

Effect of Wire Jailing at Side Branch in 1-Stent Strategy for Coronary Bifurcation Lesions



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ABSTRACT

OBJECTIVES This study aimed to determine whether side branch (SB) wire jailing before main vessel (MV) stenting could prevent SB occlusion after the 1-stent strategy for bifurcation percutaneous coronary intervention.

BACKGROUND The benefits of SB wire jailing in the 1-stent strategy remain unclear.

METHODS From the COBIS (Coronary Bifurcation Stenting) III registry, 1,890 patients with bifurcation lesions who underwent the 1-stent strategy using second-generation drug-eluting stents were identified and classified into 2 groups according to the use of SB wire jailing: wire jailing (n = 819) and non-wire jailing (n = 1,071). The incidence of SB occlusion (Thrombolysis In Myocardial Infarction flow grade <3) and target lesion failure (cardiac death, myocardial infarction, or target lesion revascularization) was compared.

RESULTS The incidence of final SB occlusion was not significantly different between wire jailing (1.8%) vs non-wire jailing (2.9%; $P = 0.182$). However, wire jailing at the SB was a significant protective factor for SB occlusion after MV stenting on multivariate analysis and was significantly associated with a lower incidence of SB occlusion in patients with significant stenoses ($\geq 60\%$) at the SB (5.1% vs 11.3%; odds ratio: 0.42; 95% CI: 0.19–0.89; $P = 0.028$) or MV (3.1% vs 6.2%; odds ratio: 0.49; 95% CI: 0.24–0.95; $P = 0.039$). During follow-up (median 52 months), the incidence of target lesion failure was not significantly different between wire jailing and non-wire jailing (7.6% vs 6.3%; $P = 0.343$).

CONCLUSIONS During bifurcation percutaneous coronary intervention with the 1-stent strategy, wire jailing at the SB was associated with a lower rate of final SB occlusion following MV stenting in patients with severe stenoses at the SB or MV but not with overall bifurcation lesions. Long-term clinical outcomes were comparable between the 2 groups. (J Am Coll Cardiol Interv 2022;15:443–455) © 2022 by the American College of Cardiology Foundation.

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ABBREVIATIONS AND ACRONYMS

DES = drug-eluting stent(s)
DS = diameter stenosis
IPTW = inverse probability of treatment weighting
MI = myocardial infarction
MV = main vessel
PCI = percutaneous coronary intervention
POT = proximal optimization technique
SB = side branch
TLF = target lesion failure

Despite the favorable outcomes of the 1-stent strategy for coronary bifurcation lesions, it is associated with side branch (SB) occlusion, which may lead to serious adverse clinical events.^{1–3} Various treatment modalities have been introduced and attempted to prevent SB occlusion with this strategy.^{3–6} Of these, wire jailing at the SB before main vessel (MV) stenting is frequently performed to prevent SB occlusion and to facilitate rewiring to the SB and provisional SB stenting after MV stenting.^{4,5,7,8} However, the real benefits of wire jailing at the SB in the 1-stent strategy have not been clearly elucidated. Therefore, we sought to evaluate the impact of wire jailing at the SB before MV stenting in bifurcation percutaneous coronary intervention (PCI) using the 1-stent strategy on the angiographic and clinical outcomes following second-generation drug-eluting stent (DES) implantation and to investigate the role of wire jailing at the SB and the major determining factors enforcing physicians to perform such procedure.

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METHODS

STUDY POPULATION AND PROCEDURES. The COBIS (Coronary Bifurcation Stenting) III registry is a retrospective, multicenter, and observational registry of patients with coronary bifurcation lesions undergoing PCI with second-generation DES implantation; MV diameter ≥ 2.5 mm and SB diameter ≥ 2.3 mm on quantitative coronary analysis were included. The detailed explanations regarding the COBIS III were

provided in the previous study.¹ To investigate the pure role of SB wire jailing in 1-stent strategy, coronary bifurcation lesions requiring SB wiring such as: 1) elective 2-stent techniques; 2) SB pre-dilation before MV stenting; or 3) significant stenosis only at the SB without significant MV stenosis (Medina 0.0.1) were excluded in this analysis. Decision of stent strategy before bifurcation PCI and the type and reason of SB treatments after MV stenting were comprehensively investigated. Bifurcation lesions in which there was a clear intention to conduct PCI of SB before MV stenting were excluded from the study, together with the exclusion of all cases undergoing elective 2-stent strategies (Crush, double-kissing crush, T-stenting, V-stenting, Culotte stenting, kissing stenting, etc.). As a result, the 1-stent strategy in this study refers to cases with MV stenting without a planned or intentional 2-stent strategy or pre-dilation of SB in coronary bifurcation. Finally, a total of 1,890 patients fulfilling the inclusion criteria were enrolled for this analysis and then classified into 2 groups according to whether they underwent wire jailing at the SB: the wire-jailing group (n = 819 [43.3%]) and non-wire-jailing group (n = 1,071 [56.7%]) (Figure 1). In addition, the attempts for wiring to the SB before MV stenting were investigated among patients with non-wire jailing. This registry was supported by the Korean Bifurcation Club and the Korean Society of Interventional Cardiology. The Institutional Review Board of each hospital approved the study protocol and waived the requirement for written informed consent caused by the retrospective nature of the study.

Coronary interventions and medical treatment were conducted in accordance with current standard guidelines.⁷ Medical therapy provided before and after PCI was described in a previous study.¹ The

