ORIGINAL ARTICLE

Intravascular Ultrasound (IVUS) Assessment of Safety and Efficacy of Stent Balloon Kissing Technique in Protection of an Important Side Branch in True Bifurcation Lesions [ALTIEB TRIAL]

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Abstract

Background: ***Fifteen to twenty percent of all percutaneous coronary procedures (PCIs) involve coronary bifurcation lesions, which are notoriously difficult to treat. Cardiovascular complications are more common in bifurcation PCI lesions compared to non-bifurcation lesions.***

Aim: ***To assess the feasibility and acute procedural safety of the stent balloon kissing technique (SBKT) for protection of an important side branch (SB) in true bifurcation lesions, as evaluated by intravascular ultrasound (IVUS).***

Subjects and methods: ***This prospective, single-center, single-arm observational study included 50 patients with angiographically confirmed true bifurcation lesions (Medina classification 1,1,1; 0,1,1; or 1,0,1), undergoing PCI at Al-Hussein University Hospital, Al-Azhar University, Cairo, Egypt, between August 2023 and March 2025. IVUS was used pre- and post-PCI for lesion and stent assessment.***

Results: ***The Pre-PCI IVUS showed a mean minimum lumen area of 2.9 ± 0.79 mm² (range: 1.8–4.4 mm²) and plaque burden of 78.7 ± 8.4% (range: 64.2–93.1%). Lesion length averaged 18.4 ± 4.1 mm (range: 11.8–26.6 mm), with reference vessel diameter of 3.6 ± 0.6 mm (range: 2.6–4.8 mm). Calcification (>180° arc) was present in 20 patients (40.0%). Post-PCI, minimum stent area was 6.3 ± 0.9 mm² (range: 4.8–8.2 mm²) with SB ostial plaque burden of 41.2 ± 6.7% (range: 32.1–54.6%). Optimal stent expansion (MSA ≥90% reference) was achieved in 43 patients (86.0%), while malapposition occurred in 7 (14.0%). Plaque burden >85% predicted need for SB intervention (OR 3.2, 95% CI 1.1–9.3; p=0.03). Calcified lesions had 4.1-fold higher odds of malapposition (95% CI 1.3–13.2; p=0.02). The single SB dissection case occurred in a patient with maximal plaque burden (93.1%).***

Conclusion: ***In this single-center exploratory cohort, IVUS-guided Stent Balloon Kissing Technique (SBKT) for true bifurcation lesions was feasible and associated with favorable acute IVUS and angiographic outcomes, including a high rate of optimal stent expansion and a low incidence of immediate complications. Pre-procedural plaque burden >85% and heavy calcification (>180° arc) were the strongest independent predictors of SB intervention and stent malapposition, respectively. Given the observational, single-arm design and limited sample size, these findings are hypothesis-generating and warrant confirmation in larger, controlled, and preferably randomized studies with blinded core-lab IVUS.***

Keywords: SBKT; IVUS; Bifurcation lesions; SB protection

1. Introduction

Both the European Society of Cardiology and the European Bifurcation Club recommend using a single stent rather than a two-stent approach for bifurcation lesions due to the superior clinical outcomes that the former yields.[1]

Although the provisional one-stent technique simplified bifurcation PCI, there remains a risk of SB compromise, periprocedural myocardial infarction, and long-term adverse effects.[2]

Coronary bifurcation intervention is associated with an increased risk of SB compromise and adverse outcomes.[3]

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When conducting bifurcation lesion intervention, one of the primary principles is to protect the SB in order to maintain its open state. Many dedicated bifurcation strategies have been suggested to aid SB protection, including the jailed wire technique (JWT), jailed balloon technique (JBT), and the jailed corsair technique.[4]

To reduce this possibility, various methods have been suggested; one of these is the stent balloon kissing technique (SBKT), which entails inflating a balloon in the SB at the same time as placing a stent in the main branch. This maintains patency and ensures that the stent is properly apposed at the bifurcation point.[5,6]

The aim of this study was to evaluate the safety and efficacy of SBKT in the protection of an important side branch guided by intravascular ultrasound (IVUS).

2. Patients and methods

Fifty patients undergoing percutaneous coronary intervention (PCI) at Al-Hussein University Hospital, Al-Azhar University, Cairo, Egypt, from August 2023 to March 2025 had angiographically confirmed coronary true bifurcation lesions (Medina classification 1,1,1; 0,1,1; or 1,0,1). The study was prospective and had a single arm. An ethical review board from Egypt's Al-Azhar University's Faculty of Medicine gave its stamp of approval to the research. Every single patient gave their signed, informed consent.

