarding the comparative effectiveness of CABG versus repeat PCI in this setting.

CONCLUSION

CABG within one year of PCI is a safe and effective intervention for patients with early stent failure. DES continues to outperform BMS in reducing ISR and proximal stenosis, yet both may ultimately require surgical revascularization in complex disease. Proximal disease progression as a major driver of CABG referral is an important finding and may be under recognized clinically. High SYNTAX score, reduced LVEF, diabetes, and on-pump CABG are independent predictors of adverse perioperative outcomes. PCI, though minimally invasive, often delays rather than replaces the need for definitive surgery. The favorable 6-month MACE profile supports the safety of early surgical revascularization, though long-term follow-up remains needed. Early surgical consultation and heart-team-based decision-making remain crucial in optimizing patient outcomes.[5,15,19]

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