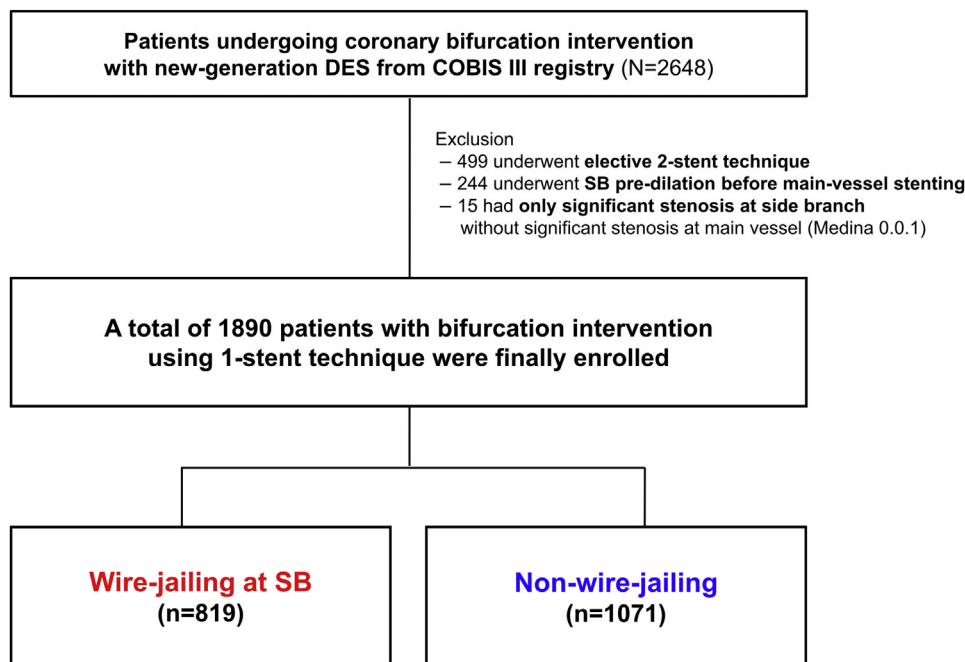
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FIGURE 1 Study Flowchart of the COBIS III Registry



COBIS = COronary Bifurcation Stenting; DES = drug-eluting stent(s); SB = side branch.

treatment strategy for the approach site; types of guiding catheter, guidewire, and DES; use of intra-vascular imaging devices or intravascular functional assessment; and rewiring after stenting were left to the discretion of the operators. The executive committee of the Korean Bifurcation Club recommended pre- and post-procedural intravascular ultrasound evaluation for the establishment of strategy and stent optimization in coronary bifurcation lesions. In case of decreased SB flow after MV stenting, balloon dilation of SB was recommended. When angiographic findings of SB after MV stenting was vague (moderate or undetermined severity of stenosis), physiologic assessment of SB was recommended. The use of the proximal optimization technique (POT), re-POT, or kissing balloon technique was left to the operators' discretion based on the angiographic, imaging, or physiologic findings.

DATA COLLECTION AND ANGIOGRAPHIC ANALYSES.

Using a Web-based reporting system, we obtained data regarding patients' baseline clinical, angiographic, and procedural characteristics. Additional data, including follow-up clinical outcomes, were obtained from medical records, and telephonic contacts were conducted in case of follow-up loss.

Pre- and post-procedural coronary angiograms were examined and analyzed quantitatively in an angiographic core laboratory (Samsung Medical Center) using a validated and automated edge-detection system (Centricity CA 1000, GE Healthcare).¹ Before and after the procedures, the bifurcation angle, minimal lumen diameter, reference vessel diameter, and lesion length were measured, and percent diameter stenosis (DS) was calculated in both the SB and MV. The bifurcation lesions were classified using the Medina classification and divided into 3 segments: proximal, distal, and SB. True bifurcation was defined as cases with Medina classifications of 1.1.1, 1.0.1, and 0.1.1. The bifurcation angle was defined as the angle between the distal MV and SB with the widest separation of the 2 branches. Calcification was differentiated by apparent radiopacities within the vascular wall at the site of stenosis. Heavy calcification was defined as radiopacities without cardiac motion before contrast injection. Other detailed explanations regarding quantitative coronary angiographic analyses have been provided in a previous study.²

STUDY OUTCOMES AND DEFINITIONS. The primary outcome was the occurrence of final SB occlusion after MV stenting, defined as Thrombolysis In

TABLE 1 Baseline Characteristics

	Wire-Jailing SB Group (n = 819)	Non-Wire-Jailing SB Group (n = 1,036)	P Value
Age, y	63.4 ± 10.7	63.4 ± 11.2	0.916
Male	633 (77.3)	789 (76.2)	0.605
Hypertension	463 (56.5)	597 (57.6)	0.671
Diabetes mellitus	255 (31.1)	340 (32.8)	0.471
Current smoker	240 (29.3)	337 (32.5)	0.150
Chronic kidney disease	38 (4.6)	38 (3.7)	0.352
Previous MI	36 (4.4)	44 (4.2)	0.967
Previous percutaneous coronary intervention	97 (11.8)	103 (9.9)	0.216
Clinical presentation			0.506
Stable angina	316 (38.6)	383 (37.0)	
Acute coronary syndrome	503 (61.4)	653 (63.0)	
Left ventricular ejection fraction ≤40%	34 (4.2)	56 (5.4)	0.255
2- or 3-vessel disease	435 (53.1)	527 (50.9)	0.702
Bifurcation location			<0.001
Left main	321 (39.2)	286 (27.6)	
Left anterior descending artery	380 (46.4)	486 (46.9)	
Left circumflex artery	90 (11.0)	177 (17.1)	
Right coronary artery	28 (3.4)	87 (8.4)	
Medina classification			<0.001
1.1.1	279 (34.1)	175 (16.9)	
1.0.1	47 (5.7)	47 (4.5)	
0.1.1	60 (7.3)	62 (6.0)	
1.0.0	99 (12.1)	173 (16.7)	
0.1.0	174 (21.2)	364 (35.1)	
1.1.0	160 (19.5)	215 (20.8)	
True bifurcation	386 (47.1)	284 (27.4)	<0.001
Type of drug-eluting stent			<0.001
Biolimus eluting	156 (19.0)	236 (22.8)	
Everolimus eluting	437 (53.3)	437 (42.2)	
Zotarolimus eluting	201 (24.5)	301 (29.1)	
Others or mixed	25 (3.1)	62 (6.0)	
Use of intravascular ultrasound	386 (47.1)	329 (31.8)	<0.001
MV stent diameter, mm	3.2 ± 0.6	3.1 ± 0.6	0.032
MV stent length, mm	28.0 ± 12.2	29.4 ± 14.8	0.030

Values are mean ± SD or n (%).

MI = myocardial infarction; MV = main vessel; SB = side branch.