Sample Size Rationale:

The sample size of 50 patients was chosen based on institutional recruitment feasibility during the study period and the exploratory, hypothesis-generating nature of this pilot investigation. No formal power calculation was performed because the primary aim was to assess procedural feasibility and acute IVUS-defined outcomes rather than to test a superiority hypothesis. Future controlled studies will use these pilot data to calculate definitive sample sizes.

Inclusion criteria:

Individuals undergoing percutaneous coronary intervention (PCI) who are between the ages of 18 and 75 and have a side branch diameter more than 2.5 mm, as well as a verified angiographically-identified coronary true bifurcation lesion with a Medina categorization of 1,1,1; 0,1,1; or 1,0,1

Exclusion criteria:

Conditions such as a left ventricular ejection fraction below 40%, significant liver and/or renal illness, lesions in the left main bifurcation, coronary artery bypass grafts, severely calcified lesions, excessively tortuous lesions, stent restenosis, and a life expectancy below 12 months are applicable.

Methods:

We took thorough medical histories, performed comprehensive physical examinations, and ran standard laboratory tests on all of our patients.

Standard 12-lead electrocardiogram (ECG):

All patients admitted to the hospital had a standard 12-lead electrocardiogram (ECG) taken within 10 minutes of first medical contact (FMC) in accordance with ESC criteria for acute coronary syndrome in 2023. At the time of admission, every patient must have the following leads attached to their body: I, II, III, aVR, aVL, aVF, and a set of chest leads from V1 to V6. Certain patients underwent the insertion of leads to the right side of the heart (V3R, V4R, V5R, V6R) as well as leads to the back of the chest (V7 to V9) in order to identify infarctions in the right ventricle and posterior wall.

Procedure data:

6- or 7-Fr guiding catheters were used to execute PCI through radial or femoral access. The operator had discretion over the selection of guidewires, balloons, and stents. A provisional stenting method was used to treat all bifurcation lesions. This strategy involved placing a stent in the main branch (MB) and, if needed, additional stents in the side branch (SB). In order to optimize the stent, all patients had IVUS both before and after the PCI procedure.

Stent balloon kissing technique:

Coronary guidewires of the conventional 0.014-inch variety were used to access the MB and SB. A standard balloon was used to pre-dilatate the MB and SB if indicated. A stent was inserted into the right spot at the target lesion in the MB, followed by advancement of a balloon to SB with a size that is close to or less than the reference vessel diameter of the SB, which is typically 1.5-2.5mm. The SB balloon was protruding into the MB at the level or slightly lower than the proximal stent edge. The SB balloon was inflated to low pressure (6–8 ATM), and the main branch stent was then deployed to nominal pressure so that the side-branch balloon and main-branch stent "kissed,". Both the stent and SB balloons were deflated at the same time.

The wire is still in SB, and the MB stent balloon was left in place while the SB balloon was removed. The stent balloon has been fully expanded to high pressure to ensure optimal complete expansion and to rectify any distortion that may have occurred during inflation. Next, the SB guidewire was rewired, and if post-dilatation is necessary, a non-compliant balloon will be utilized for the best possible stent expansion. Coronary angiography was performed to verify the findings and ascertain whether the SB required postprocessing.

Rationale for IVUS:

Among the indications that adhered to the ESC

2018 criteria were the evaluation of calcification, optimization of stent deployment, and ambiguous lesion severity.[7] In order to optimize the stent, all patients had IVUS both before and after the PCI procedure.

Pre-PCI IVUS:

A 20MHz IVUS catheter (Volcano™, Philips Healthcare) was used to manually pull back the catheter in order to measure the following: the minimum lumen area (MLA) at the bifurcation core, the plaque burden (%), the length of the lesion, the presence of calcification (arc>180°), and the reference vessel diameter (RVD) of the MB and SB. Ultrasound-based stent size criteria: The stent's diameter should be modified to match the distal RVD, while the stent's length should be sufficient to cover the entire lesion plus an additional 2-3mm either way.

Post-PCI IVUS:

Stent expansion was assessed using the contemporary IVUS criteria: optimal expansion defined as minimum stent area (MSA) ≥90% of the reference lumen area or ≥100% of the distal reference lumen area. Malapposition (>0.2mm gap between stent struts and vessel wall) and edge dissection (>60° arc) were documented. Final kissing balloon inflation (FKBI) was guided by IVUS to ensure optimal SB ostium coverage.