Myocardial Infarction (TIMI) flow grade <3. The secondary outcomes included: 1) the occurrences of target lesion failure (TLF), defined as the composite of cardiac death, myocardial infarction (MI), and target lesion revascularization; 2) the individual components of TLF; and 3) angiographic or procedural success.

Angiographic success was defined as final TIMI flow grade 3 and <30% residual stenosis in the MV and <50% residual stenosis in the SB, and procedural success was defined as an angiographic success with no cardiac death, ST-segment elevation MI, or emergency coronary artery bypass grafting during the hospital stay.⁸

Abrupt SB occlusion and restoration of SB flow after SB occlusion were defined as TIMI flow grades

0 and 3 to the SB, respectively. If the noncardiac cause of death was unclear, a death was considered a cardiac death. MI during hospital stay was defined as the elevation of cardiac enzyme levels with concomitant ischemic symptoms or signs on electrocardiography unrelated to the index PCI procedure. Target lesion revascularization was defined as revascularization of the MV or SB within 5 mm of the stent deployment site.

STATISTICAL ANALYSIS. Continuous variables were reported as mean ± SD and compared between groups using Student's *t*-test or the Wilcoxon rank sum test. Categorical variables were reported as numbers and frequencies (percentages) and compared between groups using a chi-square test or Fisher exact test. The cumulative incidence of clinical outcomes was presented as survival curves using Kaplan-Meier estimates and compared using a log-rank test. The variables were analyzed to identify the independent determinants of wire jailing at the SB or final SB occlusion using a multiple logistic regression analysis. Odds ratios with 95% CIs were presented. The Cox proportional hazards model was applied to confirm the relevance of SB occlusion and clinical outcomes by presenting HRs with 95% CIs. Inverse probability of treatment weighting (IPTW) was used to balance differences in baseline characteristics including the pre-procedural stenosis severity of the MV and SB, and the performance of optimization techniques such as POT, re-POT, or FKB as a covariate for propensity score weight.

The linearity assumption between the angiographic parameters and the risk of SB occlusion was explored using penalized spline functions. Receiver-operating characteristic analysis was performed to determine the best cutoff values for the predictors of final SB occlusion after MV stenting. Statistical analyses were performed using R statistical software (version 4.0.3, R Foundation for Statistical Computing). All *P* values were 2-tailed, and *P* values of <0.05 were considered statistically significant.

RESULTS

BASELINE CHARACTERISTICS. There were no significant differences in the baseline clinical characteristics between the wire-jailing and non-wire-jailing groups (Table 1). However, there were significant differences in the location and classification of the bifurcation lesions; the wire-jailing group compared with the non-wire-jailing group had higher incidences of left main and true bifurcation and lower incidences of left circumflex and right

coronary artery bifurcation. In addition, intravascular ultrasound and noncompliant balloon were more frequently used in the wire-jailing group than in the non-wire-jailing group (Table 1).

Comparisons of the angiographic data are presented in Table 2. In the pre-procedural analyses, the wire-jailing group had a shorter minimal lumen diameter, greater DS, longer lesion length of the SB, shorter lesion length of the MV, and higher incidence of moderate or heavy calcification or thrombus at the SB compared with the non-wire-jailing group. In the post-procedural quantitative coronary analyses, the variables were comparable in both groups. The independent determinants of wire jailing at the SB are presented in Supplemental Table 1. A pre-procedural DS of the SB or MV of $\geq 50\%$ and left main coronary artery involvement were the independent determinants of wire jailing at the SB.

ANGIOGRAPHIC OUTCOMES ACCORDING TO WIRE JAILING AT THE SB. As for the occurrence of the primary outcome, final SB occlusion, there was no significant difference between the wire-jailing and non-wire-jailing groups (1.8% vs 2.9%; IPTW-adjusted HR: 0.62; 95% CI: 0.33-1.16; $P = 0.133$) (Table 3). The incidence of any abrupt SB occlusion during the procedure was not significantly different between them. However, the incidence of SB flow restoration after abrupt SB occlusion was significantly higher in the wire-jailing group than in the non-wire-jailing group (1.7% vs 0.8%, IPTW-adjusted HR: 2.74; 95% CI: 1.14-7.24; $P = 0.037$). Regarding the treatment of bifurcation lesions, the wire-jailing group had significantly higher rates of final kissing ballooning, POT usage, ballooning or stent implantation in the SB, and noncompliant ballooning for the MV than did the non-wire-jailing group (Table 3). There were no cases of wire breakage in either group during the procedure. The rates of angiographic and procedural successes were not significantly different between the groups; in addition, there was no significant difference in the rates of in-hospital death or ST-segment elevation MI. In analyses excluding the patients with an attempt for SB wiring before MV stenting in the non-wire-jailing group, consistent findings were noted (Supplemental Tables 2 to 4).

PREDICTORS OF FINAL SB OCCLUSION IN THE 1-STENT STRATEGY. The independent determinants of final SB occlusion after MV stenting are presented in the Central Illustration and Supplemental Table 5; wire jailing at the SB was a significant factor along with greater pre-procedural DS of the SB and MV and lesion length at the MV. In the analysis of the risk for SB occlusion in the lesions with significant predictors,

TABLE 2 Baseline Angiographic Data

	Wire-Jailing SB Group (n = 819)	Non-Wire-Jailing SB Group (n = 1,036)	P Value
Pre-procedure			
RD, mm			
Proximal MV	3.6 $\pm$ 0.7	3.6 $\pm$ 0.6	0.174
Distal MV	2.9 $\pm$ 0.5	2.9 $\pm$ 0.5	0.840
SB	2.6 $\pm$ 0.4	2.6 $\pm$ 0.4	0.261
MLD, mm			
Proximal MV	1.2 $\pm$ 0.8	1.2 $\pm$ 0.8	0.253
Distal MV	0.8 $\pm$ 0.4	0.8 $\pm$ 0.5	0.720
SB	1.6 $\pm$ 0.8	1.8 $\pm$ 0.8	<0.001
Diameter stenosis, %			
MV	74.4 $\pm$ 13.1	74.6 $\pm$ 14.5	0.798
SB	41.1 $\pm$ 25.6	33.0 $\pm$ 24.3	<0.001
Lesion length, mm			
MV	18.3 $\pm$ 9.7	19.5 $\pm$ 10.5	0.008
SB	4.7 $\pm$ 6.0	2.9 $\pm$ 5.3	<0.001
Bifurcation angle, °	72.2 $\pm$ 23.8	71.0 $\pm$ 21.2	0.232
Heavy calcification			
MV	157 (19.2)	180 (17.4)	0.350
SB	59 (7.2)	49 (4.7)	0.031
Thrombus containing			
MV	20 (2.4)	32 (3.1)	0.486
SB	7 (0.9)	1 (0.1)	0.025
Post-procedure			
MLD, mm			
Proximal MV	2.9 $\pm$ 0.5	2.9 $\pm$ 0.5	0.988
Distal MV	2.8 $\pm$ 0.5	2.8 $\pm$ 0.5	0.123
SB	1.6 $\pm$ 0.8	1.6 $\pm$ 0.8	0.318
Diameter stenosis, %			
MV	15.0 $\pm$ 9.4	15.5 $\pm$ 10.0	0.328
SB	41.5 $\pm$ 25.1	39.6 $\pm$ 25.4	0.104

Values are mean $\pm$ SD or n (%).

MLD = minimal luminal diameter; RD = reference diameter; other abbreviations as in Table 1.

the risks of SB occlusion progressively increased as the pre-procedural DS of the SB and MV increased and the lesion length at the MV increased (Figures 2A to 2C). The best cutoff values for predicting final SB occlusion after MV stenting were as follows: 1) pre-procedural DS of the SB of 51%; 2) pre-procedural DS of the MV of 60%; and 3) lesion length at the MV of 14 mm (Supplemental Figure 1A to 1C). In the comparison of the incidence of final SB occlusion according to the stenosis of the SB and MV and lesion length, the lesions with tight SB and MV stenoses and long lesions at the MV showed the highest incidence of SB occlusion among the subsets (Figure 2D).

IMPACT OF WIRE JAILING AT THE SB ON FINAL SB OCCLUSION ACCORDING TO THE STENOSIS OF THE SB AND MV AND LESION LENGTH. The analyses of the associations between wire jailing at the SB and the significant predictors of SB occlusion after MV

TABLE 3 Acute Angiographic and Procedural Outcomes

	Event Rate		Unadjusted		IPTW Adjusted	
	Wire-Jailing SB Group (n = 819)	Non-Wire-Jailing SB Group (n = 1,071)	OR (95% CI)	P Value	OR (95% CI)	P Value
Final SB occlusion	15 (1.8)	31 (2.9)	0.63 (0.34-1.17)	0.141	0.62 (0.33-1.16)	0.133
Any abrupt SB occlusion during procedures	29 (3.5)	40 (3.7)	0.95 (0.58-1.54)	0.824	0.68 (0.35-1.32)	0.257
Restoration of SB flow after abrupt SB occlusion	14 (1.7)	9 (0.8)	2.98 (1.34-7.80)	0.026	2.74 (1.14-7.24)	0.037
Treatments of bifurcation after MV stenting						
Final kissing ballooning	214 (26.1)	65 (6.1)	5.47 (4.07-7.36)	<0.001	5.25 (3.52-7.83)	<0.001
Proximal optimization technique	304 (37.1)	259 (24.2)	1.88 (1.53-2.29)	<0.001	1.50 (1.22-1.86)	<0.001
SB ballooning without kissing balloon	39 (4.8)	27 (2.5)	1.87 (1.43-3.08)	0.014	1.67 (1.27-2.77)	0.024
SB ballooning after MV stenting	253 (30.9)	92 (8.6)	4.76 (3.67-6.17)	<0.001	5.18 (3.61-7.42)	<0.001
SB stent implantation	58 (6.8)	14 (1.3)	5.54 (3.06-10.03)	<0.001	5.92 (3.24-10.80)	<0.001
Noncompliant ballooning for MV	161 (19.7)	163 (15.2)	1.36 (1.07-1.73)	0.028	1.46 (1.03-2.05)	0.032
Wire broken during procedures	0 (0.0)	0 (0.0)	—	—	—	—
Angiographic success	520 (63.5)	695 (64.9)	0.94 (0.78-1.14)	0.529	1.13 (0.86-1.50)	0.374
Procedural success	518 (63.2)	692 (64.6)	0.94 (0.78-1.14)	0.540	1.14 (0.87-1.51)	0.372
In-hospital death or ST-segment elevation myocardial infarction	2 (0.2)	4 (0.4)	0.65 (0.12-3.57)	0.623	0.70 (0.13-3.86)	0.683

Values are n (%).

IPTW = inverse probability of treatment weighting; OR = odds ratio; other abbreviations as in Table 1.

stenting are provided in Figure 3. Although the incidence of final SB occlusion after MV stenting in all patients was not significantly different between the 2 groups, the wire-jailing group had a significantly lower incidence of final SB occlusion in the lesions with a pre-procedural DS of the SB of $\geq 60\%$ or MV of $\geq 60\%$ (Figure 3). In the comparison of the incidence of final SB occlusion according to wire jailing at the SB and the severity of stenosis of the SB or MV, the wire-jailing group had a significantly lower incidence of final SB occlusion in the lesions with a pre-procedural DS of the SB of $\geq 60\%$ and MV of $\geq 60\%$ (HR: 0.30; 95% CI: 0.12-0.69; $P = 0.007$) (Central Illustration). However, among the other subsets with a pre-procedural DS of the SB of $<60\%$ or MV of $<60\%$, there were no significant differences in the incidence of final SB occlusion between groups. Consistent impact of wire jailing was also noted after excluding the patients with an attempt for SB wiring before MV stenting in the non-wire-jailing group (Supplemental Figure 2).

Other subgroup analyses of the impact of wire jailing at the SB on the final SB occlusion are presented in Supplemental Figure 3; in the true bifurcation lesions, wire jailing at the SB was significantly associated with a low incidence of final SB occlusion (HR: 0.51; 95% CI: 0.26-0.98; $P = 0.047$). The incidence of final SB occlusion was not significantly different between the wire-jailing strategy and left main lesions.

CLINICAL OUTCOMES ACCORDING TO WIRE JAILING AT THE SB. During clinical follow-up (median 52 [interquartile range: 36-69] months), there were no significant differences in the rates of TLF (7.6% vs 6.3%; IPTW-adjusted HR: 1.33; 95% CI: 0.81-2.19; $P = 0.259$) (Figure 4) and the individual components between the groups (Supplemental Table 6).