Postprocessing of the SB:

The procedure of SB rewiring and SB dilation with a compliant balloon was performed following main-branch stent implantation if coronary angiography revealed an ostial SB stenosis of 80% or more, a TIMI flow grade of less than III in the SB, and a reference vessel diameter of 2mm or greater. The final kissing balloon was then applied. If the reference vessel diameter was 2.5 mm or greater and the ostial side-branch stenosis was 80% or greater, a kissing balloon was produced, and an SB stent was deployed. Coronary angiography was then repeated in such cases. In the event of dissection or substantial flow limitation following FKBI, a bailout stent is inserted in the side branch. At last, in order to accomplish optimal apposition of the proximal MB stent, the repeated POT method is required. Furthermore, it should be highlighted that in order to avoid irreversible carina shift, the MB stent should be sized according to the distal main vascular diameter. For POT, the non-compliant balloon should be selected and sized in accordance with Murray's law.

To successfully alter the physiological anatomy, the SB was rewired, and then POT was administered, provided that the SB was uncompromised. The stent was evaluated using intravascular ultrasound following the percutaneous coronary intervention (PCI) protocol to rule out stent fracture, side branch ostial dissection, and other potential problems.

Primary outcome:

The primary clinical endpoint was side-branch (SB) patency after mechanical optimization of the main-branch (MB) stent, defined as TIMI flow grade III in the SB following MB stent re-expansion/optimization. Partial flow (TIMI grade II) was considered reduced patency but not complete success; SB occlusion (loss of patency) was defined as TIMI grade 0–I. The primary endpoint is reported as the proportion of patients with TIMI III flow in the SB after MB optimization.

Primary IVUS Outcome:

The primary IVUS endpoint was the proportion of patients achieving optimal stent expansion, defined as minimum stent area (MSA) ≥90% of the average reference lumen area or ≥100% of the distal reference lumen area.

Secondary outcomes:

Rate of successful SB rewiring. Achievement of TIMI flow grade III in MB and SB after MB stent optimization. Requirement for additional SB intervention (balloon dilation or stent implantation). Incidence of procedure-related complications (SB dissection, stent malapposition).

Secondary IVUS Outcomes:

Correlation between pre-PCI plaque burden and SB compromise. Association between calcification (arc > 180°) and stent malapposition

Statistical analysis:

Data were analyzed using SPSS version 26 (IBM Corp., Armonk, NY, USA). Normality was assessed with the Shapiro–Wilk test and by visual inspection of histograms. Normally distributed continuous variables are presented as mean ± standard deviation (SD); non-normally distributed variables as median (interquartile range, IQR). Categorical variables are reported as counts and percentages. Between-group comparisons used Student's t-test or Mann–Whitney U test for continuous variables and Pearson's Chi-square or Fisher's exact test for categorical variables, as appropriate. Variables with $p < 0.10$ on univariate screening were entered into multivariable logistic regression models to identify independent predictors of outcomes (stent malapposition, requirement for SB intervention); adjusted odds ratios (aOR) with 95% confidence intervals (CI) are reported. Multicollinearity was assessed with variance inflation factors (VIF). Model calibration and discrimination were assessed by the Hosmer–Lemeshow test and area under the receiver-operating characteristic curve (AUC). Because several outcomes had small event counts, multivariable analyses are exploratory and should be interpreted cautiously. A two-sided $p < 0.05$ was considered statistically significant.

3. Results

Table 1. Demographic data of the studied patients.

		(N=50)
AGE (YEARS)	Mean±SD	58.2 ± 8.9
	Range	42.0 – 73.5
SEX	Male	36(72%)
	Female	14(28%)
WEIGHT (KG)	Mean±SD	82.7 ± 10.4
	Range	68 - 103
HEIGHT (CM)	Mean±SD	167.3 ± 6.8
	Range	154 - 181
BMI (KG/M^2)	Mean±SD	29.6 ± 3.9
	Range	24.5 - 36.8

BMI:Body mass index.

The age ranged between 42.0–73.5 years with a mean value (±SD) of 58.2 ± 8.9 years. There were 36 (72%) males and 14 (28%) females. The weight ranged between 68–103 kg with a mean of 82.7 ± 10.4 kg. The height ranged between 154–181 cm with a mean of 167.3 ± 6.8 cm. The BMI ranged between 24.5–36.8 kg/m² with a mean of 29.6 ± 3.9 kg/m² .(Table 1).

Table 2. Risk factors of the studied patients and diagnosis at presentation.