DISCUSSION

The principal findings of our analyses are as follows: in overall bifurcation lesions treated with the 1-stent strategy, wire jailing at the SB was not associated with a reduced risk of final SB occlusion after MV stenting; however, bifurcation treatments for optimization, such as final kissing ballooning, POT, SB ballooning, and noncompliant MV ballooning, were more frequently performed in the wire-jailing group than in the non-wire-jailing group. Consequently, wire jailing at the SB before MV stenting was a protective factor against final SB occlusion after MV stenting in the 1-stent strategy. In particular, in the lesions with a pre-procedural DS of the SB of $\geq 60\%$ and MV of $\geq 60\%$, wire jailing at the SB was significantly associated with a lower incidence of final SB occlusion than was non-wire jailing, suggesting the beneficial roles of wire jailing without consequent complications for specific lesion subsets, such as severe stenosis of both SB and MV or true bifurcation in the 1-stent strategy. Additionally, Regarding the

occurrence of TLF during follow-up after MV stenting using second-generation DESs, there was no significant difference between the wire-jailing group and non-wire-jailing group.

Although recent consensus documents on bifurcation PCI suggest the preferential 1-stent technique followed by the provisional SB stenting strategy, SB occlusion remains a serious issue that can jeopardize clinical outcomes of bifurcation PCI.^{4,9} Therefore, numerous attempts have been made to identify patients at risk for SB occlusion after stent implantation and to prevent SB occlusion in the 1-stent strategy for bifurcation PCI.³⁻⁶ Of these, the wire-jailing strategy was originally used as a stand-alone technique or as part of the provisional strategy when the operator may need to eventually dilate the SB or insert a stent at the SB.^{4,5} Wire jailing at the SB before MV stenting in the 1-stent strategy assists in keeping the SB ostium intact and helps to approach the SB easily.⁴ Given that a jailed wire at the SB could guide rewiring after stenting, the recrossing of guidewires could be easier than that in non-wire jailing.^{3,10} In this strategy, there may be advantages in preventing SB occlusion; however, there would be risk of some complications, such as fracture of the jailed wire or embolization of the hydrophilic coating.^{4,5} Nevertheless, because there are no established data or guidelines regarding the effects of wire jailing at the SB on the occurrence of final SB occlusion in the 1-stent strategy, wire jailing is performed without specific indications or targets in regular PCI practice.⁵ Thus, the current registry study was conducted to evaluate the impact of wire jailing at the SB on the outcomes of bifurcation lesions treated with the 1-stent strategy in actual clinical settings.¹¹

To investigate the pure role of wire jailing at the SB as much as possible, we initially excluded cases requiring SB wiring, such as those that underwent elective 2-stent techniques and SB pre-dilation before stenting and those with Medina classification of 0.0.1, from the analyses. In overall bifurcation lesions, wire jailing at the SB was not associated with a low risk of final SB occlusion. The clinical outcomes after second-generation DES implantation were not significantly different between the wire-jailing and non-wire-jailing groups. Taken together, the universal wire-jailing strategy before MV stenting could not improve the angiographic and clinical outcomes in the 1-stent strategy for all bifurcation lesions.

Our study demonstrated that wire jailing at the SB, in addition to severe stenoses of the SB and MV and long lesion length at the MV, was one of the major determinants of the occurrence of final SB occlusion after MV stenting. Accordingly, an increase in the

stenosis of the SB or MV on the pre-procedural angiogram, along with the lesion length at the MV, was positively associated with the occurrence of final SB occlusion, and wire jailing at the SB was found to be protective against final SB occlusion. Especially, in the bifurcation lesions with severe stenoses at both the SB and MV, which would be classified as true bifurcation, including those with Medina classification of 1.1.1, 1.0.1, or 0.1.1, the incidence of final SB occlusion after MV stenting was significantly lower in the wire-jailing group than in the non-wire-jailing group. Therefore, in bifurcation lesions with severe stenosis at the SB and MV, wire jailing at the SB should be considered to reduce the risks related to SB occlusion.

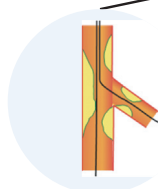
When considering the roles of wire jailing at the SB for the prevention of SB occlusion during the 1-stent strategy, the jailed wire itself may act as a small passage for vessel patency after MV stenting.¹² In addition, wire jailing can facilitate wiring to the SB and sequential procedures, such as kissing balloon inflation, POT, or high-pressure ballooning at the stented portion, which are well known to cause stent optimization and are expected to preserve or restore SB flow by improving angiographic findings.^{4,10} In the present analyses, despite relatively low rate of POT (~30%), the use of POT, final kissing balloon, or adjuvant noncompliant balloon more frequently occurred in wire-jailed group than in the non-wire-jailed group, supporting the role of wire jailing for the facilitation of stent optimization, as the European Bifurcation Club recommended.¹³ The incidence of SB flow restoration after abrupt SB occlusion was significantly higher in the wire-jailing group than in the non-wire-jailing group. If jailing or occlusion of the SB occurred with plaque or carina shift after MV stenting, initial rewiring at the SB and consecutive procedures for the restoration of SB flow could be easily and effectively performed with the wire-jailing strategy.^{14,15} Thus, this strategy itself could be important for the maintenance of SB opening and facilitation of consecutive procedures to protect the SB in bifurcation lesions with severe stenoses at both the MV and SB, rather than in all bifurcation lesions. In this regard, future research considering these factors together is required.