	(N=50)
HYPERTENSION	36(72%)
SMOKER	21(42%)
DYSLIPIDEMIA	19(38%)
DIABETES MELLITUS	16(32%)
HISTORY OF PCI	4(8%)
DIAGNOSIS AT PRESENTATION	
NSTEMI	36(72%)
CCS	10(20%)
STEMI	4(8%)

PCI = Percutaneous Coronary Intervention; NSTEMI = non-ST-elevation Myocardial Infarction; CCS = Chronic Coronary Syndrome; STEMI = ST-elevation Myocardial Infarction.

Among cardiovascular risk factors, hypertension was present in 36 patients (72.0%), followed by current smoking (21 patients, 42.0%), dyslipidemia (19 patients, 38.0%), and diabetes mellitus (16 patients, 32.0%). Four patients (8.0%) had a history of prior PCI. Regarding presentation diagnoses, non-ST-elevation myocardial infarction (NSTEMI) was most common (36 patients, 72.0%), followed by chronic coronary syndrome (10 patients, 20.0%) and ST-elevation myocardial infarction (4 patients, 8.0%) (Table 2).

Table 3. Vital signs, ejection fraction and regional wall motion of the studied patients.

		(N=50)
HEART RATE (BEATS/MIN)	Mean±SD	105.8 ± 10.7
	Range	87–126
BLOOD PRESSURE (MMHG)	Mean±SD	143.2 ± 16.9
	Range	109–174
EJECTION FRACTION (%)	Mean±SD	52.3 ± 6.8
	Range	41–64
REGIONAL WALL MOTION	Hypokinesia	20 (40.0%)
	Akinesia	5 (10.0%)
	Normal	25 (50.0%)

The heart rate (HR) ranged between 87–126 beats/min with a mean value (±SD) of 105.8 ± 10.7 beats/min. Systolic blood pressure ranged between 109–174 mmHg with a mean of 143.2 ± 16.9 mmHg. Ejection fraction ranged between 41–64% with a mean of 52.3 ± 6.8%. Regarding regional wall motion, 20 patients (40.0%) exhibited hypokinesia, 5 (10.0%) had akinesia, while 25 (50.0%) showed normal wall motion (table 3).

Table 4. Lesion characteristics and procedural outcomes.

	(N=50)
LESION LOCATION	
LAD	28(56%)
LCX	17(34%)
RCA	5(10%)
MEDINA CLASSIFICATION	
1.1.1	30(60%)
1.0.1	10(20%)
0.1.1	10(20%)
FINAL TIMI FLOW GRADE < 3	0(0%)
SIDE BRANCH DISSECTION	1(2%)
SIDE BRANCH POST PROCESSING:	5(10%)
- SIDE BRANCH BALLOON DILATION	4(8%)
- SIDE BRANCH STENT IMPLANTATION	1(2%)

LAD = Left Anterior Descending; LCX = Left Circumflex;
RCA = Right Coronary Artery; PCI = Percutaneous Coronary Intervention;
TIMI = Thrombolysis in Myocardial Infarction; SB = Side Branch

Lesion location was most frequently in the left anterior descending artery (LAD) (28 patients, 56.0%), followed by the left circumflex (LCX) (17 patients, 34.0%) and right coronary artery (RCA) (5 patients, 10.0%). Medina classification showed 1.1.1 lesions in 30 patients (60.0%), 1.0.1 in 10 patients (20.0%), and 0.1.1 in 10 patients (20.0%). Post-procedurally, no patients had TIMI flow <3 in the side branch. One patient (2.0%) experienced side branch dissection. Five patients (10.0%) required side branch post-processing, consisting of balloon dilation in 4 patients (8.0%) and stent implantation in 1 patient (2.0%) (Table 4).

Table 5. Pre- and Post-PCI IVUS Characteristics (n=50).

PARAMETER	STATISTIC	VALUE	ASSOCIATION STATISTICS
PRE-PCI FINDINGS			
MINIMUM LUMEN AREA(MM²)	Mean±SD	2.9±0.79	
	Range	1.8-4.4˄	
PLAQUE BURDEN (%)	Mean±SD	78.7±8.4	
	Range	64.2-93.1˄	
PLAQUE BURDEN >85%	n (%)	15 (30.0)	aOR=3.2 (1.1–9.3), p=0.03*
LESION LENGTH(MM)	Mean±SD	18.4 ± 4.1	
	Range	11.8–26.6˄	
REFERENCE VESSEL DIAMETER (MM)	Mean±SD	3.6 ± 0.6	
	Range	2.6–4.8˄	
CALCIFICATION (ARC >180°)	n (%)	20 (40.0)	aOR=4.1 (1.3–13.2), p=0.02*
POST-PCI FINDINGS			
MINIMUM STENT AREA (MM²)	Mean±SD	6.3 ± 0.9	
	Range	4.8–8.2	
PLAQUE BURDEN AT SB OSTIUM (%)	Mean±SD	41.2 ± 6.7	
	Range	32.1–54.6†	
OPTIMAL STENT EXPANSION˅	n (%)	43 (86.0)	
STENT MALAPPOSITION	n (%)	7 (14.0)	