In the wire-jailing strategy, there are concerns regarding complications, such as wire damage, fracture, or embolization of the hydrophilic coating, when polymer-coated wires are used and jailed.^{4,5} In our study, however, there were no cases of wire-related complications observed; our finding reinforces the benefit of wire jailing in SB that mitigates the risk of SB occlusion and further facilitates the following SB treatments. However, there still remains

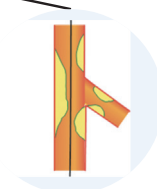
CENTRAL ILLUSTRATION Predictors for Final SB Occlusion and the Impact of Wire Jailing According to the Disease Severity

Effect of Wire-Jailing at Side Branch in 1-Stent Strategy for Coronary Bifurcation Lesions

Patients undergoing DES implantation for coronary bifurcation lesion with 1-stent strategy from the COBIS III registry



Wire-Jailing at SB

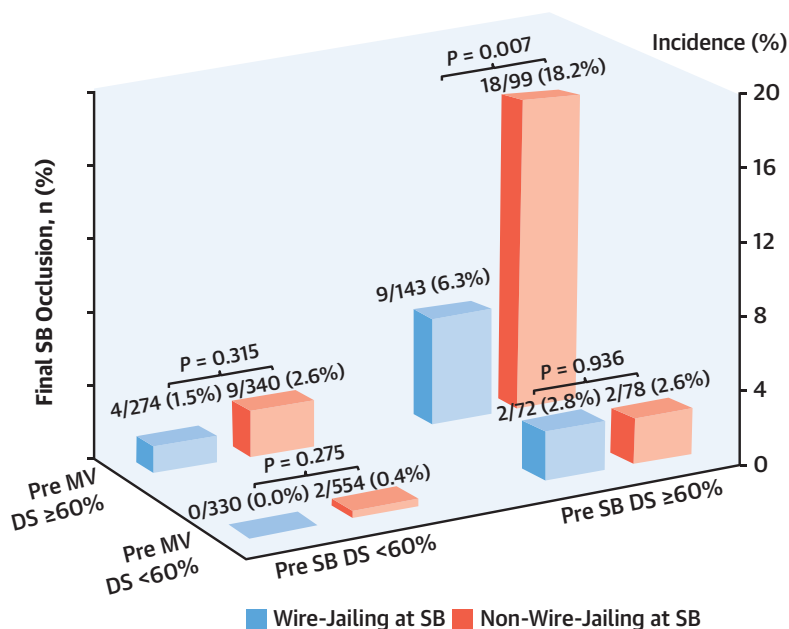


Non-Wire-Jailing at SB

A

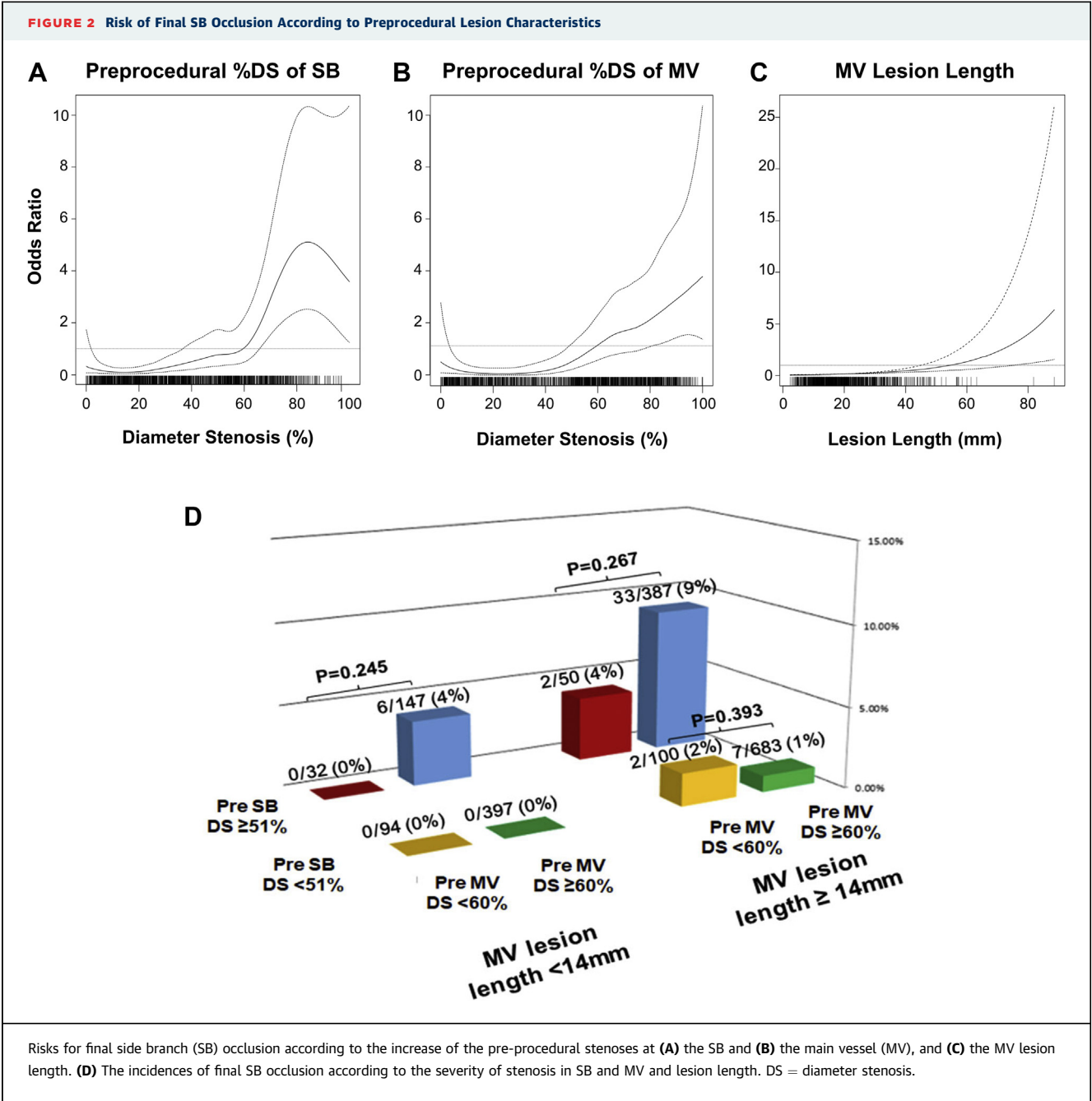
Variables	Final SB Non-Occlusion	Final SB Occlusion	Odds Ratio (95% CI)
Preprocedural DS of MV			1.02 (1.01-1.04)
Preprocedural DS of SB			1.03 (1.02-1.05)
MV lesion length			1.03 (1.01-1.06)
Wire-jailing at SB			0.48 (0.25-0.91)

B



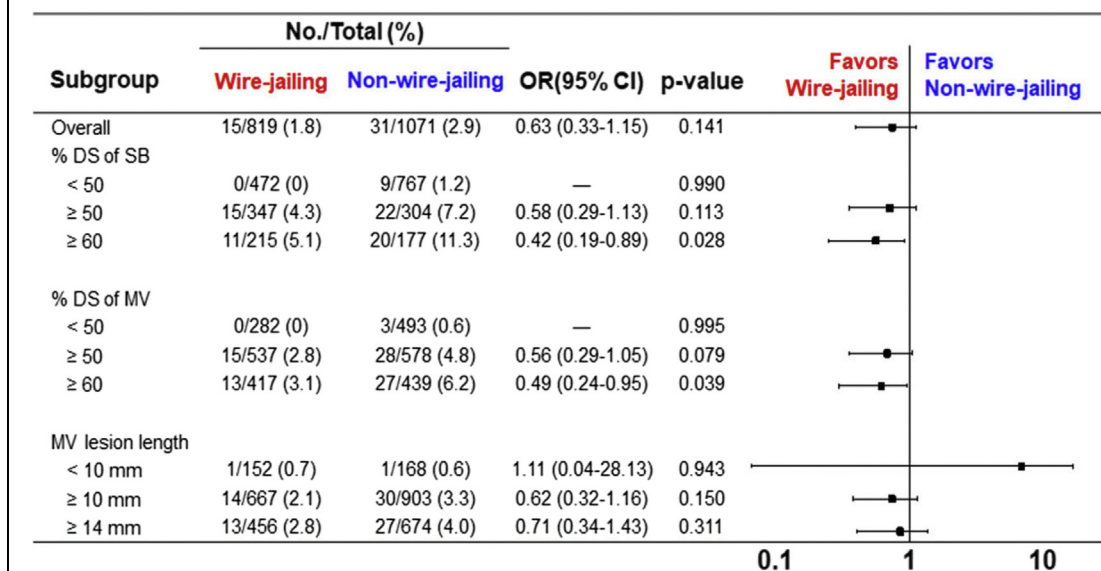
Choi, Y.-J. et al. J Am Coll Cardiol Interv. 2022;15(4):443-455.

Continued on the next page



CENTRAL ILLUSTRATION Continued

This study aimed to determine whether side branch (SB) wire jailing before main vessel (MV) stenting could prevent SB occlusion after the 1-stent strategy for bifurcation percutaneous coronary intervention. (A) Wire jailing was associated with lower risk of final SB occlusion and (B) the beneficial impact was particularly distinct in patients with significant stenosis in both MV and SB before percutaneous coronary intervention. COBIS = Coronary Bifurcation Stenting; DES = drug-eluting stent(s); DS = diameter stenosis.

FIGURE 3 Comparison of Final SB Occlusion According to the Disease Severity (Stenoses at the SB or MV and Lesion Length) and Wire Jailing at the SB

The Forest plot reveals that the differences of final SB occlusion according to diameter stenosis of the SB or MV, lesion length of the MV, and wire jailing at the SB. OR = odds ratio; other abbreviations as in [Figure 2](#).

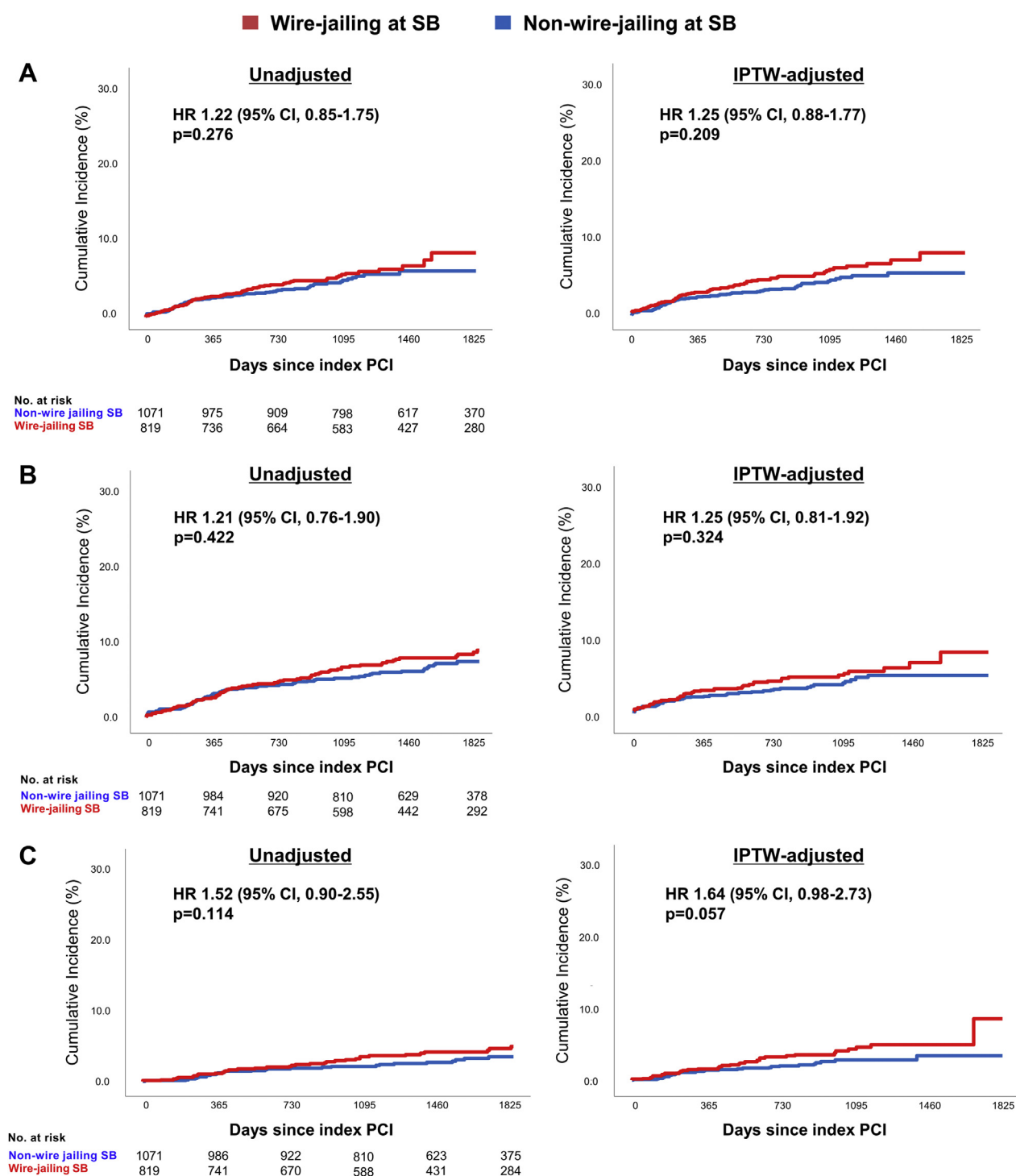
an increased risk of wire damage when high-pressure ballooning is performed with wire jailing or wiring is done at tortuous SB diseases with an acute angle. Care should then be taken to achieve successful wire jailing in the 1-stent strategy.⁴