* Binary logistic regression; ˄ Calculated as mean ± 2SD; ˅ Defined as MSA ≥90% of reference lumen area

aOR = adjusted Odds ratio for: 1) Plaque burden >85% predicting SB intervention; 2) Calcification predicting stent malapposition

Pre-PCI IVUS showed mean minimum lumen area of 2.9 ± 0.79 mm² (range: 1.8–4.4 mm²) and plaque burden of 78.7 ± 8.4% (range: 64.2–93.1%). Lesion length averaged 18.4 ± 4.1 mm (range: 11.8–26.6 mm), with reference vessel diameter of 3.6 ± 0.6 mm (range: 2.6–4.8 mm). Calcification (>180° arc) was present in 20 patients (40.0%). Post-PCI, minimum stent area was 6.3 ± 0.9 mm² (range: 4.8–8.2 mm²) with SB ostial plaque burden of 41.2 ± 6.7% (range: 32.1–54.6%). Optimal stent expansion (MSA ≥90% reference) was achieved in 43 patients (86.0%), while malapposition occurred in 7 (14.0%).

Pre-PCI ostial plaque burden was 78.7 ± 8.4% compared with 41.2 ± 6.7% post-PCI (mean difference 37.5%; paired t-test p < 0.001).

Plaque burden >85% predicted need for SB intervention (OR 3.2, 95% CI 1.1–9.3; p=0.03). Calcified lesions had 4.1-fold higher odds of malapposition (95% CI 1.3–13.2; p=0.02). The single SB dissection case occurred in a patient with maximal plaque burden (93.1%). (table 5).

Table 6. Predictors of Side Branch Intervention Requirement

VARIABLE	UNIVARIATE OR (95% CI)	MULTIVARIABLE AOR (95% CI)	P-VALUE
PLAQUE BURDEN >85%	4.10 (1.30–13.20)	3.20 (1.10–9.30)	0.03
AGE (PER YEAR INCREASE)	1.05 (0.97–1.14)	1.03 (0.95–1.12)	0.42
CALCIFICATION >180°	2.30 (0.80–6.60)	1.80 (0.60–5.40)	0.29
LESION LENGTH (PER MM INCREASE)	1.08 (0.96–1.22)	1.05 (0.93–1.19)	0.41
REFERENCE VESSEL DIAMETER	0.90 (0.40–2.00)	0.85 (0.37–1.95)	0.70
DIABETES MELLITUS	1.60 (0.55–4.65)	1.40 (0.48–4.10)	0.53

Model statistics: Hosmer-Lemeshow x²=4.32, p=0.74; AUC=0.78 (95% CI: 0.65–0.91)

aOR = adjusted odds ratio; CI = confidence interval

Given the small number of events (e.g., malapposition in 7 patients), these regression analyses should be interpreted cautiously as hypothesis-generating.

Table 7. Predictors of Stent Malapposition

VARIABLE	UNIVARIATE OR (95% CI)	MULTIVARIABLE AOR (95% CI)	P-VALUE
CALCIFICATION >180°	5.20 (1.50–18.10)	4.10 (1.30–13.20)	0.02
PLAQUE BURDEN >85%	2.10 (0.70–6.30)	1.60 (0.50–5.10)	0.42
AGE (PER YEAR INCREASE)	0.98 (0.91–1.06)	0.97 (0.90–1.05)	0.45
LESION LENGTH (PER MM INCREASE)	1.04 (0.93–1.16)	1.02 (0.91–1.14)	0.75
REFERENCE VESSEL DIAMETER	1.20 (0.60–2.40)	1.15 (0.55–2.40)	0.71
DIABETES MELLITUS	1.80 (0.65–5.00)	1.50 (0.52–4.30)	0.46

Model statistics: Hosmer-Lemeshow x²=3.85, p=0.80; AUC=0.75 (95% CI: 0.62–0.88)

aOR = adjusted odds ratio; CI = confidence interval

Table 8. Multivariable logistic regression analysis of predictors of stent malapposition.

VARIABLE	AOR	95% CI	P
CALCIFICATION (ARC >180°)	4.10	1.30–13.20	0.02
PLAQUE BURDEN >85%	3.20	1.10–9.30	0.03
AGE (PER YEAR)	1.03	0.95–1.12	0.42

Multivariable model adjusted for diabetes mellitus. Variables with p < 0.10 in univariable screening were entered into the multivariable model. aOR = adjusted odds ratio; CI = 95% confidence interval; Hosmer–Lemeshow p = 0.74; AUC = 0.78.

This table presents the results of a multivariable binary logistic regression model evaluating independent predictors of stent malapposition following IVUS-guided PCI for bifurcation lesions. Variables with p < 0.10 in univariate analysis were entered into the multivariable model. Calcification (arc >180°) and high plaque burden (>85%) emerged as significant independent predictors. Age was included as an adjustment variable. Odds ratios (aOR) are adjusted for diabetes. Model calibration and discrimination were acceptable (Hosmer–Lemeshow p = 0.74; AUC = 0.78).

Table 9. Multivariable logistic regression analysis of predictors of side-branch intervention.

VARIABLE			95	
	OR	% CI		
PLAQUE			1.1	
BURDEN >85%	.20	0–9.30		.03
CALCIFICATION			0.7	
(ARC >180°)	.90	0–5.10		.21
LESION LENGTH			0.9	
(PER MM)	.05	8–1.13		.14

Multivariable model adjusted for diabetes mellitus.Variables with p < 0.10 in univariable screening were entered into the multivariable model. aOR = adjusted odds ratio; CI = 95% confidence interval; Hosmer–Lemeshow p = 0.81; AUC = 0.76.

This table summarizes the multivariable logistic regression model evaluating independent predictors of the need for additional SB intervention after IVUS-guided PCI for bifurcation lesions. Variables with p < 0.10 in univariate analysis were entered into the model. Pre-procedural plaque burden >85% was the only significant independent predictor. Odds ratios (aOR) are adjusted for diabetes. Model performance was adequate (Hosmer–Lemeshow p = 0.81; AUC = 0.76).

Because some outcomes had low absolute event counts (e.g., malapposition in 7 patients), the multivariable models should be considered exploratory and used to generate hypotheses rather than to confirm causal associations.

Case Presentation:

A 55-year-old man, known hypertensive and smoker, presented with Non-ST Elevation Myocardial Infarction (NSTEMI).

Figure 1. An angiogram showed severe stenosis at a true LAD-D1 bifurcation segment (Medina 1,1,1).

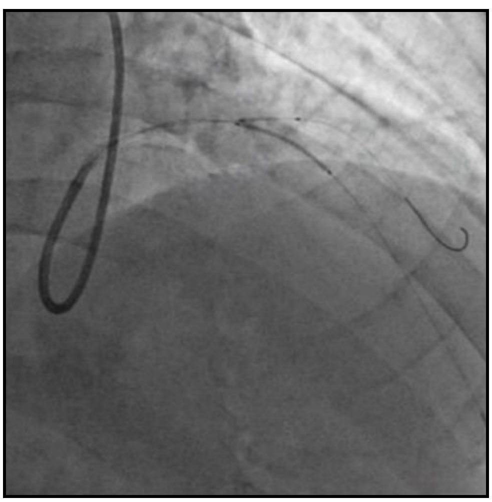

Figure 2. Both LAD stent and Diagonal branch balloon positioned at the same level

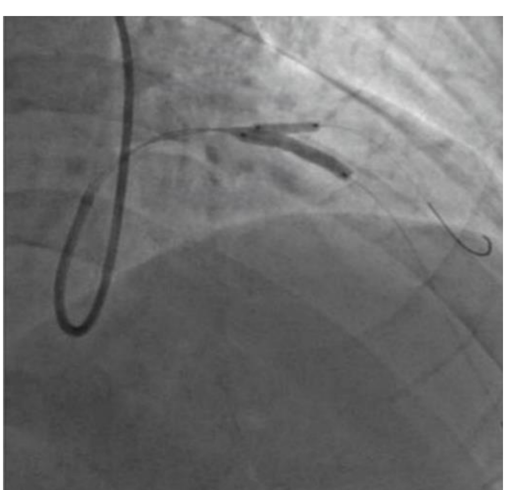

Figure 3. simultaneous inflation "kissing" of SB balloon and main branch stent.