As for the difference in clinical outcomes between the wire-jailing and non-wire-jailing groups following second-generation DES implantation in our study, there were no significant differences found despite a lower incidence of final SB occlusion in the lesions with severe stenosis of the SB or MV in the wire-jailing group than in the non-wire-jailing group. This might be attributed to the low event rate and small size of the population enrolled to investigate the clinical outcomes according to the patency of the SB after MV stenting. For the evaluation of the outcomes of bifurcation lesions treated with the 1-stent strategy, the impact of SB occlusion on total myocardial mass and long-term clinical follow-up should be considered. Even though SB occlusion might occur after MV stenting, the impact of SB occlusion on clinical outcomes might differ according to the location and territory of the SB supplying the myocardial mass.¹⁶ Therefore, the role of wire jailing in the prevention of SB occlusion and related clinical outcomes should be considered separately. If there is a risk of occlusion of a large SB supplying a large

territory, the strategy for the prevention of SB occlusion should be thoroughly conducted with consideration of the upstream 2-stent technique. In addition, DES-related factors could affect the outcomes after PCI of bifurcation lesions using the 1-stent strategy. Second-generation DES implantation has been reported to show superior outcomes compared with those of first-generation DES implantation for coronary bifurcation lesions.^{17,18} Thus, long-term follow-up studies with larger populations considering all factors related to bifurcation, including the location and territory of the SB, strategy for SB protection, and specific type of DES implanted, are needed in the future.

STUDY LIMITATIONS. First, given that this study was not a randomized trial, but rather was a retrospective and observational study, indication bias including the decision for bifurcation treatment strategy or wire jailing could exist. In addition, the treatment approach for the 1-stent strategy, including the types of balloon and DES, use of intravascular devices, performance of kissing ballooning or proximal optimization, criteria for stent optimization, and medications after the interventions, were left to the discretion of the operator. There were no exact angiographic, imaging, or physiologic criteria for the wire jailing to SB before MV stenting. Although IPTW

FIGURE 4 Time-to-Event Curves for Clinical Outcomes According to Wire-Jailing at SB



Kaplan-Meier survival curves and inverse probability treatment of weighting (IPTW)-adjusted survival curves for (A) target lesion failure, (B) cardiac death or myocardial infarction, and (C) target lesion revascularization. PCI = percutaneous coronary intervention; SB = side branch.

adjustment was performed to minimize these concerns, residual confounding variables could persist, and the findings presented in this study cannot be used to establish casual associations. Second, the incidence and impact of SB occlusion after MV stenting on the clinical outcomes could differ according to the location of bifurcation, especially whether a left main bifurcation is present or not. Although there was no significant interaction between wire jailing at the SB and left main bifurcation in this study, it is considered that the sample size of the current registry was too small to perform separate analyses according to the bifurcation locations. Third, there were no data regarding the success or failure of rewiring after MV stenting and the delivery of the balloon to the SB. Fourth, there were no data regarding the level of cardiac enzymes for the diagnosis of post-procedural MI after PCI. Fifth, because this study only included vessels with MV diameter of ≥ 2.5 mm and SB diameter of ≥ 2.3 mm, extrapolation of the results to other subsets requires caution. In addition, there could be concerns that bifurcations treated by elective 2-stent strategy with MV-first stenting method are included in this study population, which is hard to discriminate with the provisional 1-stent approach in some cases. However, because the decision for bifurcation strategy was investigated before PCI and the lesions with SB predilation before MV stenting were all excluded, the potential bias caused by this issue could be minimized. Last, many strategies, including jailed ballooning or microcatheter techniques, have been suggested to prevent final SB occlusion.¹⁹ Thus, future studies comparing wire jailing with other jailing procedures, such as jailed balloon or microcatheter strategies, are needed.

CONCLUSIONS

In the 1-stent strategy using second-generation DES, wire jailing at the SB before MV stenting was significantly associated with a lower rate of final SB occlusion in patients with severe stenoses at the SB or MV but not with overall bifurcation lesions. There were no significant differences in the long-term clinical

outcomes between wire jailing and non-wire jailing. Thus, routine wire jailing at the SB does not need to be recommended for all bifurcation lesions treated with the 1-stent strategy, but rather only for specific lesion subsets with severe stenoses of the SB or MV. Randomized trials with longer follow-up durations are needed in the future to clarify the role of wire jailing at the SB in the 1-stent strategy.

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PERSPECTIVES

WHAT IS KNOWN? Coronary bifurcation lesion is a challenging field and is associated with serious adverse clinical events. The 1-stent strategy is usually preferred based on clinical data for the treatment of the bifurcation lesion; however, the benefit of wire jailing at the SB has not been clearly elucidated.

WHAT IS NEW? Although there were no significant differences of long-term clinical outcomes, wire jailing at the SB is associated with a lower rate of final SB occlusion in patients with severe stenosis at the SB or MV.

WHAT IS NEXT? Further prospective trials specifically targeting patients with bifurcation lesions are required to clarify the benefits of wire jailing at the SB.

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KEY WORDS drug-eluting stent(s), myocardial infarction, percutaneous coronary intervention

APPENDIX For supplemental tables and figures, please see the online version of this paper.