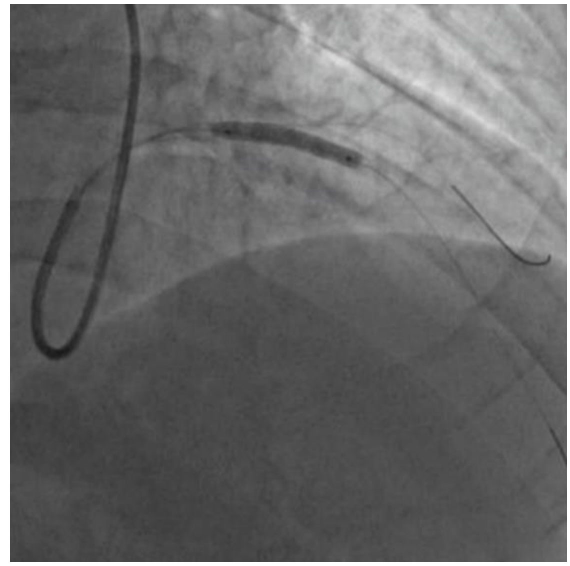

Figure 4. stent balloon optimization after SB balloon removal.

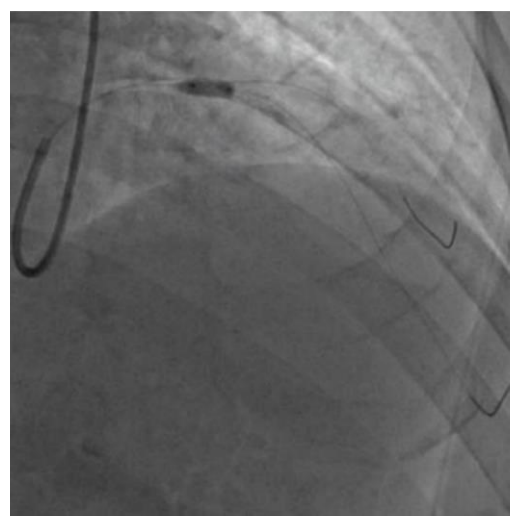

Figure 5. proximal optimization technique (POT) after Diagonal branch rewiring

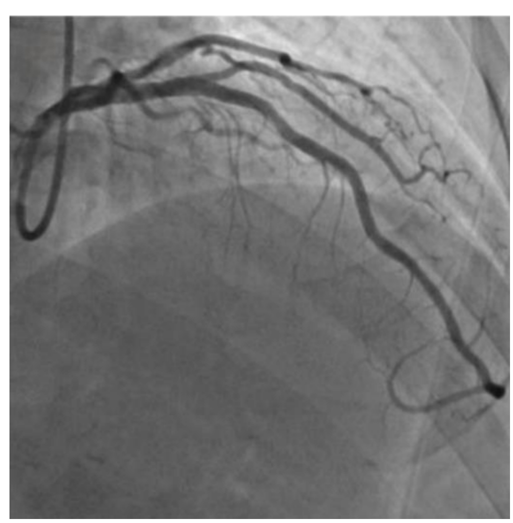

Figure 6. Final angiographic results.

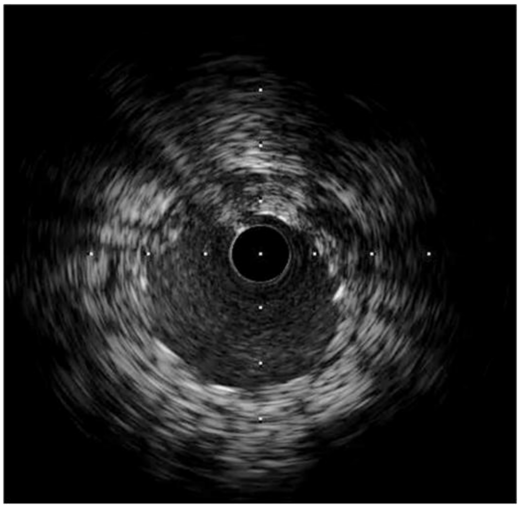

Figure 7. IVUS confirmation of patent Diagonal branch ostium

4. Discussion

Coronary bifurcation lesions, constituting approximately 20% of percutaneous interventions, present unique challenges, including elevated restenosis rates and complex revascularization requirements.[8,9] This study characterizes Egyptian patients undergoing bifurcation PCI, revealing distinct demographic and clinical patterns that contextualize procedural decision-making. Critically, our findings demonstrate that intravascular ultrasound (IVUS)-guided optimization effectively mitigates anatomical complexities prevalent in this cohort, particularly high plaque burden and calcification.

Mechanistically, SBKT preserves guidewire access and prevents complete SB ostial coverage during MB stent deployment, thereby reducing carina shift and maintaining ostial geometry. Simultaneous SB balloon inflation may also facilitate better stent apposition at the bifurcation by counteracting deformation during MB stent deployment. These remain theoretical benefits that require confirmation in larger, controlled studies.

Our cohort exhibited a distinctly younger presentation (mean age 58.2 ± 8.9 years) with male predominance (72.0%) compared to global studies (Choi et al.: 66.0 ± 11.3 years).[10] The cardiovascular risk profile showed markedly elevated hypertension prevalence (72.0%), exceeding reports from Elsheikh et al. (61.4%), [11] and aligning with Egypt's national burden, where >40% of adults are hypertensive. Notably, diabetes prevalence (32.0%) was lower than Western cohorts[11] but reflected regional epidemiological trends. Anthropometric data confirmed significant obesity challenges (mean BMI 29.6 ± 3.9 kg/m²), consistent with urban Egyptian populations where metabolic syndrome affects >40% of adults—a key modifier of plaque morphology.

Acute presentation patterns included tachycardia (105.8 ± 10.7 bpm) and elevated systolic pressure (143.2 ± 16.9 mmHg), consistent with sympathetic activation in our NSTEMI-dominant cohort (72.0%). Ventricular function was moderately preserved (mean EF 52.3 ± 6.8%), though regional wall motion abnormalities were common (hypokinesia: 40.0%; akinesia: 10.0%) and correlated strongly with angiographic complexity. The LAD predominance (56.0%) matches Egyptian registry data, while low complication rates (side branch dissection: 2.0%; TIMI<3 flow: 0%) attest to procedural expertise despite frequent true bifurcations (Medina 1.1.1: 60.0%).

Our IVUS analysis yielded three pivotal findings:

Plaque burden >85% (30.0% of lesions) independently predicted side branch intervention need (OR 3.2, 95% CI 1.1–9.3; *p*=0.03), with maximal burden (93.1%) directly causing our single dissection.

Calcified lesions (>180° arc; 40.0%) carried 4.1-fold higher malapposition risk (95% CI 1.3–13.2; *p*=0.02), explaining the 14.0% malapposition rate despite 86.0% optimal stent expansion.

Significant plaque shift management was achieved, evidenced by ostial burden reduction from 78.7 ± 8.4% pre-PCI to 41.2 ± 6.7% post-PCI (*p*<0.001).

Compared to European cohorts[12], Egyptian patients demonstrated higher calcification burden (40.0% vs. 14.8%) and younger presentation age—factors necessitating aggressive plaque modification. Our technical success rate (97-98% main branch) mirrors global standards but was achieved with fewer side branch stents (2.0%), suggesting IVUS-guided provisional stenting optimizes resource utilization. For Egyptian cath labs, we recommend:

Routine IVUS for Medina 1.1.1 lesions

Preemptive plaque modification for burdens >85%

Mandatory post-stent optimization for calcification >180°

While a single-center design limits generalizability, our risk factor prevalence aligns with Egyptian national registries, supporting validity. Future studies should validate IVUS-derived SB intervention thresholds (e.g., ostial burden >45%) in multicenter Egyptian cohorts and explore long-term outcomes of physiology-guided versus anatomy-guided approaches.

Limitations: This is a single-center, single-arm observational study without a control group. The modest sample size and limited number of adverse events constrain the precision of effect estimates and preclude formal hypothesis testing.

IVUS analysis was performed by the treating operator, and there was no blinded core-lab adjudication or formal inter-observer reproducibility assessment. The multivariable models presented are exploratory. Follow-up was limited to acute procedural outcomes, and longer-term clinical endpoints were not assessed.

4. Conclusion

In this exploratory, single-center cohort, IVUS-guided Stent Balloon Kissing Technique (SBKT) for true bifurcation lesions was feasible, safe, and associated with high acute procedural success, characterized by a high rate of optimal stent expansion and a low incidence of complications. Pre-procedural plaque burden >85% and heavy calcification (>180° arc) were the strongest predictors of side branch intervention and stent malapposition, respectively. While these findings support the role of IVUS in optimizing bifurcation PCI, the study's single-arm design and limited sample size warrant cautious interpretation. Larger, multicenter, and ideally randomized studies with blinded IVUS core-lab analysis are recommended to confirm these results and refine anatomical thresholds for intervention.

Disclosure

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